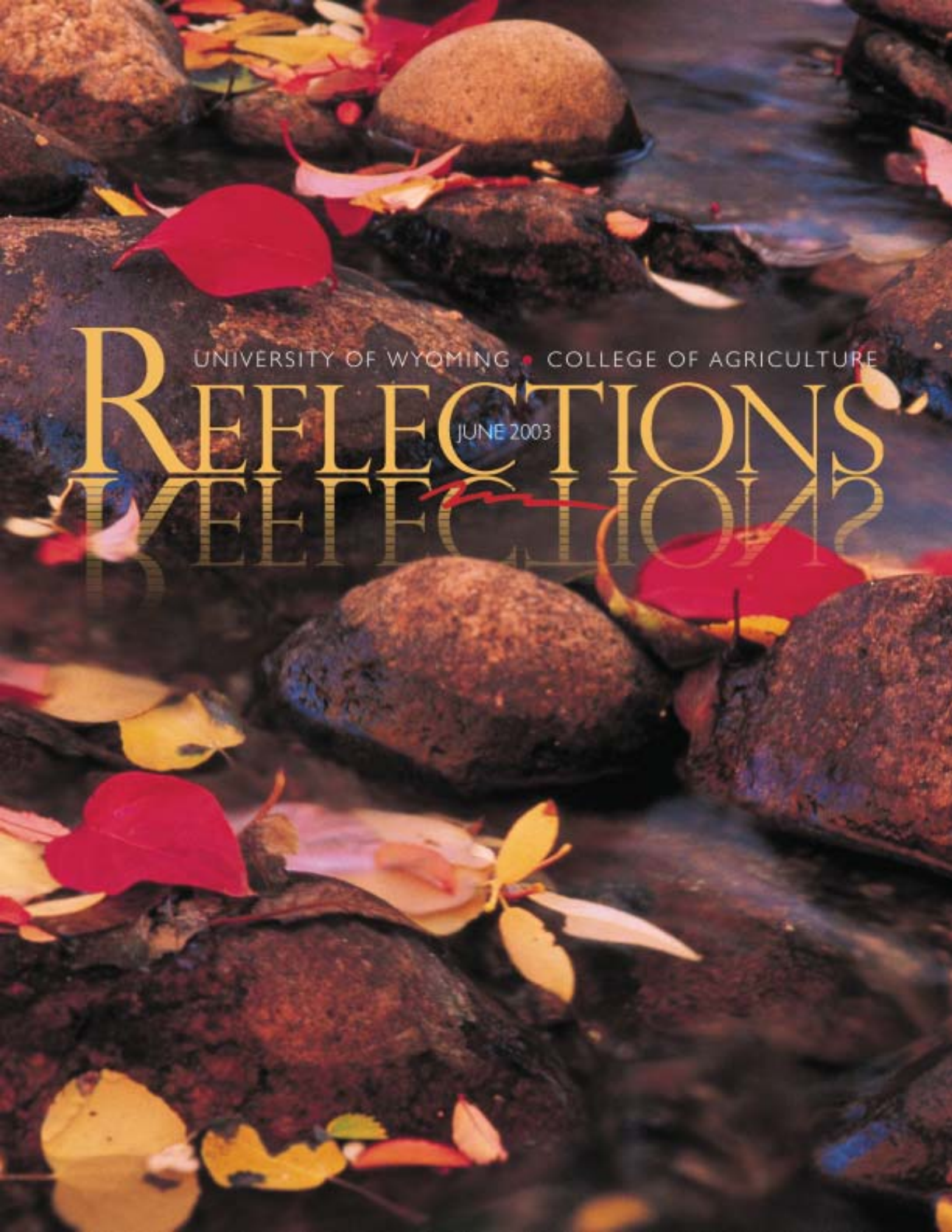

UNIVERSITY OF WYOMING • COLLEGE OF AGRICULTURE
REFLECTIONS
JUNE 2003

THE FUTURE:
Rebirth and Continuity

"The innovative people of the College of Agriculture, with a presence in every county, are dedicated, like you, to making a better future."

Each new season of the year provides distinct images. From the multiple colors of fall to the spring greening, the transformations signify change while at the same time reaffirming the continuity of growth. Just like the seasons, it is the people of Wyoming who provide continuity through changing times while building the state's future.

People in the College of Agriculture are researchers and educators who work closely with those they serve to apply the land-grant principles of learning, engagement, and discovery. Scientists conduct research in laboratories and on private farms and ranches, educators provide research-based programs, and advisory boards and individuals offer suggestions and direction for study. Results from these close-working relationships are featured throughout *Reflections 2003* in articles such as "Tracking a killer: the search for West Nile virus in Wyoming," which shows how a deadly disease can be challenged by research at its best. Like the seasons, the land-grant values are part of a cycle of stability:

- Learning – Outreach provides research-based educational programs to individuals, businesses, and communities.
- Engagement – Supported by advisory committees and individuals, emerging needs are explored.
- Discovery – Researchers gain knowledge and share results with educators, citizens, and students, who in turn make contributions of their own.

Just like the seasons, the cycle continues. It is all about people and the future. The innovative people of the College of Agriculture, with a presence in every county, are dedicated, like you, to making a better future. They are your neighbors, friends, and colleagues.

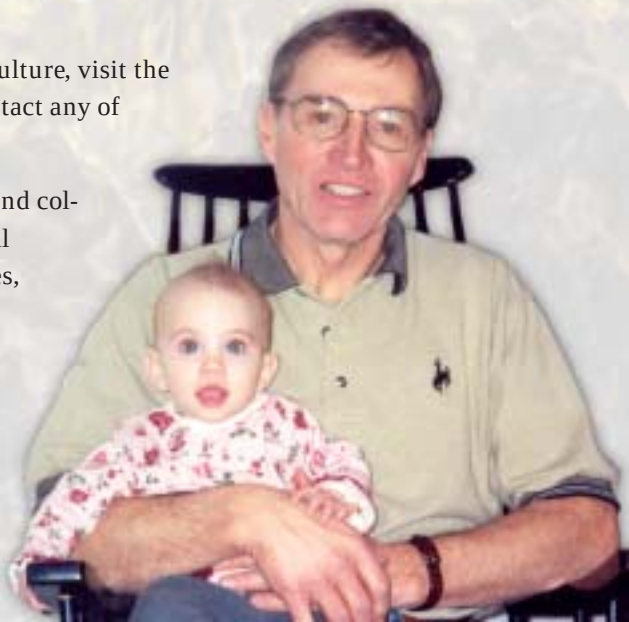
For more information about the College of Agriculture, visit the college's Web site at www.uwyo.edu/agcollege or contact any of the departments listed on the inside back cover.

Better yet, stop by and visit one of your friends and colleagues to share your ideas. Working together, we will build a better future for Wyoming families, businesses, and communities.

I hope you enjoy this year's *Reflections*.

Jim Jacobs

Director and Associate Dean, Wyoming Agricultural Experiment Station



Welcoming people to the College of Agriculture is this colorful, strategic visioning painting that weaves together views of citizens' aspirations for Wyoming's rural landscape in 2012. Created by artist Gary Keimig, the painting shows a blending of agriculture, natural resources, and rural communities.

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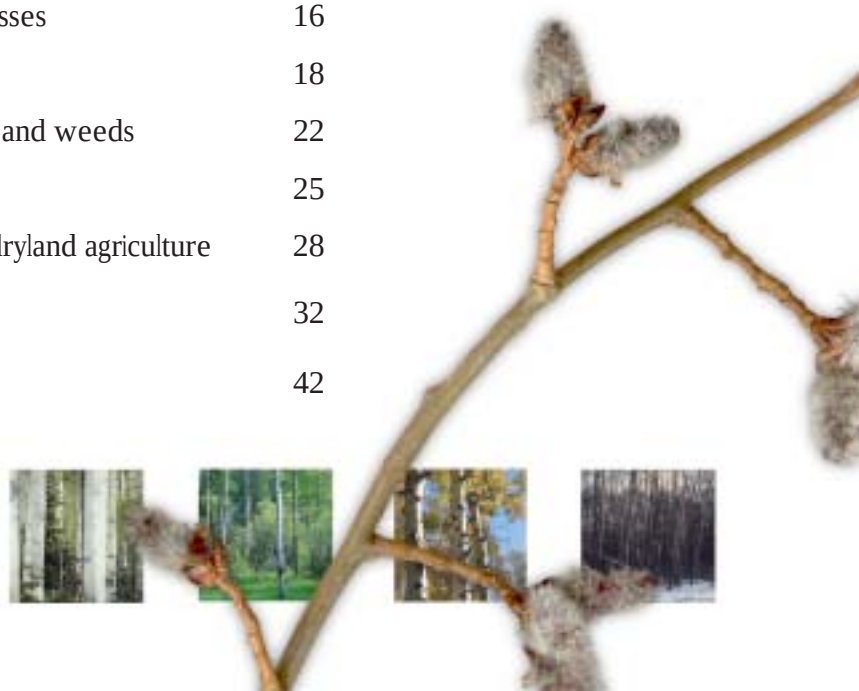


TRACKING A KILLER:

Todd Cornish, Assistant Professor, Department of Veterinary Sciences

Terry Creekmore, Vectorborne Disease Surveillance Coordinator, Wyoming Department of Health

ARS Photo

West Nile virus (WNV) first appeared in the United States in the summer of 1999, striking birds, horses, and humans in New York City and surrounding areas. By the summer of 2000, WNV had re-emerged in the northeastern U.S. and had spread to several states along the Atlantic Coast. WNV was identified in 12 states, and experts at the Centers for Disease Control and Prevention predicted that the virus was here to stay. In 2001 there was dramatic expansion of WNV to the Midwest, and further predictions were made that the virus would spread throughout the contiguous 48 states within a period of years. These predictions were correct, but the speed and magnitude of the spread in the year 2002 caught most people by surprise. During the summer of 2002, WNV moved from previous strongholds in the Midwest to involve most states in the Great Plains and Rocky Mountain regions, and it had reached the Pacific Coast (Washington and California) and involved a total of 43 states by the end of the summer (Figure 1).

West Nile virus is a mosquito-borne viral disease of birds, horses, and humans, with birds acting as reservoirs and amplifying hosts for the virus. Mosquitoes that feed on infected birds can transmit the virus back to more birds or to horses, humans, and other species, causing a very small proportion of mammalian hosts to become ill. West Nile virus has been found in more than 140 species of birds

the search for West Nile Virus in Wyoming

in the United States, but among the most sensitive are crows, ravens, magpies, and jays, all species that serve as the most useful indicators of WNV activity and form the core of most bird surveillance programs. Horses and humans are in essence "dead-end hosts," capable of becoming infected and in some cases ill but not efficient at transmitting the virus back to mosquitoes or directly to other people or animals. While WNV has been found in a variety of other wild and domestic animal species (gray squirrel, mountain goat, striped skunk, reindeer, dog, cat, sheep, and llama among them), most domestic pets and livestock other than horses appear to be quite resistant to the development of clinical disease.

In 2001 a team of experts was assembled in Wyoming to prepare for the approach of WNV. Veterinarians, physicians, public health professionals, wildlife professionals, and livestock professionals from the University of Wyoming College of Agriculture, the Wyoming Department of Health, the Wyoming Game and Fish Department, the Wyoming Livestock Board, and the U.S. Department of Agriculture's Animal and Plant Health Inspection Service met and formed a working group to coordinate plans for WNV surveillance, diagnosis, prevention, and educational programs. Two diagnostic centers were created – one at the Wyoming State Veterinary Laboratory (WSVL) for surveillance and diagnosis of WNV in domestic and wild animals and one at the Wyoming Department of Health for the diagnosis of WNV in humans. Active surveillance for WNV officially began in June 2002 with testing of wild birds and horses at the WSVL. The first case of WNV was diagnosed in a horse from Goshen County on August 16, 2002. More cases from Goshen County soon followed, and by the end of the summer of 2002, news of horses and birds testing positive for WNV had been received from 15 counties in Wyoming (Figure 2). Unlike WNV outbreaks in states east of the Mississippi River, more horses than birds were diagnosed with WNV in Wyoming in 2002 (96 positive horses, 22 positive birds). West

Figure 1. The spread of West Nile virus in the U.S. from 1999 to 2002, from the Centers for Disease Control and Prevention in Atlanta, Georgia.

