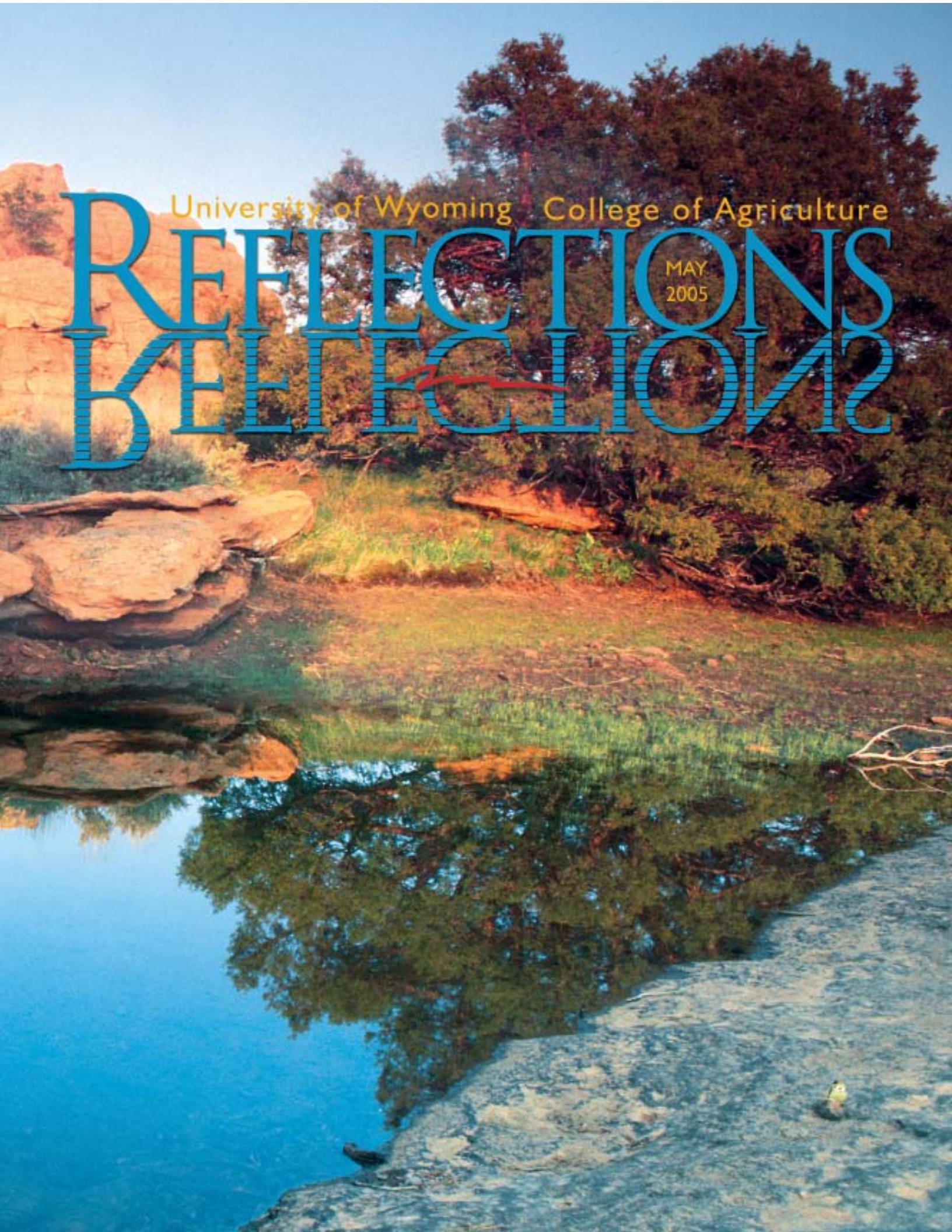

University of Wyoming College of Agriculture
REFLECTIONS
MAY
2005

Variety is something that most people enjoy in their everyday lives. In the College of Agriculture, it is automatically ingrained in the tri-partite mission of instruction, research, and extension/service. In addition to offering variety through this mission, the seven departments in the college provide diversity in the undergraduate and graduate degrees offered, the research conducted, and the outreach programs delivered throughout Wyoming.

With seven undergraduate and 20 graduate degrees, the array of educational opportunities in the college is impressive. The choices include options ranging from production agriculture to human nutrition to molecular biology to rangeland ecology and watershed management. Check it out yourself by contacting any of the departments listed inside the back cover.

With articles on such topics as brucellosis, cancer, mountain pine beetles, the Preble's meadow jumping mouse, and a Kenyan watershed, this year's *Reflections* illustrates the variety of projects underway in the college. These efforts range from molecular research conducted in specialized laboratories to applied research conducted at the college's research and extension centers and with cooperators across the state.

There is still much to learn. As Shakespeare noted, "In nature's infinite book of secrecy, a little I can read." Without extramural funding, both the extent and variety of research endeavors would be greatly diminished. During the past year, faculty members in the College of Agriculture led the University of Wyoming in outside funding with $12.4 million in extramural awards. This is particularly noteworthy since the college is small in terms of faculty positions.

The next time you visit campus stop by the Agricultural Experiment Station office or any of the departments to witness faculty and student efforts firsthand. Through service labs, research and extension centers, and cooperative extension offices spanning the state, the college also provides a selection of outreach/service programs for its constituents. Educational efforts range from specialized workshops to field days to individual contacts.

While looking through *Reflections*, think about the multiplicity of topics covered in the articles. To learn more about the "Infinite Variety" of education, research, and outreach/service programs, please visit the college's Web site at www.uwyoadminweb.uwyo.edu/UWAG/ or better yet stop in at settings throughout the state. You might be surprised, but at the same time pleased, with the assortment of opportunities and information the college provides. Enjoy *Reflections* and remember to fill the year with variety.

"In nature's infinite book of secrecy, a little I can read."

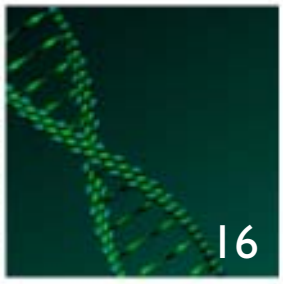
*William Shakespeare*

Director and Associate Dean
College of Agriculture, Agricultural Experiment Station

# INFINITE


The Wyoming Agricultural Experiment Station (AES) team at the University of Wyoming's College of Agriculture coordinates the publication of *Reflections* with the Office of Communications and Technology. AES staff members include, from left, Sara Skalsky, student office assistant; Joleen Pantier, accounting associate; Jim Jacobs, director; and Kathleen Bertoncelj, senior office associate. (Photo by Robert Waggener)

# VARIETY

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## Feature articles




# The Mountain Pine Beetle:

## Preeminent Forest Pest of the West

*Diana Dean, Graduate Student*
*Alexandre Latchininsky, Assistant Professor*
*Department of Renewable Resources*



Brilliant red is the third stage of death for a once beautiful, timeworn limber pine. The tree communicates the stages of its demise through color.

As the tree is gradually robbed of its critical nutrient layer, the pine needles that were once a healthy green change from yellow, orange, red, and brown to the final death knell, gray.

A gray tree is fittingly called a ghost tree. The ghost tree stands on the landscape as a silent witness to the appetite of its uninvited guests. Many victims loom among their brilliantly red and yellow neighbors as a signpost that has only one end: gray death.

The uninvited guests to hundreds of thousands of such trees every year are mountain pine beetles, *Dendroctonus ponderosae*. They are among several hundred species called bark beetles because they spend their lives under the bark of trees. Once they are adults, bark beetles chew their way out to select new host trees and spawn their next generation. They can kill more trees every year than all wildfires combined.

In recent times as many western forests have been stressed by severe drought, the beetles' attacks have become especially devastating. Aerial surveys revealed that between 1997 and 2001, all species of bark beetles combined killed 1.3 million acres of forests annually. In 2002 the area of their destruction tripled, and in 2003 they killed an incredible 10.6 million acres of western forests. Mountain pine beetles were responsible for a major proportion of this loss.

Pine beetles are the focus of a great deal of research not only because of the number of trees they kill but also because of the number of species of

This dying lodgepole pine is dotted with pitch tubes. However, the beetles managed to overcome the tree's defense. (Photo by Diana Dean)

trees they kill. Most bark beetles generally attack only a few types of trees. Some of the insects are very host-specific and select only one or two. The mountain pine beetle, however, will attack and kill as many as 13 different species of pine trees.

This pest is a miniature crawling, flying, chewing chemistry lab. The female chooses which tree to attack based on the chemical odor plume it exudes. Once she selects a tree in which to lay her eggs, she makes a chemical signal with a pheromone, calling the males to her. Other females follow this pointer as well, knowing it means the tree is a good food source for their young. The males, too, broadcast a chemical indicator for aggregation. When the tree has reached a beetle saturation point, the creatures send out another volatile message saying "There is no room at the inn." The number of guests that triggers the signal to stop the attack is still unknown.

The female hollows out a chamber shaped like a small lima bean, mates, and lays her eggs. They hatch about 10 days later, and the young feed on the tree from early fall until late the following spring when they become full adults about one-quarter-inch long. The adults feed one last time before chewing through the bark to start the cycle over again. Once these beetles are under the bark, there is no human way to save the tree.

The tree itself, although immobile, is not defenseless. It has its own protective resources that can often thwart an attack. It uses its pitch to attempt to evict the beetle as it chews through the bark. If the tree has a good volume of pitch, it can prevent the beetle from having a successful invasion. The creature is pushed back out of its entrance hole by the pitch and hardened into the syrupy, sticky mass. A tree's defenses are greatly reduced in drought years due to its inability to produce enough pitch for protection. This has contributed to the dramatic increase of the insect's economic importance the past four years.

Until recently, the mountain pine beetle was found to cause mor-

Funnel traps aimed at luring mountain pine beetles enable researchers to study the emergence and flight periodicity of the destructive insects. (Photo by Diana Dean)

The beetles' attacks have become especially devastating as many western forests have been stressed by severe drought. Aerial surveys revealed that between 1997 and 2001, all species of bark beetles combined killed 1.3 million acres of forests annually.

tality mainly in lodgepole and ponderosa pine stands. At higher elevations in Wyoming, it appears to be selecting limber pine and whitebark pine first and then moving into lodgepole stands. Researchers in the College of Agriculture's Department of Renewable Resources are studying this apparent shift in host selection, focusing on limber/lodgepole mixed stands.

Dying limber pine trees are shown in the Medicine Bow National Forest. They provide a food source for mountain pine beetles. (Photo by Diana Dean)



Using specially designed traps, the scientists are investigating the flight periodicity of the beetles in these mixed habitats. The decoys are made out of 12 black funnels, not unlike oil funnels for vehicles. Each one is "baited" with two kinds of chemicals – an artificially produced compound identical to what the trees give off and with pieces of plastic containing male and female beetle pheromones. The combination attracts both sexes of mountain pine beetles. By analyzing the trap collections on a weekly basis, researchers can find out when the insects first emerge and fly to attack a tree, when their population reaches its peak, and when they end their emergence.

The first trapping season started in May of 2004 and was completed in October, and University of Wyoming entomologists are continuing to study the results. The flight pattern of the creatures does appear to be substantially different from information gathered during trappings in lodgepole-only and ponderosa-only stands.

There are also10 plots that have been established in the Medicine Bow National Forest to track how many limber and lodgepole pines are attacked. By measuring the height and circumference of all the sickened trees, scientists can try to find out if there is any variation in the characteristics of the victimized conifers.

The "you-are-what-you-eat" theory may encompass non-humans as well as humans. Using a recently developed stable isotope analytic technique, it will be possible to check whether the assumption is applicable to animals, too. Stable isotopes are naturally occurring atoms of an element with different atomic masses and are expressed as ratios. For

Bark beetles chew through the bark of lodgepole pine trees. (Photo by Wayne Ohnesorg)

Tree pitch can prevent mountain pine beetles from successful invasions. (Photo by Wayne Ohnesorg)

A tree's defenses are greatly reduced in drought years due to its inability to produce enough pitch for protection. This has contributed to the dramatic increase of the insect's economic importance the past four years.

example, $^{13}C/^{12}C$ describes the ratio of "light" carbon ($^{12}C$) to "heavy" carbon ($^{13}C$). Because the isotopes do not decay over time and their relationship appears to be unique for each plant species, it is possible to find a distinct isotopic signature, creating a "fingerprint" of the diet item. This fingerprint can then be identified in the animal.

Using special rearing chambers, the researchers are cultivating mountain pine beetles separately in limber pines and in lodgepoles with the intent of applying the principles of diet reconstruction. Organic compounds from host pine phloem are being ingested, metabolized, and incorporated into mountain pine beetle body tissues. If the investigators can identify the insect's province by which host tree species it has been eating, then this method can be used in the wild to potentially track which tree species the beetles attack first and where they move afterwards. This tracking could help create new management strategies and prevent the further devastation of coniferous forests by bark beetles.

Humans have studied the mountain pine beetle for almost 100 years. It has always been a part of the forest. The mystery is what causes the insect to jump from being part of an innocuous population feeding on a very limited number of trees to joining a devastating outbreak killing hundreds of thousands of acres of trees a year.

So far this beetle is at least one step ahead of those who study it. UW entomologists hope their work will take them closer to comprehending the dynamics of this ruthless killer and close that gap.

# what's it WORTH to you PREBLE'S II?

*David "Tex" Taylor, Professor*

*Thomas Foulke, Assistant Research Scientist*

*Roger H. Coupal, Associate Professor*

*Department of Agricultural and Applied Economics*

"What's it worth to you?" said Roger Coupal, leaning back in a chair in his office in the College of Agriculture. "Sorry, that's a loaded question. Value is relative. If you are an environmentalist, habitat is priceless. If you are a developer, then it is the market value, and if you are a rancher or farmer it is the production value of the land. What decision-makers want to know is which assessment to use to best reflect society's value for this resource when deciding what measures to take to protect habitat and species."

Coupal is referring to the value of a mile of riparian habitat in southeastern Wyoming occupied by the Preble's meadow jumping mouse (PMJM). Readers of last year's *Reflections* will remember a feature article detailing research on the impact of the mouse on the economy of the area. Since that time, a final report has been submitted to the governor's office. However, the story continues. A number of events beyond the scope of the project have fueled the controversy. (See timeline.)

Significantly, in December of 2003 researchers at the Denver Museum of Nature and Science made public their findings from a study on the genetics of PMJM. Their report found that the mouse was not significantly different from the Bear Lodge meadow jumping mouse. In other words, they did not think PMJM was a distinct species. This finding was subsequently endorsed by the biologist who had originally identified PMJM as a separate species back in the 1950s.

Shockwaves flew through the region as farmers, ranchers, and developers pushed for removing the species' threatened status as listed under the Endangered Species Act (ESA). Environmentalists decried the findings as inconclusive, focusing instead on the geographic isolation of PMJM as making it a distinct population and thus still eligible for protection.

State of Wyoming officials have maintained that PMJM is not a distinct species and jumped into the fray by petitioning the U.S. Fish



This hay meadow in Laramie County has been designated as critical habitat for the Preble's meadow jumping mouse. (Photo by Tom Foulke)

and Wildlife Service to review the listing status of the mouse in February of 2004. A panel of experts was convened to study the situation and deliver its findings by December of 2004. Meanwhile, the University of Wyoming project which included Tex Taylor, Roger Coupal, and Thomas Foulke of the Department of Agricultural and Applied Economics used the time to fine-tune their estimates of the economic impact of critical habitat designation on the economy of southeastern Wyoming.

On the floor below Coupal's office, Taylor sat at a cubicle-style desk and summed up the focus of the research. "This project uses a mathematical model of a typical southeastern Wyoming cattle ranch (the predominant enterprise on critical habitat) to estimate the economic effects on the ranch and how they might translate to the regional economy. In particular, we are interested in the value of a mile of habitat to producers. That is to say, if a rancher has one, two, three, or up to six miles of habitat on his or her property that could no longer be used due to the presence of the mouse, how would that affect annual income? What would be the cost of protecting that land, say by fencing it off and having to provide alternate sources of feed, forage, and water for livestock?"

Since the mouse inhabits areas of dense willows adjacent to streams and along irrigation ditches and has been found on both grazing-land riparian zones and in hay meadows near water, the researchers postulated two types of land that would be typically affected—irrigated hay meadows and sub-irrigated pasturelands along creek bottoms (riparian zones). The model they developed removed one-mile increments in each of these land classes from one to six miles to see how ranch profitability might be affected.

