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Farm & Home RESEARCH

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SUN GRANT INITIATIVE

biobased plan to revitalize rural communities while strengthening national energy security

A DAB OF DORPER

may add mothering ability and lamb vigor to the flock

GAP ANALYSIS

looks at native biological diversity



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On the cover:

South Dakota State University is involved in a nationwide project to “find new and better ways to create wealth from the land,” says SDSU President Peggy Gordon Miller. In addition to a continuing research, teaching, and Extension commitment to a safe food national supply, scientists in the project will work to discover renewable, biobased alternatives to fossil fuels, “farmaceuticals,” and other biotech products. This collaboration will promote new uses for new and traditional crops and will encourage economic diversification in rural America through an expanding biobased economy.

Director's comments

BY KEVIN KEPHART

Director, South Dakota Agricultural Experiment Station



Kevin Kephart

'We're going to need the creativity of science as we shape the next generation of farm products'

Americans have become increasingly concerned with energy availability and security since the attack on America last September 11 and the resulting war on terrorism.

It's clear there's a finite supply of fossil fuels, and a lot of that supply is not under U.S. control. Even if it were under U.S. control, expanding use of fossil fuels is clearly having a negative impact on the global environment.

Agriculture can be part of the solution to the country's energy concerns. We can do this through development and production of fuels, power, and products that are ag-based and that displace petroleum-based feedstocks. SDSU has been working with U.S. Sen. Tom Daschle since long before September 11 on a plan to broaden the role of land-grant institutions to include ag-based products and renewable energy. The principle behind the plan is one that South Dakota agricultural producers use every day: diversity.

The Sun Grant Initiative, as it is called, has a three-fold mission: find biobased renewable energy sources, develop other new biobased products, and help revitalize the rural economy. To think of it another way, biological diversity—a mix of crops, some current and some yet to be developed—can lead to economic diversity as producers find new products to sell. The healthy rural communities that result will lend social diversity to America's increasingly urban landscape.

All three branches of the land-grant system, teaching, research, and Extension, will be involved. The plan will look beyond colleges of agriculture to use the expertise in our engineering and pharmacy colleges and in other disciplines. It also will rely on cooperation among the states as land-grant institutions across the U.S. work together on the Sun Grant Initiative's mission.

Delivering traditional food and fiber will always be the key task of agriculture. But there's no reason we can't also grow industrial solvents, building materials, and pharmaceuticals in our fields. The ethanol industry is proof that we can grow energy.

We're going to need the creativity of science as we shape the next generation of farm products. Our current crops might not be the ones that are used in energy production in 20 years. Certainly 100 years ago few people had a vision that soybeans would be grown in South Dakota to the extent that they are. The future could see South Dakota farmers growing native warm-season grasses for energy production, or using materials like cornstalks as feedstocks.

If diversity is essential to our future, it's also firmly a part of our present. It's the fundamental basis of crop rotations, which is what Clair Stymiest's West River work is all about.

For those in the livestock industry, SDSU research is re-writing the book on marbling by challenging old assumptions. Our earlier assumptions have been that it is in late finishing diets where producers can put fat on their livestock and try to marble. But we're finding that producers make management decisions early in the animal's life that impact marbling. That's research that can help producers raise the kind of beef consumers want.

This issue of Farm & Home Research also discusses topics from corn borer moths and wildlife to Dorper sheep and farm policy. It's a look at diverse research activities, all aimed at benefiting South Dakota agriculture, natural resources, and rural people. At the South Dakota Agricultural Experiment Station, research is what we do to contribute to the diversity that makes up South Dakota. ♦

A dab of

DORPER

may add genetics for lamb vigor
and mothering ability to flock

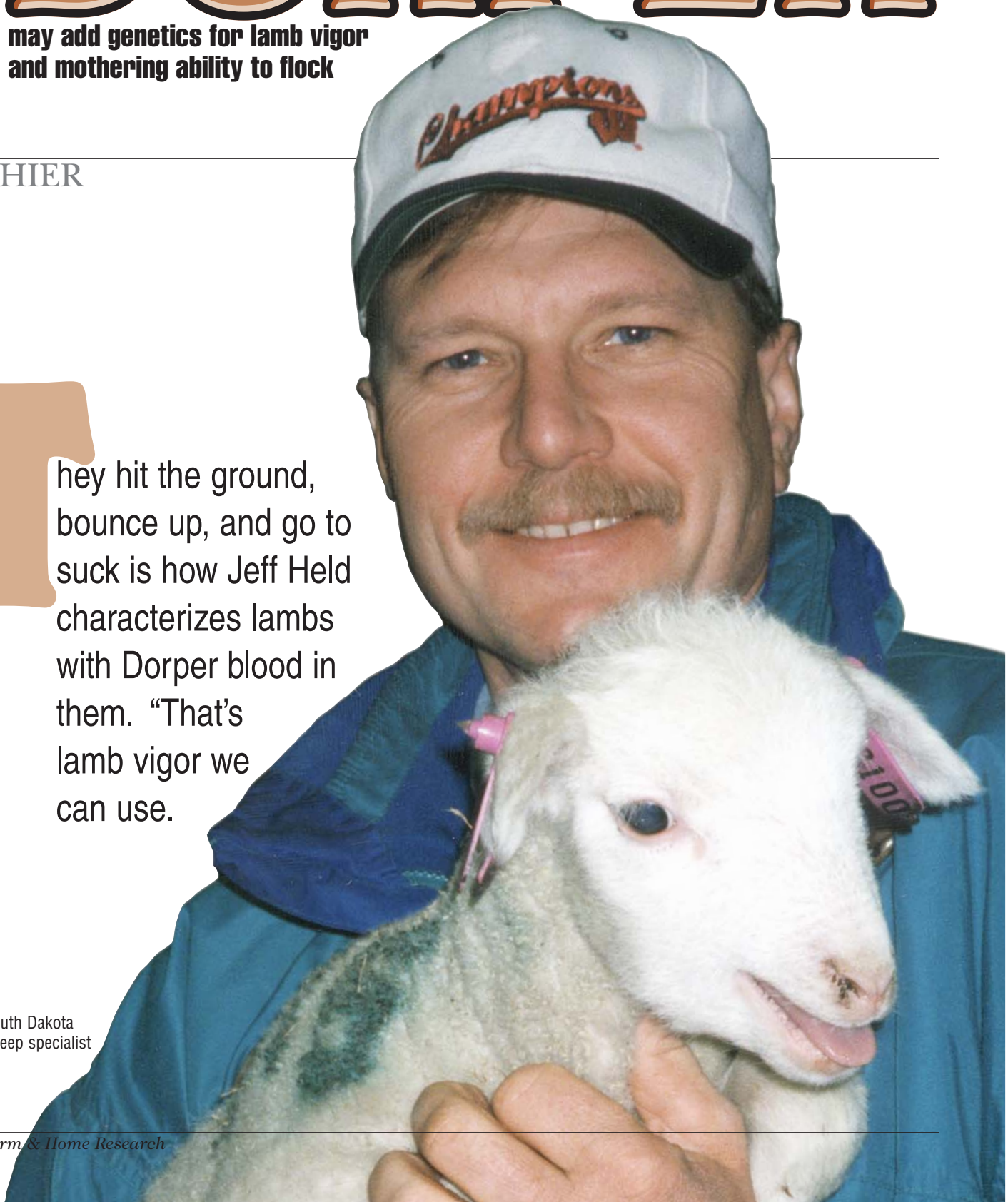
by Mary

BRASHIER

T

hey hit the ground, bounce up, and go to suck is how Jeff Held characterizes lambs with Dorper blood in them. “That’s lamb vigor we can use.”

Jeff Held, South Dakota
Extension sheep specialist





Dorper-sired lambs come in all degrees of hairiness. Greater advantages, however, says Held, are the breed's contributions to mothering ability, lamb vigor, and carcass merits. These babies were among those born just before and during the 2002 spring sheep open house at SDSU.

"And their moms take exceptional care of them. Add mothering ability to lamb vigor, and you've got two great traits to put in your sheep flock. You may find yourself raising more sheep or taking less time with your existing flock size. Mom and her lamb family pretty much take care of themselves."