Terry Creekmore, left, and Todd Cornish at the Wyoming State Veterinary Laboratory.

Nile virus will probably be a permanent resident in Wyoming for the foreseeable future. The long-term picture for this disease is difficult to predict, but if WNV in Wyoming behaves like the disease in states to the east, significantly more cases in birds, horses, and humans may be expected in future years.

In the summer of 2002, there were approximately 3,950 human cases of WNV and 254 deaths in the U.S., contrasted with just 66 human cases in 2001 and nine deaths. The number of human cases in 1999 was 63 (with seven fatalities), and the number in 2000 was 21 (with two fatalities). There was only one confirmed human case of WNV in Wyoming in 2002; however, this number likely will rise in 2003. Most WNV infections in humans result in no clinical signs or illness, but in a few cases, especially in people over 50, there may be flu-like illness with fever, headache, body aches, swollen lymph nodes, and in some cases a mild rash. A small proportion of people will progress to develop severe disease with high fever, stiff neck, stupor, disorientation, tremors, convulsions, muscle paralysis, and coma. These signs are indicative of meningitis or encephalitis and warrant rapid medical care since death may result. While there currently is no WNV vaccine available for humans, there are helpful precautions to take to avoid WNV infection, including measures that limit exposure to mosquitoes. Among these precautions are avoiding prolonged time spent outdoors during peak mosquito activity periods (dusk to dawn), wearing protective clothing like long-sleeved shirts and long pants, the use of mosquito repellants, maintenance and repair of window screens and screen doors, and removal or frequent changing of standing water sources where mosquitoes can breed (old tires, bird baths, swimming pools, water troughs, etc.).

West Nile virus infection in horses shares some features of the disease in humans. The vast majority of horses infected probably never

Figure 2. The number of 2002 West Nile virus cases in Wyoming horses by county.

become ill. In those horses that do, however, common clinical signs include depression or anxiety, incoordination or stumbling, weakness of limbs, muscle twitches, and recumbency (downer animals). Fatality rates in horses that display clinical signs range from 20 to 40 percent, although this figure appeared to be lower in Wyoming in the summer of 2002. A vaccine for horses is available through veterinarians, and horse owners are strongly encouraged to pursue vaccination of their animals. Two doses are required three weeks apart, with an annual booster thereafter. Protection does not seem to be complete until several months after the second dose. Accordingly, horse owners are being advised to begin vaccinating early in the spring (before mosquitoes become active) to achieve maximum protection. While the disease protection provided by the vaccine is probably not perfect, all known fatal WNV cases in horses in Wyoming in 2002 involved horses that were not vaccinated.

West Nile virus infection can be diagnosed using a variety of tests such as virus isolation, polymerase chain reaction (PCR) tests, serum tests looking for specific antibodies in blood, and immunohistochemistry (using antibodies to detect the virus in tissue sections). At the WSVL, all avian cases in 2002 were diagnosed using PCR and immunohistochemistry (Figure 3). Most Wyoming equine WNV cases in 2002 were diagnosed using a serum (blood) test that detects specific antibodies called IgM and can differentiate between an infected horse and a horse that was vaccinated. The last positive avian case for 2002 was received at the WSVL on October 16, and the last positive equine case for 2002 was received on October 29. No new infections should be expected until the spring of 2003 when mosquitoes will re-emerge with warmer temperatures.

Figure 3. Positive immunohistochemistry test for West Nile virus (stained red) in the heart of a magpie that died in Goshen County, Wyoming.

Active surveillance for WNV activity in birds in Wyoming is conducted during summer months and will begin again May 1, 2003. People finding dead birds, especially corvid species (crows, ravens, magpies, and jays) or raptors (hawks, owls, and eagles), are encouraged to call the WSVL [Todd Cornish at (307) 742-6681, Extension 191, or Terry Creekmore at (307) 742-6681, Extension 105] for consultation and to arrange testing of samples. Veterinarians and horse owners with questions about WNV or desiring testing for WNV in their patients or animals should also call Cornish at the WSVL. Questions about WNV in humans should be directed to the Wyoming Department of Health at (307) 777-3593.

Collaborative research projects examining the effects of WNV on wild bird populations in Wyoming are expected to begin in 2003. Also, there are plans to begin a more thorough study of mosquito species involved in WNV transmission in Wyoming by identifying their distribution and density throughout the state, with the ultimate goal of detecting and mapping high-risk areas where humans and horse owners may need to take extra precautions. Long-term research projects will investigate the potential for WNV to infect and cause disease in cattle and other domestic and wild animal species important to the economy of Wyoming.

$elling carbon credits: a potential

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

(Photo by John Kimble)

Field soil samples are taken to aid in carbon sequestration research.

Many countries are considering ways to reduce atmospheric concentrations of greenhouse gases such as carbon dioxide (CO_2) that potentially contribute to global warming. While several countries have chosen to ratify the Kyoto protocol, the United States has not. Instead, the administration has announced a voluntary initiative to reduce concentrations of greenhouse gases with an option for future mandatory limits if further reductions are needed. Many firms anticipate that a cap on emissions of greenhouse gases will eventually be imposed, either through an international agreement like the Kyoto protocol or through domestic policy, and have started to take voluntary actions to reduce their emissions of CO_2 or to purchase CO_2 credits from other sources.

One way that industries can directly lessen their CO_2 emissions is by reducing fossil fuel combustion. In many cases this requires firms to develop and adopt new technologies or to change existing production methods earlier than planned. These options can be very costly. Another alternative is to purchase CO_2 credits from a less expensive source until it is economically efficient to bring new technologies on line.

Although trading rules are not finalized, private companies and non-profit groups are engaging in pilot projects that generate CO_2 credits. For example, the energy company PacifiCorp has invested in forest preservation in Bolivia as well as tree-planting projects in Oregon. The Nature Conservancy and Winrock International are also involved in many activities in South and Central America that generate CO_2 credits from forest activities. There are incentives for buyers to purchase CO_2 credits voluntarily in the absence of a formal U.S. market, such as gaining early mover advantage in a developing market by amassing experience with early trades or informing the policy debate. CO_2 credit sellers may also participate for similar reasons as well as for the opportunity to market a new commodity.

Since 1996, approximately 65 credit trades have occurred worldwide, and since 1995,

Soil samples are analyzed to

more than 150 projects have been implemented to reduce CO_2 emissions or increase carbon (C) sequestration. Approximately 10 percent of these projects have increased C sequestration in forests, but recent research suggests that agriculture could also compete in the emerging market for CO_2 credits.

future commodity for agriculture?

Up to 8 percent of U.S. emissions could be offset by increasing the amount of C sequestered in agricultural cropland soils. Why, then, has agriculture not figured more prominently in these early trades? It is primarily because the institutions, contracts,

(Photo by John Kimble)

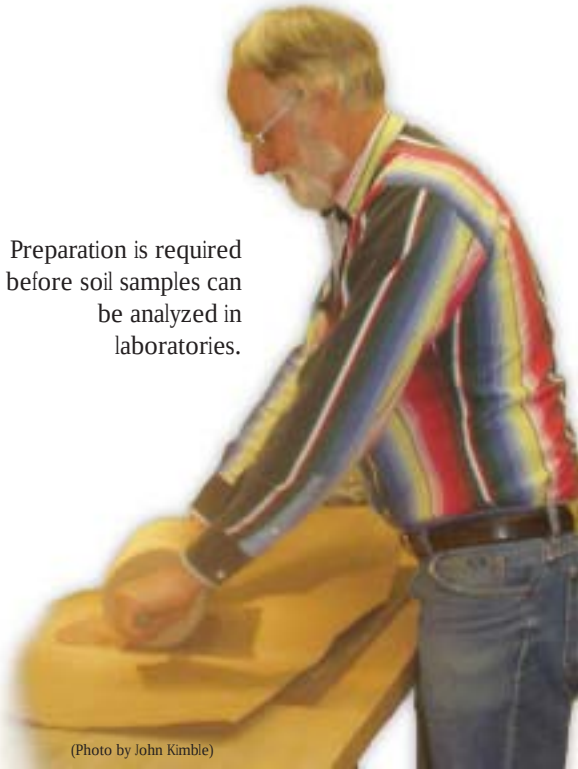
determine their carbon content.

enforcement mechanisms, and policies have not been standardized for agricultural soil C. In fact, scientists and policymakers have questioned whether it would be feasible to include credits generated by agricultural soil C sequestration in a market for tradable carbon dioxide credits, in part because of the potential costs associated with measuring the number of credits that are produced.

Recent research by Siân Mooney of the Department of Agricultural and Applied Economics and John Antle and Susan Capalbo of Montana State University has shown that in some areas CO_2 credits from cropland soils are economically competitive with credits produced by forest projects. A recent grant from the U.S. Department of Agriculture National Research Initiative Competitive Grants Program is funding additional research to develop a measurement protocol for contracts that trade CO_2 credits from agricultural soils. The research will also estimate the costs of implementing the measurement protocol for CO_2 credit trades. A transparent, verifiable, and low-cost measurement scheme would enable agricultural producers to sell their CO_2 credits in competition with other credit sources in a market system.

A system of linked economic and biophysical models will be used to predict the amount of cropland that might enter into contracts to supply CO_2 credits at a range of different credit prices. Once the contract participants are identified, the research proposes to use predictive biophysical models to estimate the expected rate of soil C sequestration resulting from changes in management practices within the contract area, taking into account specific climatic and soil conditions. These estimates can then be used to develop a sampling scheme to measure baseline levels of C within an area with field measurements and laboratory testing. These activities are repeated several times to track increases in soil C (and thus carbon dioxide credits). Preliminary results suggest that the cost of measuring C changes in agricultural soils is not likely to be large enough to prevent agricultural producers from participating in a market for CO_2 credits. Over the next year, the research will explore how important factors such as the expected minimum tradable numbers of credits or the degree of spatial variability within different regions influence measurement costs. In addition, the research will consider whether geo-statistical techniques can be used to gain more information that could further reduce measurement costs.

Additional information regarding this project can be obtained by contacting Siân Mooney at (307) 766-2389.



Preparation is required before soil samples can be analyzed in laboratories.

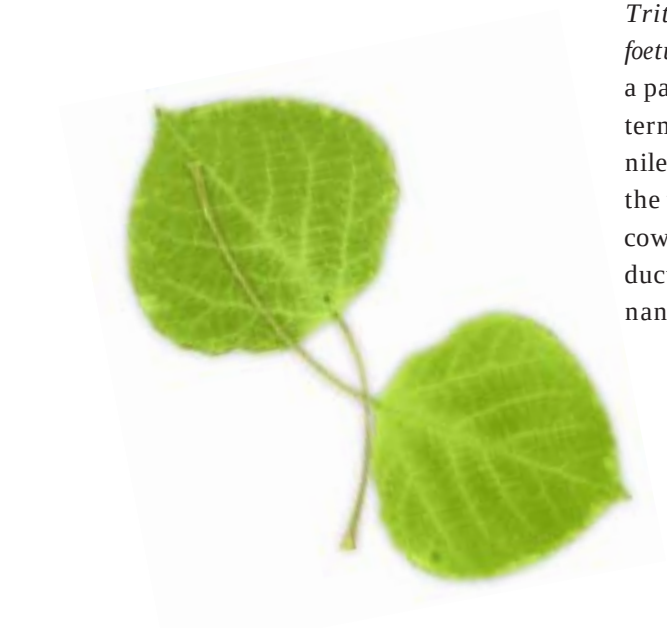
(Photo by John Kimble)

Battling bovine tricho

Tritrichomonas foetus, a protozoan flagellate, parasitic in the reproductive tract of cattle.

William R. Jolley, Associate Professor, Department of Veterinary Sciences

Jim Logan, Wyoming State Veterinarian, Executive Director of the Wyoming Livestock Board



The Villain

A tiny protozoan parasite inhabits the reproductive tract of cattle virtually everywhere in the world, including Wyoming. To qualify as a parasite, an organism must be detrimental to its host species and live in or on a host animal in a long-term, intimate relationship. The "star" of this story, *Tritrichomonas foetus* (*T. foetus*), fully qualifies as a parasite within those terms, living in the penile sheath of bulls and the vagina and uterus of cows and causing reproductive failure in pregnant cattle.