The results illustrated how removing this land from production impacted ranch returns. In Table 1, just one mile of fenced-off, sub-irrigated pasture land was estimated to cost a producer about $2,300 per year or about $26 per acre. If the same land

## Preble's timeline

**May 1998**
PMJM listed as a threatened species.

**May 2000**
Draft environmental impact statement released by USFWS.

**July 2002**
Critical habitat proposed by USFWS.

**February 2003**
UW Ag & Applied Economics project starts.

**June 2003**
Critical habitat designated by USFWS.

**December 2003**
Denver Museum of Nature and Science releases results of DNA study.

happened to be irrigated hay meadow, then Table 2 would be applicable and a mile of habitat would be estimated to cost a producer more than $7,000 per year or about $82 per acre. Irrigated hay meadow was more valuable not only because of improvements and productivity but also because the lost production meant a rancher would have to purchase alternative sources of feed for livestock during the winter months.

Turning down the classical music on his computer, Foulke leaned forward for emphasis. "From a valuation perspective, we took the landowners' point of view. Why? Because this is mostly a private-lands issue. Farmers and ranchers are the first link in the economic chain. Landowners will be the ones most directly impacted by any mitigation efforts instituted by the federal government. This speaks to the wider implications for the regional economy. Environmentalists might say that a relatively small number of people are involved and that protecting this species is in society's best interest. Therefore, implementing habitat land-use restrictions is the proper course of action. Yet in many parts of the mouse's range in Wyoming, agriculture is the largest employer. So something that adversely affects agricultural production puts those jobs at risk."

Approximately 88 percent of PMJM critical habitat in southeastern Wyoming is on private land. Should the federal government implement restrictions to private-land use (which it may be able to do under the ESA), then this could be construed by some as a "taking" by the government and could result in litigation from property owners and allied support groups. Indeed, the issue of appropriating without compensation is one of the reasons

**Table 1. This shows the model results for a sub-irrigated pasture scenario.**

| | Base | 1 mile | 2 miles | 3 miles | 4 miles | 5 miles | 6 miles |
|---|---|---|---|---|---|---|---|
| Ranch profits | $39,423 | $37,152 | $34,754 | $32,170 | $29,443 | $25,898 | $22,328 |
| Profit reduction | $0 | -$2,271 | -$4,669 | -$7,253 | -$9,980 | -$13,525 | -$17,095 |
| Percent reduction | $0 | -6 % | -12 % | -18 % | -25 % | -34 % | -43 % |
| Loss/mile habitat | $0 | -$2,271 | -$2,334 | -$2,418 | -$2,494 | -$2,705 | -$2,849 |
| Loss/acre habitat | $0 | -$25.96 | -$26.69 | -$27.64 | -$28.53 | -$30.93 | -$32.58 |

**Table 2. This shows the model results for an irrigated hay meadow scenario.**

| | Base | 1 mile | 2 miles | 3 miles | 4 miles | 5 miles | 6 miles |
|---|---|---|---|---|---|---|---|
| Ranch profits | $39,423 | $32,260 | $24,978 | $17,673 | $10,071 | $2,056 | -$6,253 |
| Profit reduction | $0 | -$7,163 | -$14,445 | -$21,750 | -$29,352 | -$37,367 | -$45,676 |
| Percent reduction | $0 | -18 % | -37 % | -55 % | -74 % | -95 % | -116 % |
| Loss/mile habitat | $0 | -$7,163 | -$7,222 | -$7,250 | -$7,338 | -$7,473 | -$7,613 |
| Loss/acre habitat | $0 | -$81.90 | -$82.59 | -$82.90 | -$83.91 | -$85.46 | -$87.05 |

**Table 3. This shows the estimated per-year costs for PMJM critical habitat protection.**

| Land class | Cost per acre | Estimated value |
|---|---|---|
| Irrigated meadow | $84.48 | $952,662 |
| Sub-irrigated pasture | $29.27 | $330,071 |



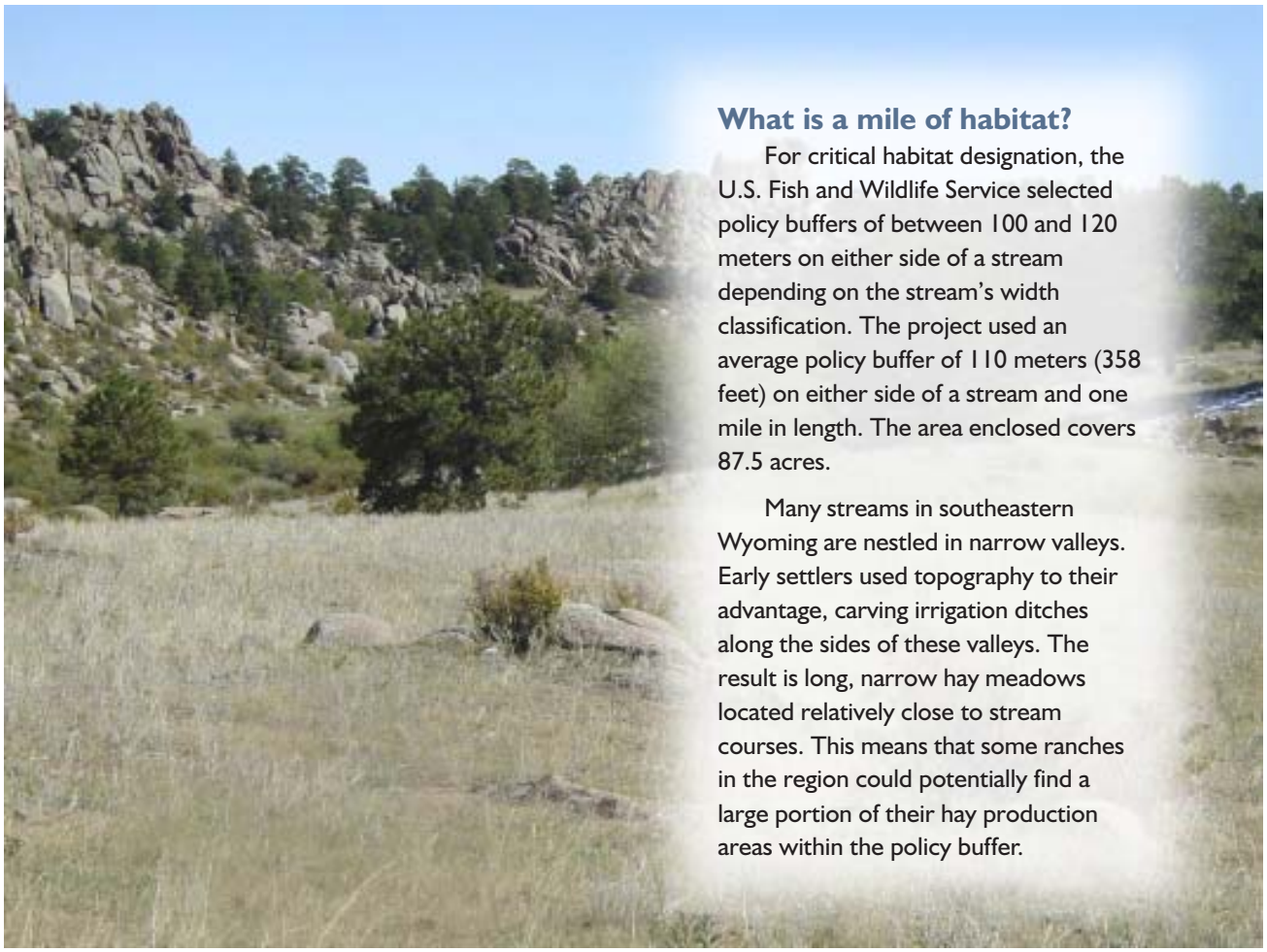
**January 2004**
State of Wyoming petitions USFWS to delist PMJM.

**March 2004**
USFWS agrees to review PMJM listing status.

**May 2004**
4(d) rule made permanent by USFWS.

**September 2004**
UW Ag & Applied Economics research project completed.

**December 2004**
USFWS releases decision on listing status of PMJM.



### What is a mile of habitat?

For critical habitat designation, the U.S. Fish and Wildlife Service selected policy buffers of between 100 and 120 meters on either side of a stream depending on the stream's width classification. The project used an average policy buffer of 110 meters (358 feet) on either side of a stream and one mile in length. The area enclosed covers 87.5 acres.

Many streams in southeastern Wyoming are nestled in narrow valleys. Early settlers used topography to their advantage, carving irrigation ditches along the sides of these valleys. The result is long, narrow hay meadows located relatively close to stream courses. This means that some ranches in the region could potentially find a large portion of their hay production areas within the policy buffer.

Suitable habitat for the Preble's meadow jumping mouse is shown in this area of the Laramie range in southeastern Wyoming. (Photo by Tom Foulke)

PMJM has become a "poster child" for endangered-species reform. Other endangered species' habitats have occurred mainly on public land, so the designation of critical habitat has not had as direct an impact on property owners or their ability to gain a livelihood from their land. With PMJM, however, there is the potential to have private property rights and the ability to gain one's income from one's own land become central issues in the controversy.

The question is raised of who will pay for habitat protection. The model shows that on the average, sub-irrigated pastureland will cost a rancher about $29 per acre, and irrigated meadow will cost about $84 per acre. The private land portion of designated critical habitat encompasses more than 11,000 acres. The results range from about $330,000 per year to more than $950,000 per year depending on the land use. The more hay meadow there is in critical habitat the higher the cost since it is the most productive land. It is also important to remember that these are just the direct costs to landowners and do not include subsequent changes in the number of jobs or income in the wider economy due to money no longer spent by ranchers and farmers.

Value is relative. Yet when it comes to paying for species protection, the issue quickly becomes contentious. The controversy over PMJM is a good example of how these issues affect not only the landowners directly involved but also the regional economy at large.

For more information or for a copy of the report for this project, visit the **Wyoming Economic Atlas** at Agecon.uwyo.edu/EconDev. Click on the PMJM button.

SPREAD THEM OUT:

# The Issue of Brucellosis & Feedgrounds

*Donal O'Toole, Professor and Head, Department of Veterinary Sciences and Director, Wyoming State Veterinary Laboratory*

*Cathy Purves, Western Wyoming Field Director, Wyoming Wildlife Federation*

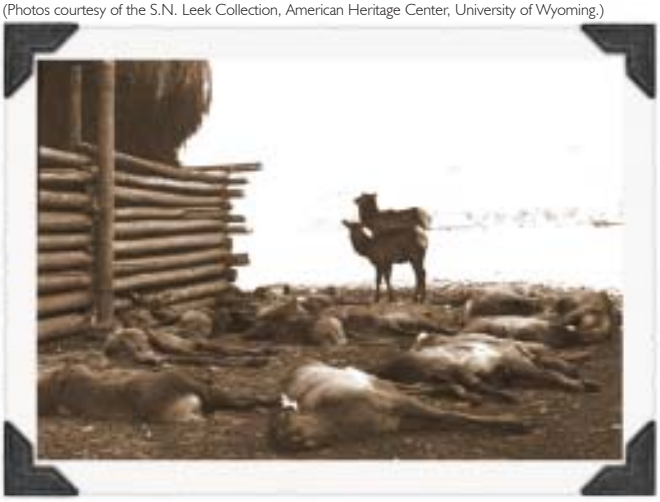
The establishment of feedgrounds for elk at the turn of the 20th century in Wyoming solved one problem but exacerbated another: brucellosis in elk, bison, and now cattle.

The years 1908, 1910, and 1911 were hard on Wyoming's elk. They died in the thousands, to the distress of ranchers and residents in the northwestern part of the state. The deaths were due to a combination of harsh winters, a loss of migration routes, and disappearing winter habitat. Jackson Hole homesteader Stephen Leek recorded the event in a series of painful photographs. The proposed solution was to feed elk in winter. The initial purpose was to provide supplemental food to substitute for lost habitat. The result was the National Elk Refuge and, eventually, 22 Wyoming Game and Fish Department (WGFD) feedgrounds.

The grounds became controversial when animals fed in concentrated areas in the winter were diagnosed with a high incidence of brucellosis, an important cause of infectious abortion in cattle and elk. By contrast, free-ranging elk elsewhere were essentially free of infection. In late 2003, the transmission of brucellosis from elk to cattle near a WGFD feedground resulted in the slaughter of a large cattle herd. Wyoming lost its brucellosis-free status, costing the state millions of dollars.

In 2004, Governor Dave Freudenthal charged a representative group of citizens (called the Wyoming Brucellosis Coordination Team) with developing achievable recommendations by early 2005 for reducing and eradicating brucellosis in the state's elk. The group included wildlife experts, state and federal officials, veterinary diagnosticians, ranchers, sportsmen, and conservationists. Frank Galey, dean of the College of Agriculture, chaired the efforts with technical assistance from University of Wyo-

(Photos courtesy of the S.N. Leek Collection, American Heritage Center, University of Wyoming.)



Starving elk are shown near a haystack in Jackson Hole in 1911. The elk in the foreground are dead. This and the accompanying photographs were taken by Stephen Nelson Leek (1858–1943), a Canadian who homesteaded in Jackson Hole. His photographs and writings were instrumental in establishing the National Elk Refuge, which was founded to end such scenes.

The human impulse to prevent starvation in elk led to the establishment of winter elk feedgrounds. However, the feedgrounds have crowded stressed wildlife and predisposed them to infectious disease. Artificial feeding does not substitute for habitat.

ming faculty members. The work of the team was an interesting, difficult, and occasionally contentious process.

For many members it came down to a choice: Should the state keep its feedgrounds or try to phase them out? If the team decided to eliminate the feedgrounds, how could it be done so that elk didn't die in large numbers during hard winters? Also, could the risk of transmitting brucellosis to cattle as elk dispersed be kept to a minimum? A decision to close the feedgrounds would entail the reduction of elk numbers in the northwestern part of the state. This would be difficult to explain and justify to sportsmen and conservationists who contributed to elk management for decades. In spite of divergent interests represented on the team, there was consensus that state and federal feedgrounds have distinctly positive and negative aspects.

Brucellosis in elk is a man-made problem. It is created by the unnatural crowding of elk at

Associate Professor Don Montgomery, a pathologist with the Department of Veterinary Sciences at the University of Wyoming, performs necropsies on cattle with brucellosis. Facial protection is necessary due to the ease with which *Brucella abortus* infects people and causes human brucellosis (undulant fever). Human brucellosis is one reason why 70 years of effort and billions of dollars were invested in eradicating the disease in the United States. Wyoming and Texas remain the only "infected" states in the nation. (Photo by Vicki Hamende)

precisely the time when the disease is transmitted – late winter and spring, when elk are carrying calves and can abort. The team determined that it is paramount that the progressive loss of winter habitat and its impacts on elk be considered and reversed. The decline in habitat has accelerated due to recent rapid development in Sublette and Teton counties. If elk feedgrounds are to be maintained, the team noted, the state may be confronted with more complicated, intractable diseases down the road. Purchasing or otherwise securing additional winter habitat for elk in counties where feedgrounds can be eliminated, team members concluded, will benefit wildlife and the Wyoming livestock industry.

A necropsy is performed on the carcass of a starved elk in 1911. Stephen Nelson Leek, the man with the moustache and cowboy hat on the right side of the picture, fellow ranchers, and other wildlife advocates were alarmed at the winterkill of elk in Jackson Hole from 1909 to 1911.

An unidentified man touches a starved elk in the winter of 1911.

## Why Does Brucellosis Occur in Elk on Feedgrounds?

Domestic cattle harbored the disease as far back as the late 1800s, and it was first confirmed by culture in the United States in 1910. Cattle probably infected elk and bison during the early days of the cattle industry in Wyoming. The first report of the disease in bison came in 1918.

Brucellosis in cattle, elk, and bison is due to a small, highly infectious bacterium called *Brucella abortus*. As animals abort, numerous organisms are discharged into the environment in placental fluids. The disease is of national and international importance because of the economic impact that abortion outbreaks have on cattle operations. This impact is captured in the simple name the disease once had: infectious abortion. Ranchers with infected cattle are under pressure from state and federal agencies to depopulate their herds. The alternative is quarantine, loss of commercial reputation, and a long series of blood tests. Most ranchers send their adult female cattle to slaughter.

The artificial feeding of elk creates a dilemma for wildlife managers who wish to maintain healthy populations and an economic threat to ranchers who must keep their cattle free of the disease or run the risk of going out of business. While technical solutions such as vaccination and the physical separation of elk and bison from cattle have been pursued, a major ingredient for controlling the disease is to protect winter habitat so that elk can be dispersed.