Held is the South Dakota Cooperative Extension sheep specialist. He has been closely watching lambs from Dorper sires and Finn-Dorset-Targhee (FDT) ewes since the first crop was born last fall at the SDSU Sheep Unit north of campus. The project is funded by the Agricultural Experiment Station.

"Fall lambing is another big advantage of Dorper genetics," Held says. "Fall lambing spreads out the arrival of lamb at market. That usually means increased profitability for the producer."

The unit's FDT ewes are already highly successful out-of-season performers, producing fall lamb crops with just a little bit of coaxing, Held says.

Given their preferences, ewes lamb in the spring. Shorter daylength in the fall kicks their hormones into gear

and initiates the breeding cycle. Several years ago, SDSU scientists began to select ewes that had extended breeding seasonality. Now, out-of-season breeding success nearly equals that of fall breeding.

Dorpers and other "hair breeds" have longer breeding seasons since they were developed near the equator where daylength is constant, Held says.

"It's a big advantage to bring in a set of genetics with a propensity to lamb out of season," Held says. "Dorpers in our fall lambing program are a natural fit. They improve the predictability of out-of-season ewe success."

Dorper advocates also claim that the lambs lay on fat at a later age, thus coming to market at Yield Grade 2. (Of five yield grades, YG1 indicates the least fat.)

SDSU sheepmen won't comment on that yet; carcass data will be collected on Dorper-sired lambs this summer. Brent Larson, Sheep Unit manager, says that the medium-framed Dorpers are very muscular. "Determining an ideal finished weight for this cross is one objective for the research."

"Determining an ideal finished weight for this cross is one objective for the research this summer."

—BRENT LARSON,
MANAGER OF SDSU'S
SHEEP UNIT

Four 3/4 Dorper sires were purchased in March 2001 and were "stars of the show" at this spring's Sheep Unit open house.

"There is interest in Dorpers in this state," Larson says. "Some folks are a little skeptical about their frame size, but if they're crossed with bigger breeds, that can even out."

“If, in our tests the **Dorper** lives up to its advance billing, producers are going to have a very **valuable** option to consider adding to their flocks.”

—JEFF HELD,
SDCES SHEEP
SPECIALIST

Fall-born Dorpers “are showing a better average daily gain than our regular FDT crosses,” Larson says. “I don’t know if it’ll prove out as statistically significant in the end, but it’s noticeable. We’ll wait for the data to be sure.”

“The spring lambs don’t appear to be growing as fast, compared to those sired by the Hampshires, but this isn’t surprising, since Hampshires have a larger frame size. The Dorpers are vigorous, really healthy. They seem to have more resistance to sickness.”

Held has spring 2002 Dorper lambs “on the ground” at the Antelope Livestock and Range Field Station in Harding County. “Mothering ability is particularly important on range where you have more ewes and less chance to get around to help or observe each one. We shed lamb, but still the maternal traits and lamb vigor are important.”

He will retain 3/8-Dorper ewes and will evaluate maternal traits over a 1-year period. “We want the positive traits—the mothering ability and lamb vigor—to shine and the negative traits—particularly the smaller frame size—

to be minimized by choosing an appropriate terminal cross.”

A smaller to medium frame has its advantages. “The smaller bodied animal has lower nutritional needs. For each mouthful it consumes, it needs less to maintain body weight. Larger-framed animals have higher maintenance costs.

“The sheep industry is changing, and producers always need to excel in areas they can control. They can control genetic selection that impacts economic performance traits. It’s very desirable to have higher growth performance because that means fewer days on feed, which means lower costs of gain.

“Our goal is to determine whether the maternal contributions of Dorper genetics exceed any undesirable impact on lamb growth performance and profitability.”

With all the things they have going for them, Dorpers attract attention because of another trait. They shed.

A half century ago, South African farmers developed the Dorper from a Dorset Horn x Blackhead Persian cross. Dorpers are now numerically the second largest breed in South Africa, and they arrived in the U.S. about 10 years ago. Some are black-headed, others white. That’s a matter of preference; all other traits are equal.

One of those traits is hairiness.

That appeals to some sheep producers. They like the idea of saving shearing costs.

Held says that most research shows that the percentage of Dorper in an animal must be 7/8 or higher for it to shed completely. “Why change an entire sheep operation gene pool just to save a \$2 management charge, the cost to shear an animal? Over the long run,



Brent Larson is manager of the SDSU Sheep Unit, responsible for care of all breeds at the facility.

when you increase the percentage of Dorper in the flock, you could very well sacrifice more important performance characteristics.”

Larson agrees. “There are more benefits to the Dorper than the liability of the pelt. The key will be how much Dorper genetics are introduced into the flock. There can be a fair amount of variation.”

That is illustrated by the four purchased rams, who have the same amount of Dorper genetics. Two have wool on all parts of their bodies; two have bellies that shed; and one of them has a mane.

“Our primary goal is to evaluate Dorper contributions to maternal traits and carcass merits. We’re not interested in developing a line of sheep that would not require shearing,” Held says.

“If, in our tests the Dorper lives up to its advance billing, producers are going to have a very valuable option to consider adding to their flocks. That’s good, the sheep industry in the U.S. is very depressed and sheep numbers are at a historic low.

“Economic survival is going to depend on more efficient production of lean lamb. The Dorper contribution may be a shot in the arm. Our data will tell.”◆



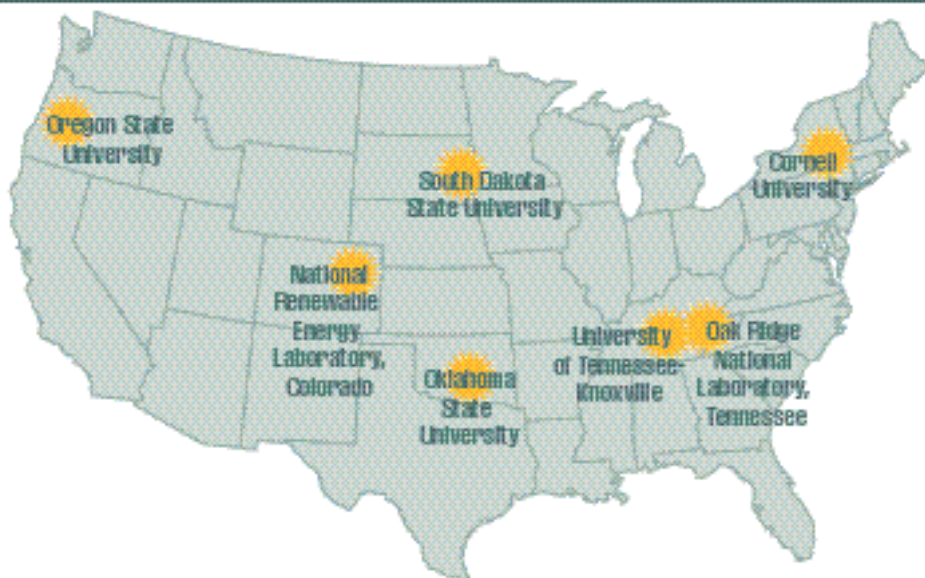
South Dakota launches nationwide

Sun Grant Initiative

by Lance
NIXON

South Dakota State University is set to enter a new era. The Sun Grant Initiative, a nationwide program originated by South Dakotans, could be the most significant new public service since creation of the land-grant system, says Kevin Kephart, South Dakota Agricultural Experiment Station director.

Regional Centers of Sun Grant Initiative



Launched by U.S. Senate Majority Leader Tom Daschle in summer 2001, the plan would create new emphasis in the nation's land-grant system on research, teaching, and Extension work into biobased energy and other non-food products.

"The Sun Grant Initiative is really about revitalizing rural communities with new opportunities," Kephart says.

SDSU President Peggy Gordon Miller agrees that the Sun Grant mission will complement SDSU's traditional mission.

"The goal of this new category of land-grant university research will be to find new and better ways to create wealth from the land," Miller says.

Outcomes of the Sun Grant Initiative could "include renewable fuels, pharmaceuticals, plastics, and many other biotech products. This interdisciplinary initiative would not replace our

commitment to research related to food and food systems but would add another important dimension to our land-grant research mission."