Biology of the Problem

The protozoan flagellate causes little or no damage in the sheath of a bull, which, once infected, may remain a carrier for life. When bred by an infected bull, a cow receives the protozoan in addition to the semen delivered by the bull. If the cow becomes pregnant, *T. foetus* invades the fetal membranes, usually causing early death and reabsorption or abortion of the developing foetus. A few infected cows produce normal calves, but the majority of infections result in termination of pregnancy. As infected cows begin ovulatory cycling after aborting, they transmit the protozoan to uninfected bulls that breed them. Most bulls are thought to remain infected for life, whereas most infected cows lose the infection spontaneously within about 100 days of sexual rest; however, a few cows are also known to retain a long-term infection. The few chronically infected cows that produce normal calves provide a hidden reservoir from which "clean" bulls can acquire the parasite. As the transmission continues to cycle among breeding animals, the number of infected hosts in a herd increases and reproduction decreases. The disease results in significant economic loss to cattle producers. The co-mingling of cattle on

monad abortion— the war in Wyoming

public grazing land, the purchase and/or borrowing of mature bulls and cows for breeding purposes, and the contact of bulls with cows through broken fences are some of the many ways the disease trichomoniasis has infected cattle herds in Wyoming.

Pre-War Conditions

Prior to the year 2000, cattle were bought, sold, traded, mixed on public grazing allotments, and shipped into Wyoming without concern for the importance of *T. foetus*. Low reproduction in a herd sometimes prompted cattlemen to have their animals tested for one of the viral or bacterial agents known to cause reproductive failure, and a few were tested for *T. foetus*, usually at the urging of an experienced veterinarian. During the 1970s, 80s, and early 90s, as few as 10 herds of cattle in some years and as many as 400 in other years were tested for *T. foetus* at the Wyoming State Veterinary Laboratory (WSVL). Awareness of the problem increased during the late 1980s and the decade of the 1990s, raising concern among producers who began to have larger numbers of their bulls tested. It became apparent to many in the cattle industry that regulations were needed to combat the problem.

The Battle Plan

During the late 1990s, numerous public meetings took place around the state of Wyoming to educate producers, veterinarians, and the public regarding the presence, spread, effect, economics, and options for control of bovine trichomoniasis. After much input, the Wyoming Livestock Board (WLB) drafted rules designed to enable producers to eliminate the agent and protect their animals from re-infection. Former Governor Jim Geringer signed the Chapter 15 Trichomoniasis Rules into effect in March 2000. Since the rules took effect, any "non-virgin" bulls to be released on common grazing allotments must test negative once before release. A waiver can be granted bypassing the rule for testing if all members of a grazing association request it in writing. "Virgin" bulls are exempt from testing. One negative test is required prior to importation into Wyoming of any bull intended for breeding in the owner's herd. Three successive negative tests, with at least a week's time between each sampling, are required on any bull intended for breeding prior to any change of ownership or leasing. A bull that breaches a fence and mingles with cows of another owner is required to undergo a single test. When an in-

The map summarizes the testing of bulls for *T. foetus* in Wyoming from January 1, 2000, through November 30, 2002. Figures show the number of samples tested in each county and the number found infected. Samples were also tested for bulls outside of Wyoming boundaries, with some bulls tested prior to being brought into the state for breeding. The data summarizes results from samples sent for analysis to the WSVL parasitology laboratory; additional analyses of samples are performed by some individual veterinary clinics in Wyoming and are not included here.

fected bull is identified, the entire herd of exposed animals is quarantined. Quarantine release requires all infected bulls in a herd to be branded with a "V" on the base of the tail and sent to slaughter; other bulls in the herd must be found uninfected by three negative tests. Depending on the time of year and the breeding season, cows in a trich-positive herd may also be quarantined to prevent transmission of the protozoan to "clean" bulls.

Trichomonas test results are sent to the Wyoming State Veterinarian's office, where diagnostic data are logged and enforcement procedures coordinated. Veterinarians who participate in trichomoniasis control sampling and/or analysis must be certified by the WLB to ensure consistency and quality diagnosis. The certification workshops for veterinarians are scheduled by the Wyoming State Veterinarian and conducted annually at various locations in Wyoming.

Initial Results of Combat

As the informational meetings stimulated enthusiasm from the livestock industry and regulations to combat trichomoniasis became imminent, diagnostic samples received and processed in the parasitology lab at the WSVL increased. In 1999, for example, 1,525 bulls were tested, 41 of which were found to be infected. Prior to that year, the largest number of tests performed was 1,040 and the fewest less than 50. In contrast, 4,604 (76 positive) were analyzed in 2000, a total of 6,025 (78 positive) in 2001, and 6,151 (65 positive) toward the end of 2002. As shown on the prevalence map, infected bulls have been detected in many counties in Wyoming. The numbers on the map are based only on data from the files of the WSVL. The results of tests conducted by individual veterinary clinics, if added to those shown, would enlarge the prevalence and distribution figures.

Ongoing Skirmishes

Bovine trichomoniasis will not be easily eliminated. Undetected, chronically infected cows and bulls will provide a reservoir from which the tiny parasite can gain access to healthy hosts for many years. Management practices such as testing bulls, culling infected bulls and open cows, maintaining a battery of young bulls, avoiding the use of borrowed and leased bulls, keeping fences in good condition, and avoiding the co-mingling of herds with unknown history can all be used to control trichomoniasis. Consistent cooperative and individual efforts of livestock producers and state regulatory personnel are a key factor in determining the degree of victory that can be achieved over this disease.

Genechips reveal hidden secrets —from bacteria to humans

Mark Stayton, Associate Professor, Department of Molecular Biology

Mark Gomelsky, Assistant Professor, Department of Molecular Biology

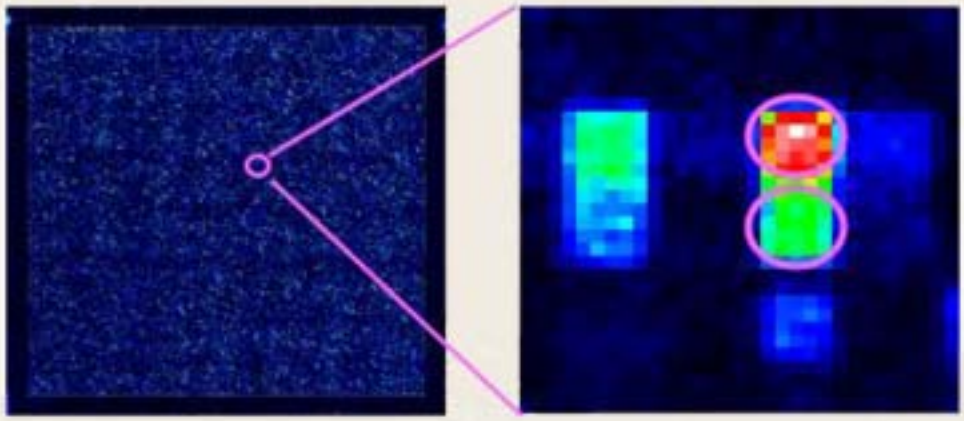
The complete DNA sequence (or genome) of an organism is its blueprint. Since 1995 when the first complete genome for a cellular organism was reported, genomic sequences for approximately 100 microbes have been completed, including the causative organisms for malaria, Lyme disease, and tuberculosis. Genome sequences are also available for multicellular organisms including mice and humans. Only about 1.5 percent of the human genome encodes proteins, yet proper embryonic development along with the appearance and function of each person is dependent largely on proteins. Each protein must be produced at the proper time in development, in the correct tissue, and to the proper concentration. Malfunctioning or improper production of any protein could result in disease or death. The pharmaceuticals approved for use in the U. S. target only 483 different proteins out of about 35,000 found in humans.

Currently, there are no methods for monitoring activities or even concentrations of all cellular proteins at a given time, something that would be needed to obtain a comprehensive picture of the physiologic state of a cell. However, a recently developed technology termed DNA microarrays allows scientists to approximate the physiologic state of a cell. DNA microarrays simultaneously measure concentrations of all cellular messenger RNAs (mRNAs). An mRNA is a necessary intermediary between a gene and its protein; therefore, measurements of mRNA provide a relative estimate of corresponding protein levels. This new technology has afforded new insight into cellular function.

A collaborative group of scientists at the University of Wyoming from the Colleges of Agriculture, Arts and Sciences, and Health Sciences, sponsored by a COBRE grant from the National Institutes of Health, is applying a type of DNA microarrays called genechips to study heart attacks and the mechanisms by which cells monitor and respond to oxygen deprivation. Both graduate and undergraduate students are involved in the research.

Despite years of study, heart disease remains a major cause of death in the country. A heart attack occurs when blood supply to a heart muscle is cut off. If not cleared, the blockage causes oxygen deprivation, resulting in tissue death and infarct scar formation. The surviving heart muscle attempts to compensate, but, unfortunately, these changes often become

A collaborative group at the University of Wyoming has employed genechips to obtain a global and unbiased view of the changes in mRNA that occur after a heart attack or myocardial infarction.



These are samples of *Rhodobacter* cells grown at levels of high, low, or no oxygen (top). These cultures are used for genechip analysis to help uncover sensors of oxygen. A genechip image is shown of all 5,000 *Rhodobacter* genes after processing and magnification of individual genes (bottom). Extensive computational analysis of these images allows scientists to decipher mRNA levels.

maladaptive and lead to heart failure. The group has employed genechips to obtain a global and unbiased view of the changes in mRNA that occur after a heart attack or myocardial infarction (MI). In mice, the left anterior descending coronary artery is permanently tied off with a surgical suture to induce a heart attack. The next step is to measure the concentration of 36,000 mRNAs in three regions of the heart and at time intervals stretching to 48 hours.

Within the infarcted tissue, about 200 genes show changes in expression at 15 minutes post-MI with as many as 3,000 genes showing changes in up to 24 hours. In the surviving left ventricular tissue and in the septum that divides the two ventricles, similar patterns are observed but with fewer genes showing MI-induced mRNA. At this point the three heart regions express distinctly different sets of genes. Thus, the physiologic adaptations triggered by the MI are different in different parts of the heart. A group of mRNA changes designed to stiffen the heart wall, to improve contractility in surviving heart muscle, and to control inflammation can be observed. In addition, induction of many genes of unknown function can be seen. Developing a predictive model for the biochemical changes that occur after an MI is a major focus of the Stayton laboratory. The objective is to use elegant and powerful new technology to improve diagnosis and treatment options for heart disease.

One surprising result of the research is the unexpectedly slow induction of genes that were expected to be activated by low oxygen concentrations. This suggests that our understanding of how heart cells sense oxygen remains poor.

Oxygen is an essential component in the generation of biological energy in a variety of organisms. Humans have some flexibility in adapting to lower oxygen levels; however, sustained decrease in oxygen availability causes disease. In addition to heart attacks, strokes and cancer are linked to an insufficient oxygen supply to certain organs and tissues. The phenomenon of oxygen deprivation is known as hypoxia. Specific proteins in cells are designated to monitor oxygen concentration and to govern cellular responses when oxygen supply is diminished.

In order to combat hypoxia-related diseases, scientists need to know the identity of cellular oxygen sensors and to understand how they sense oxygen and what processes they control.

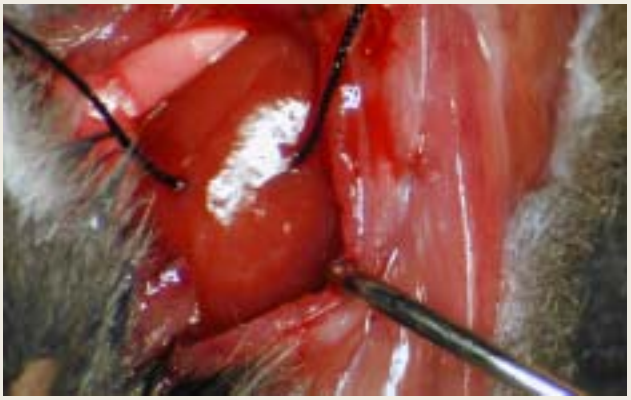
A single Affymetrix Genechip™(as shown) will measure relative mRNA concentrations for about 12,000 genes, so a set of three genechips is required to assay all 36,000 mRNAs in a mouse. Each genechip designed for a mouse can be used only once and costs $400.