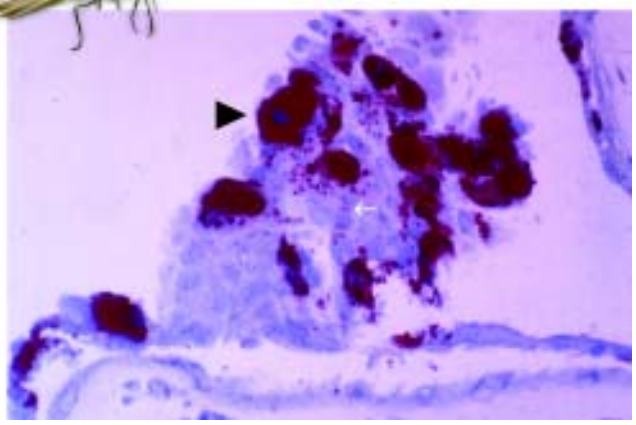
Thanks to a 70-year effort at a cost of $3.5 billion, brucellosis in cattle is now *almost* eradicated in the United States. Almost, but not quite. A large endemic focus of brucellosis persists in the Greater Yellowstone Area. A group of scientists who evaluated brucellosis in that location in 1998 on behalf of the National Academy of Sciences concluded that brucellosis is unlikely to be maintained in elk once feedgrounds are closed and elk dispersed across the landscape. A vaccine has been used by WGFD to battle the infection in elk, but its effectiveness is limited. There is little immediate prospect of a better vaccine.

A contentious issue is whether *Brucella*-infected wildlife transmit the disease to cattle. In January of 2004 a strain of *B. abortus* was isolated from cattle at the Wyoming State Veterinary Laboratory by personnel from the UW Department of Veterinary Sciences, WGFD, and the U.S. Department of Agriculture (USDA). The DNA was essentially identical to that of elk on a nearby WGFD feedground. There is no longer any question that, on occasion, elk infect cattle with *B. abortus.*

## Brucellosis in Wyoming's Wildlife

When USDA began the national brucellosis eradication program in 1934, the importance of the disease in wildlife was modest because the disease in cattle was





The microscopic appearance of *B. abortus* in placental tissue is illustrated. The organism is stained red. Most organisms are inside cells, which is one reason it is difficult to develop a highly successful vaccine for wildlife such as elk.

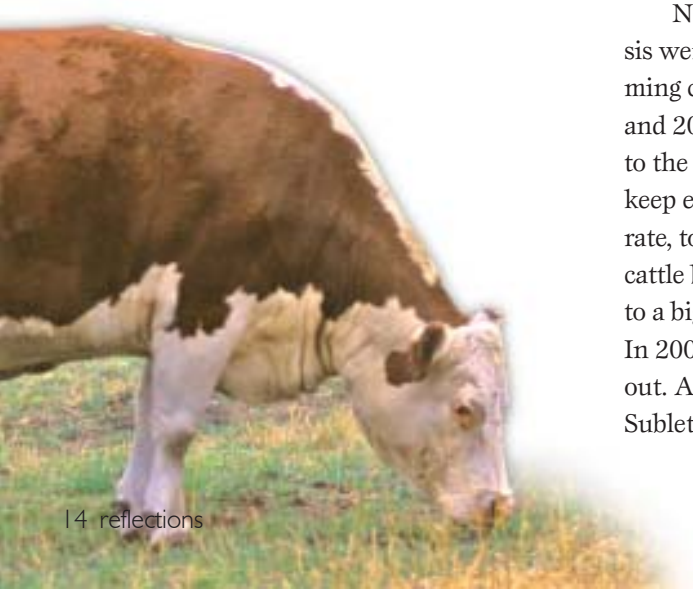
common, and the role that wildlife played in sustaining it was small. Five years later the Wyoming Legislature put in place a big-game damage law because of the concentration of elk on private ranch lands. That prompted WGFD to experiment with the winter feeding of elk. Eventually multiple state elk feedgrounds were established in northwestern Wyoming. They were geographically situated to gather elk and shortstop them from entering private lands and damaging hay crops. Problems with the program have been acknowledged. Feeding is expensive at $1.3 million annually. It implies that feedgrounds can substitute for winter range and that habitat does not matter. By causing crowding, they make elk more susceptible to disease.

No cases of brucellosis were detected in Wyoming cattle between 1989 and 2003. This was due to the efforts of WGFD to keep elk and cattle separate, to the vaccination of cattle by producers, and to a big element of luck. In 2003 that luck ran out. A herd of cattle in Sublette County became infected. A total of 37 animals tested positive for the disease. The subsequent culling and testing of elk on the adjacent feedground established that the cattle and elk had a closely related strain of *B. abortus*. Since then, two other infected cattle herds were identified in Teton County.

Wyoming lost its brucellosis-free status in February of 2004. It is unlikely to regain it until 2006 at the earliest. As a result of this loss, the state veterinarian and the Wyoming Livestock Board mandated the increased testing of female cattle throughout the state. Wyoming's reputation as a source of healthy, disease-free cattle took a hit. The costs remain to be quantified but are probably in the range of $5 to $10 million. From the standpoint of the cattle industry in other states, Wyoming has brucellosis in its wildlife that spills over into cattle. It may be risky to buy Wyoming cattle. This directly threatens the marketability of the animals.

At the heart of the issue is whether state feedgrounds should be continued or gradually decommissioned. Almost all specialists agree that closure of the feedgrounds and the dispersal of elk will lead to the eventual elimination of brucellosis in elk. The disease does not appear to sustain itself in dispersed, non-feedground populations. However, the short-term impacts may be high. Closing the grounds would cause an appreciable drop in elk numbers in northwestern Wyoming. Elk-hunting income would likely no longer generate $42 million annually in the state. A decline in elk numbers would have substantial effects on communities depending on tourism and hunting in western Wyoming. Ranchers are understandably nervous about infected elk spread over a wide geographical area that might cause more, not fewer, infected cattle herds.

The brucellosis coordination team determined that a comprehensive closure approach was not practical at this time. Whether to close individual feedgrounds on a case-by-case basis and under monitored parameters remains on the table. WGFD will use feedground closure as a management tool if and when the opportunity



arises. That opportunity translates to adequate available winter habitat. The department will continue to vaccinate elk, while recognizing the limited effectiveness of doing so. The team has recommended to the governor that the legislature provide WGFD with an adequate elk brucellosis-control budget. A realistic line-item budget for the department would allow it to run a comprehensive program to try to keep elk and cattle separate.

Another recommendation of the team is that a five-year pilot project be initiated by WGFD to evaluate a test and slaughter program, possibly leading to the closure of specific feedgrounds. The project would focus on young female elk that are most likely to transmit disease. This is a new approach. No one knows whether the sustained culling of infected elk would eliminate the disease.

## Loss of Winter Habitat in Wyoming

For casual visitors, the state appears to have no shortage of open space for elk and other big game. The impression belies a major and growing problem: Wyoming's winter habitat is under pressure from human population growth in precisely those areas where habitat is needed most for the state's western elk herds – Sublette and Teton counties.

Between 1990 and 2000, the two counties saw the first and second highest human population increases in Wyoming at 63.3 percent and 22.2 percent, respectively. Much of this growth has occurred in rural areas. Many of these newcomers are buying second homes, which comprise 20.7 percent and 26.2 percent of all housing units in the two counties. While development is welcome, it erodes the amount of open space available for wildlife if it is not managed correctly. There has been an increase in the number of homeowners reluctant to allow hunting on their properties, which adds a challenging dimension to controlling wildlife numbers. Not all residents understand that hunting is one of the major tools available to WGFD to manage wildlife.

Intensive gas and oil development in the 200,000-acre Pinedale Anticline and the 30,000-acre Jonah Field is narrowing and closing off migration routes for big game. The Upper Green River Valley is one of the three most threatened big game migration corridors in Wyoming.

Investing in winter habitat for elk and improving what currently exists is critical if artificial feeding is to be reduced and eliminated. A major program in Sublette and Teton counties to secure various types of conservation easements, land swaps, and habitat improvement projects will go a long way toward maintaining open spaces, protecting viable agricultural operations, and providing winter habitat. It could be done by the state through the Wyoming Wildlife and Natural Resource Funding Act and by private organizations such as the Rocky Mountain Elk Foundation, the Wyoming Stock Growers Agricultural Land Trust, and other non-profits such as The Nature Conservancy.

Social acceptance of managing brucellosis by slaughtering infected young elk cows will be difficult to achieve. Yet maintaining the status quo is intolerable for livestock producers and wildlife managers. The historic image of thousands of starved, dying, and dead elk in the early 1900s is a prudent reminder of the centrality of adequate winter habitat for wildlife. What was then a humane effort to help starving elk is now a burden to the WGFD and the Wyoming cattle industry. Investing in habitat is a disease-management tool as important as vaccines and hunting.

Perhaps it's time to put it into play.



# DEVELOPMENT
## What Can be Learned

*David Fay,*
*Assistant Professor*

*Aaron Bender,*
*Graduate Student*

*Department of*
*Molecular Biology*

The body is an exceptionally complex machine. When someone is born, much of the developmental program has already been completed or set in motion. The heart beats, the lungs allow breath, and the brain processes signals from the environment.

In the next several years the body grows and matures due to rapid, tightly controlled cell divisions. What is it that allows a single cell, the embryo, to generate a fully functional adult consisting of more than 50 trillion cells? The answer lies in DNA.

Each of the body's many cells has an identical copy of DNA, which is a mixture of genes donated from both parents. It is DNA that "instructs" the cells to divide or to stop dividing. Although environment plays a role, it is the DNA that truly directs the course of development and allows for tissue maintenance. If altered, DNA can lead to devastating diseases such as cancer.

Humans are not the only organisms that must develop in order to survive. Most plants and animals must also undergo the transition from embryo to adult in order to pass their genetic material to the next generation.

The developmental processes of other organisms are of interest to scientists because of the many similarities those progressions have with humans. In fact, many genes involved in the growth of plants, flies, and worms are comparable. Because of this, scientists can draw parallels between the development of simple organisms and of people. Furthermore, they can use these organisms as a model to study the basics of many human diseases.

Such research is being conducted in the laboratory of Assistant Professor David Fay of the College of Agriculture's Department of Molecular Biology.

### The Nematode *C. elegans*: An Introduction

Nematodes are tiny worms that can be found in marine or terrestrial environments. Some species are parasitic, but many are "free living" and do not depend on a host for survival.

One such species, *Caenorhabditis elegans,* has been studied for many years and can be found in the soil feeding on bacteria. However, in the laboratory these worms are fed a special type of *E. coli* bacteria which grows on the surface of small petri dishes. Adult *C. elegans* are about a millimeter in length and cannot be seen without the aid of a microscope. The bodies of these animals are transparent, thus allowing scientists to see the internal organs without having to dissect them (Figure 1).

There are only two main organ systems in *C. elegans* – the gut and the

# AND CANCER:
## from a Tiny Nematode

gonad. This makes sense because the behavior of worms involves mainly reproduction and feeding. Like humans, *C. elegans* reproduces sexually through the fusion of a sperm and an egg. However, fertilization in the worm can occur either by mating or by the self-fertilization of a hermaphrodite harboring both sperm and eggs. Once fertilized, the embryo is deposited as a small egg that, after hatching, takes only a few days to become a mature adult itself. Such a short developmental time frame is convenient, allowing laboratory study of many generations in a matter of weeks.

In 2002, the Nobel Prize in Physiology or Medicine was awarded to Sydney Brenner, John Sulston, and Robert Horvitz for their work on *C. elegans,* which led to a vast understanding of how a single cell can give rise to a functional adult organism.

**Figure 1.** This shows adult hermaphrodite *C. elegans* viewed at 40x magnification through a compound microscope. Note the transparent nature of the animals. (Photo by David Fay)

Since the 1960s, the number of labs working on *C. elegans* has grown to more than 200.

Fay, who joined the College of Agriculture faculty in 2000, was a post-doctoral fellow at the University of Colorado when he began his research on *C. elegans*. He and his research team are focusing on understanding the function of *C. elegans* genes that may be involved in human cancer. For this reason, the Fay laboratory is supported by funding from the American Cancer Society and the National Institutes of Health.

### Humans and Worms: Not as Different as One Might Think

Biology has been revolutionized by the ability to sequence genomes. So far, more than 235 complete genome sequences have been published. In addition to humans and *C. elegans*, the sequences of several bacteria, fungi, plants, viruses, and animals are now known. This allows researchers not only to understand more about any one organism but also to compare the genetic sequences of different organisms.

Although *C. elegans* and humans look very different, it might amaze people to know how much they have in common at the genetic level. For example, humans have between 20,000 and 25,000 genes. *C. elegans* has approximately 19,000 genes. Incredibly, the human genome and that of the worm share a 40-percent similarity at the DNA sequence level.

Many developmental biologists are really geneticists who study biological problems by trying to understand the genetic basis for certain disorders. As mentioned earlier, if changes are made to the DNA of an organism, development can be altered. These changes are called mutations and can lead to diseases like cancer. All

**Figure 2.** This is an image of an adult hermaphrodite gonad. The square cells are mature eggs preparing to be fertilized by sperm within the spermatheca. Fertilized embryos are seen at the bottom.

people carry mutations in their genomes. These can be caused spontaneously from things such as sunlight, or they can be inherited from parents. Most mutations are "silent" and are not harmful. In fact, it is thought that mutation is the driving force behind evolution. However, if a mutation causes an important gene to stop working properly, the results can be quite severe.

The genome in all human cells consists of 23 chromosomes, each containing many hundreds of genes. A gene is simply a functional unit of DNA which normally encodes the sequence of a protein. A gene specifies the production of a specific protein which may have one or more functions inside or outside the cell in which it was made. Importantly, evolution has provided redundancy in the genetic code. This means that in many cases there is more than one gene controlling a given cellular process. If this were not the case, a higher percentage of mutations would be detrimental to survival.

*C. elegans* also has a high percentage of genetic redundancy. When the function of certain genes is eliminated, there is no resulting affect or "phenotype" because of the ability of other genes to compensate in their absence. It is the phenomenon of genetic redundancy that interests Fay and his research team.

## Cars as a Model for Functional Redundancy

Genetic or "functional" redundancy as it applies to living things is complex and can be difficult to comprehend. However, many examples of functional redundancy exist that may help to understand the biological phenomenon. Consider, for example, a car parked on a hill. Cars have two functionally redundant parts – the shift lever and the emergency brake – to keep them from rolling down a hill. If the emergency brake fails but the shift lever is in "park," the car will stay put. The reverse situation is also true. It is only when both the brake and the shift lever fail that the car would roll. It could be said that the emergency brake and the transmission function redundantly to control unwanted rolling.

The *C. elegans* gene of primary interest to Fay and those in his laboratory is known as *lin-35*. Humans have a similar gene known as *Rb,* which has been found to be inactivated in most types of cancer. By studying *lin-35*, the molecular biology researchers hope to learn

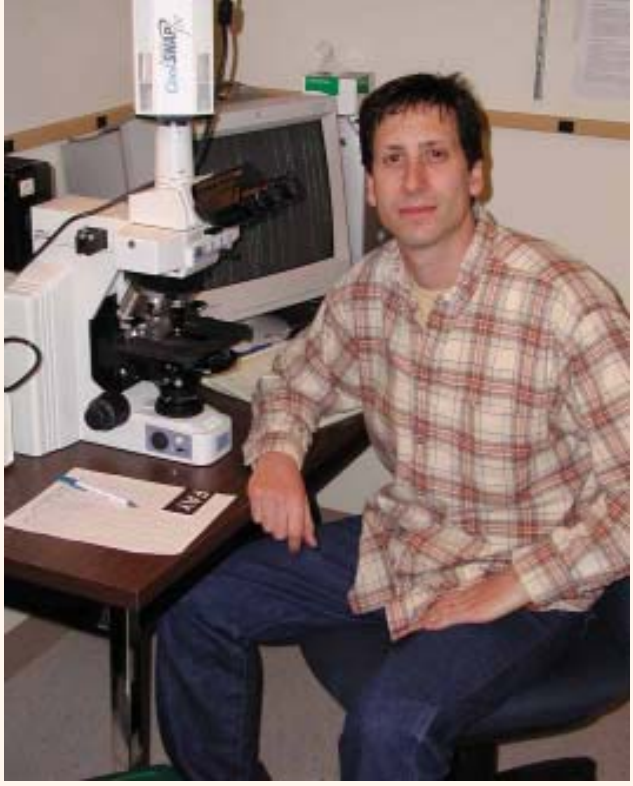
more about the genetics of cancer as well as *C. elegans* development.

By using the example above, *lin-35* can be thought of as the brakes. It turns out that eliminating the function of *lin-35* does not cause the car to roll down the hill (the worms have no phenotype).