The Sun Grant Initiative's mission is three-part:

- Contribution to national energy security through renewable, biobased alternatives to fossil fuels;
- Biobased diversification and sustainability by promoting new uses for farm products;
- Opportunities for rural America from biobased economic diversification.

"Diversity is needed in agriculture today," Kephart says. "We want to focus on non-food areas such as energy and other non-food products to boost a new, diversified biobased economy."

And Daschle is also enthusiastic about the plan's potential for rural America.

"The Sun Grant Initiative provides a framework for major new investments in research into alternative uses for agricultural commodities, and ensures that independent farm families and their rural communities will reap the tremendous benefits from the results of that research," Daschle says. "Many producers are struggling to make ends meet, and this funding provides them with new economic promise. There is enormous potential in the promotion of non-food uses for farm commodities."

Fred Cholick, dean of SDSU's College of Agriculture and Biological Sciences, believes that the Sun Grant Initiative also may signal a major shift in American farmers' viewpoint of energy to "something they can grow and harvest year after year in their fields rather than something they mine or pump from fossil reserves underground. It will be agriculture based fuel rather than petrochemical-based fuel."

The proposal will also change the way people think about products ranging from solvents and adhesives to building materials, all of which can be made from agricultural products, he adds.

As Arlington, S.D., banker Roger Petersen sees it, the Sun Grant Initiative brings new thinking about a resource very old and basic to life: the sun.

"The most important part of the Sun Grant Initiative, it seems to me, is that we need to have educational profiles, educational regimes, that are outside the scope of what we have traditionally thought," Petersen says. "We are just now beginning to realize that the solar energy that is stored in plants has all kinds of new applications that we have never thought of."

Lead institution in planning the Sun Grant is SDSU. The University of Tennessee-Knoxville, Oklahoma State University, Cornell University, and Oregon State University are other regional centers around the nation. Planning grant funds have been provided through the Cooperative State Research, Education, and Extension Service.

Regional centers will serve as liaisons with two federal Department of Energy laboratories involved in the project: Oak Ridge National Laboratory in Tennessee and the National Renewable Energy Laboratory in Colorado.

Kephart says the five universities also will oversee distribution of funds to foster biobased teaching, Extension, and research in the land-grant colleges in their regions. The exact amounts available to set up Sun Grant centers and to disburse in grants are still in flux.

Some research projects being conducted at SDSU already fit under the Sun Grant banner, Kephart says.

Arvid Boe, SDSU forage breeder, says the U.S. Department of Energy already has been very curious about the possibilities of using plant materials, or biomass, as alternative energy sources. Boe is developing one or more new varieties of switchgrass, a potential biomass crop of the future.

"Switchgrass is adapted over a wide range of habitats, particularly in the Great Plains area," Boe says. "It grows well from Winnipeg to Panama, all the way through the central United States and to the East Coast. And it yields well in situations where other plants don't.

"I see its value to a farmer in that he could produce switchgrass for biomass on land that wouldn't produce much of anything else."

Boe adds that other native grasses also have potential as biomass crops.

Scientists at other regional centers also are ready for Sun Grant funding.

Oregon scientist Steven Knapp is domesticating a new crop that could let farmers grow the only U.S. source of oils that go into shampoos and detergents. Manufacturers currently must use imported coconut and palm kernel oil.

He works with cuphea, a wild plant that produces some of these oils. "If we had domestic supplies, it might alter the economic picture," he says, "and I think the Sun Grant would push it forward."

And in Tennessee, biosystems researcher Don Tyler is working with crops that a farmer can market at the local power plant, not the local grain elevator.

He also believes the Sun Grant can help his research. He is looking at short-rotation woody crops as a fuel that could partially replace the fuel in coal-fired power plants while also providing an additional environmental benefit by sequestering carbon.

But Tyler says his research is ahead of markets, and his project, now in its seventh year, will run short of funding unless some far-sighted groups see the potential market that may develop in the future.

If such a problem develops, Kephart says, the Cooperative Extension Service, the outreach arm of land-



Arvid Boe, SDSU forage breeder, is developing switchgrass varieties to be used as biomass fuels.

grant universities, will be instrumental in transferring Sun Grant technical information to the public and linking scientists and entrepreneurs.

Kephart says the Sun Grant Initiative will spur colleges of agriculture to look to other disciplines for help.

"It's broader than all of our ag programs at our land-grant colleges," he says. "We need to include, for example, the expertise that resides in the engineering colleges and pharmacy colleges. I'm hoping we also can add new majors and new academic programs in the biobased area.

"The Sun Grant Initiative has a tremendous future ahead of it, not only for SDSU but also for everybody in rural America. I'm proud to be associated with all the people who have put this initiative together," says Kephart. ♦

The Sun Grant Initiative website is <http://sdaes.sdstate.edu/sungrant>

A quarter of farm operators are
working harder at

off-farm JOBS



Carolee Little drives from a farm near Castlewood to teach in Volga. She says jobs off the farm are becoming the rule, not the exception.

by *Lance*
NIXON

One face of South Dakota agriculture looks a lot like Carolee Little, farm wife since 1985 who commutes 38 miles one way from her rural Castlewood farm each day to work as a teacher in Volga.

“It’s my career. I was a teacher before I was a wife or a mother,” says Little, special education teacher for grades 8-12 in the Sioux Valley School District.

Little says, from what she knows of other farm families, her job off the farm is the rule, not the exception. An increasing number of South Dakota farm operators or their spouses are looking to such jobs for any number of reasons.

“I think it’s the economy, partly,” Little says. “But I think it also gets lonesome out on the farm without someone to talk to. And it’s also a trend in our career-oriented society.”

Whatever the reason, what Little knows anecdotally to be true is the same story the statistics tell. SDSU economists Matt Diersen and Larry Janssen point out that the number of farm operators claiming a different occupation than farming has been increasing, and the pace has picked up in recent years. In 1978, only 16.5% of South Dakota farm operators worked 200 or more days in an off-farm job. That compares to 25% in 1997.

It’s a nationwide trend. Since 1964 most net income earned by farm families in the U.S. has come from non-farm sources.

Based on 1989 survey data of South Dakota farm households extrapolated to off-farm employment rates reported in the 1997 South Dakota Census of Agriculture, Janssen and Diersen made these projections of the employment picture for married farm couples in the state:

- 64% of South Dakota farms with married couples had some off-farm employment.
- 52% of married farm spouses and 45% of married farm operators were employed off the farm, part-time or full-time.
- Both operator and spouse worked off the farm, either part-time or full-time, in 33% of households.
- Only 36% of farm households in the state had no off-farm employment by operator or spouse.

“There’s probably a combination of factors driving these figures,” Janssen says. “Families simply may need the money. I think an important reason is that they may need the health insurance coverage. And frankly, many spouses just want to have their careers.”

South Dakota has seen a corresponding decline in the percentage of farm operators who report farming as their principal occupation, from 81% some years ago to 73%.

Not surprisingly, very small farm operations with less than \$20,000 in gross farm sales show a higher number of operators with full-time, off-farm jobs. In 1997, operators in that category accounted for about two thirds of the farm operators who worked more than 200 days in off-farm jobs and/or who did not consider farming their main occupation.

Age is another factor Diersen and Janssen considered. Farmers aged 55 or older were more likely to list their principal occupation as farming compared to young or middle-aged farmers.

The trend became more apparent in the period from 1978 to 1987, when there was a noticeable shift from farmers working off the farm part time—less than 200 days—to farmers working closer to full time off the farm—more than 200 days. That trend continued from 1987 to 1997.

The South Dakota findings dovetail with the USDA Economic Research Service (ERS) 2001 family farm report. What’s new about the trend nationwide is not that farmers and their spouses are working off the farm, but that they’re working more days at those non-farm jobs.

Although dependence on off-farm income is commonly viewed as a recent development, a fourth to a

third of farm operators worked off-farm in the 1930s and 1940s, according to the ERS report.

The ERS also notes that it isn’t only small farms that have an operator or spouse working off the farm, although the trend is more pronounced there. “One in six operators of large and very large family farms also work off-farm,” ERS researchers write.