These topics are the focus of study in the Gomelsky laboratory. Researchers are just beginning to understand how oxygen sensing occurs in various mammalian cells and tissues. As is often the case in biomedical research, knowledge from simple organisms, including bacteria, helps tremendously by yielding important insights. Unlike mammalian cells, many bacteria are well adapted to various oxygen levels or to conditions of no oxygen because they have both oxygen-dependent and oxygen-independent ways of generating energy. Research in microbial biochemistry and genetics has revealed several mechanisms of oxygen sensing. Fortunately, the basic biochemistry of bacterial and human cells is similar. Nature tends to keep and propagate its successful inventions.

Thus, in addition to studies of oxygen deprivation during a heart attack, the Gomelsky laboratory is studying hypoxia in a model organism, the bacterium *Rhodobacter*. A genechip that provides an unbiased view of which genes respond to hypoxia has been constructed in the Gomelsky laboratory. Computational analysis of genechip data in combination with genetic approaches can lead to identification of new oxygen sensors in this bacterium and hence yield insight into how oxygen sensing operates during a heart attack.

Rhodobacter is also worth studying in its own right because of its unmatched metabolic capabilities, which can be used in environmental applications and for energy production. A grant from the U.S. Department of Energy is funding joint research efforts by the Gomelsky laboratory and scientists from five other universities. The goal is to understand the molecular basis for the metabolic versatility of *Rhodobacter* and then to use this knowledge in real world applications.

These studies also contribute to the teaching program at the University of Wyoming, where the basics of gene expression analyses including genechips are being taught to molecular biology and microbiology majors. The goal is to make students competitive by exposing them to modern technologies in their fields.



An exposed mouse's heart is beating at about 400 vibrations per minute as a suture is passed underneath the left anterior descending coronary artery.

The mouse's artery is permanently tied off with a surgical suture to induce a heart attack. Above the knot is a region of bulging tissue lacking oxygen. The bulge indicates that the tissue is no longer contracting and that the blood pressure is pushing the ventricular wall outwards. The tissue will die within several hours to create an infarction.

Figure 1. Winter wheat infested with jointed goatgrass.

Clearfield winter wheat system:

a new technology for selective control of winter annual grasses

John Frihauf, Graduate Assistant, Department of Plant Sciences

Stephen Miller, Professor, Department of Plant Sciences

Jointed goatgrass, downy brome, and feral rye, as many producers in Wyoming know, are troublesome weeds in winter wheat. These weeds can reduce wheat yields through competition and contamination of harvested grain, also increasing dockage losses. Downy brome can reduce wheat yields by 56 percent. In addition, jointed goatgrass in the U.S. infests seven million acres of winter wheat. Feral rye causes economic losses greater than $0.5 million annually in Wyoming and $10 million in Colorado. Selective grass herbicides to control all three of these annual grasses in winter wheat are not available. However, the development of herbicide-tolerant wheat may provide good control of these problematic grasses. A new technology called the Clearfield wheat system, developed by the BASF Corporation, allows growers to selectively kill grass weeds such as jointed goatgrass, feral rye, and downy brome in winter wheat.

The Clearfield wheat system combines the use of Beyond herbicide with Beyond-tolerant wheat varieties. For the wheat varieties containing a gene that expresses tolerance to Beyond, the herbicide may be used with minimal risk of crop injury. Winter wheat varieties not containing this gene will be seriously injured or even killed when treated with Beyond.

The Clearfield winter wheat system utilizes wheat varieties that are not genetically modified

Table 1. Response of feral rye, downy brome, and jointed goatgrass to Beyond herbicide, 1997-2001.

	Grass		
Timing of Application	Rye	Downy Brome	Jointed Goatgrass
	percent		
Early Fall (before tiller)	93	93	97
Late Fall (1 to 2 tillers)	80	92	96
Spring (> 3 tillers)	70	91	97

Treatments included non-ionic surfactant 0.25% V/V + nitrogen 1.0% V/V

Figure 2. Control of jointed goatgrass utilizing Beyond herbicide with Clearfield winter wheat.

Figure 3. Clearfield winter wheat treated with Beyond herbicide compared to wheat with no treatment.

and thus not subject to restrictions in domestic or overseas markets. The technology used to develop the Clearfield varieties utilizes traditional plant-breeding techniques that have been used for decades to create improved crop varieties grown throughout the world.

Field studies conducted in southeastern Wyoming indicate that Beyond herbicide at four ounces per acre provides excellent control of jointed goatgrass and downy brome. Good control of feral rye requires application in the early fall with five ounces per acre. Previous technology did not provide growers with good selective control of jointed goatgrass or feral rye in winter wheat.

There are some concerns, however, with the Clearfield wheat system. One is the possible development of herbicide-resistant weeds. Since Beyond provides such excellent control, it will exert high selection pressure on weeds. Beyond is a member of the herbicide class known as ALS-inhibitors. Other herbicides in this class have a history of quickly developing herbicide-resistant weed populations. Herbicide resistance has been documented in kochia, prickly lettuce, and pigweed due to continued use of ALS-inhibiting herbicides such as Glean and Pursuit.

Herbicide resistance in jointed goatgrass may not only occur because of selection pressure. Resistance may also be transferred from herbicide-tolerant wheat to jointed goatgrass through the small percentage of natural cross pollination that occurs in the field. Jointed goatgrass and winter wheat are genetically related, and the gene linked to herbicide tolerance is found on a set of chromosomes in both species. Research has shown that there is a slight chance of moving the resistance gene from Clearfield wheat varieties to jointed goatgrass. Without sufficient preventatives, resistance to Beyond herbicide may be common in a few years.

In response to this concern, a stewardship program has been developed. The program requires the use of certified wheat seed and does not allow growers to use the Clearfield wheat system more than twice in a four-year period. However, research has indicated that this requirement is not sufficient to delay the development of herbicide-resistant weeds; therefore, researchers are suggesting that growers use Clearfield winter wheat once every three years.

A second concern with the Clearfield wheat system is its cost. The labeled rate is four to six ounces per acre, and the four-ounce treatment costs approximately $14 to $16 per acre. Growers in the Great Plains region who purchase Clearfield certified seed and Beyond herbicide will be eligible for a rebate of $2 per acre; however, with low wheat yields and prices, this a substantial investment. Despite these concerns, Clearfield wheat was planted on more than 75,000 acres in Colorado and 5,000 acres in Wyoming during the fall of 2002.

Thomas Foulke, Assistant Research Scientist, Department of Agricultural and Applied Economics

James Thompson, Associate Professor, Department of Agricultural and Applied Economics

David Taylor, Professor, Department of Agricultural and Applied Economics

Roger Coupal, Assistant Professor, Department of Agricultural and Applied Economics

NEW DIRECTIONS

"State lands," "school lands," "school sections," and "school land trust" are some of the various names for lands owned by the state of Wyoming. Most Wyomingites are aware that the state owns considerable real estate (about 3.5 million acres) and that revenue from these lands is used to help fund schools. Beyond that there is less clarity because the rights to use and lease state lands have become engulfed by tradition, politics, and the law. Opinions and misunderstandings, sometimes encouraged by different constituencies, have added to the complexity of the issues, fostering an air of distrust. Unlike national forests that are managed for multiple use, these lands are not true "public" lands in the sense that their mandate is to be managed for revenue purposes. Add to that the changing nature of economic conditions in agriculture and the economies of western states, and the result is a recipe for downright confusion.

A research project, funded by the William D. Ruckelshaus Institute of Environment and Natural Resources and conducted by faculty members from the University of Wyoming College of Agriculture and a group of citizens with a broad knowledge base regarding land issues, took a different view of state lands. The approach used was to see if there was a way in which the state could enhance returns from its lands by moving beyond the current allocation of dispersed parcels of pasture land to acquiring whole agricultural operations with more amenity value. The researchers' idea was that a higher lease rate and the higher appreciation rate associated with an enhanced bundle of resources would financially outperform the more traditional scenario of scattered parcels. It was also hoped, but not tested, that preservation of agricultural lifestyles, critical wildlife habitats, and improved public access would be ancillary benefits of the research.

James Thompson, rural sociologist in the Department of Agricultural and Applied Economics and principal investigator for the project, summed it up this way: "We asked the question, is there a better way of doing things with regard to the type of land the state owns and the returns the state receives? The state is

required to manage land for the beneficiaries, and we wanted to see if we could get higher returns by looking at acquiring other types of real estate."

The study group, composed of University of Wyoming faculty members, representatives of various public interest groups, and staff members from the Office of State Lands and Investment who manage the school lands, first met in April of 2001. There was little consensus at that meeting as disparate opinions were poured out before the group. Some felt that access to state land was the overriding issue. Others were more concerned with wildlife habitats and their intrinsic value. After struggling with the issues, economists from the Department of Agricultural and Applied Economics offered the concept that in order for any change to occur, the result must make economic sense. In other words, the state is charged with generating money for the beneficiaries. Any change must earn more money for schools than the current situation in order to be feasible. The economists developed a relatively straightforward approach with three scenarios and compared the results to find the one with the greatest return (Table 1). Each of the scenarios was designed to represent an investment alternative that assumed that the state had $1,500,000 to invest. Of course there would be a host of other factors that would have to be considered before any purchase could be made, but since the state is obligated to earn money for schools, financial feasibility seemed like a good place to start.

Scenario One was dubbed "River Ranch." This 700-acre ranch was a model for the type of high-amenity property that the study group wanted to consider as an investment. The group tried to use a hypothetical ranch for the project but soon realized that there were just too many variables to consider. They needed to have a real piece of property that represented the set of resources and challenges that the state could reasonably expect to encounter should it decide to invest in such real estate. Thus, a currently existing river ranch was adopted. This ranch has all the attributes that the project needed to be classified as a high-amenity property. These include trees bordering river frontage and habitat for big game such as deer and elk. It also has a newly remodeled 19th century log home. Lower commodity prices have made the ranch no longer viable for a single family trying to make ends meet, yet it is still attractive on the real estate market. The scenario assumed that the state would buy the ranch and lease it out for three percent of the purchase price ($45,000 per year). The researchers interviewed a number of appraisers who indicated that property such as this is appreciating at a conservative rate of about 6.5 percent per year.

IN STATE LANDS?

Scenario Two was the grazing lands concept. This scenario mimicked the way in which the state currently obtains money from the typical school section of scattered parcels of grazing land with little amenity value. Such lands often do not have water, trees, or public access. The scenario assumed that the $1,500,000 principal would be used to buy lands of this type at current market value and that the lands would then be leased out for grazing. The study group did not consider how this project would affect the amount of school lands owned by the state. In other words, it was assumed that the project would not result in any significant change in the total amount of land the state owns. Nor was it considered whether the money came from state school land accounts or from the sale of other lands. The researchers used a series of previous UW studies on Wyoming land values to establish the price and growth rate for dry pasture land values. They found that this type of low-amenity land has been appreciating at about 2.1 percent per year.

Scenario Three was the financial portfolio. This "no land" scenario assumed that the principal was invested in financial instruments such as bonds or stocks at the state treasurer's projected rate of return (6.7 percent). The study group understood that cashing in all state lands was not likely or even desirable but wanted to test the alternatives as a benchmark.

Table 1. Results of the three scenarios

	River Ranch	Grazing lands	Financial portfolio
Total annual revenue	$1,125,000	$725,000	$2,513,000
Rate of return/lease fee	3 percent	1.9 percent	6.7 percent
Appreciated asset value	$7,242,000	$2,499,000	$1,500,000
Average annual appreciation rate	6.5 percent	2.1 percent	0 percent
Total of revenue and appreciation	$8,367,000	$3,224,000	$4,013,000
Internal rate of return	7.9 percent	3.4 percent	6.6 percent
Net present value 3 percent discount rate	$2,565,000	$135,000	$918,000

One caveat applied to all three scenarios. Under current state law, all annual income must be distributed to the beneficiaries, not reinvested[1]. This provides somewhat of an advantage to land portfolios since the underlying asset (land) tends to appreciate over time. However, the rate at which these assets appreciate is critical for identifying the most economically feasible scenario. Should the state at some future time decide to invest these funds in financial markets, state law would need to be altered to allow for some principal growth beyond inflation.

The results in Table 1 show that the financial portfolio outperformed the other scenarios when only annual income was considered. That is, over the 25-year lifespan of the project, this alternative would distribute the most to the beneficiaries. However, at the end of the project, the principal would actually have *less* value due to the effects of inflation. The river ranch scenario, though not returning as much on an annual basis, significantly outperformed the other scenarios when both annual revenue and appreciation were taken into account. This was primarily due to the higher appreciation rate accorded to high-amenity lands in the last several decades. The grazing lands scenario lost on both counts because low returns from grazing and a low appreciation rate made them unattractive investments from both annual and appreciation standpoints.