However, by randomly damaging parts in addition to the brakes, the scientists can cause it to roll. In other words, they can take animals that have a dysfunctional *lin-35* gene and make additional changes that lead to a phenotype.

The process of making random changes (mutations) in a laboratory animal's DNA and then finding out what genes have been mutated is known as forward genetics. By examining many animals containing the same *lin-35* mutation as well as different random mutations, researchers can identify worms in which the transmission has been damaged as well. This process is known as a forward genetic screen. They can then locate damaged genes by using a technique known as single nucleotide polymorphism (SNP) mapping, which is similar to the method used to compare DNA samples from a crime scene.

In this way, four genes in *C. elegans* which function redundantly with *lin-35* have been identified in the Fay laboratory. Interestingly, none of these genes show any phenotype if they alone are mutated. It is only when *lin-35* is also mutant that the animals containing these mutations display a developmental defect. *Fzr-1*, the first gene to be identified, acts with *lin-35* to control abnormal cell division. This is significant because animals with mutations in both *lin-35* and *fzr-1* have what appear to be tumors in many different tissues within the worm.



Assistant Professor David Fay of the Department of Molecular Biology sits next to a microscope that can be used to view single cells within *C. elegans*. (Photo by Vicki Hamende)

Although there are obvious differences in humans and nematodes, much of the underlying biology is conserved. Both worms and humans must develop from a single cell. If this process is altered, the result can be catastrophic for both species. Of course, one cannot always draw clear parallels between what is learned from model organisms like *C. elegans* and what is happening in humans. However, because of studies on model organisms, scientists now know much about how genes control the formation of a functional adult organism.

Because researchers can use the power of random forward genetics to alter development in a model species, they can pick apart many intricate details that are not observable in more complex organisms. This allows them to construct important hypotheses about evolution and the genetic basis for the formation of diseases such as cancer.

**Figure 3.** This image shows a double mutant gonad. Note the disorganized structure as compared to the wild type in Figure 2.

# Undernourished Lambs Could be

*Stephen Ford, Professor and Rochelle Chair, Department of Animal Science*

Western white-faced ewes reared in diverse range conditions on dissimilar amounts of forage can respond differently to maternal stressors such as undernutrition. The health of their offspring can be affected in varied ways as well.

So concludes an analysis of the impacts of early maternal undernutrition on sheep fetal growth and development as well as on the health and progress of the resulting lambs.

The research is taking place at the University of Wyoming's Center for the Study of Fetal Programming, which opened in the fall of 2002 to learn about the fetal origins of offspring health, growth efficiency, and longevity. These efforts are focused on producing healthier lambs and calves and have direct relevance toward improving the health of human infants.

The initial studies have looked at the impacts of early maternal undernutrition in sheep on fetal development as well as on the health and growth efficiency of the resulting offspring.

## Pre-Partum Effects of Maternal Undernutrition

As part of the project, western white-faced ewes selected over a period of many years under harsh range conditions and limited nutrition near Baggs in south-central Wyoming were shown to maintain normal fetal weights when subjected to 50-percent undernutrition from day 28 to day 78 of their 150-day gestation cycle. In contrast, western white-faced ewes of similar breeding, age, weight, and body condition from the UW flock whose prior selection was associated with above-adequate nutritional inputs experienced a 30-percent decrease in fetal weight under the same nutrient restriction. The growth-retarded fetuses of the UW ewes exhibited enlarged hearts.

Also, histochemical examination showed that skeletal muscle from growth-retarded UW fetuses contained a significantly lower number of secondary myofibers compared to the control-fed UW fetuses, and the average area of muscle fibers was smaller. Since the number of fibers in each muscle is determined during pre-natal development, this decrease in secondary myofibers in fetuses is expected to have physiological consequences on these offspring after birth. This potential reduction in muscle mass could result in diseases such as obesity and diabetes because skeletal muscle is the primary site for the utilization of glucose and fatty acids in the body.

Why were the Baggs ewes able to withstand this prolonged bout of undernutrition with no discernable effects on fetal growth and development while UW ewes experienced asymmetric fetal retardation?

In sheep, cotyledons on the outside of the placental membranes attach by finger-like projections to button-like areas known as caruncles on the uterine wall. This unit is called a placentome and is the functional area of nutrient and waste product exchanges between the mother and fetus. There are between 40 and 80 placentomes attaching each placenta to the uterine wall in a sheep.

Major placentomal growth is complete by mid gestation before the main period of fetal development begins. Individual placentomes may, however, continue to undergo morphologic and functional transforma-

# Predisposed to Later Health Problems

tions as the fetal demand for nutrients increases in late gestation.

The ability of Baggs ewes to maintain fetal weight under this severe nutrient restriction was associated with an early conversion of placentomes by day 78 of gestation while undernourished UW ewes, whose fetal weight was decreased by 30 percent, had only slight placentome transformation on that day. This data is consistent with the premise that the ability of the Baggs ewes to convert placentomes in a more advanced way during the nutrient-restriction period may have increased the efficiency of nutrient delivery to their growing fetuses. This goes along with the fact that fetal blood glucose (a major source of energy for a fetus) was significantly depressed in fetuses from day-78 undernourished UW ewes but was normal in fetuses from undernourished Baggs ewes.

This information suggests that the multigenerational selection of ewes under markedly different production systems influences the early conversion of these placentomes to more efficient types in response to undernutrition. What is not known is whether this early conversion results from fetal or maternal signals.

Professor Stephen Ford of the Department of Animal Science co-directs the UW Center for the Study of Fetal Programming with Dr. Peter Nathanielsz of the University of Texas Health Sciences Center in San Antonio. (Photo by Vicki Hamende)

Center researchers are now investigating the differential gene expression and protein production of progressing placentomes. This will provide insights into the genes responsible for increases in placental vascularity and efficiency, factors which prevent intrauterine fetal growth restriction and negative impacts on offspring health and growth efficiency in later life.

## Post-Partum Effects of Maternal Undernutrition

After digestion, glucose passes into the blood stream where it is used by cells for growth and energy. When people eat, the pancreas releases just the right amount of a hormone called insulin which is required to move the glucose from the blood stream into body cells. In the early stages of type 2 diabetes, the pancreas releases enough insulin, but the body can't use it to move glucose into body cells. This is known as insulin resistance. In later stages, insulin production in response to increased blood glucose markedly decreases, resulting from pancreatic failure. As a result, glucose builds up in the blood stream and passes out of the body in urine rather than supporting the growth of body cells. In the United States, type 2 diabetes has increased steadily among young people until it has reached near epidemic proportions. Could maternal diet play a role in its occurrence? Studies to follow may shed light on this problem.

In subsequent experiments in which UW and Baggs ewes undernourished by 50 percent from day 28 through day 78 were nourished at 100 percent from day 79 through lambing, lambs born to both UW and

Baggs ewes were of similar size, weight, and viability.

By 2 months old, lambs born to undernourished UW ewes exhibited an increased release of insulin and insulin resistance in response to an intravenous infusion of glucose but not in lambs born to other ewes in the study. By 8 months old, lambs born to undernourished UW ewes exhibited possible pancreatic failure and a decreased glucose uptake to a similar intravenous infusion of glucose compared to the lambs from control-fed UW ewes. This suggests that these lambs may be predisposed to exhibit type 2 diabetes in later life.

Further, lambs from undernourished UW ewes ate more, grew faster, and were fatter than control-fed UW ewes during the first 8 months of life. Lambs from nutrient- restricted UW ewes also exhibited a significantly higher blood pressure at 8 months old than lambs from control-fed UW ewes.

The lambs of undernourished ewes tested at the Center for the Study of Fetal Programming could be predisposed to future health problems. (Photo by Vicki Hamende)

At slaughter, which was performed immediately after the blood pressure recordings were taken, it was determined that lambs from undernourished UW ewes still possessed enlarged hearts, had contained greater amounts of subcutaneous and intra-abdominal fat, and were characterized by fewer kidney nephrons (filter impurities from blood) than lambs from control-fed UW ewes.

Decreases in kidney filtration rates are known to lead to increases in blood levels of the hormone angiotensin II, which is a potent vasoconstrictor, and could contribute to the observed increase in blood pressure in lambs from nutrient-restricted UW ewes. Differential gene expression and the protein production of cardiac and skeletal muscles and kidneys are underway in the offspring of nutrient-restricted versus control-fed UW ewes. To date, researchers have observed no differences in the growth rate, insulin sensitivity, pancreatic function, or kidney nephron numbers between lambs from undernourished and control-fed Baggs ewes, suggesting that they were unaffected by maternal undernutrition.

## Conclusions

The symptoms exhibited by the undernourished lambs born to UW ewes are consistent with a predisposition of these lambs to develop health problems later in life such as type 2 diabetes, hypertension, obesity, and cardiovascular disease. It also appears that females selected under markedly divergent production environments can respond differently to maternal stressors such as undernutrition with diverse consequences to the health of their offspring. Researchers intend to monitor the health as well as the growth and reproductive efficiency of UW and Baggs lambs derived from this undernutrition study throughout their lives to confirm differences in offspring development. These results will have significant implications for both livestock production and human health.

# GUESS WHO ISN'T COMING TO DINNER?

## The Development of Simple Tests Could Rid the Food Supply of the Deadly Pathogen *E. coli* O157:H7



*Escherichia coli* (*E. coli*) O157:H7 is a particularly deadly form of the normally benign bacteria *E. coli*. It was first recognized as a foodborne pathogen in 1982 when 47 people became ill after eating at restaurants in the same fast food chain in Oregon and Michigan.

Ingestion of these bacteria can cause serious medical conditions such as bloody diarrhea, kidney disease, and death. Young children and the elderly are particularly susceptible to these illnesses, which have been collectively termed as "hamburger disease." This is because many *E. coli* O157:H7 outbreaks have occurred as a result of eating undercooked ground beef. In fact, it has been estimated that meat recalls due to contamination with *E. coli* O157:H7 have cost the beef industry approximately $1.6 billion in lost demand.

However, it is now clear that in addition to attacking beef and other meats, this pathogen can contaminate foods such as fruits and vegetables, fruit juices, dairy products, and water.

Each year, foodborne contamination with *E. coli* O157:H7 results in approximately 62,500 illnesses, 1,843 hospitalizations, and 52 deaths.

There are many methods used to detect *E. coli* O157:H7 in food and water. These detection systems include cultural techniques, immunological procedures, and nucleic acid-based assays.

However, most of these tests require a combination of long incubation times to grow the bacteria to high enough levels for detec-

*Lawrence Goodridge, Assistant Professor, Department of Animal Science*

*John Willford, Undergraduate Student, Department of Molecular Biology*

**Figure 1.** *E. coli* O157:H7 cells attach themselves to beads via specific antibodies to form bead-bacteria complexes.

tion, meaning that test results are not known for several days. In the time interval required to obtain a test result, contaminated food may have already been disseminated to retail stores and purchased by consumers. Also, these tests are expensive and often quite complex, requiring intensive training for laboratory personnel. Therefore, there remains a need for very sensitive, rapid, and simple methods capable of detecting *E. coli* O157:H7.

Reporter bacteriophages represent a novel and sensitive alternative to conventional methods for the detection of bacteria within food. A bacteriophage (phage) is a virus that specifically infects bacteria, and a reporter gene is a segment of DNA that encodes for a protein that is easily measurable (i.e. a fluorescent protein or an enzyme). In this method, a bacteriophage is modified to carry a reporter gene. The reporter gene is introduced into a target bacterium via the bacteriophage during its normal infection cycle. Once the reporter gene has been introduced to the bacterium, it is expressed (i.e. the protein is produced), thereby allowing bacterial cells to be rapidly identified.

Recently, researchers in the food microbiology laboratory in the College of Agriculture's Department of Animal Science have developed a novel assay to detect *E. coli* O157:H7 that is based on the use of reporter phages.

The first step in the detection method is to isolate the *E. coli* O157:H7 from the food sample. The isolation procedure is accomplished with the use of a technique called immunomagnetic separation or IMS.

The IMS technique is based on the use of microbeads (approximately 2.8 micrometers in diameter) that are coated with specific antibodies. These beads are magnetizable and superparamagnetic, meaning that unlike conventional magnets, the beads are only magnetic in the presence of a magnetic field. Once the field has been removed, the microbeads lose their magnetism. Due to this property, the beads can easily be re-suspended when the magnetic field is removed.

This discovery has revolutionized the isolation and separation of

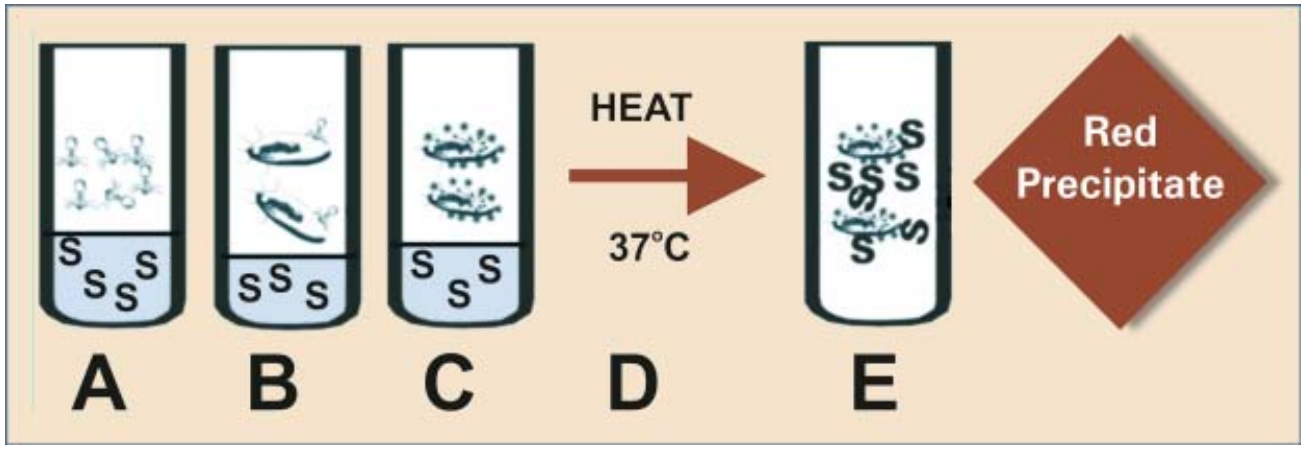



**Figure 2.** A simple reporter phage has been developed to detect *E. coli* O157:H7 following immunomagnetic separation.

many biological materials. In the case of microbiology, the attachment of target-specific antibodies to the surface of the beads allows for the capture and isolation of intact bacteria such as *E. coli* O157:H7.

As part of the IMS technique, a homogenous mixture of the sample to be tested is incubated in a sample tube in the presence of the magnetic beads. If there are any *E. coli* O157:H7 cells present in the sample, they will attach themselves to the beads via the specific antibodies to form bead-bacteria complexes (Figure 1).

At this point, if a magnetic field is applied to the outside of the sample tube, the bead-bacteria complexes will be attracted to the field, allowing for easy removal of the rest of the sample. After being washed, the bead-bacteria complexes are re-suspended in a buffer and may be analyzed using a variety of methods including reporter phage detection.

A simple reporter phage has been developed (Figure 2) to detect *E coli* O157:H7 following IMS. The reporter-phage method is based on the phage-induced production of the enzyme beta-galactosidase in *E. coli* O157:H7 cells. This enzyme (similar to the enzyme in humans that allows for the digestion of lactose) can react with several enzyme substrates to form a visible color reaction. In the newly developed assay, the development of a color reaction indicates the presence of *E. coli* O157:H7 within the test sample.

To make the test easy to perform and interpret without the need for elaborate training and equipment, the entire process has been designed to be performed in a single tube (Figure 3). The tube contains the enzyme substrate, which is entrapped at the bottom by a layer of wax. The sample to be tested is added to the tube with the magnetic beads, and IMS is accomplished as described above.

Following IMS, the bead-bacteria complexes are re-suspended in a buffer that contains the reporter phage. The phage infects any *E. coli* O157:H7 cells present, causing the beta-galactosidase enzyme to be produced. After this step (which takes approximately 1 hour) the tube is placed in warm water, which melts the wax layer and allows the beta-galactosidase enzyme and its substrate to mix together. A red color will develop indicating a positive test if there is any beta-galactosidase enzyme present in the sample (which would be due to the presence of *E. coli* O157:H7 cells). If there were no *E. coli* O157:H7 cells present in the sample, then no beta-galactosidase would be produced because there would be no bacteria for the reporter phage to infect. As a result, the test would be negative (i.e. no red color would form).

It is envisioned that this newly developed rapid test will be used to analyze food and water for the presence of *E. coli* O157:H7 before the food is shipped to the retail arena. This would allow any contaminated food to be identified long before it reached grocery stores and consumers.