The agency adds that, partly due to those off-farm jobs, farm operator household incomes were actually about 15% higher than the average for all U.S. households in 1998—\$59,700 compared to \$51,900.

Only 38.2% of U.S. farm households have neither operator nor the spouse working at an off-farm job—and more than half of those farm operators are older than 65, say Janssen and Diersen. That means 61.8% of farm households have at least somebody working elsewhere.

Most farm family members who work off the farm do it because of a need for additional income. Economists such as Tobias Madden of the Federal Reserve Bank of Minneapolis say that’s the very thing that makes working off-farm jobs a trend likely to continue in ag states such as South Dakota.

“It reduces the risk to farmers,” Madden says. “If they can rely on off-farm income, it can tide them over if they’ve got some bad years.”

Farm operators in the farm belt of the Midwest are less likely than their counterparts nationwide to rely on off-farm income. Diersen and Janssen found that 51.5% of Midwest farm operators do not work off the farm, very similar to the 55.5% of South Dakota operators who held no off-farm jobs.

The SDSU economists agree that the trend of working off the farm is likely to continue, noting that it



SDSU economists Larry Janssen, I, and Matt Diersen say that more South Dakotans are working off the farm and for more days per year than reported in previous surveys.

is consistent with the move toward rural industrialization that has been going on in North America and other industrialized nations.

Especially along the eastern edge of South Dakota, in the Black Hills area, and around some thriving trade centers of the state, farm residents are able to count on off-farm employment, Janssen says.

One drawback of the trend is that farm families may have to run a smaller or more specialized farm operation, choosing not to move into new enterprise areas that could make the farm more profitable.


Little says that for her and her husband Barry and sons Isaac and Eli, her job as a teacher isn’t really a matter of necessity. Barry has been able to turn a profit on the farm raising corn, soybeans, beef cattle, and occasionally wheat, barley, and sunflowers.

But it’s clear the additional income makes a difference.

“There are things we couldn’t buy if I wasn’t working,” Little says. “We wouldn’t be able to eat out as much. We wouldn’t be able to buy the car that I have to make this trip every day. Our lifestyle would be far different.” ♦

'Wheat is still king' but multi-year rotations pay off in West River

by Lance
NIXON



Cair Stymiest, SDSU agronomist who will retire this summer, is a strong proponent of longer rotations with a broader variety of crops. His reasons: they fight diseases and pests better and they use moisture and nitrogen more efficiently.

Cair Stymiest knew crop rotations would be a priority when he began work as West River agronomist for the South Dakota Cooperative Extension Service in 1978.

The dry country west of the Missouri River grew fine wheat, but farmers who planted it year after year ran into problems with diseases such as common root rot caused by the fungal organisms *Cochliobolus sativus* and *Helminthosporium sativus*.

The logical solution, in Stymiest's view, was to grow a broader variety of crops, including broadleaves such as safflowers and sunflowers, so that the disease-causing organisms couldn't build up in the soil.

"But then I ran into that old stone wall of the farm program," Stymiest recalls. "I could put out a test plot and folks would say, 'Boy, that corn looks good,' or 'The sunflowers look great.' And then they'd say, 'I'd like to grow some of those things, but I just don't have those crops in my farm base acres.'"

Farmers trying to farm within the guidelines of the farm program typically ended up letting a portion of their land sit fallow in years they weren't growing wheat. That practice was much cheaper when fuel, land, and machinery were all less expensive than they are today.

Stymiest adds that producers sometimes had misconceptions about the benefits of fallow and its ability to conserve moisture as compared to more diverse crop rotations.

In a typical winter wheat/fallow cycle, land is in crops 45% of the time, Stymiest said. In a typical rotation that includes winter wheat, sunflowers, millet, winter wheat, and fallow, the land is cropped 50% of the time, or only slightly more than under the winter wheat/fallow pattern. With modern farming and no-till technology, Stymiest said, farmers are able to trap more moisture and more than make up for the added moisture requirement of the diverse crop rotation.

Stymiest adds that crop rotations pay off in several ways:

- There's less carryover of crop disease from one crop to the next.
- Weed control is better because more diverse herbicides are used.
- Rotations allow better use of moisture and deep nitrogen.
- Rotations allow for better use of farm machinery and labor.

That's why Stymiest was happy to see a major policy change in the 1996 farm bill, commonly called Freedom to Farm. The new policy let growers plant whatever they chose to grow without penalizing them with reduced program payments if they used new crops on their farm.

"I would say producers are able to do a better job now using more diverse rotations," says Stymiest. "Wheat is still king as far as number of acres in western South Dakota. It's in every rotation."

Selecting complementary crops for rotations requires flexibility

Year 1	Year 2	Year 3	Year 4	Year 5
Cool-season small grain with early season moisture demands.	Warm-season crop like corn, sunflower.	Warm-season, low-moisture-requirement crop, millet.	Winter wheat can be planted with good yield potential on both fallow and millet stubble fields.	Warm-season crop, but not the same crop as year 2.
This crop can make use of stored soil moisture.	This crop has a mid-season moisture demand.	Millet is planted later and allows the soil to recharge with moisture. Fallow could also be used if season is very dry.		
This crop will develop during the cool portion of the summer.	The crop will take moisture from the soil into the early fall.			

Stymiest says several crops have wide adaptation to West River conditions: alfalfa, wheat, oats, barley, sunflowers, millet, field peas, and forage sorghum.

Crops with limited adaptation to West River conditions are canola, chick peas, corn, grain sorghum, safflowers, and soybeans.

Stymiest said West River geography and climate are generally the limiting factors for crops. For example, grain sorghum is a tropical plant that does well in places such as Lyman, Jones, Stanley, and Haakon counties, which are generally not much above 2,000 feet in elevation. But at higher elevations farther west, cool nights send sorghum into a partial dormancy from which it doesn't recover until temperatures warm up the next day.

Similarly, soybeans have limited adaptation in West River rotations because the crop likes rain in August—something the region rarely delivers. Crops that thrive under hot, dry August conditions are chickpeas and safflowers; the dry weather limits disease pressure on those crops.

Stymiest says that since 1996 more acres of sunflowers, corn, field peas, millet, and some soybeans are being grown in western South Dakota. The change isn't solely a result of Freedom to Farm; producers also are seeing better economic returns from crops other than winter wheat.

Stymiest adds that SDSU's ongoing work with crop rotations illustrates why local research is so important.

Data from Kansas and Nebraska indicate that in rotations that include sunflowers, subsequent wheat yields are less than in other rotations. In South Dakota that's not the case. The West River studies suggest farmers can use safflowers, sunflowers, and peas strategically in their rotations and do very well with wheat.

Winter wheat in a rotation that includes sunflower with a millet transition crop has had a 3-year average yield of 51 bushels an acre in the SDSU studies. Its production cost, at \$2.27 a bushel, was the lowest of any wheat in the crop rotation study, Stymiest said.

Stymiest believes winter wheat fares better in sunflower rotations in western South Dakota because the region sees considerably less evaporation than Nebraska or other states farther south. And no-till technology lets the soil recharge faster.

"We have been recording crop budgets for the rotations. This helps determine how much it cost to grow each crop and the returns for the total rotation," Stymiest says.

"The benefit of long-term studies is that we can evaluate the total effect of the crop rotation rather than only

consider one season's results. We would not be able to evaluate the effects on crop yields, weed control, and plant diseases over a single year. Crop rotations must be carried out for more than one cycle to get the full benefit."

Stymiest's current studies began in 1994 and are located at Wall. The research has had multiple sources of funding: SDSU, the South Dakota Wheat Commission, and the South Dakota Oil Seeds Council.

Previous crop rotation studies were conducted at Winner 1980-1986 and Hayes 1987-1995. ♦

The effect of crop rotation on winter wheat yields 1998-2000

- Winter wheat following millet in broad leaf crop rotation. Average 51 Bu/A. Average cost/Bu \$2.27
- Winter wheat following millet with corn rotation. Average 43.8 Bu/A. Average cost/Bu \$2.69
- Winter wheat / millet no-till continuous crop. Average 36.5 Bu/A. Average cost/Bu \$2.70
- Winter wheat following spring wheat in sunflower rotation. Average 39.0 Bu/A. Average cost/Bu \$3.23
- Winter wheat / fallow reduced tillage. Average 64.8 Bu/A. Average cost/Bu \$2.53



Mike Catangui

Tracking **corn borer moth flights** on Internet

by *Lance*
NIXON



Corn borer moth

American agriculture has taken two strides forward in the fight against a persistent crop pest.