The approach taken in this study is by no means the only way the state can obtain higher returns from its land base. It does provide a philosophical starting point for the debate about the future of state lands. In essence, this project is about land quality over quantity. It is about changing the way people view state land resources, a process that reflects the economic as well as the social changes impacting Wyoming, the Rocky Mountain West, and the entire nation.

For a complete copy of the study group's report or the PowerPoint presentation given to the State Land Board (June 20, 2002), visit the Wyoming Economic Atlas at AgEcon.uwyo.edu/EconDev. Click on the "School Lands" button.

[1] Recent changes in state law allow adjustment for inflation, but it will take 20 years for full implementation.

Narrowing the gap between

Craig Alford, Temporary Associate Research Scientist, Department of Plant Sciences

Katherine Nelson, Graduate Research Assistant, Department of Plant Sciences

Stephen Miller, Professor, Department of Plant Sciences

Sugarbeets are a very important crop to Wyoming producers, contributing $40 million to the state's economy each year. Weeds continue to be the number one problem for sugarbeet growers. There are several herbicides available for use in sugarbeets, but at times they cause crop injury and provide only marginal weed control.

With the micro-rate herbicide program, some weed control is intentionally sacrificed in order to save money on herbicide inputs. Herbicide-resistant weeds, in particular ALS-resistant kochia, have become a serious problem in some areas of the state. If producers switched to herbicide-tolerant sugarbeets, it would help solve some of these weed problems; however, it would not be a magic bullet. Cultural practices also need to be incorporated into a production plan. One such practice that is currently being studied at the University of Wyoming (UW) is the effect of reducing sugarbeet row spacing from 22 or 30-inch rows to either 15 or 22 inches and evaluating how the change affects weeds in the field. In studies previously conducted by UW, it was shown that sugarbeet yields were increased by 1.5 tons per acre when row spacing was reduced to 22 inches from 30 inches.

Studies were conducted in 2001 and 2002 at the Torrington Research and Extension

Research results are affecting the way sugarbeets are planted.

Yields increased by 12 to 17 percent when spacing between sugarbeet rows was decreased.

sugarbeets and weeds

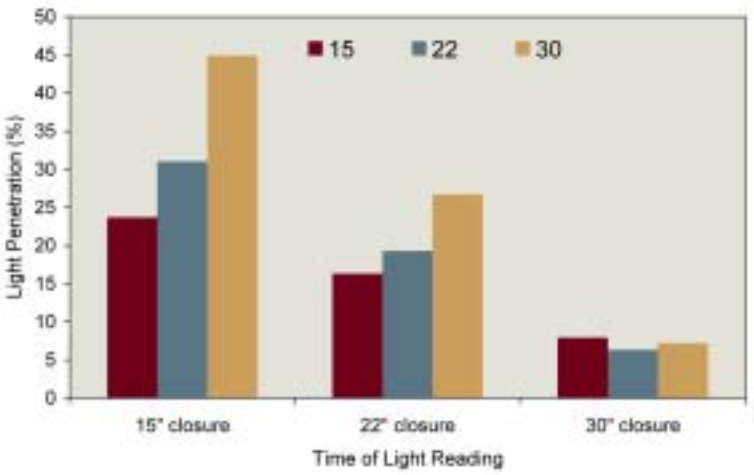
Center to determine the effect of row spacing, plant population, and herbicide treatment on sugarbeet yield and weed growth. The row spacings were 15, 22, and 30-inch rows while the populations ranged from 15,000 to 100,000 plants per acre. The studies were conducted with Roundup Ready sugarbeets. The herbicide treatments included Roundup applied at 1 quart per acre or 1 pint per acre applied twice, the micro-rate program, a standard program, a hand-weeded check, and a weedy check. The row-spacing and population studies were kept weed free in order to determine their effect on sugarbeet yield. The weed-control portion included only the herbicide treatments and row spacings to determine how weed control would be affected by reduced row spacing.

Weed control ratings along with weed biomass samples were collected to determine how row spacing impacted weeds. In addition, light readings were taken in each row spacing when plants closed the row to understand how light penetration was affected through the crop canopy. The plots were hand harvested each year and processed by Western Sugar Company.

Yields were increased by 12 to 17 percent in 15-inch rows compared to 22 and 30-inch rows. These studies confirmed results obtained previously with 22-inch rows outyielding 30-inch rows by 1.5 tons per acre. Sugar content decreased as row spacing decreased while sugar lost to molasses increased with decreasing row spacing. This was not unexpected since these parameters are related to sugarbeet size. In narrow rows sugarbeets tend to be larger since plants are spread out within a row and thus given more room to grow. As beet size increases, sugar percentage decreases, and the level of impurities (SLM) increases. While these parameters result in lower overall levels of recoverable sucrose in narrower rows, the amount of sucrose produced per acre is still increased.

Weed biomass is greatly reduced by switching production to narrow rows. The main reason for the reduced weed growth in narrow rows is that the crop closes the row earlier in the narrower rows than the wider rows and eliminates light from getting through the sugarbeet canopy that can be used by weeds for growth. The 15-inch rows closed two to three weeks earlier than the 22 or 30-inch rows. Roundup applied at 1 quart per acre provided the best weed control, while the conventional program and Roundup at 1 pint per acre provided slightly less but similar

Figure 1. Effect of row spacing on light penetration through the sugarbeet canopy during the growing season.



control. The micro-rate system was slightly less effective than the conventional program. All herbicide treatments provided weed control equal to or better than that currently achieved by producers. Visual weed control did not appear to be affected by row spacing.

The crop stand that provided the highest yield was 37,000 plants per acre, and this was consistent across row spacings. When the population was increased above this level, yields either remained constant or decreased slightly.

These studies indicate that growers may be able to switch to 15-inch rows while increasing yields and reducing weeds. Yields are greatly increased compared to either 22 or 30-inch rows. In areas of the state that have problems with ALS-resistant kochia, 15-inch row production may provide an integrated approach to controlling these weeds. There are planters commercially available with the capability of planting sugarbeets and other crops in 15-inch rows. However, at this time there are no sugarbeet harvesters available that can dig beets in 15-inch rows. One producer in Michigan who grows sugarbeets in 15-inch rows makes two passes through the field with a 30-inch beet harvester to successfully harvest his crop. This technique may be a possibility for Wyoming growers. The next step in this research will be to conduct some larger-scale trials to determine if it would be economically feasible for Wyoming producers to switch their production to 15-inch rows.

Table 1. Effect of row spacing on sugarbeet yield parameters and weed biomass.

Spacing	Yield	Sugar	SLM[1]	Sucrose	Weed Biomass
(inches)	(tons/acre)	(percent)	(percent)	(pounds/acre)	(tons/acre)
15	35.23	13.94	1.73	8682	1.58
22	31.57	14.10	1.69	7965	1.98
30	30.06	14.27	1.67	7697	3.37

[1]Sugar loss to molasses

Studies at the TREC are determining the effect of row spacing, plant population, and herbicide treatment on sugarbeet yield and weed growth.

Wide-open spaces in Wyoming are a marketable commodity.

Diversifying for rural success

As farmers and ranchers see declining profits from traditional agricultural enterprises, many are taking an "out-of-the box" approach to increasing the bottom line.

Gail Gordon, Cooperative Extension Specialist, Department of Agricultural and Applied Economics

Matt Hoobler, Agriculture Program Coordinator, Wyoming Department of Agriculture

At a loss of more than a million acres per year nationwide, over 14 million acres of rangeland in the last 10 years have been taken out of agricultural production. Consumed by urban and rural sprawl, much of this grassland has been subdivided for residential development, resulting in new challenges for rural communities.

Loss of this rangeland dominos into numerous secondary losses including the removing of habitat for wildlife, the thrashing of open space resulting in a scattered and fragmented viewshed, and the suffering of local economies due to less financial support from farmers and ranchers.

Communities in the Rocky Mountain West are on the front lines of sprawl. Land prices have skyrocketed alongside the cost of production for the use of the land, all while the selling price of agricultural commodities like cattle and hay has remained constant. Farmers and ranchers are finding it increasingly difficult to remain financially viable and are therefore being forced to take a look at their options.

"We were looking for other avenues of income, because 'ag' is tough," says Kris Johnson, owner with her husband Jerry of their Prairie Rides enterprise. "I thought and thought and kind of assessed what we had available. We didn't

know what we needed, we didn't know what we were going to do, we just started with nothing," adds Kris.

The Johnsons, with the support of their children and extended family, began offering horse rides across their land, the Johnson 99 LLC Ranch, during the summer of 1996. "We started with a barbwire corral and one ride that first day," recalls Kris. Jerry jokes, "We soon learned that barbwire and inexperienced human beings don't mix."

During the last seven years of ranch diversification, the Johnsons have learned much, and Prairie Rides has grown to include mountain and hunting rides, horsemanship classes, and, of course, a pole-rail corral replacing the barbwire.

One man's daily work can be another man's vacation.

Ag Diversification Explored

Like Prairie Rides, thousands of unique diversification examples exist throughout the West. For the purpose of learning more about the opportunities available, a small group of agricultural professionals gathered to research agricultural diversity. In 2000, the Western Region Sustainable Agriculture Research and Education (SARE) Administrative Council funded a project called Sustaining Western Rural Landscapes, Lifestyles, and Livelihoods through Agricultural Enterprise Diversification. According to Boyd Byelich, project coordinator and Natural Resources Conservation Service (NRCS) technician, "The general purpose of this project is to better enable agricultural professionals at the field level to provide consistent technical assistance to farmers and ranchers interested in enterprise diversification."

Such diversification can work as a tool to allow farm and ranch families the opportunity to generate external income. These families can incorporate new and different markets rather than pinning the entire livelihood of a farm or ranch to one market. Diversification involves more than just hanging out a sign and announcing that the door is open for business. It includes community support, funding availability, natural resource considerations, and many assessments and analyses to avoid failure and minimize risk.

"Our grant partnership is also a key strength as it's so diverse," says Cindy Garretson-Weibel, project partner and Wyoming Business Council manager of leadership and diversification training. "We've all been able to learn from one another and incorporate that knowledge into a resource guide for the professionals." The partnership includes the NRCS, University of Wyoming Cooperative Extension Service (UW CES), Wyoming Department of Agriculture, Wyoming Business Council, Wyoming Small Business Development Center, Wyoming Rural Development Council, and the Sonoran Institute (Bozeman, Montana). Partners were selected based on specific expertise and the focus of their current positions.

Many project components existed, including the development of a resource guide on planning for a diversified agricultural enterprise, local workshops, an interactive Web site, and a regional conference. The project had a target constituency of agricultural professionals and producers in a five-state area encompassing Wyoming, Montana, Utah, Idaho, and Colorado.

Initially, a survey of CES and NRCS professionals in the five-state target area was completed to assess awareness and also the amount of technical assistance being provided for agricultural enterprise diversification. It also identified aspects of diversification where

The prairie of the Johnson 99 LLC Ranch.

Jerry and Kris Johnson of Prairie Rides.

additional technical materials were needed. These results helped determine the content of the resource guide, which includes an introduction to diversification, a series of assessments to help collect information from producers for making diversification decisions, a template for comparing the feasibility of specific enterprises, and supporting information for implementing a new enterprise.

Five workshops took place across Wyoming from the fall of 2001 to the spring of 2002. "These hands-on enterprise diversification workshops allowed us to reach 150 professionals and producers from all five target states," says Byelich. "The conversations were very rewarding in the workshops, as a majority of them related to actual diversification."