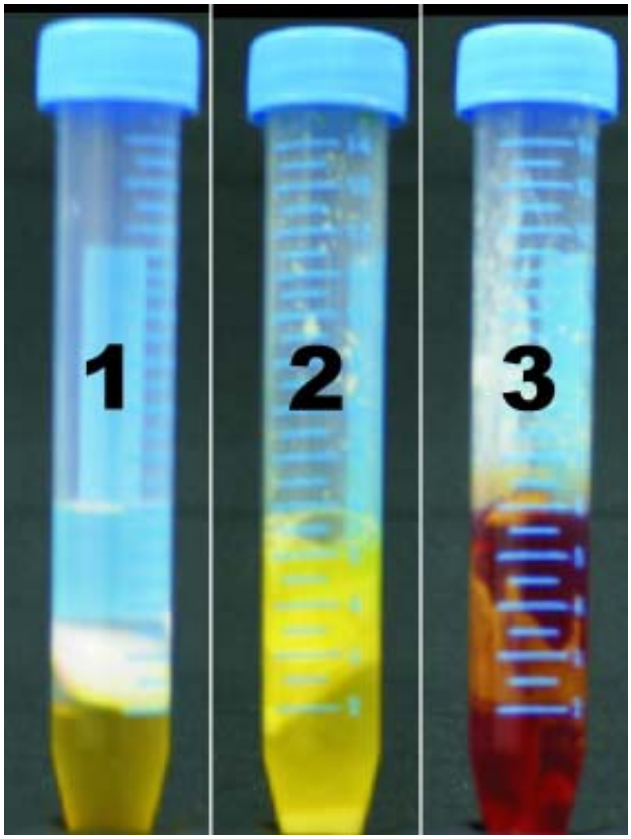



**Figure 3.** The phage infects any *E. coli* cells present, causing the beta-galactosidase enzyme to be produced, mixed with its substrate, and identified.

# SERVICE LEAR

## The Academic Approach

*Rhoda Schantz, Associate Professor, Department of Family and Consumer Sciences*

Associate Professor Rhoda Schantz, left, of the Department of Family and Consumer Sciences, helps students in her fall food systems production class evaluate the aesthetic and health-safety characteristics of meals served at a local senior center to older adults. Class members include, from left, graduate student Haiying Lin and undergraduate dietetics majors Samantha Ellsbury, Shawna Comer, Ashley Cariveau, and Jessica Todd. (Photo by Vicki Hamende)

University of Wyoming students are learning about nutrition and helping the community at the same time.

Teaching methods evolve from experiences that provide both valuable and satisfying hands-on education for students. Service learning gives them a chance to apply what they have learned while meeting a community need. They are offered structured opportunities for satisfying academic objectives linked with service objectives. The approach to service learning is to encourage students to enhance their academic growth by conducting background research, implementing a project, and reflecting on the experience.

Those enrolled in food systems production class in the fall of 2004 evaluated menus for a congregate meal site that serves older adults. The meals were assessed aesthetically, for food-safety risks, and for the nutrients they provided. Congregate meal sites receive federal funding to offer these meals and are required to provide nutritionally appropriate and safe food to clients.

As the students researched regulatory guidelines, they found that meals must provide one-third of the daily recommended dietary allowances. The necessary nutrients include calories (less than 30 percent from fat), carbohydrates, proteins, fat, vitamins A, C, and D, calcium, iron, sodium (less than 800 milligrams), and cholesterol (less than 100 milligrams).

The nutritional analysis was conducted using a computer software program developed to analyze recipes, menus, and diet records. If the required nutrients were not contributed by the meal, an appropriate menu was created and its nutrients were confirmed through a reanalysis.

Once the aesthetic, safety, and nutritional evaluations of the project were underway, the class toured a local senior center kitchen. On separate days, each student assisted in the food preparation for one meal. They became familiar with the facility and its personnel and gained an apprecia-

# NING to Helping the Community

UW Dietetics major Jessica Todd, second from right, interviews clients at a local senior citizen center about the meals they are served at the facility. (Photo by Vicki Hamende)

tion for the goal of the project. In addition, this hands-on experience gave them the confidence to move toward a classroom assignment that involved developing a survey to be used to interview clients at the center.

The responses to the questions confirmed a hypothesis that social and economic needs were met through congregate meal sites. Meal satisfaction was rated as very high by the clients interviewed.

This strategy of a one-on-one interview contributed to the personal learning of individual students. By talking to the clients, the students achieved competence in the civic learning objective of developing intergenerational skills.

Students reflected in writing on the richness of the interview experience in their academic lives. They used their evaluations as electronic portfolio contributions to their permanent professional experiences.

Self-assessment throughout the project helped the students become aware of how to be leaders in nutrition care. During classroom discussions, these learners reported that they had gained academic confidence. Many discovered that they were able to demonstrate their mastery of knowledge and knew more than they realized about the ethics of care. As future dietitians, the students developed job skills that can be used during their dietetic internships and careers.

The students continued to work on the project once the semester was completed by volunteering their time to assist in the preparation of a final report which was submitted as a poster session for the Wyoming Dietetic Association's annual meeting in Jackson in April. This written submission and their attendance at the meeting contributed to their professional development.

The project was made possible through a grant from the UW Office of Academic Affairs and the Center for Volunteer Services. Three faculty members representing the colleges of agriculture, arts and sciences, and engineering received the funds. To meet the requirements of the grant, the trio reported on the benefits and challenges of incorporating service learning into their courses during a faculty panel at the spring Shepard Symposium on Social Justice.

Schantz taught students like Haiying Lin, who is working on a master's degree in food science and human nutrition, how to use computer software to analyze the nutritional content of recipes, menus, and diet records.

# Is Precision Fertilization of

*Sully Taulealea, Graduate Student, Department of Agricultural and Applied Economics*

*Larry Held, Professor, Department of Agricultural and Applied Economics*

*Bart Stevens, Assistant Professor, Department of Renewable Resources*

*Edward Bradley, Associate Professor, Department of Agricultural and Applied Economics*

Precision farming is the process of identifying and managing small-scale spatial variability within a field. Variable-rate technology is a tool used within precision farming to apply different amounts of fertilizer and other agricultural chemicals to particular areas of a field based on site-specific soil productivity or fertility.

Spatially referenced data about nutrient content, soil quality, and yield potential are captured through computerization using the global positioning system (GPS). This technology enables a producer to identify site-specific nutrient levels and allows for the determination of the optimum amount of fertilizer to be applied at any given location within a field. GPS uses signals from three or more of the 24 GPS satellites to map the amount of nutrients in the soil, thus allowing computerized equipment on the ground to dictate how much fertilizer to apply at any designated point.

Sugar beets produced in Wyoming are a high-value crop but are very expensive to grow because they require large quantities of purchased additions such as nitrogen fertilizer.

Although precision-input application can be expensive to implement, GPS technology can help avoid the possibility of a field being over or under fertilized and may potentially reduce fertilizer usage and increase productivity. A concurrent environmental benefit is the achievement of better groundwater quality due to the reduced leaching of nitrates as a result of the more efficient utilization of fertilizer.

UW graduate student Sully Taulealea shows some of the experimental sugar beet plots used in Powell to study the economics of uniform-rate versus variable-rate nitrogen fertilizer applications. (Photo by Sully Taulealea)

Is precision or variable-rate nitrogen fertilization a worthwhile alternative to the conventional uniform-rate method based on fertilizer usage and profitability in Wyoming's sugar beet farming areas?

To answer this question, a study was conducted in the state's Big Horn Basin near Powell to examine both fertilizer usage and the profitability of the variable application of nitrogen compared to a uniform application for sugar beets grown under furrow irrigation. Field trials were conducted on a cooperating farmer's land on three different sites in 2001 and 2002. Site 1 was evaluated in 2001, and sites 2 and 3 were assessed in 2002. The three locations contained 4.9 acres, 6.7 acres, and 5.4 acres, respectively.

# Wyoming Sugar Beets Worthwhile?

The recommended uniform-rate fertilizer applications were based on a field-average soil test while the suggested variable rates were calculated separately at different grid points using precision technology.

Nitrogen in the study was added on both a pre-plant and post-emergence side-dress or fertilizer-boosting basis.

The percentages contained in some of the treatment designations show that the application rate was increased above the recommended rate by the indicated amount. This was done to determine the effect of nitrogen application rates on the efficacy of each application method from the standpoint of root yield, sugar content, and profitability.

**Table 1.** This shows the net returns generated by pre-plant and side-dress variable and uniform nitrogen application rates for treatment sites in the Big Horn Basin of Wyoming.

| Study Site | PP N Applied | SD Treatment | Total N Applied | Net Return | VR Advantage |
|---|---|---|---|---|---|
| | Pounds per acre | | Pounds per acre | Profit per acre | Dollars per acre |
| 1 | 100 | VR | 180 | 641 | 23 |
| 1 | 100 | UR | 190 | 618 | — |
| 1 | 100 | VR + 25 % | 227 | 654 | -18 |
| 1 | 100 | UR + 25 % | 240 | 672 | — |
| 2 | 100 | VR | 251 | 768 | -4 |
| 2 | 100 | UR | 253 | 772 | — |
| 2 | 100 | VR + 20 % | 294 | 761 | -9 |
| 2 | 100 | UR + 20 % | 303 | 770 | — |
| 3 | 100 | VR | 239 | 726 | 65 |
| 3 | 100 | UE | 239 | 726 | — |
| 3 | 100 | VR + 20 % | 277 | 683 | 6 |
| 3 | 100 | UR + 20 % | 284 | 677 | — |

## Economic Analysis

Partial enterprise budgeting was used to generate a net-return value for each treatment in the study. The results shown in Table 1 were obtained by subtracting specified variable costs from the per-acre gross returns realized from corresponding treatments. Those costs included sampling, mapping, side-dress fertilization application, fertilizer materials, and harvesting and hauling the sugar beets. The total revenue by treatment was the product of the average sugar beet yield in tons per acre and the sugar beet price per ton. Prices by treatment were based on the average sugar content and wholesale sugar prices as specified in a 2001 Western Sugar Company contract.

## Net Return

A comparison made between variable and uniform-rate treatments for each site is summarized in Table 1. At site 1, the variable form was more profitable than the uniform rate by $23 per acre when nitrogen was applied at recommended levels. However, when the nitrogen application amount was increased by 25 percent, the uniform rate was more profitable than the variable by $18 per acre.

The field at site 2 had the least variable soil properties of the three study sites, so it was not surprising that there was little differ-

A defoliator machine cuts off sugar beet tops in preparation for beet harvesting on the Faxon farm in Powell in 2003. (Photo by Sully Taulealea)

ence between variable and uniform-rate nitrogen applications at that location. The results showed that the uniform treatment topped the variable one by $4 and $9 per acre at the recommended and also the recommended-plus-20-percent application rates, respectively.

Similar to the first site, results at site 3 showed a $65-per-acre net-return advantage of the variable over the uniform amount when nitrogen was applied at the recommended rate. The two application methods produced similar net returns when the average application was increased by 20 percent, with the variable approach being more profitable by only $6 per acre.

Sugar beet plots are irrigated via gated pipes on a farm near Powell. (Photo by Sully Taulealea)

When results from all of the sites were considered as a whole, both the variable and uniform rates rendered similar profits in terms of net return; however, a closer look shows that variability has a more consistent advantage when nitrogen is applied at the recommended amount than when the application standard is increased by 20 to 25 percent.

Based on these results, it is reasonable to predict that variable-rate application may hold even more of an advantage at nitrogen application rates less than the recommended amount. This shows how inherent soil variability can be masked by applying excess fertilizer, but the approach is becoming less practical as profit margins become narrower and producers are forced to look for ways to reduce inputs.

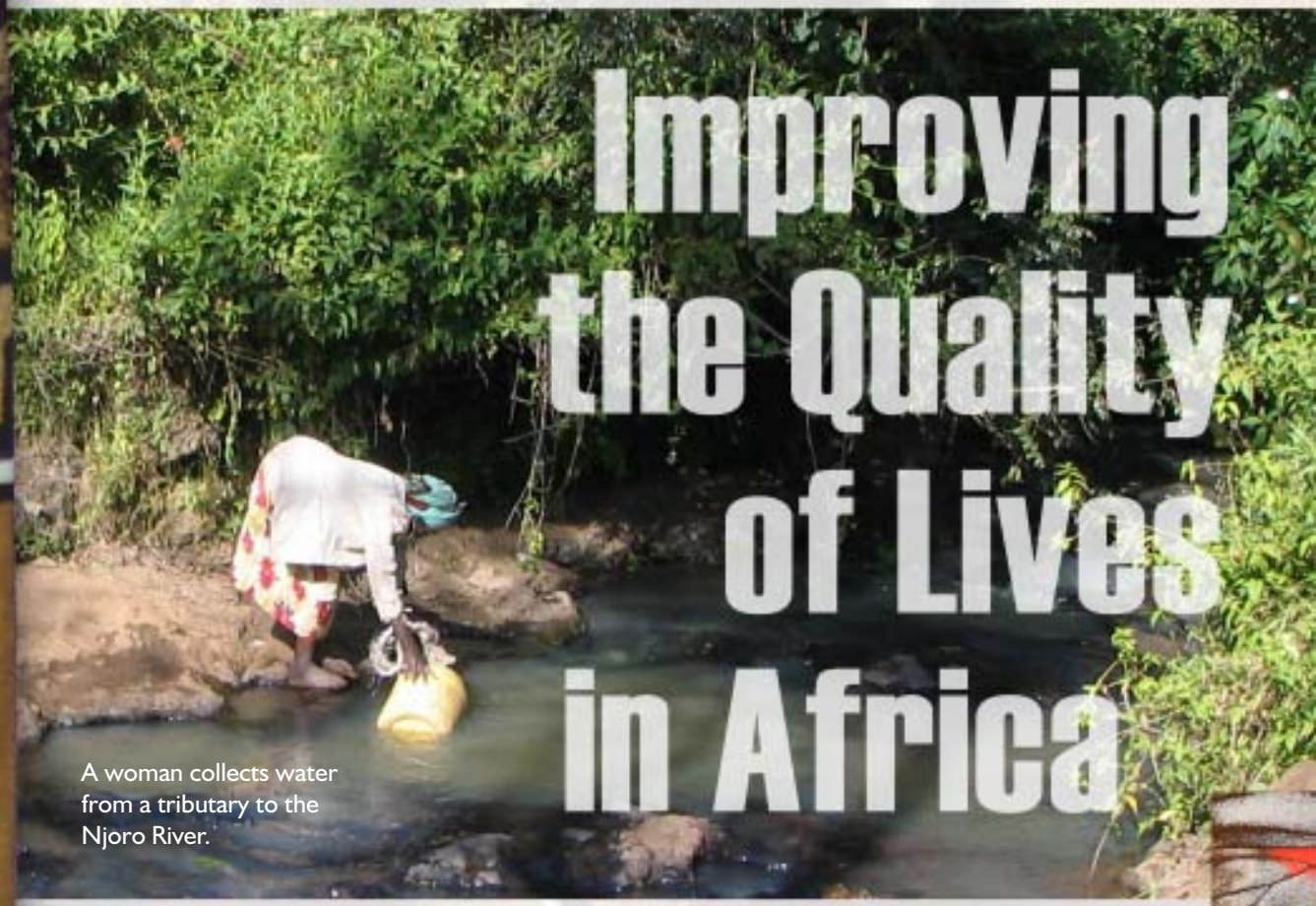
## Fertilizer Applied

The beneficial impact of using less fertilizer by following a variable compared to a uniform rate is obvious in Table 1 at all three study sites. The advantage of adopting precision farming will surface as more precise and smaller quantities of fertilizer are applied. This has the potential to not only cut skyrocketing fertilizer costs but will likely also benefit the environment by reducing the amount of leftover fertilizer that can move into groundwater.

## Conclusion

Results from this study were promising in terms of indicating that precision variable-rate fertilization has the potential to be a worthwhile alternative to traditional uniform fertilization for Wyoming sugar beet producers. As was expected, the amount of nitrogen applied in a variable manner was consistently less than that applied by uniform rates. Moreover, this savings in fertilizer material was achieved with little or no reduction in expected profitability. Indeed, in many cases a dual benefit was realized in terms of achieving even more profitability with less nitrogen. Because the profitability between variable versus uniform-rate fertilization was quite close in some cases, more study is warranted before the wide-scale adoption of variable-rate fertilization can be recommended for use in Wyoming sugar beet production.

# Improving the Quality of Lives in Africa



A woman collects water from a tributary to the Njoro River.