The nation's farmers planted the first *Bt* corn, genetically modified so that it produces its own pesticide lethal to corn borers, in 1996. In the same year, SDSU began monitoring flights of corn borer moths in the state, using the Internet to post information to farmers.

From the original three monitoring stations, the project has grown to 35 sites in the 2001 growing season. More are likely in year 2002.

The tracking project involves not only the South Dakota Agricultural Experiment Station and its research farms, but also seed companies, private crop consultants, and South Dakota Cooperative Extension Service (CES) educators. Nebraska and North Dakota also are cooperating, as they track corn borers in related projects.

Scientists believe the European corn borer (*Ostrinia nubilalis*) probably entered the United States in broom corn from Italy or Hungary in the early 1900s. Larvae were first discovered on sweet corn near Boston, Mass., in 1917.

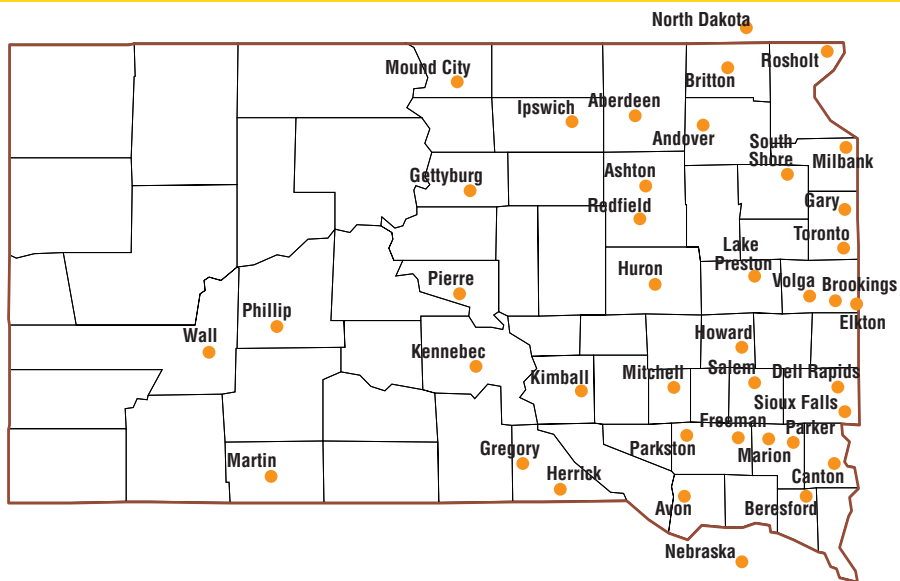
Corn borers reached Illinois in 1939, Iowa in 1942, Nebraska in 1944, and South Dakota probably about 1946. All 66 counties now have European corn borers, usually on corn and proso millet but also on soybeans, sorghum, potatoes, tomatoes, green beans, and weeds.

The insect causes damage after its eggs hatch and larvae begin to feed on plants. Corn borers lower yields by interrupting the flow of nutrients as they bore into stalks.

Mike Catangui, CES entomologist, says there are at least three very important kinds of information the Internet site can provide.

First, a glance at the previous year's numbers at a particular location could help a farmer determine whether he wants to plant *Bt* corn in the spring. A high moth count the previous year, especially if the winter was mild, may suggest corn borer trouble in the year to come.

Sites with corn borer flight information on the Internet



Once the growing season has begun, the site can help farmers who didn't plant *Bt* corn know when to start scouting their fields for signs of corn borer larvae. The site also shows economic thresholds at which chemical treatment pays off.

"The advantage of the site is in having a direct connect to the corn borer moth flight at its peak. Then farmers know when to spray non-*Bt* corn," says Gary Erickson, Brown County Extension educator who helps monitor traps.

Delton Strasser, Wilmot area farmer, says many farmers routinely plant *Bt* corn because of the ease it offers in corn borer control. But he agrees the SDSU site is a big help to all corn growers.

"It's good information," Strasser says. "It has to be very timely information because you don't have a very large window to do that spraying."



Bob Berg and the light trap in Beresford.



A corn borer moth lies with other insects in a collection bag. Entomologists must sort and count every 24 hours before posting results to farmers through the Internet.

“The advantage of the site is in having a direct connect to the corn borer moth flight at its peak. Then farmers know when to spray non-Bt corn.”

—GARY ERICKSON,
BROWN COUNTY
EXTENSION EDUCATOR

Monitoring moth flights gives producers advance warning, since the moths must lay their eggs and the larvae must hatch before major damage begins.

In addition, the site can help producers who grow proso millet, Catangui says. It's not economically feasible to spray proso, but data from the site can help farmers time their planting after summer moth flights have occurred.

Catangui says the project has cleared up some misconceptions about corn borers in the state.

It's now known that South Dakota has two types of corn borer moths: univoltine, whose numbers peak only once; and bivoltine with two peaks in a single season. Univoltine larvae can be more destructive because they remain in the plant, feeding from June through harvest, not transforming into pupae until the following spring.

A feeding lull of about 2 weeks occurs in the bivoltine cycle as the larvae change to pupae and then to adults which lay the eggs that become the second brood larvae.

“Before we did this, we used to assume there was only one type of moth flight in South Dakota, the bivoltine.”

The moth-tracking project has made it clear that univoltine moth flights occur on the North Dakota border and north of Minnehaha County along Interstate 29. Bivoltine moth flights occur along and to the south of Interstate 90.

In addition, some areas of the state are what Catangui calls transition zones. The corn borer moth flight near Dell Rapids, for example, has both bivoltine and univoltine components. In other areas of the state,

particularly west of the Missouri River, the moth flight pattern isn't yet known.

Catangui sees the corn borer tracking project proving another point: Farmers don't have to grow Bt corn every year.

Several locations saw a significant Bt advantage in 2 of the past 6 years. Bivoltine corn borers were bad in 1996-97, and univoltine corn borers were bad in 1996-98, but there has been no major, widespread outbreak since then.

Catangui credits Bt corn with raising the profile of the European corn borer so that more farmers are aware now of the damage the pest can cause in outbreak years.

“Before that, relatively few people would spray for European corn borers.”

The SDSU project uses black-light traps to lure the insects into a funnel that guides them into a pail or container. There, insecticide-impregnated strips kill the insects quickly.

Each day, the trap tender records the number of moths caught during a given 24-hour period. That can be a daunting task: A trap at Beresford caught more than 1,750 moths on August 26, 2001.

The corn borer moth tracking project is a cooperative effort with SDCES, Pioneer Hi-Bred International, Syngenta Seeds, crop consultants, North Dakota State University, and the University of Nebraska. ♦

The Internet address for corn borer moth-tracking data is
http://www.abs.sdstate.edu/plantsci/ext/ent/ecb/SD_ECB_2001.htm



GAP analysis

shows the connection between space satellites, land stewardship, a nematode, & over 400-wildlife species

by Mary
BRASHIER

Jon Jenks and Chad Kopplin discuss the distribution map for the gizzard shad, a fish species that has been found in Eastern South Dakota (red) but may occur statewide (yellow).