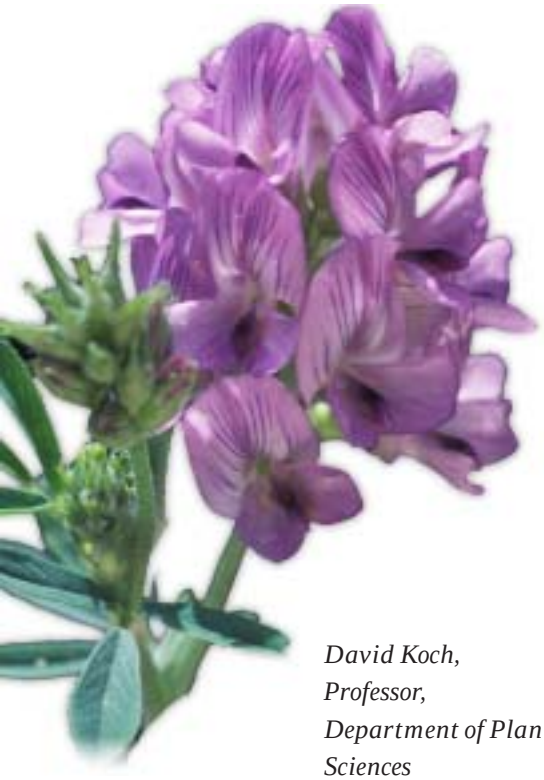
West-Wide Conference

Less than one year after the local workshops, agricultural producers interested in diversification found themselves once again in Wyoming at the first ever West-Wide Conference on Agricultural Diversification. This three-day gathering included agricultural professionals, farmers and ranchers, lenders and bankers, and a variety of people interested in the marketing of products, services, and resources.

Testimonials of successful operations were given, such as the story of Darren Schmall of Mandera, California, whose passion for agriculture is evident from his "out-of-the-box" approach to increasing farm profits. He has developed a circular "pizza farm," or a farm divided into "slices" where each ingredient of pizza is grown on the operation, including olives, tomatoes, peppers, wheat, beef and dairy cattle, and hogs. The farm is less than one-half acre in size, yet nearly 30,000 children per year visit it. Schmall's pizza farm was originally opened as a community service project with the main focus on educating children about the importance of agriculture and how everyone is affected by the production of goods. At the end of the tours, everyone is fed pizza.

"Diversifying can offer families unique opportunities to work together and pursue new interests involving all family members," says Garretson-Weibel. Diversification is one more tool available for farmers and ranchers and is now available locally with a lender, district conservationist, or extension educator. Like the Johnson family with Prairie Rides, taking the first step towards diversification is the most important. The preparation and training are now available for farmers and ranchers to add an enterprise in order to remain viable.

To obtain a copy of the *Agricultural Diversification Workbook* or the West-Wide Conference proceedings, contact Garretson-Weibel at (307) 777-6589, Byelich at 307 (722-2015), or visit online at www.agdiversity.org.



Forage legumes are keys to

David Koch,
Professor,
Department of Plant Sciences

Jeffery Flake,
Research Associate,
Department of Plant Sciences

What will the Great Plains landscape look like 100 years from now? Today's wheat-fallow cropping system is not sustainable, and changes seem inevitable. Will the changes be in the direction of the past – a Buffalo Commons, as some have suggested – or will practices be identified that will sustain a diverse crop and livestock agriculture? Legumes offer many potential benefits and can play key roles in a sustainable agricultural landscape.

Nitrogen-fixing nodules on alfalfa roots.

The value of legumes is dependent on how well they establish, how competitive they are with associated grasses, how they persist, and their impact on forage production, nutritive value, and animal performance. A 12-year study was initiated by the University of Wyoming to determine the impact of three different legumes on dryland pasture. Experimentation took place at the Archer Research and Extension Center near Cheyenne. The soil at the site supports mainly range and non-irrigated crops. Annual crop production is limited by rainfall and wind erosion. The topsoil (about 7 inches) is loam with a moderate risk of wind erosion. The 7 to 13-inch zone is clay loam, and the lower profile to 60 inches or more is sandy loam. The available water-holding capacity is 7.5 to 9.5 inches. The field was in wheat-fallow strips for about 30 years with an average of 31 bushels per acre of wheat yield in recent years.

Bozoisky Russian wildrye was seeded in rows 24 inches wide to allow the spacing needed for the other species to be vigorous. Replicated plots (about ½ acre each) of Spredor II alfalfa, Remont sainfoin, and Monarch cicer milkvetch were cross drilled in 24-inch rows in order to minimize soil erosion and competition for solar radiation. Forages were drilled into oat stubble that had previously been grazed.

Weaned lambs that had been adjusted to grass pastures for one to two weeks were rotationally grazed in a three-paddock system from about mid-June to mid-July or until forage was 65 percent utilized.

Annual precipitation for the study period varied from 9.8 to 25.9 inches. There were no consecutive years be-

sustainable dryland agriculture

Russian wildrye needs to be in wide rows to be vigorous. Cross-drilling with legumes reduces erosion.

tween 1991 and 2000 with below-average precipitation. Averaged over years, precipitation was near normal (30-year average of 16.5 inches) from 1990 to June 1999. Since 1999, the site has been experiencing a severe drought.

Alfalfa proved to be more competitive than sainfoin with the more slowly establishing Russian wildrye. Alfalfa and sainfoin represented 88 percent and 58 percent of total forage in the third year. All species except cicer milkvetch produced near ideal stands. Cicer milkvetch established more slowly than Russian wildrye, and its stand was irregular. Despite its rhizomatous nature, cicer milkvetch never thickened over the years, evidently due to the competitive nature of Russian wildrye. Established Russian wildrye excludes weeds due to an extensive surface root system and may in a similar manner prevent legume seedling establishment, particularly since it starts growth earlier in the spring than cicer milkvetch.

A legume plant gets first chance at plant-usable nitrogen since its roots are intimately associated with nitrogen-fixing rhizobia. A portion of legume roots and nodules die and decompose each year, providing nitrogen for the grass. Another source of nitrogen is the recycling of nitrogen back to the soil by grazing animals. Indirect evidence from the study showed little legume benefit to grass in the first five years; however, the production and protein content of grass increased in subsequent years. Grass production was greater from 1996 to 2000 when grass was competing with alfalfa and sainfoin than when grass was grown alone. Other evidence was that crude protein content declined from earlier to later years with grass alone while grass associated with alfalfa and sainfoin maintained

similar crude protein content.

Alfalfa and sainfoin did not significantly increase forage production over Russian wildrye alone the first five years of grazing but more than doubled forage production in 1997 to 2001. Cicer milkvetch depressed production in the early years but did not affect production compared to Russian wildrye monoculture over the long term. The solid grass stand declined in production more than 50 percent after the sixth year (1996). The legumes in the trial started declining after 10 years but continued to provide benefits to the grass until the 12th year.

Figure 1. Dry matter yields of Russian wildrye (RWR) alone and in mixtures with three legumes.

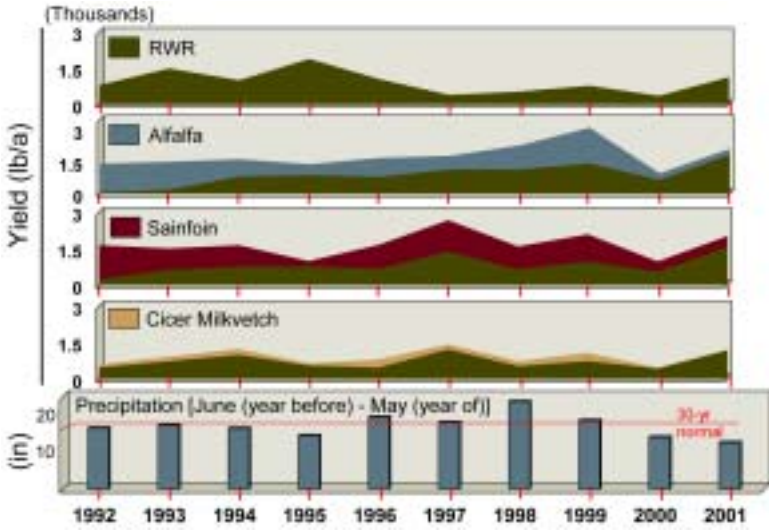
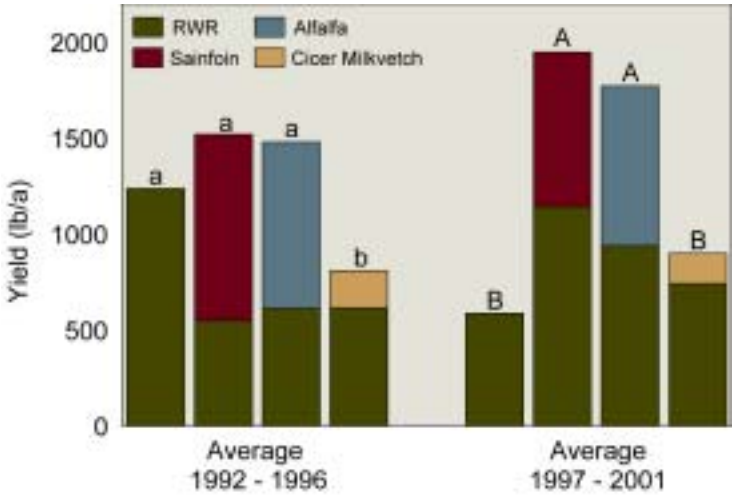


Figure 2. Forage production (dry matter) in early and later years of stands.



Alfalfa and sainfoin provided a desirable legume-grass balance (53 to 57 percent legume) over the long term while cicer milkvetch contributed only 20 percent on the average. The legume component in mixtures had higher crude protein, lower fiber, and higher in-vitro digestibility than Russian wildrye. None of the legumes increased the crude protein content of the grass component of the mixture. However, the mixture of alfalfa and grass had higher crude protein content than grass alone throughout the study. Sainfoin and cicer milkvetch mixtures had higher crude protein content than grass alone in later years. Perhaps a better measure of the combination of legumes was the total amount of protein produced per acre. The alfalfa mixture produced 246 pounds per acre of crude protein, equivalent to about 40 pounds of elemental nitrogen in the forage produced. Russian wildrye in pure stand produced only 78 pounds of protein, equivalent to 12.5 pounds of nitrogen. Sainfoin and cicer milkvetch mixtures produced intermediate amounts of protein and nitrogen.

The results suggest that seeding improved forage species such as Russian wildrye in mixture with alfalfa or sainfoin will more than double forage production over that of a native range in good condition.

The bottom line with regard to pasture evaluation is animal performance. Lambs gained faster on legume-grass mixtures

than on pure grass. While grazing alfalfa and sainfoin-grass mixtures, lambs gained slightly over ½ of a pound per day. Lambs grazing the cicer milkvetch-grass mixture gained about 3/8 of a pound per day, and lambs grazing the monoculture of Russian wildrye gained slightly over ¼ of a pound per day. Averaged over several years, lamb gain was 37 pounds per acre on straight grass. Lambs grazing alfalfa-grass and sainfoin-grass mixtures gained 98 to 100 pounds per acre, and lambs grazing cicer milkvetch-grass mixtures gained 58 pounds per acre.

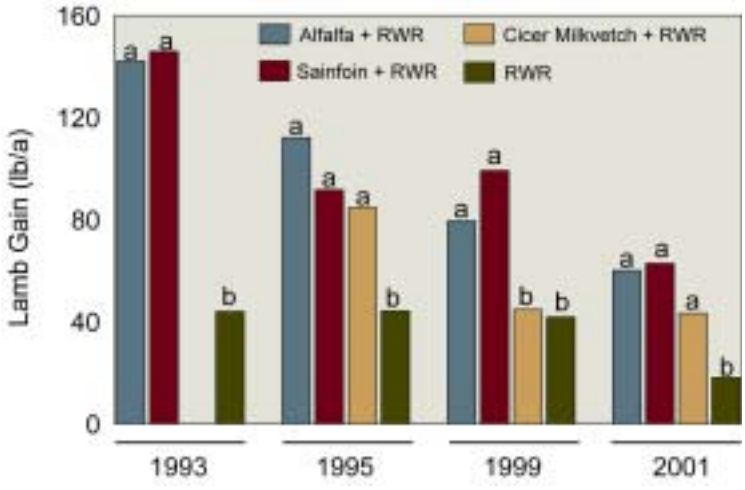
The soil used in the study is suited to native range, improved forage, or annual crops. Grass-legume perennial forage would provide income every year. It would also reduce fertilizer, pesticide, and energy inputs compared to annual crop production. Animal production from perennial pasture would diversify and help stabilize income and reduce risk.

The results suggest that seeding improved forage species such as Russian wildrye in mixture with alfalfa or sainfoin will more than double forage production over that of a native range in good condition. After a 10-year period or when the legume declines, the land can be returned to wheat or other annual crops for expected residual benefits or left in grass with expected long-term production of 900 pounds or more per acre per year.