*Siân Mooney, Assistant Professor, Department of Agricultural and Applied Economics*
*Scott Miller, Assistant Professor, Department of Renewable Resources*
*Mimi Jenkins, Professional Research Engineer, University of California, Davis*



In Wyoming and the rest of the United States, people do not always think about how their access to clean, abundant drinking water and good sanitation contributes to keeping them healthy. It is rare to hear of adults and children in the nation dying from diseases such as typhoid, cholera, and dysentery as a consequence of drinking and using contaminated water or not having enough water to practice the most basic hygiene tasks taken for granted every day.

Unfortunately, people living in many other parts of the world are not as lucky. It is estimated that more than 1.5 million children under the age of 5 die each year because they contract diseases such as cholera and dysentery. This adds up to approximately 4,100 deaths each day.

Future deaths due to these causes can be avoided by improving the quantity and quality of water available for household consumption and in some cases providing education about sanitation and health. Water quality and quantity are also important for watershed health because they affect the functioning of aquatic and terrestrial plants and animals.

Researchers from the departments of renewable resources and agricultural and applied economics at the University of Wyoming are working with the University of California, Davis, Utah State University in Logan, and Egerton and Moi universities in Kenya, Africa, to improve water quality and quantity, watershed health, and human health and to reduce poverty in the Njoro watershed, a key basin in the Rift Valley of Kenya.

Assistant professors Scott Miller and Siân Mooney of the UW College of Agriculture and engineer Mimi Jenkins of the University of California are being funded by

The Njoro River in Kenya is used for bathing and laundry.

Cattle water directly in the river.

the Global Livestock and Pond Dynamics Collaborative Research Support Programs supported by the U. S. Agency for International Development to work with Kenyan researchers and students from both nations to develop a sustainable management of watersheds (SUMAWA) project. SUMAWA was started in 2002 to tackle the problem of declining water quantity and quality in the Njoro watershed and to examine whether these problems were linked to land-management practices there. (See www.sumawa-crsp.org.)

The primary goal of the SUMAWA project is to identify and demonstrate how changes in the development and management of watershed resources such as land, water, and forests can improve human well-being and livelihoods for people in the area while at the same time balancing ecosystem protection and downstream needs.

Mammals such as the endangered white rhinoceros inhabit Lake Nakuru National Park in Africa.

The outlet of the Njoro River flows into Lake Nakuru at Lake Nakuru National Park. The area is well known for its abundant bird species (approximately 450 kinds) as well as large mammals including endangered white rhinoceroses. The Kenya Wildlife Service is concerned that changes in water quality and quantity from the river may affect the integrity of the Lake Nakuru ecosystem.

Local communities are directly involved in the SUMAWA project. Town-hall-style meetings were set up by Kenyan researchers at Egerton University in all the major local communities within the Njoro watershed during 2003 and 2004. These meetings offered a chance for residents to inform SUMAWA scientists about how they use land, forests, and water within the watershed as well as to identify how resource issues such as water quality and land use affect their daily lives. A significant portion of the Njoro watershed residents do not have access to the modern comforts that Americans take for granted such as electricity, running water, and sewers and have to use the river and public forested areas for their household water and fuel needs.

At these meetings, local householders told researchers about the ways they use the river and how they have been affected by resource degradation within the Njoro watershed, possibly caused by recent rapid land-use changes involving migration and deforestation. Local residents said they use river water primarily for domestic consumption, cooking, washing (of humans and clothes), and watering livestock.

Local residents expressed concern that increased encroachment on riparian areas, the watering of cattle in the stream, deforestation in the upper watershed, the lack of water and of a sanitation infrastructure, and the increasing demand for water from an expanding popula-

Flamingoes and other birds grace the shores of the Lake Nakuru National Park.

tion were affecting both the quality and quantity of water as well as other resources within the watershed.

Many residents said they were worried about health issues as well as a lack of employment opportunities and low incomes. A survey of almost 400 households within the Njoro watershed showed that average household incomes were approximately $50 per month while the average size of a single household was eight persons.

In addition to collecting local knowledge, SUMAWA project personnel and students have installed equipment to measure water quality and quantity along the course of the river. This information will help identify whether there are specific locations that are of concern to human and watershed health.

In the next phase of the project, the research team will develop an integrated modeling approach to provide insight into the effects of such things as new technologies, policies, and agricultural practices on water quantity and quality, human health, and poverty within the Njoro watershed. This collaborative effort will link watershed hydrology, water supply and demand, and economic decision making to human well-being and health consequences.

This tool can be used to suggest "on-the-ground" practices that can be adopted by watershed residents to reduce premature deaths due to waterborne diseases as well as to offer alternatives that might reduce the incidence of poverty within the area. This method will also allow SUMAWA researchers to examine the impacts of human activities on the health of other important natural resources such as Lake Nakuru.

The instruments and modeling framework developed by SUMAWA will also be useful in many other areas including Wyoming and parts of the United States. Although people in Wyoming face very different problems compared to the residents of the Njoro watershed, the ability to integrate and examine the hydrologic, engineering, health, environmental, and economic interrelationships present in many complex problems will help researchers within the College of Agriculture gain a better understanding of the relationship between natural and human systems.

The expectation is that this project can improve the quality of life for residents within the Njoro River watershed by enhancing their economic well-being and improving both human health and the health of the resources they use.


This map of Kenya shows the proximity of the Njoro watershed to Nairobi.

European wines, cheeses, and olives are among the products showing geographic designations of origin.

# Food Designations of Origin: Controversy and

There's a lot to be "read" for careful grocery shopping these days.

The use of trademarks, brand names, product labels, grading information, and various kinds of geographic designations of origin is increasing in order to differentiate high-quality food and agricultural products from those less desirable.

Can listing the state, region, country, and breed background of a food item or whether it was farm-raised, free-roaming, range-fed, organically grown or non-genetically modified increase the returns to commodity and food producers?

Country of origin labeling (COOL) for fruits, vegetables, peanuts, and most meats other than poultry is the latest in a series of controversial designations being studied by researchers in the College of Agriculture's Department of Agricultural and Applied Economics. Few things are more debated by Wyoming ranchers than the expected performance of both voluntary and mandatory COOL for beef and lamb products.

Competition for sales in domestic and foreign markets has never been more intense than it is today. Technological and institutional changes continue to globalize the food industry, forcing everyone involved to compete not only in price but also in product quality. The need for profitability and survival requires producers to deliver more value as efficiently as possible to more consumers. Buyers appreciate freshness, wholesomeness, nutritiousness, good texture, good taste, ease of preparation, and consistent quality. Paying attention to value as well as cost allows successful innovators to receive premium prices for the products consumers find superior. Designations of origin that denote above-average quality in Idaho potatoes, Virginia hams, Vermont cheddar cheeses, Washington apples, Mountain State lamb, and certified Angus beef allow sellers to charge premium prices.

## In Search of More Profit from Better Marketing

The 2002 Farm Bill instructed the U.S. food system to implement COOL by the fall of 2004. Some agricultural interests lobbied strongly for this mandatory program, but today many U.S. food processors want to change it to a voluntary, more selective one. A U.S. Department of Agriculture (USDA) study estimated that recordkeeping costs to ensure accurate labeling under a voluntary COOL program would cost about $1.9 billion in its first year. The U.S. General Accounting Office disputes this figure and reports that costs would be considerably less. Regardless, the question is whether the program benefits can outweigh the costs.

Congress knows that consumer groups support COOL. Better knowledge about the origin of what one eats is clearly welcomed. However, the opinions of domestic agricultural producers, food processors, and even federal agencies are widely divided. These divisions caused Congress in 2003 to postpone implementing COOL until 2006. It is possible that Congress may even decide to re-

# Consequences

peal the mandatory provisions in order to quell the controversy.

## Geographic Indicators

Many foreign countries have more experience in using geographic designations of origin for marketing agricultural commodities and food products. Goods that have brands and trademarks based on geographic locations are common in the European Union (EU). For example, only feta cheese produced in Greece can be marketed within the EU as feta cheese, and only sparkling wine produced in the Champagne region of France can be marketed as champagne.

The EU licensing procedure for geographic indicator or protected designation of origin emphasizes quality control. It has been shown and documented in Europe that quality requirements for licensed products must be set at high levels or consumers will purchase similar products from competitors at a lower price.

## Conclusions and Implications

The experience of Europeans in establishing food products with protected designations of origin shows that consumers may be willing to pay more for such products than for regular undifferentiated items. The key is for those designations to truly indicate high quality. Strict production standards and certification protocols for EU foods with licensed geographic indicators are designed to yield more consistent top-notch, value-added products.

COOL was enacted in the United States without any new provisions to ensure product quality. Additional costs have become associated with labeling and traceability. The "produced in the United States" label will represent average U.S. quality, leaving private brand names or more specific geographic designations of origin to denote the true differences in the quality of nationally produced foods. Studies show that the majority of U.S. consumers are non-ethnocentric in their choice of consumer goods. Thus, domestic food producers should not expect the mandatory implementation of COOL to necessarily result in better prices. Both the potential benefits and costs of COOL at times have been exaggerated.

**Edward Bradley**
*Associate Professor, Department of Agricultural and Applied Economics*

**Barnett Sporkin-Morrison**
*Undergraduate Student, Departments of Agricultural and Applied Economics and International Studies*


Many consumers look for process designations such as "organically grown" in the food they purchase.

# Researchers seek diagnostic

Ranching in Wyoming's high elevations can be a challenge, particularly when a producer's cattle are stricken by altitude sickness.

A faculty and student team of University of Wyoming researchers hopes to develop a diagnostic test based on gene expression that will help the state's livestock enterprises curb the 3- to 6-percent calf crop losses they can face due to pulmonary hypertension disease, commonly known as "brisket."

"It can mean the difference between profit and loss in some operations," says Associate Professor Mark Stayton of the College of Agriculture's Department of Molecular Biology.

He is collaborating with Professor Rich McCormick of the Department of Animal Science and veterinarian Tim Holt, a faculty member at Colorado State University, on the project. Holt, who has a private practice in Gunnison, Colorado, has studied high-altitude sickness in cattle for more than 24 years.

Stayton and McCormick's interest is twofold – a predictive test could help fight the fatal sickness, and a study of what happens to the enlarged heart of a brisket sufferer could have applications to human heart disease, their primary research focus.

"In brisket these animals are starved for oxygen because it's difficult for them to force blood through their lungs. In certain human diseases patients are also desperate for oxygen. If an artery is completely blocked, they have a heart attack," Stayton explains.

"What we learn about it in humans can apply to cattle and vice versa," he adds. "Many genes are similar among vertebrates. That allows us to extrapolate from one species to another."

Cattle, particularly those less than 1 year old, tend to be sensitive to high-altitude stress. At elevations above 5,000 feet, reduced oxygen pressure causes the blood vessels in their lungs to constrict. The heart is thus required to work harder to push the blood through the body.

The heart muscle enlarges to compensate but may stretch so much that the valves inside do not meet as they should, thus producing a backflow of blood with each contraction. The heart continues to balloon as it has to push even harder, and the problem becomes more severe.

Stricken livestock fail to thrive and are characterized by swelling in the neck and chest due to fluid accumulation in those areas. The cattle also experience depression, weakness, diarrhea, and eventually heart failure.

The only "cure," McCormick says, is to move the cattle out of high-altitude areas. "However, if brisket disease syndrome has damaged the heart and lungs, then even a lower elevation will not reverse its effects."

Stayton adds, "At sea level you can't tell which cattle are going to be susceptible to brisket. When ranchers purchase semen or buy breeding stock from low altitudes, they run the risk that these animals will become sick."

Currently the only diagnostic test available

# test for altitude sickness in cattle

prior to the outbreak of symptoms is a heart catheterization process perfected by Holt which involves passing a fine plastic tube through the jugular vein into the lower right heart ventricle and lung to measure blood pressure.

"What we are shooting for," McCormick notes, "is an affordable rapid diagnostic kit that is less burdensome and that can be used by the ranchers themselves. Not everyone can do heart catheterizations on cattle and interpret the results."

What Stayton and McCormick have been working on for several months is a project that involves drawing blood from both healthy and stricken cattle and analyzing the gene expression of the samples with DNA chips.

"What we are looking for are genes that are altered in an animal that has brisket disease. We need a fingerprint," Stayton explains. "Once we have identified those genes, we can invent a field diagnostic test."

The team has applied for grants to pay for the DNA chips, which can be used to measure the expression of some 20,000 genes simultaneously.

Stayton says he became interested in the research when brisket was discovered in cattle at the UW stock farm. "I thought our technology might apply," he adds, noting that he has been researching heart disease in mice for the past three years. "This is a very nice spinoff from that work."

Stayton hopes the time will soon come when brisket disease no longer gnaws at the profits of producers.

"We'll eventually use computers to analyze our data and to look for altered patterns," he says.

Finding the fingerprint in brisket calves to compare to normal calves will involve screening thousands of genes, Stayton says. "But we're used to that kind of a challenge."

Stephanie Ezidinma, a molecular biology undergraduate, pours a gel that will aid in the expression of gene proteins to help identify cattle that are predisposed to high-altitude sickness. Flanking her are molecular biology Associate Professor Mark Stayton, left, and animal science Professor Rich McCormick, collaborators on a project to develop a diagnostic test. (Photo by Vicki Hamende)

**Vicki Hamende**
*Senior Editor and Writer, Office of Communications and Technology*

# Macromolecular Core Equipment Facility Supports

Researchers lacking the sophisticated equipment needed for their projects can easily find it on campus.

The Macromolecular Core Equipment Facility (MCEF) was established at the University of Wyoming in the fall of 2002 as a part of a $6 million National Institutes of Health Biomedical Research Excellence grant awarded to UW to promote research infrastructure.

MCEF's purpose is to support scientific research by providing equipment that is otherwise too expensive for one researcher to afford or maintain. Use of the instruments is offered at a reasonable rate in order to help foster new research endeavors that could ultimately result in new grants for UW.

The center, located in the Physical Sciences building, is supervised and managed by Justin Jones under the directorship of Professor Jim Rose of the Department of Zoology and Physiology. Serving on an advisory committee with the two are Professor Thomas Hansen of animal science, Assistant Professor Francisco Basile of chemistry, and Professor Randy Lewis of molecular biology.

The equipment MCEF offers is diverse and geared toward the analysis of chemical and biological macromolecules. The instrument of focus in the core is a MALDI-TOF (matrix assisted laser desorption ionization – time-of-light) mass spectrometer. The MALDI-TOF's claim to fame is its ability to elucidate the molecular weight of large molecules.

Being able to analyze large molecules is impressive, but the instrumentation has truly found its stride in the elucidation of small molecules. The MALDI-TOF is also capable of performing "fingerprinting" to allow researchers in the growing field of proteomics to identify proteins through a data base.

A second significant piece of equipment is the BioRad iCycler for performing real-time polymerase chain reaction (PCR) techniques. Traditional PCR is a method by which amplification of specific pieces of DNA can be used to better understand the DNA and its actions.

The Macromolecular Core Equipment Facility, which is managed by Justin Jones, provides equipment that would be too expensive for one researcher to afford or maintain. (Photo by Vicki Hamende)

# Expensive Research

This system has found applications within the College of Agriculture for studying cancer, bovine reproduction, and interferon's anti-viral role in the human body.

The MCEF center also houses a nitric oxide analyzer that is capable of examining trace amounts of nitric oxide in a sample. This substance has been implicated in everything from sperm motility to cancer. The analyzer is the standard for nitric oxide research, and it is currently being used by Associate Professor Mark Stayton of molecular biology to study heart attacks in mice.

The facility maintains a large, upright minus 70°C ultra-low-temperature freezer outfitted with a carbon dioxide back-up system, a remote call system, and a temperature recorder. This means that should the power go out or the compressor on the instruments fail, the $CO_2$ will maintain the temperature for up to four hours and the remote call system will signal the problem day or night.

The MCEF advisory committee includes, from left, Professor Thomas Hansen of animal science, Professor Randy Lewis of molecular biology, Professor Jim Rose of zoology and physiology, manager Justin Jones, and Assistant Professor Francisco Basile of chemistry.

All of this equipment is available for use by researchers at UW, other universities, businesses, and state entities. If someone lacks the funds to use the instrumentation, fees can be waived to support preliminary data collection that can be used to facilitate the acquisition of research funds.

MCEF now serves more than 50 individual users spread across nine departments and four colleges and has also tested samples for the University of Colorado's Health Sciences Center and the Wyoming Game and Fish Department. The facility maintains a Web site (uwacadweb.uwyo.edu/MCEF/) that contains equipment information and a calendar that allows users to schedule time to use the instruments.