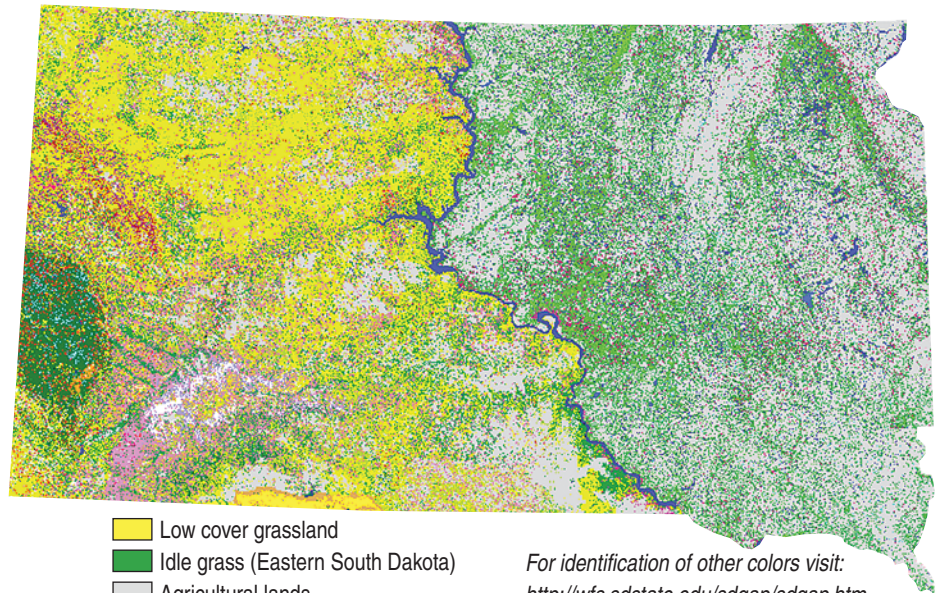
Attractive enough to hang on a living room wall, Jon Jenks' maps of South Dakota answer some questions while posing others.

Every summer his phone rings with calls from vacationers asking about "hot spots" for bird and wildlife watching or fishing. Jenks, professor in the SDSU Wildlife and Fisheries Sciences Department, consults the maps and passes on his three or four favorite locations. To support his choices, he steers the callers to the SD-GAP web site.

If he needs to take a wildlife class out in the field, Jenks can tell, from looking at the satellite-generated maps, where he could likely find representatives of 79 different mammals, 31 reptile species, 17 kinds of amphibians, 226 different birds, or 116 fish species.

There are some empty spots on those maps. They raise the most puzzling questions.

Those empty spots, especially when they occur on lands that could be expected to house certain species, are "gaps" in native biological diversity, Jenks says. They might be an early warning of trouble on the planet.



*For identification of other colors visit:
<http://wfs.sdstate.edu/sdgap/sdgap.htm>*

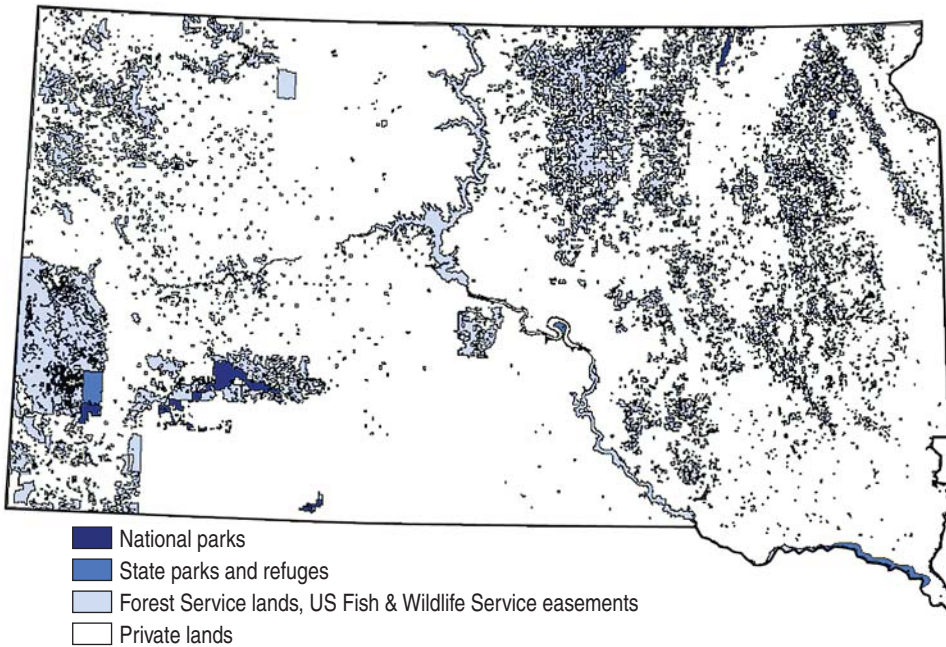
"Biodiversity is the environment's way of telling us that all is well," Jenks says. "If the environment is healthy, then the species that live in it—and that includes us, no matter how we try to distance ourselves from it—are very likely healthy."

The **Gap Analysis Program (GAP)**, funded by the U.S. Geological Survey, Biological Resources Division, seeks to find species-rich areas in every state in the nation. Similar projects are underway in Mexico and Canada.

In the interests of a healthy environment, to save gene pools that may in the future become life-saving to the human species, and to aid in stewardship of the land and its inhabitants, GAP was designed to stem the loss of biodiversity before species became threatened, endangered, extirpated, or extinct.

"Waiting until the last minute before trying to save a species is inefficient and expensive," Jenks says. "Last-ditch efforts tend to become politicized, pit economic interests against each other,

South Dakota land stewardship



and usually are biased toward big, beautiful animals, what we call ‘megafauna.’ Yet scientists believe that vertebrates actually account for less than 2% of all animal species. About 27,000 species go extinct around the world every year and we hardly notice.

“GAP, which is the first step in maintaining self-sustaining species in their natural environment, is much less costly than an intensive management program to save a species from extinction when it may be too late anyway.”

The vegetation map generated from 18 satellite passes over South Dakota is the start of the GAP process, says Jenks. EROS, the Earth Resources Observation Systems Data Center north of Sioux Falls, supplied landcover maps for all states in the GAP program.

Applying GAP to benefit cattle producers



Jon Jenks, Bill Epperson, and Mike Hildreth in a spring pasture.

Another question GAP will help answer for Jenks, Mike Hildreth, SDSU biology professor; and Bill Epperson, Cooperative Extension Service veterinarian, is the connection between roundworms, cattle, and “green up” in the spring.

“Why do certain herds get high parasite loads and others don’t? We think the maps can help us find the answer,” Jenks offers.

Hildreth will consult the vegetation map once he finishes collecting data on economic losses sustained by cattle producers in central South Dakota from a complex of roundworms collectively called strongyle nematodes. Quite often, producers don’t even know their animals are infected.

This group of nematodes is found in higher numbers in the southern U.S., Hildreth says, and cattlemen there automatically deworm their herds. “In South Dakota, infected cattle don’t look ‘wormy.’ Usually, they just have diminished appetites and lose feed efficiency. If so, we call that subclinical parasitism, and cattle producers are losing money without knowing it.

“Even with all the normal diagnostic tools we have at hand, it’s difficult to predict when and where these losses are economically significant. Most cattle have low loads of roundworms anyway. It’s just a question of how many worms have built up in the cattle and pasture to become significant.

“The juvenile stages of these nematodes live in the soil and climb up on the grass, so they are influenced by the same climate and weather factors that influence grass growth. When we look at the maps, maybe a prediction of where infestations might appear will jump out at us.”

When the South Dakota images were separated into land cover classifications, combined grassland categories dominated the landscape at 56% of the land area. Ag land accounted for 31%; prairie potholes, numerous but small, and other water categories, 4.5%; forest categories of the Black Hills, 2.7%; and the Badlands, less than 1.3%.

Then begins the process of relating known species distributions to the habitats on the land cover map. “We locate species from data we already have, and then work outward from those spots, adding hexagons in ‘probable’ sites.

“So, if we have already confirmed that the black-footed ferret is in a certain corner of a county, and the EROS map shows the habitat to be similar in the adjoining county, it’s probable the species will be there too. For some species, we might need to go out and see if this all hangs together, if the animal really does show up where we predict it will be. Two things gap analysis

does not reveal is quality of the habitat or the number of individuals in an area.”

The matching won’t be perfect, Jenks says. It’s called a “coarse filter” approach. Yet about 85 to 90% of animal species can be protected without having to resort to the expense and time commitment of individual surveys.

The stewardship map, prepared to overlay the vegetation map and showing how private landowners, organizations, and federal and state agencies protect and conserve land in South Dakota, was a happy surprise for Jenks. “When you look at this, it really hits you. You say, ‘Wow, look at the conservation efforts we have in this state.’”