Forage legumes can play an important role in the design of a sustainable agroecosystem. The current Great Plains landscape, dominated by range and winter wheat grown in alternate strips with fallow, is likely to evolve into a more diverse landscape including other cash crops and improved perennial forages, including legumes.

Legume-grass pastures need to be rotationally grazed in order to prevent selective grazing and premature loss of legumes.

Figure 3. Lamb gain per acre with Russian wildrye (RWR) alone and in mixture with three legumes.



Crop sprayer offers applications for precision agriculture research, teaching, and extension

Why did the University of Wyoming Department of Plant Sciences put a Global Positioning System and a computer on a pesticide sprayer? A new sprayer with state-of-the-art electronic controls designed for precision agriculture applications is giving the department new possibilities for research, teaching, and extension education.

Precision agriculture technology allows a producer or commercial applicator to limit pesticide applications to specific areas of a field infested with a pest. This approach can reportedly reduce herbicide costs.

Scientists at UW are testing this technology under Wyoming conditions to develop management strategies that effectively control pests, that are economical, and that minimize environmental impacts. One such project, funded by the Western Region Integrated Pest Management Program, is researching the control of skeletonleaf bursage.

The controls for the sprayer include (clockwise from top center) a computer, a GPS receiver, a rate controller, boom control switches, and mapping switches.

The Global Positioning System (GPS) uses a satellite signal to provide a constant update of the sprayer's location using longitude and latitude coordinates. The computer and GPS work together in three ways. First, the locations of applications are recorded, thus improving documentation. Second, the equipment can be used to map fields and weeds. Third, the computerized maps can be used to automatically control pesticide applications.

Another feature of the sprayer is an injection system which eliminates mixing pesticides in water before going to the field. Instead, the pesticide is injected into the water during spraying. The advantages include reduced preparation time, less contaminated waste, faster cleanup, and, most important, reduced exposure of the operator to pesticides. The injection system also makes possible variable rate applications in which the application rate is changed from one part of the field to another according to the severity of a pest infestation.

The total cost of the sprayer is $25,000. This amount includes the electronic controls, cables, and injection system; the sprayer, tanks, engine, and pump; and miscellaneous steel and hardware to modify it for research needs.

This equipment will benefit programs at the University of Wyoming in three general ways:

- as a management tool for weed, insect, and disease control in field research;
- as a tool to research precision agriculture methods in Wyoming; and

The sprayer features two chemical injection pumps which use 8-gallon removable tanks as a reservoir for pesticides. Changing pesticides in the field takes less than five minutes.

- as an educational tool for students, producers, and extension personnel.

Students who are familiar with precision agriculture equipment and methods will be more competitive in the job market.

Dave Claypool, Research Associate II, Department of Plant Sciences

Stephen Miller, Professor, Department of Plant Sciences

Larry Held, Professor, Department of Agricultural and Applied Economics

Ron Delaney, Professor and Head of the Department of Plant Sciences

Herdin' cattle on the Web

A Web site developed at the University of Wyoming by Cooperative Extension Service (CES) Beef Cattle Specialist Steve Paisley is helping to promote Wyoming cattle that have been produced through the sound management practices certified by the Beef Quality Assurance (BQA) program of the National Cattlemen's Beef Association.

Funded by the association and the Wyoming Business Council, www.wyobeef.com is an Internet cattle-listing service promoting the use of BQA procedures and attracting attention to cattle produced in Wyoming. Cattle buyers can visit the site to find current listings of BQA-certified calves, yearlings, replacement heifers, bred heifers and cows, cow-calf pairs, and bulls.

"The Web site is not an auction site – producers can continue to market their cattle as they choose," Paisley says. "Wyobeef.com is intended to complement their current marketing efforts, expanding the audience of potential buyers and attempting to add value by providing additional in-depth information about the cattle."

Finding specific cattle on the Web site is easy since listings are grouped into categories for easy viewing and for sorting into specific requirements such as weight, breed, etc. For each type of cattle, detailed information is offered about such things as herd genetics, management, vaccination programs, and carcass quality. Producers who list their own cattle can also provide pictures to be included with their listings.

Designed by Ridge Creative, a Laramie-based company specializing in print advertising and Web-based design, the cattle listing service is free to all BQA-certified producers. For additional information or to list cattle, visit the site or contact Paisley at (307) 766-5541 or at spaisley@uwyo.edu.

Hands-on training in diagnosing crop injuries related to herbicide misuse is offered as part of a program at the Powell Research and Extension Center.

Producers can learn symptoms of herbicide injury

Herbicides are an important tool for controlling weeds in crops. Many herbicides are selective in their activity, injuring or killing weeds while being safe to use on a registered crop. From time to time, however, crop injury due to herbicide misuse does occur. This generally happens through herbicide carryover, herbicide drift, improper application rate and timing, or improper herbicide choice.

In the field, crop injury diagnosis is mostly based on morphological symptoms that are easily observable. However, herbicide injury symptoms are sometimes hindered by what are called "look-alike" symptoms that are caused by other factors such as nutrient deficiencies, salinity, drought, insects, weather, and disease. It is helpful to know what type of injuries to expect from herbicides that are commonly used.

For this purpose, weed scientists in the plant sciences department organize herbicide injury training programs every other year at the Powell Research and Extension Center. Consultants, pesticide dealers, chemical representatives, producers, and university personnel from primarily Wyoming and Montana attended the training in 2002. After learning about herbicide injury symptoms in crops, participants observed those symptoms in the field. Demonstration plots consisting of six crops (barley, Roundup Ready canola, corn, dry beans, sugar beet, and sunflower) had been sprayed with 20 herbicides (six pre-plant and 14 postemergence). The students were shown how to make accurate visual diagnoses of crop injuries, taking into account each herbicide's mode of action and the different ways the normal growth and shape of the roots, stems, and leaves of plants can be affected.

Growth Regulators: (2,4-D, Dicamba, Stinger)
Malformation or necrosis of terminal meristematic areas can occur with these regulators. Abnormal growth responses result in leaves being strap-shaped, cupped upward (dicamba) or downward (2,4-D), and left with mesophyll reduction, abnormal vein patterns, and early petioles turned down (epinasty). Corn plants exhibit "onion leaf" formation. Broadleaf plants may show more cupping than strapping of leaf tissue. Stem elongation or shortening, nastic curvature, twisting, and lateral swelling are symptoms related to affected stems while root fusion and thickening are symptoms of affected roots.

Photosynthesis Inhibitors: (Atrazine, Basagran, Betamix)
Plant injury from these products is confined to foliage that has come into contact with the herbicide. Affected leaves become yellow or bronze in color and eventually turn brown and die. The contact of a low rate of herbicide

with leaves may result in spotting or speckling of the leaf surface. Older and larger leaves are affected first because they take up more of the herbicide from the water solution and are the primary photosynthetic tissue of the plant. In grass plants, leaf tips and margins become chlorotic and necrotic and then suffer from interveinal chlorosis and lower leaf drop. In broadleaf plants, yellowing between leaf veins may occur. Injured leaf tissue eventually turns brown and dies.

Amino Acid Synthesis Inhibitors: (Raptor, Matrix, Liberty, Roundup Ultra Max)
Affected plants treated with these herbicides show a loss of apical dominance, chlorosis, and a shortening of internodes. Grass plants may be stunted with chlorosis or purpling. Corn plants may be stunted and show symptoms of root inhibition such as the pruning of lateral roots. Leaves emerging from the corn whorl may not unfurl properly and may be yellow to translucent in appearance. Broadleaf plant injury can range from the stunting to the death of the terminal growing point. Leaves may be yellow in appearance, and leaf veination may appear red or purple in color. New growth turns yellow, then brown, and it dies within 10 to 14 days.

Seedling growth inhibitors: (Prowl, Harness)
Leaf malformation (onion leaf), crinkling, and thickened dark green leaf tissue can result from these herbicides. Heart-shaped leaves due to midvein inhibition become rough, crinkled leaves with some cupping possible. Stunted or malformed shoots may experience tight leaf rolls. In grass, leaf tips may not unfurl from the coleoptile properly, resulting in a buggy-whip effect. Shoots are short and thick and may appear red or purple in color. Broadleaf plants may have enlarged cotyledons and swollen hypocotyls and root tips. The inhibition of main and lateral roots may occur.

Cell Membrane Disruptors: (Gramoxone, Ro-Neet)
Plant leaves treated with these products have a limp, water-soaked appearance, followed by browning and necrosis of leaf tissue when injury has occurred. Foliar burn is left at the site of droplet deposition. Drift injury appears as speckling on leaf tissue. Plant leaves will show reddish-brown spotting on the leaf surface shortly after the herbicide is applied, followed by interveinal chlorosis and then turning brown and dying. Plants that do not die may be stunted for a week or more.

Crops in the Powell Research and Extension Center test plots display the symptoms of injuries caused by herbicide misuse.

Lipids Synthesis Inhibitors: (Select)
Leaves redden and stems become necrotic at the nodes from these inhibitors. Newer leaf tissue is yellow (chlorotic) or brown (necrotic), and the leaves in the leaf whorl can easily be separated from the rest of the plant. The growing point turns yellow, turns brown, and then dies.

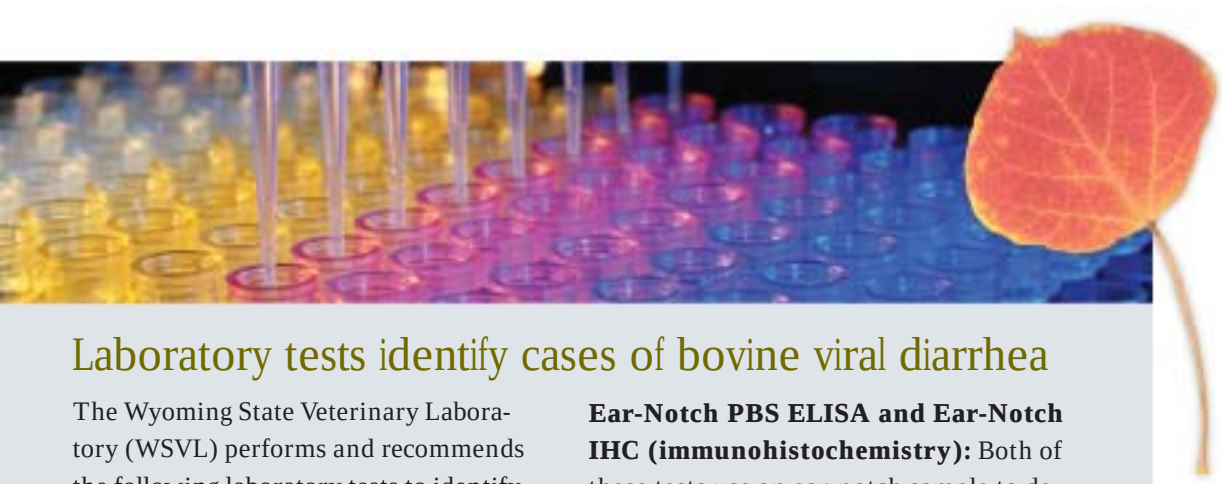
Pigment Inhibitors: (Command)
Plants in this category turn white after becoming translucent at the leaf tips. Interveinal whitening of leaf and stem tissue becomes apparent as susceptible seedlings emerge from soil. Tissue eventually becomes necrotic and dies.

Abdel Mesbah, Research Scientist, Department of Plant Sciences

Stephen Miller, Professor, Department of Plant Sciences

Craig Alford, Temporary Associate Research Scientist, Department of Plant Sciences

Mike Killen, Research Associate II, Powell Research and Extension Center



Laboratory tests identify cases of bovine viral diarrhea

The Wyoming State Veterinary Laboratory (WSVL) performs and recommends the following laboratory tests to identify persistently infected (PI) animals:

For animals older than 4 months

Microtiter Serum ELISA: The name of this test derives from the technique used to detect the virus, but in principle it isolates the virus. The test consists of incubating serum or plasma from an unclotted blood sample on cells capable of growing BVDV and then staining the cells to detect the presence of the virus. Each sample is observed under a microscope, and the results are manually recorded individually for each one. This very sensitive test has been used extensively at the WSVL to help in the detection and eradication of PI animals from affected herds.