**Justin Jones**
*Manager*
*Macromolecular Core Equipment Facility*

Justin Jones, supervisor and manager of the UW Macromolecular Core Equipment Facility, explains the importance of this ultra-low freezer in preserving research samples.

# "Discovering" Brucellosis—The Search for Novel Virulence Genes in *Brucella abortus*

Since the discovery of the causative agent of "undulant fever" or brucellosis in 1887, efforts to thoroughly understand the pathogenesis of *Brucella* continue to frustrate scientists today. This fact is particularly true in the quest for a safe and effective veterinary vaccine against *Brucella abortus* in livestock and wildlife.

Although some efficacy has been demonstrated in cattle through immunization with the vaccine strain *B. abortus* RB51, this candidate has failed in elk, a presumed reservoir for the microorganism in Wyoming. Another live, attenuated vaccine known as *B. abortus* S19 has similarly shown poor performance in this host species.

Since the measure of the effectiveness of certain veterinary vaccines must include their ability to provide broad host-range protection, it is quite clear that improved vaccine contenders against brucellosis need to be identified and further developed. The very fact that the current *Brucella* vaccines fail in at least one target species but are successful in another supports the notion that certain aspects of the biology of this pathogen still remain an enigma.

Despite the preponderance of work done to define the disease mechanisms of brucellosis through molecular methods, most of the strategies used to date have yielded limited new information. Using a different approach, the Department of Veterinary Sciences will soon undertake a research effort to identify and characterize novel vaccine candidates for brucellosis in cattle and elk. Specifically, investigators will attempt to identify components of the bacterium required for survival and replication, which the microorganism only produces while in its host.

This gene-discovery strategy, known as "in vivo-induced antigen technology" or IVIAT, has been successfully used by other laboratories for such pathogens as *Mycobacterium tuberculosis* and *Vibrio cholerae*. IVIAT is actually a combination of molecular techniques which relies on the use of immune sera from previously infected animals as a screening tool for identifying the novel *Brucella* virulence components.

IVIAT is not only less cumbersome than other strategies, but it is much more economical. It does not require custom or specialized equipment, nor is it dependent on costly reagents. A major advantage of IVIAT over other approaches is that *Brucella abortus* genes encoding newly identified virulence components can be rapidly isolated and characterized. Furthermore, IVIAT could potentially yield virulence components of the bacterium uniquely produced in response to one host species but not the other. An additional utility of this method is the ability to identify virulence genes that are only transiently expressed (during infection) and the potential to identify virulence components specific to the route of infection or stage of disease.

The College of Agriculture's efforts will hopefully provide the basis for a more thorough understanding of *Brucella* pathogenesis in domestic livestock as well as in wildlife. Ultimately, the application of IVIAT for brucellosis should lead to the discovery of novel targets for "next-generation" vaccines that can be used as stand-alone products or can augment primary immunization with the existing live, attenuated vaccine platforms.

**Gerry Andrews**
*Assistant Professor, Department of Veterinary Sciences*

# "How Do We Know Students Are Learning What We Teach?"

Evaluating the finished products of student fashion design work serves as one form of learning assessment in the Department of Family and Consumer Sciences. Here UW spring textiles and merchandising graduate Amber Rettmann of Stewart, Minnesota, consults with Associate Professor Sonya Meyer about the flowing train of her "Deepa Lolita Avani" gown creation.

How can universities accurately measure students' academic success?

"At first blush that seems like a simple question, but it's a very complex question with complex answers," says Professor Jim Wangberg, associate dean and director of Academic and Student Programs for the College of Agriculture.

Test scores and grades on papers, he says, are just a small part of the package. Direct and indirect methods involving components such as portfolio and employer evaluations are also important.

"We're looking for more wide-ranging evidence that students meet objectives and retain what they have learned down the road," Wangberg adds.

"It's very much a priority not only at this university but nationally. Assessment is getting greater emphasis in accrediting institutions and from the public. Citizens want to see proof and documentation of how we are measuring the success and quality of our programs and student learning outcomes. How do we know that students are learning what we teach?"

The University of Wyoming, Wangberg says, has mandated that all departments develop strategic ways to measure the acquisition of student knowledge and then to use the information gathered to improve academic programs.

On its Web site for the assessment of student learning, UW officials define the process as "the systematic collection, review, and use of information about educational programs undertaken for the purpose of improving student learning and development."

Wangberg is one of several assessment coordinators named to help units across campus understand and develop comprehensive plans.

"We are a resource, and we direct them to other resources," he explains. "We also provide forums and orchestrate programs throughout the year to help people move forward."

Faculty members in the College of Agriculture are at different stages in the formulation of more comprehensive assessment techniques, according to Wangberg.

The Department of Family and Consumer Sciences, he says, has been a leader, making use of such techniques as curriculum mapping in competency areas, exit interviews, and electronic portfolios that chronicle the work of students from the time they start their programs until they graduate.

Wangberg says other methods of evaluating learning include recording how well students perform on entrance and exit examinations for advanced degree programs, gathering employer ratings of the skills of recent graduates, and surveying current students and alumni.

The UW assessment Web site also lists grades and pass rates on appropriate licensure/certification exams, rubric-scored work or performances, summaries and analyses of electronic class discussion threads, score gains between entry and exit on tests and writing samples, the consideration of internships and co-curricular activities, and capstone experiences such as research projects, presentations, thesis dissertations, oral defenses, and exhibitions as forms of tangible evidence of what students have learned.

"When it comes to assessment, most departments have had more experience and more success and more understanding of how to evaluate programs," Wangberg says. "The assessment of student learning is a greater challenge, and one that we are striving to meet."

On the Web: http://uwadmnweb.uwyo.edu/AcadAffairs/ASSESSMENT/

**Vicki Hamende**
*Senior Editor and Writer, Office of Communications and Technology*

Soil surface roughness is shown inside an Upper Government Draw exclosure in Fremont County.

The roughness of the soil surface outside the same exclosure in Fremont County is quite different.

# Long-Term Grazing Removal Alters Soil Properties

**Sally Madden**
*Graduate Student*

**Larry Munn**
*Professor*

**Ann Hild**
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Sagebrush grasslands are extensive in Wyoming and serve important watershed and wildlife habitat functions as well as providing grazing opportunities for domestic livestock. As part of a cooperative research effort between the University of Wyoming and the Bureau of Land Management, more than 100 exclosures in such areas were established in the state starting in the 1950s. Many of these exclosures are intact today and are a valuable resource for investigating the effects of long-term removal of grazing on these rangeland systems.

As part of ongoing projects involving Wyoming's rangelands, researchers in the renewable resources and botany departments selected 10 exclosures to study in sagebrush-grassland vegetation communities in Fremont, Washakie, and Natrona counties to evaluate the effects of the long-term removal of grazing by domestic livestock.

They took measurements of the soil's physical and vegetation properties inside and outside each exclosure, systematically sampling different microsites under shrubs, under grasses, and within bare interspaces.

In semiarid systems it has been suggested that "resource islands" under grasses and shrubs contain increased nutrients. Graduate student Sally Madden and faculty members in the departments of renewable resources and botany were interested to learn whether soil physical properties were also affected by the presence of shrubs and grasses and long-term grazing removal.

The 10 exclosures studied were established approximately 40 years ago. The UW scientists discovered some differences in soil and plant characteristics as a result of the long-term removal of grazing at the research sites. They determined that soil surface roughness had increased inside the exclosures.

Soil roughness or microtopography is important for reducing the rate of run-off and ero-

sion following rainfall and snowmelt and for curbing wind erosion. Roughness also contributes to the presence of "safe sites" for germination and the establishment of plants by increasing moisture retention, humidity, and shading.

The researchers also found an increased canopy covering of shrubs following the domestic livestock removal but no difference in the total density of shrubs. This suggests that the shrubs inside the exclosures have developed larger crowns, possibly due to the absence of browsing by native ungulates (hoofed animals). Although exclosure fences were constructed to exclude cattle and sheep only, such ungulates may have also been deterred from entering the areas.

Soil-water infiltration rates under bare interspaces differed from infiltration under grasses or shrubs. Inside the exclosures the infiltration was slower within interspaces, but equally fast infiltration was found under grasses and shrubs. Outside the exclosures, infiltration was highest under shrubs but was not different under grasses and interspaces. Overall, infiltration rates were higher inside the exclosures under grass than they were outside exclosures.

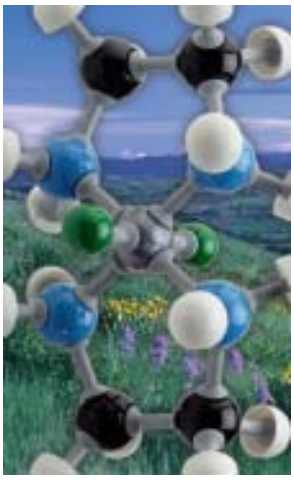
Soil compaction as determined by bulk-density measurements was comparable inside and outside the exclosures, but soil compaction was greater within bare interspaces. There was more bare ground outside the exclosures than inside. In combination, the higher cover of bare ground, higher interspace bulk density, and slower infiltration may mean that the overall infiltration and ability of the soils to hold onto water are lower outside exclosures. These differences may be important on a watershed scale, particularly on sloping landscapes where intense thunderstorms may produce more runoff from grazed allotments.

The research team concluded that long-term grazing removal affects soil physical properties and can improve hydrologic processes even though these differences may not be apparent in the vegetation. Understanding these effects should allow better long-term management of Wyoming rangelands. In the absence of exotic annual weeds including cheatgrass, more direct management such as prescribed fires may be a useful tool for reducing shrub dominance on a rangeland site following long-term grazing removal.

Soil-water infiltration following a thunderstorm is shown inside the Upper Government Draw exclosure in Fremont County.

This photograph showing ponding on the soil surface outside the exclosure following a thunderstorm was taken within 30 seconds of the previous picture. When reduced infiltration occurs on a slope instead of the nearly flat surface pictured here, runoff and erosion may result.

Continued research in a variety of topographic settings will help researchers understand how long-term grazing removal influences hydrologic processes at a landscape scale.



# Committee Participation Furthers Carbon

**Siân Mooney**
*Assistant Professor, Department of Agricultural and Applied Economics*

**George F. Vance**
*Professor, Department of Renewable Resources*

**Justin Derner**
*Rangeland Scientist*

**Gerald Schuman**
*Soil Scientist*

*USDA Agricultural Research Service*

What do college professors do besides teach classes and conduct research? They are also involved in outreach activities such as offering advice and expertise to organizations within the state.

The governor's Carbon Sequestration Advisory Committee is one group that has taken advantage of the expertise available within the College of Agriculture. This committee was created through state legislation under the Wyoming carbon storage act. The main goal of the team is to provide the state with scientifically sound information and advice concerning management practices and economic opportunities for storing carbon in Wyoming's agricultural and forest lands. Many state and federal agencies are interested in carbon sequestration as a potential opportunity to reduce the threat of global warming and provide economic benefits to those who participate in programs that involve agricultural best-management practices and the marketing of carbon credits.

Agricultural producers, state agency officials, power company executives, federal employees, and UW professors within the College of Agriculture all serve as members of the governor-appointed committee.

Siân Mooney, an assistant professor in the Department of Agricultural and Applied Economics, and George Vance, a professor in the Department of Renewable Resources, were picked to be on the team because of their knowledge about the science, policy, and market factors that could influence the ability of the state to adopt practices that sequester carbon and benefit Wyoming's citizens. Their expertise has been developed through their research programs, student activities, and outreach involvement.

Mooney has spent several years investigating how much it costs producers to change to practices that store more carbon as well as contributing to the national debate about how to design policies that might lead to trades in carbon credits. Vance has conducted research on soil carbon in forest, range, and aquatic ecosystems for more than 20 years and has examined the chemical composition of substances that comprise carbon pools and transfer products.

Serving on the committee together has provided an opportunity for Mooney and Vance to collaborate within a multi-disciplinary team on carbon sequestration research as well as on outreach activities related to issues that are important to the state and nation. Interactions

A soil sample collected from a forest is shown. The darker color at the surface is due to soil organic carbon.

# Sequestration Research

between university, government, industry, and agriculture participants are vital in helping to solve complex problems relating to carbon sequestration and climate change.

Other members of the governor's committee who are affiliated with the college are soil scientist Gerald Schuman and rangeland scientist Justin Derner, both researchers at the U. S. Department of Agriculture's Agricultural Research Service High Plains Grasslands Research Station near Cheyenne.

As well as having adjunct professor status with the renewable resources department, Schuman has conducted research on increasing soil organic matter in degraded croplands. His recent work has examined the influence of grazing management practices involving the interseeding of a nitrogen-fixing legume (yellow-flowering alfalfa) on soil carbon in rangelands. Derner has evaluated grazing effects on soil carbon across different grassland ecosystems in the Great Plains, and his current research involves exploring the influence of the intensity and seasonality of grazing on soil carbon and vegetation dynamics.

Matt Mortenson, a U.S. Department of Agriculture research technician, collects soil samples on native rangeland for baseline carbon data.

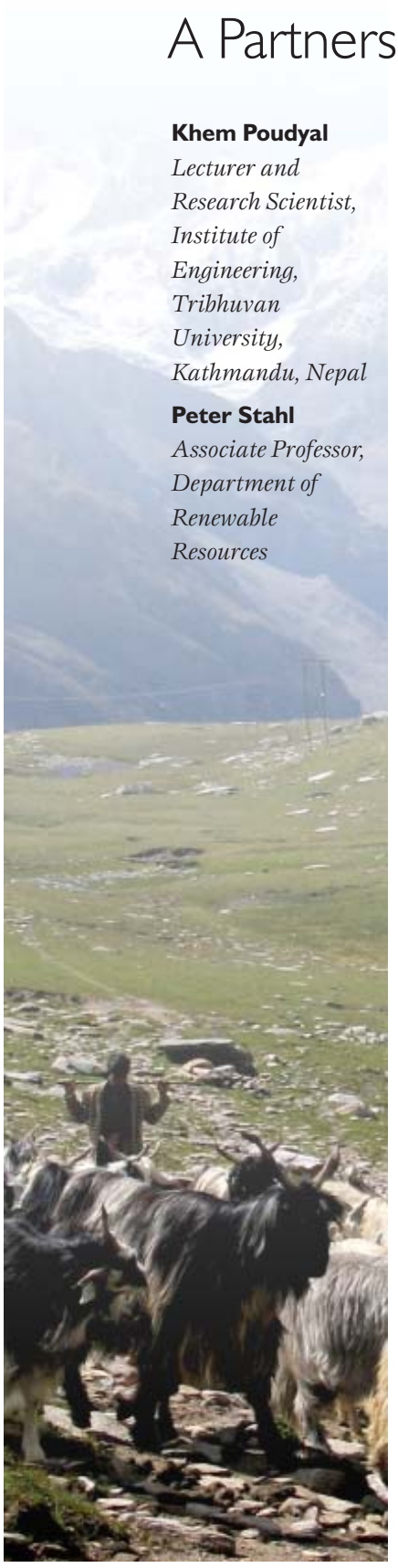
UW Research Associate Girisha Ganjegunte of the Department of Renewable Resources prepares to sample a forest floor organic level.

Along with other members of the carbon sequestration advisory committee, Mooney, Vance, Schuman, and Derner have organized and participated in an outreach workshop for Wyoming citizens explaining the concepts and policy issues concerning carbon sequestration, have initiated demonstration sites for "proof of concept" by utilizing field projects that can be viewed by agricultural producers, and are developing a Web site that will contain information about carbon sequestration and the committee's activities.

# A Partnership: Wyoming, Nepal, and High-Elevation

**Khem Poudyal**
*Lecturer and Research Scientist, Institute of Engineering, Tribhuvan University, Kathmandu, Nepal*

**Peter Stahl**
*Associate Professor, Department of Renewable Resources*



Although Wyoming and Nepal are on opposite sides of the world, they have a surprising number of things in common. Their beauty is appreciated by tourists around the globe. They share abundant natural resources and high-elevation rangelands. They have similar problems in providing rural healthcare and creating good jobs for young people.

A memorandum of understanding between the University of Wyoming and Tribhuvan University in Kathmandu, Nepal, was signed in Laramie in 2004 with both institutions agreeing to collaborate on issues and problems of mutual interest.

With this accord, the two universities have entered into a partnership that will foster academic, technical, and intercultural exchanges.

Areas of cooperation will include the development of modern technology, the establishment of joint research projects, the publication of related results and experiences in books and journals, and a study of the quality of education and socio-economic development in Nepalese villages.

Students and faculty members at Tribhuvan University in Kathmandu, Nepal, will partner with UW representatives to work on high-altitude agricultural projects of mutual interest.