There are fewer gaps in eastern South Dakota than he expected. Gaps are those areas where the combined maps reveal that areas rich in plant and animal species fall outside of protected stewardship lands. The northeastern region of the state “is a lot richer in biodiversity than we thought. And we

were also surprised at the amount of protection in East River.”

In West River, the Badlands, Wind Cave, and Custer State Park are the areas of highest biodiversity. “The planners hit it right on when they put parks there,” he says.

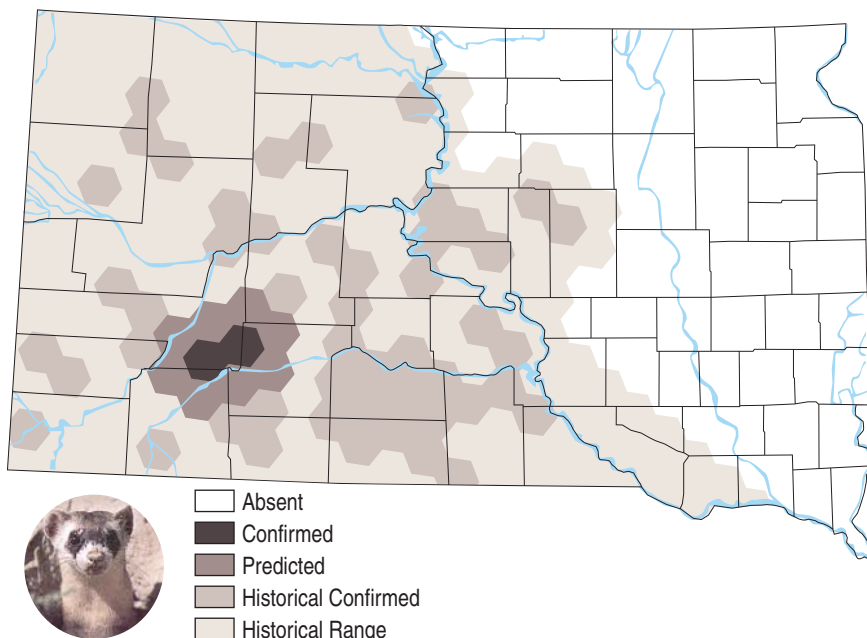
Oh yes, where would Jenks send those vacationers?

“See all that green on the map east of Chamberlain in the Fort Thompson, Big Bend, Crow Creek area? That area appears to have a lot of habitat, and therefore a bunch of animal species, and it’s accessible from I-90.

“I suggest the area north of the Black Hills for both terrestrial and aquatic diversity. The northern tip of the Prairie Coteau in Roberts County probably has the highest biodiversity in East River.”◆

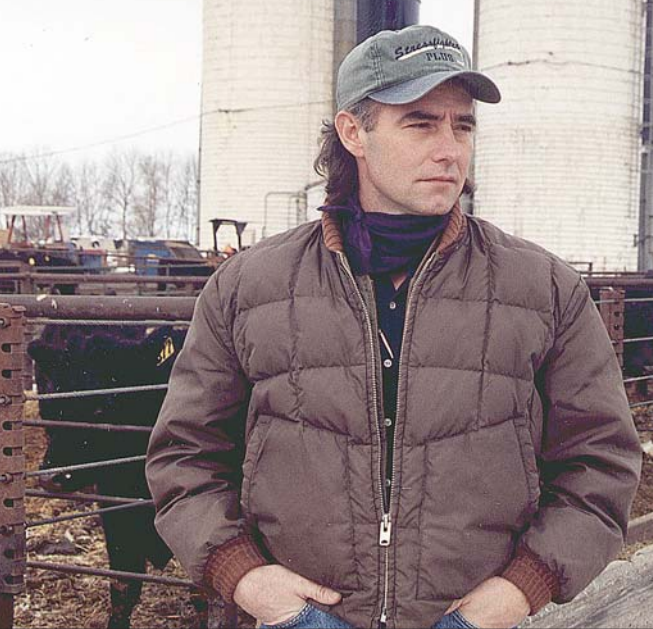
Home page for South Dakota Gap Analysis is <http://wfs.sdstate.edu/sdgap/sdgap.htm>

Distribution of black-footed ferret in South Dakota



South Dakota’s GAP began in 1997, and the first round of work will be completed this year. Funding is by the U.S. Geological Survey and its National Gap Analysis program. Cooperators in collecting data are

- South Dakota Agricultural Experiment station
- The Nature Conservancy
- South Dakota Game, Fish & Parks Department
- U.S. Fish & Wildlife Service
- National Park Service
- U.S. Army Corps of Engineers
- Forest Service
- U.S. Bureau of Indian Affairs
- Dakota Wesleyan University
- Black Hills State University
- Augustana College
- U.S. Environmental Protection Agency



'Rewriting the textbook' on

marbling

by Marianne
STEIN

Robbi Pritchard, SDSU ruminant nutritionist, says early calf management affects marbling development more than once believed.

What two SDSU beef nutrition scientists found in their study of beef marbling runs contrary to common beliefs and may have significant implications for beef producers.

"We just completed a project investigating when marbling begins to develop in beef, how it progresses as the animal grows, and how management influences that progression," says Robbi Pritchard, professor of ruminant nutrition. "We found that management of the cattle when they are relatively young influences the quality of the carcass much later."

The research was conducted by Pritchard and Kelly Bruns as part of Bruns' work towards a doctoral degree.

"Kelly's results are going to rewrite the textbook on marbling. And South Dakota producers could substantially increase the quality grade of their cattle," Pritchard states.

Marbling is fat growth, the little white flecks of fat visible in a steak within the muscle. The more marbling the better, since intramuscular fat adds juiciness and flavor

to the meat. A certain amount of marbling is required to meet U.S. Choice grading standards, granting the producer a premium price.

"Marbling was thought to be one of the last tissues to develop in cattle. It was believed that all the other fat deposits had to be made first, so the fatter you get them on the outside, the more marbling you should have. But no one had conducted any real research on it," says Bruns.

Bruns and Pritchard conducted a trial with 90 Angus steers at the SDSU Beef Research Unit, slaughtering steers at five different intervals from 700 to 1350 pounds. "Normally, these steers would be marketed at about 1200 pounds, so we harvested them at either side of their normal market weight," Bruns says.

The development of backfat starts out slowly and then gradually picks up. Marbling was thought to display a similar curve; however, the scientists saw a different pattern.

"We found that marbling starts early in the calf's life and increases at a steady rate all the way through," Bruns says.

They also found that marbling is not directly related to the amount of backfat but develops at its own rate. More backfat does not necessarily equal more marbling, Bruns notes.

This has big implications for feeding and management practices, he says. "If cattle aren't getting enough calories early in life, marbling can be hindered. Producers have always believed that they should manage for 'grade' at the tail end of feeding, but we found that it is the front end of the finishing phase which has a dramatic impact."

Marbling is genetically determined and probably cannot be increased beyond its potential, but it can be obstructed, Pritchard says.

Their second study showed the effect of growth promoting implants on marbling. About 90% of feedlot cattle in the U.S. receive implants that consist of a combination of the hormones estrogen and testosterone. Implants cause an animal to grow faster and bigger by adding more muscle tissue.

Bruns and Pritchard used 180 Angus and Limousin x Angus steers divided

into three groups, one receiving implants at 650 pounds, another at 850 pounds, and a control group receiving no implants.

The 650-pound group developed significantly less marbling than the other two.

“When the implant is given too early, you are asking the body to deposit more muscle tissue, and the calories that normally would support both muscle and fat growth are now going towards more muscle growth,” Bruns says.

“The cattle that received the implant later were consuming more feed and receiving a diet that had more energy in it. Their marbling scores were no different than those of steers that had received no implant at all.”

Conventional wisdom says that implants decrease marbling, because they cause a large demand for fuel to support increased muscle growth. But when they are given at the right time, it appears that implants do not interfere with the development of marbling, Bruns explains.

The scientists conclude that producers can significantly improve marbling of their cattle if they adjust their feeding and management strategies. Producers may do some things to cattle in the front end of the finishing phase that aren't beneficial to marbling, Bruns says. For example, they might grow them on a high forage diet without much grain, or they may be implanting too much or too early. “Oftentimes, producers may run cattle on grass or background them on a high roughage diet before they put them on a finishing ration. If an implant is administered at this time, the development of marbling may be hindered,” he says.

Bruns points out that there is no magical time to administer an implant.

It is a matter of matching the implant with the diet, when the animal has sufficient caloric intake and enough nutrients and energy to support not only muscle growth but also fat development. Breed of the animal also has to be taken into consideration; British breeds, for example, are noted for less muscle growth than some continental breeds, he says.

Bruns, now an assistant professor in the Animal and Range Sciences Department, and Pritchard are cooperating with South Dakota ranchers to determine optimum feeding and management strategies to promote marbling. They

“Kelly’s results are going to rewrite the textbook on marbling. And South Dakota producers could substantially increase the quality grade of their cattle.”

—ROBBI PRITCHARD,
SDSU RUMINANT
NUTRITIONIST

are also investigating whether factors very early in the calf's life may influence marbling.

Christine Hamilton runs Christianson Land and Cattle, a farming and ranching operation near Kimball, and backgrounds and finishes calves. Hamilton notes that it is important that beef research is done in South Dakota.

“The cattle industry is a big part of our economy, and there are some



Kelly Bruns, Animal and Range Sciences Department, checks marbling against a standard in the SDSU Meat Lab.

issues that are specific to our ecology and environment in South Dakota. As a beef producer, I find it beneficial and helpful that we have access to research that is conducted at South Dakota State University,” she says.

Don Boggs, head of the Animal and Range Sciences Department at SDSU, notes that Bruns' and Pritchard's work is a good example of a university project that greatly benefits South Dakota beef producers.

“In value-based marketing, which is becoming increasingly popular, marbling is one of the primary criteria in the market grid that determines the value of the cattle. Learning more about how marbling develops allows producers to design stronger management and marketing programs,” Boggs says.

The marbling research was funded by the South Dakota Agricultural Experiment Station and grants from the SDSU Foundation Beef Nutrition Center Fund, the Beef Industry Council, and the South Dakota Corn Utilization Council.◆

Co-products of agriculture—

societal benefits

—are ‘coming to the forefront’



by Lance
NIXON

Tom Dobbs, SDSU economist, discusses “multifunctionality,” public payment to farmers for public environmental benefits.

American farm policy may be edging closer to that of European nations where there’s growing support to pay farmers for producing goods other than food and fiber.

That’s the observation of Tom Dobbs, SDSU economist who studied European ag policy as a Fulbright scholar in the United Kingdom (U.K.) in 2000. Dobbs says the debate over agricultural policy as Congress finished writing a new U.S. farm bill this spring carried echoes of what he heard at the University of Essex, where he worked with Jules Pretty, director of the university’s Centre for Environment and Society.

In the U.K. and other countries of the European Union, Dobbs says, a term that’s popping up in farm policy discussions is “multifunctionality.”

Instead of being paid for their crops, farmers might be paid for contributing to a range of other public goods such as clean water, wildlife, carbon

sequestration in soils, flood protection, and landscape quality.

That was one theme in a joint research paper Dobbs and Pretty published in August 2001. In it the economists discuss new farm policy ideas that Europeans and Americans are beginning to explore.

“It is legitimate to pay for public environmental benefits,” Dobbs says. “Agriculture has functions broader than producing commodities for food and fiber. There are co-products that have always been recognized, and now these are starting to come to the forefront.”

Dobbs says that Europeans are now discussing “working lands” policies:

conservation on existing farmland. “Society gets the benefits from sound agricultural production, but it also gets biodiversity, water quality, and other conservation benefits.”

Both France and the U.K. are experimenting with some programs to deliver those kinds of goods. Dobbs sees aspects of the same trend in the U.S.

For example, a policy paper released in September 2001 by U.S. Secretary of Agriculture Ann Veneman speaks of “consumer-driven agriculture.” The paper notes, “Increasingly, U.S. consumers insist on defining what is produced, how food production takes place and with what effects. ... Americans consider environmental quality as a kind of ‘non-market’ good

that is extremely important in consumer choices.”

Senator Tom Harkin, Iowa Democrat who chairs the Senate Agriculture Committee, introduced a Conservation Security Plan as part of the Senate version of the farm bill. Dobbs says the Harkin plan, co-sponsored by Republican Senator Gordon Smith of Oregon, could signal the first major new direction in conservation policy since the 1985 farm bill introduced the Conservation Reserve Program and several other environmental provisions.

The Conservation Security Program will pay farmers to adopt new conservation practices or expand existing practices. Payment will be based on average county rental rate plus a percent of the cost of adopting and maintaining conservation practices. Producers putting conservation practices in place across their entire farms, Dobbs says, will receive a maximum of \$45,000 annually at the highest level of the program.

“That program is closest to what’s on the cutting edge in Europe,” in Dobbs’ opinion.

The big difference between the U.S. and the U.K. and France in developing a “working lands” policy “is the pressure the general public brings in Europe,” Dobbs says.

He adds that Europeans may be more aware of agriculture because Europe’s agricultural lands, unlike those of the United States, typically lie at the doorsteps of major cities.

In delivering environmental goods, Dobbs and Pretty see potential in ag policy for encouraging “integrated systems” that provide environmental benefits. In the U.K., there are already some programs that encourage farmers to use integrated systems through a variety of approaches including crop

rotations; appropriate cultivation techniques; minimum reliance on synthetic chemical fertilizer, pesticide, and fossil fuel inputs; enhancement of wildlife habitats; and even maintenance of the landscape.

Pretty and Dobbs cite studies showing more birds and other wildlife on organic farms than on conventional farms. Programs have been put in place in the U.K. to pay farmers to convert to organic production.

“Agriculture has functions broader than producing commodities for food and fiber. There are co-products that have always been recognized, and now these are starting to come to the forefront.”

—TOM DOBBS,
SDSU ECONOMIST

Meanwhile, other programs have paid British farmers to follow practices that limit nitrate leaching. Other programs pay farmers who enter Countryside Stewardship Scheme contracts to protect scenic landscape and habitat; while yet others pay farmers to protect or preserve heather and other shrubby moorland, for providing “countryside access,” or for trying out new methods to protect wildlife, especially birds.

The U.S., although its programs have not extended to preserving landscape to such an extent, has the Conservation Reserve Program that

pays farmers to take fragile lands out of production. Other Sodbuster and Swampbuster provisions penalize farmers by withholding subsidies if they break up fragile grasslands or drain wetlands.

Dobbs and Pretty say such programs have only “greened the edges” of agricultural heartlands, saying that until there’s a clean break with the subsidy policies of past decades, farmers in both the U.K. and the U.S. likely will continue to farm intensively because they are paid mainly for producing food and fiber, not for other benefits they could provide.

Even though the 1996 farm bill was designed to reduce farm subsidies to American producers over a transition period, production-related direct and emergency aid payments to U.S. farmers soared to \$22.9 billion in 2000.

Dobbs says the production subsidies that many producers see as necessary may have hurt farmers in the long run. Farm subsidies may have helped keep family farmers on the land until about the early 1950s, he says. Since then, however, many agricultural economists in the U.S. believe the production support policies have done as much or more to undermine moderate-sized family farms as to support them.

Dobbs and Pretty add that the experience of the U.K. and France suggests that the loss of production-related subsidies can be cushioned if the money isn’t simply taken away but is shifted to areas such as rural development and agri-environmental projects.

“Farmers are less resistant to decoupling if there is some assurance that a major portion of the funds will at least remain earmarked for agricultural and other rural supports of some kind,” they write. ♦



SOUTH DAKOTA STATE UNIVERSITY

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Garden Line is an hour-long weekly call-in program during the late spring and summer months. South Dakota State University Cooperative Extension Service specialists answer horticulture questions about lawn, garden, and house plants. Garden Line is in its 20th season during summer 2002.

Garden Line regular panelists. Front Row: David Graper, Marty Draper (host), and Leon Wrage. Back Row: Rhoda Burrows, John Ball, and Mike Catangui.

Visit us on the web at http://garden_line.sdstate.edu/