UW will provide access to its expertise in modern agriculture, ecology, rangelands, animal husbandry, and other topics. Field laboratories in rural districts of Nepal will help provide professional experience in agriculture, renewable energy, and the natural environment.

Tribhuvan University, established in 1959 and located in the capital city of Kathmandu, is the oldest and largest university in Nepal. It serves about 95 percent of the students who are pursuing higher education.

Nepal is situated in the central part of the Himalayas, sandwiched between Tibet and China to the north and India to the east, west, and south. It is a landlocked country of appealing scenery and rich cultural heritage. It is known for its majestic mountains, landscapes, green valleys, lakes, rivers, waterfalls, terraced hillsides, and diverse flora and fauna.

The collaborative research partnership between UW and Tribhuvan University will seek solutions for critical problems involving the environment and the reclamation of soil in mining and mountainous areas.

# Agriculture

The collaborative research partnership between UW and Tribhuvan University will seek solutions for critical problems involving the environment and the reclamation of soil in mining and mountainous areas.

It will also focus on grazing lands, watersheds, agricultural resources, soils, and tourism. Other topics will include high-altitude farming, altitude sickness, renewable energy in rural areas, climate, ecology, and culture.

Both universities and their states are equally prosperous in human resources and natural resources, and collaboration paves the way for greater innovation through the exchange of technology and knowledge transfer between these institutions.

This academic partnership is a positive step forward as it signals a joint commitment to work closely in enhancing the capabilities of both partners. It will have direct benefits for students who will have the opportunity to take on a diverse range of challenging projects. The overseas experience gained will also have a positive impact on their future careers.

Together the institutions can make better use of their resources to help provide humanitarian relief to benefit those in need.


This map of Nepal shows its major cities, parks, and mountain ranges.

Sybaru is a small agricultural village high in the Himalayan Mountains in Nepal.

# Reducing the Risk of Drought on Forage Yields

**Michael Smith**
*Professor, Department of Renewable Resources*

Drought is a stochastically recurring climatic event with adverse management and economic consequences for a wide variety of land users ranging from recreation and wildlife enthusiasts to ranchers and public-land managers.


Droughts lasting from one to several years regularly occur in Wyoming. Rangeland forage production and water yields have been reduced as a result. Land users and managers have responded with reductions in livestock, restrictions on land management, and the development of alternative livestock water sources. However, the response has usually been too late to avoid resource or economic damage.

The needs created by drought have been readily apparent in the actions of producers, land managers, and water-management officials. Unfortunately, there has been no tool for providing an advanced warning of impending forage shortages or for providing those affected with the ability to understand the differences between hydrologic and agricultural drought.

Hydrologic drought refers to precipitation shortages that impact supplies of water used for community needs, irrigation, and livestock drinking. Agricultural drought occurs when precipitation shortages take place in seasons of vegetation production.

Receiving advanced warning of impending forage shortages would allow for the timely planning of grazing use to minimize the adverse consequences to animal performance, rangeland resources, and the economic situations of agriculturists. University of Wyoming scientists in the College of Agriculture are working to give that notice.

Producers, researchers, and federal land-management agencies have provided sites and data for the development of predictions describing the best temporal window of spring moisture influencing forage production for the subsequent growing season. Individual producers have teamed with several Wyoming

This soil moisture probe helps to predict precipitation shortages that could affect range forage production

conservation districts, the Bureau of Land Management (BLM), the U.S. Forest Service (USFS), the Natural Resources Conservation Service, the U.S. Department of Agriculture (USDA) Agricultural Research Service, the Wyoming state climatologist, and the Wyoming Department of Agriculture.

Funding has been provided by the USDA Cooperative State Research, Education, and Extension Service, the U.S. Geological Survey, the Wyoming governor's office, the Wyoming Department of Agriculture, BLM, and USFS for the development of infrastructure and soil moisture monitoring equipment. The analysis by UW researchers of 18 or more years of rangeland productivity and seasonal precipitation data from three sites in Wyoming has revealed that good to excellent predictability of rangeland productivity is provided from the precipitation of specific temporal windows in the spring.

Caging a site near Meeteetse for drought studies are, from left, rancher Jim Gould, UW Professor Michael Smith, and Tim Morrison of the Meeteetse Conservation District.

Volunteer custodians have been solicited to maintain the varying sites for sampling annual forage yields and moisture inputs. These site managers usually represent two or more agencies in the 14 counties in Wyoming that participate. The locations have 20 cages to protect sample plots from grazing until the plots are harvested in midsummer, and each area has a soil moisture monitoring station.

Actions by land-management agencies have been more realistically tied to predicted forage yields and hydrologic conditions in the last couple of years. If drinking water for livestock is the major shortfall, the focus has been on considering that shortage as opposed to assuming that forage shortages are also present and taking inappropriate actions such as altering the grazing season or the number of animals. This change in understanding can lead to producers being able to graze on their permitted land if they provide water for their livestock.

More rational economic and resource management decisions have been made as a result of this research and education. Infrastructure is being developed to provide better local information for resource-use planning. The result will be better resource conditions and more sustainable ranching enterprises.

Landscapes are mirrors of our dreams, reflecting the texture and topography of our lives. I've lived on the high plains of the Laramie Valley for 16 years. That's about four times longer than the average American stays put, and this is the only place that my children have called home. But I didn't start here, and I've traveled perhaps more and longer than a good husband and father might, so I know other vistas.

Driving to my parents' home in Albuquerque, approaching the Sandia Mountains, stirs memories of 20 years with my wife. Our first date was more than a quarter-century ago — sweethearts at Sandia High School, named for the mountains and providing an auspicious setting for a life-long love to begin. On our drive back into New Mexico, the range peeks over the horizon from 40 miles away. With each passing minute, the mountains grow steadily but imperceptibly until they become the single, defining feature of the world. Mountains and lovers orient our lives.

Rifts in the earth evoke the glories and tragedies of life. I remember the grueling drive across the desert in a sky-blue station wagon in 1972. We parked at the cabins set back a few hundred feet from the rim of the Grand Canyon, and I sauntered to the edge with the bored arrogance of adolescence. In a matter of no more than twenty paces, the earth opened at my feet. I felt the air being sucked from my chest and felt the pounding of my heart. Like the death of a loved one or the birth of a child, the depth and breadth of that abyss could only be experienced, never described. Such times of awe, humility, and reverence are beyond our imaginings.

I've lived for a few months at the edge of a forest — lovely, dark, and deep. Trees form a demure canopy over a soft bed of leaves, and the air is thick with the musky scent of fertility. I know why my friend Diana insists on calling deforestation "rape." And I think I understand what George Meredith meant when he wrote, "Enter these enchanted woods, You who dare." To live in a forested land is to know a primal womb, the insistent pulse of life.

Desert was the landscape of my childhood. On the mesa behind our house in New Mexico, my brother and I hunted for lizards, which we sold to the neighborhood pet store for a quarter each. A good day's hunting worked out to about 17 cents an hour. By afternoon, the reptiles became difficult to flush from their shady refuges, and we became flushed with the southwestern sun. Heat exhaustion is an object lesson in humility. A mother waiting with a pitcher of iced tea personifies a child's need for protection from the harshness of the world. And so we played in the desert, but we didn't live in the

*"Now I possess and am possessed of the land where I*


## Jeff Lockwood,

*Professor, Department of Renewable Resources and Department of Philosophy*


Professor Lockwood is an experienced scientist who has published extensively about his entomology research during his career at the University of Wyoming. More recently, his scholarship has moved into exploring the interface between the humanities and the sciences. As part of that career evolution, he now has a joint appointment between the Department of Philosophy in the College of Arts and Sciences and the Department of Renewable Resources in the College of Agriculture. He is also teaching in the new master of fine arts program in the Department of English. This essay is an example of his new creative work and is published in his collection of essays *Prairie Soul: Finding Grace in the Earth Beneath My Feet*, Skinner House 2004, with the permission of the publisher.

# here are my conditions

*would be. And the curve of half Earth's generous breast shall sooth and ravish me!"*

*- From Rudyard Kipling's "The Prairie"*

desert. Like everyone else, we lived in a stuccoed house with a swamp cooler. Growing up in the desert was a constant reminder of our limits.

The coast is a landscape of joyful terror. I love to wade in the surf, but something changes when my feet no longer touch bottom. The seashore reminds me of a meeting I attended at the headquarters of a multinational corporation. It was fun to wear a tie and walk at the tidal edge of power and wealth for a few hours. Drawn in further, the undertow of unspoken deal-making began to scare me. At the end of the day, those I met with promised to call me, but to my relief the project never resurfaced. Skimming along the surface of the ocean is exhilarating until I lose sight of land. Then a whirlpool of anxiety sucks the glassy surface of my world into the unfathomable, jade-green depths.

If you close your eyes and throw a dart at a world map, there's a seven-in-ten chance that you'll hit an ocean. But if the dart strikes land, the odds are the same that it will strike grassland. Oceans of water and seas of grass are the leitmotif of our planet. And just as oceans have unique qualities and personalities, not all treeless landscapes are the same.

The grasses of the North American prairie once reached to the shoulders of the bison, and the blackness of the soil crept deeper than graves of the pioneers. The tall grasses—gentle, vulnerable, mortal—rippled in the wind. Fire and drought could not rend the living fabric, but plows and pavement proved lethal. After surviving four million sunrises, this sea of grass is drained of its vitality, shriveled to a pathetic remnant of its former glory. In contrast, the North American shortgrass prairie, or steppe, perseveres. Its grasses are too stunted and sparse to conceal even a prairie dog, and its shallow, alkaline soils are geological newborns. But this land persists. Settlers tried to tame the sere basins that stretched between the snow-capped mountain ranges. Farmers plowed and planted the shortgrass prairie and harvested despair and dust. We might drain an inland sea, but the steppe has oceanic power that is unrelenting and unforgiving. Like seasoned sailors, a few ranchers adapted to, rather than struggled against, the land.

The shortgrass prairie is devoid of the peaks and valleys of human drama. This landscape mirrors the mundane quality of lives, belying the fantasy that our existence is cloaked in excitement. Perhaps this is why we do not cherish these harsh lands. National parks and wilderness areas were not created to protect the emptiness of these grasslands. We don't need nature reflecting the uniformity of our slowly unfolding days.

In the midst of this landscape, awareness is stretched to the curvature of the earth. I am drawn to the infinity that lies just past the ever-receding horizon. I am a mote, a point on an immense

sphere suspended in a cosmos that stretches beyond imagination. Here I am utterly lost and aware that while I am absolutely unique, so are the other six billion humans on the earth. This grassland, like the immensity of society, is not intentionally hurtful. Malevolence would require that we exist as particular beings worthy of being harmed. Rather, this landscape is indifferent. Our sense of self-importance withers here like the farmsteads.

A catwalk of interstate highways crosses the shortgrass prairie. In our cars, we focus on the horizon and move as quickly as we can, hoping to reach something that will affirm our existence. For all practical purposes, most lives and western roads have no speed limits. We race along, anticipating what is to come, hoping to get there in time. For what? Our days, like the grassland, are something to be crossed on the way to sometime or somewhere else.

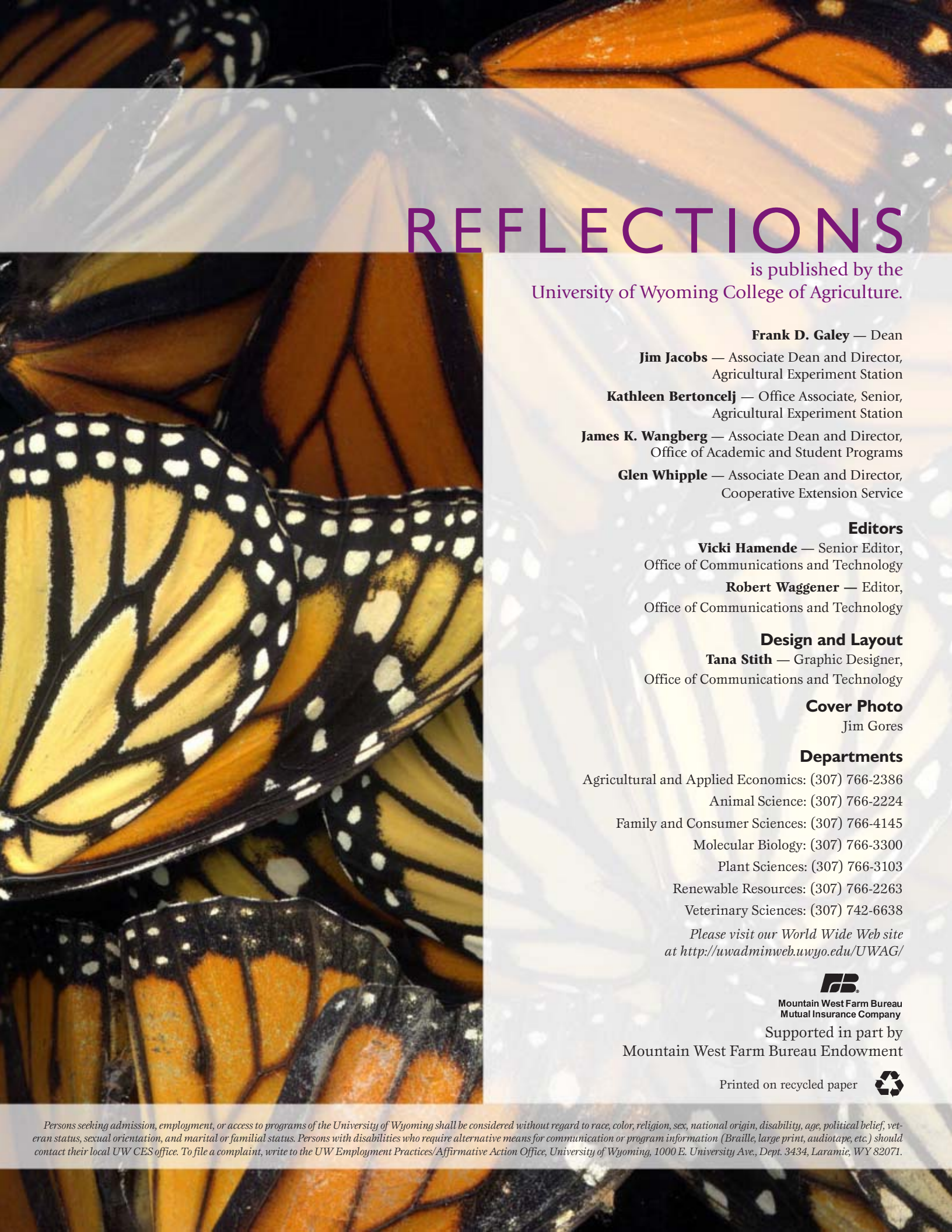
So why do I live on the prairie? Out of a sense of penance, a perverse psychic masochism? No, I stay because the landscape can be seen and lived in another way. If we focus on the patch of plants and creatures at our feet rather than on the horizon, and if we move slowly through the grassland rather than past it, then points of wonder and moments of beauty emerge. In this way, I see *Hesperotettix viridis* nestled in the luxuriously green, wickedly poisonous snakeweed that constitutes this grasshopper's only food. My next step flushes a robber-fly, laden with its meal of a dwarf cicada, from the golden stem of *Stipa comata*. Each patch, like me, has a story—not high drama or excitement but the good labor of living, competing and cooperating, sustaining self, and creating community.

And when I slow my pace of living so that I truly see the grassland, then my life comes into focus. The ordinary moments—weeding the garden with my daughter, fishing with my son, explaining a concept to a student, drinking coffee with friends— become worthy of living, infused with meaning. The grassland is a setting that reflects my life, evoking the depth and wonder of the eternal present. Every seed on the grassland, any touch of my wife, each word I write means nothing – and everything.

The grassland is not only a reflection of me but also a gateway to the ultimate manifestation of the infinite and the infinitesimal, the universal and the particular. Whatever else God might mean, to merit our reverence God must be transcendent. And to deserve our awareness, God must be immanent. When people tell me they are atheists, I always ask what sort of god it is that they don't believe in. And often, I find that I can join in their disbelief of an angry, perverse, or cruel deity. There are a lot of gods not worthy of our faith.

As a child, I was taught that God asked everything of me: total devotion and absolute obedience. Motivated by fear and awe, I tried for years to meet this demand. But I came to wonder what God could possibly want, let alone need, from me. To be fair, it seems that the creation should expect more of its creator than vice-versa.

And so, at risk of stepping beyond my station in the universe, I have formulated my expectations of the divine in simple terms. God ought to be able to draw me beyond the ever-receding horizon of the prairie — and to be manifest in the earth beneath my feet.



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