Ear-Notch PBS/Serum ELISA: This is a very sensitive test that detects the presence of the virus in a skin (ear notch) or serum sample. A skin sample is placed in a tube containing 2 milliliters of phosphate-buffered saline (PBS). The detection of the viral antigen eluted from the skin into PBS is performed using a colorimetric reaction, and the results are recorded using an ELISA plate reader.

For animals younger than 4 months

The presence of colostral antibodies can interfere with the detection of the virus in the microtiter serum ELISA, and therefore it is not recommended for animals of this age.

Ear-Notch PBS ELISA and Ear-Notch IHC (immunohistochemistry): Both of these tests use an ear-notch sample to detect the presence of the virus. Ear-notch IHC is based in the detection of viral antigen in a formalin-fixed thin section of the skin. It is important to note that samples sent for PBS ELISA should never be placed in formalin. Samples should not be collected without PBS since irreversible failure of viral detection due to sample dehydration could occur. The ear-notch IHC has no present advantage over the ear-notch PBS/serum ELISA. Furthermore, the ear-notch PBS/serum ELISA is a less complex test with a faster reporting time.

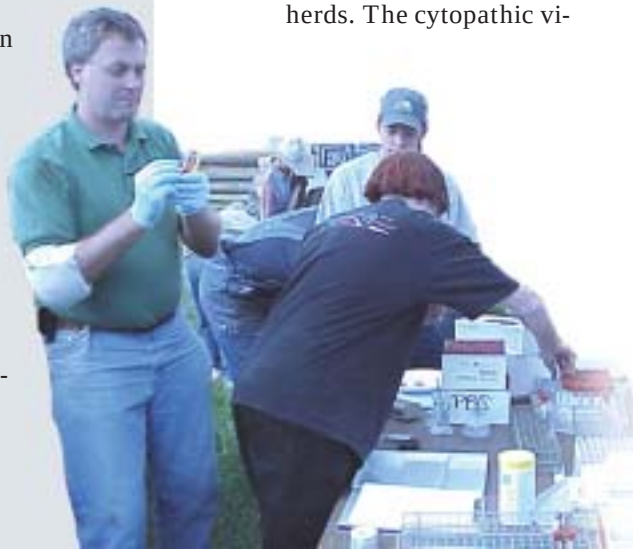
Serology: Serology in conjunction with the other tests helps in identifying problem herds when the samples are accompanied by a clear history of vaccination and potential natural exposure. In addition, in serology for BVDV, the WSVL can often differentiate between Type 1 and Type 2-specific antibodies, indicating which is the circulating genotype.

PCR: The polymerase chain reaction (PCR) is a very sensitive and rapid test for the detection of the BVD nucleic acid (genetic code). This test is used at the WSVL for the differentiation of BVDV strains into Type 1 and Type 2. Currently the test is expensive, and this makes it impractical for screening large numbers of animals. This test is successful, however, at detecting PI calves and adults of any age.

Bovine viral

Bovine viral diarrhea virus (BVDV) costs the U.S. cattle industry in excess of a billion dollars per year and continues to be the most devastating and economically important viral-based disease of cattle in the nation. Despite the availability of vaccines for more than four decades and remarkable advances in the understanding of BVDV, the most effective method of control remains the elimination of persistently infected (PI) animals. These PI animals are the main carriers of the virus.

Cytopathic and noncytopathic BVDV are two frequently used terms that describe the ability of the virus to cause damage to cells when it is grown in cell cultures in the laboratory. The non-cytopathic virus causes persistent infection and is the most commonly circulating virus in affected herds. The cytopathic vi-



diarrhea: still the most important viral disease of cattle

rus is associated with the development of an uncommon fatal syndrome. Type 1 and Type 2 are terms used to describe the genotype (differences in the nucleic acid sequence of the genome) of different viral strains.

The pathogenesis of BVDV infection has features that are unique to this virus and that vary with the virulence of the viral strain and age of the animals at the time of infection. Particularly important for the cow-calf operation is the outcome of fetal infection. During the first 120 days of gestation when the immune system has not yet developed, infection of the fetus can lead to the generation of PI calves. Infection after the first 120 days of gestation (post-development of the immune system) or after birth can lead to acute infections but not persistence.

BVDV Diagnostics

The role of PI animals in the perpetuation of BVDV infections cannot be overemphasized. The presence of a single PI calf in a herd can cause severe losses not only within the herd but also in any herd with which

This red calf is suffering from bovine viral diarrhea.

the PI calf makes contact. Some PI animals can be relatively easy to identify, but unfortunately many PI animals look perfectly normal and cannot be identified without laboratory diagnostic assistance.

Vaccination

Vaccination against BVDV is important in preventing the symptoms caused by acute BVDV infections and in helping to create herd immunity by reducing the number of completely naive animals present at any given time within a herd, such as replacement heifers. Nevertheless, there are two important aspects that should be kept in mind when vaccinating against BVDV to avoid having a false sense of security. First, vaccines prevent the appearance of symptoms but do not completely prevent infection in a vaccinated animal. Therefore, a vaccinated pregnant cow that is continuously being challenged by nursing PI calves in the herd may still produce a PI calf. In other words, a reduced incidence of fetal infection, namely "fetal protection," would not completely eliminate the risk of having extensive losses due to BVDV infection. Second, the cross-neutralizing-effect claim by the vaccine labels should be considered with great caution since the antigenic variation of BVDV seems to run in front of the efforts made by vaccine companies to incorporate new strains. In fact, there are less than a handful of BVDV strains used in the more than 100 licensed BVDV vaccines available.

Control

The most important outcome of BVDV research is the realization that PI nursing calves are the single most important source of BVDV infection and are responsible for the perpetuation of the disease. If BVDV is suspected to be the cause of disease in a herd, an aggressive approach is recommended in terms of diagnosis and removal of PI animals. All calves should be tested as soon as it is practical before the breeding season. In addition, replacement heifers and bulls should also be tested. Vaccinations to boost herd immunity are also recommended, but without the removal of PI animals, they will not solve the problem. A detailed BVDV eradication scheme can be found at wyovet.uwyo.edu in the 2003 disease update section.

Alberto van Olphen, Assistant Professor, Department of Veterinary Sciences

Lynn Woodard, Professor, Department of Veterinary Sciences

Jacqueline Cavender, Laboratory Technician III, Department of Veterinary Sciences

Many calves infected with bovine viral diarrhea look perfectly normal. Five animals in this photo are carrying the virus.

Researcher Alberto van Olphen (left) works with others in the field to collect and label blood and ear-notch samples from cattle.

Turfgrass varieties tested in Sheridan research trials

A lawn can be low or high maintenance depending on its location and growing requirements. A Wyoming golf course superintendent, a city recreation manager, and a homeowner are going to be interested in different types of grass. Many people take a great deal of pleasure in making their fairways, soccer fields, and yards all look like a green oasis. Some turfgrass planting situations may call for an aesthetic but erosion-proof covering for soil, requiring less time and money for fertilization, mowing, and watering. Certain lawn areas need to be managed the same way a ranch would be if it were lacking well water and required a drought-tolerant turfgrass for a lawn.

The Sheridan Research and Extension Center (SREC) is testing more than 200 turfgrass varieties for stand establishment, spring greenup, genetic color, drought tolerance, and fall color retention. The research trials are located at Sheridan College's Regional Agriculture Education Complex and are under an automated, pop-up sprinkler system which controls the timing and amount of water applied. Also cooperating in the study is the Powder Horn Golf Course, thus enabling five graduate student interns majoring in turfgrass management to assist in data collection during the summer months. To date, a total of 630 four-foot-square plots have been established and will be maintained for a minimum of five years.

New plots are developed for National Turfgrass Evaluation Program studies underway in Sheridan.

A group of 176 varieties of Kentucky bluegrass comprise the biggest trial at the site, and the grasses are being studied for their performance under a high-management regime in northern Wyoming's climate and soils. The National Turfgrass Evaluation Program (NTEP) is sponsoring the research, and a grant of $12,000 was received in 2000 to buy fertilizer and equipment and to hire employees. After two years, results are promising, and many varieties exhibit strong, dark green growth from early spring into the fall and have also survived the Wyoming winters. The trial is also underway in 58 other locations in the United States and Canada.

Since the majority of Wyoming's summers are short on rainfall, residents often want to select low-maintenance turfgrasses for establishment or re-seeding as opposed to trying to keep a high-water-use lawn green and stress free during a hot, windy period in July or August. To satisfy increasing clientele demand, 13 low-maintenance species consisting of turtleturf crested hairgrass, buffalograss, crested wheatgrass, and sheep and tall fescue were planted using both seed and sprigs in June of 2002. In August of 2001, a group of 23 varieties of tall fescue was established under the same low-management regime. This NTEP consumer

A. Kentucky bluegrasses are being studied at the Sheridan Research and Extension Center for their performance under a high-management regime in northern Wyoming's climate and soils.

B. Sheep fescue

C. Turfgrass trials are being conducted at Sheridan College's Regional Agriculture Education Complex.

D. Legacy buffalograss

test has a reduced number of varieties compared to the official test and will only be used to provide information to Wyoming clientele. Another low-maintenance trial comprised of creeping red, sheep, tall, chewings, and hard fescue, perennial ryegrasses, buffalograss, and blue grama has been growing at the SREC since 1996.

Every summer a turfgrass seminar is offered to showcase the ongoing research and to provide new information. To broaden that educational effort, future research will be directed toward obtaining an official bentgrass trial from NTEP to plant at the turfgrass test plot area at Sheridan College. Additionally, an NTEP finelawn fescue consumer trial is being planned for establishment at a local sod farm in Buffalo beginning in the spring of 2003.

By selecting the right turfgrass species or variety, many of Wyoming's caretakers can make their lawns a low or high-maintenance oasis. The end result may be a neighbor complimenting the greener grass on the other side of the fence.

Answers to questions about turfgrass production or maintenance and information about tours of the current research plots are available by calling (307) 737-2415, by faxing (307) 737-2413, or by e-mailing wyarno@uwyo.edu.

Roger Hybner, Director, Sheridan Research and Extension Center

UW Research shows native plants compete

When exotic weeds from other countries invade native plant populations, how do those natives fare? While it might seem like a natural question, scientists largely overlooked it until College of Agriculture researchers began asking it.

The Department of Renewable Resources team of Associate Professor Ann Hild and graduate student Brian Mealor are working to demonstrate that native plants can indeed be hardy competitors.

"We are optimistic that this could open the door to using native species to revegetate areas that have been damaged by exotic weed invasions," says Hild. The work shows that perhaps some natives are less challenged by neighboring weeds than they first appear to be.

"Mostly the approach to weeds has been to spray for control before we look at what the response of the native plant community is to being invaded," Hild notes. "This is a unique approach to this type of research." She adds, "We have been happy to find that sometimes natives hang on."

The University of Wyoming's discoveries were communicated internationally when Mealor, who is completing a master of science degree in rangeland ecology and watershed management, was one of 40 researchers selected to make presentations on "Biological Invasions in Terrestrial Ecosystems" at a European Science Foundation conference in Halle, Germany. The Georgia native suddenly found his work of particular interest to attending researchers studying in the field of invasive species ecology.

"The best case scenario would be to find native grasses that are resistant to these weeds coming in," Mealor says. "After we go in and chemically treat weeds, we will need native species that we can plant to keep the weeds from returning." He adds, "Also, these invasions are fairly new on the evolutionary time scale. If we give native communities enough time, they may be able to fight back successfully."

Mealor, who became interested in weed research as an undergraduate student in the South, has worked on the National Research Initiative Competitive Grants Program project since January of 2000. Hild has applied for two grants to allow him to continue his work as a doctoral candidate.

Under the NRI project title of "Using Exotic Weedy Invasions to Select Competitive Ability in Native Species," Hild and Mealor first hypothesized that given sufficient time, competition with invading exotic weeds could result in the development of some native species into a stronger subset of their original populations. The initial questions they considered were:

- Do native plants persist in the midst of long-term invasions?
- Do invaded and non-invaded native plants differ in their ability to tolerate weeds?

Eight sites in Wyoming and Idaho that have been invaded by Russian Knapweed and Hoary Cress for more than 25 years have been the focus of the research. After first determining that native plants were indeed surviving within weed invasions, Hild and Mealor collected seeds from those survivors to grow with and without the weeds. They are testing to confirm whether the weeds have picked out (or naturally selected) native plants that can thrive in the midst of an invasion. They are also studying the genetic differences between the plants that persist inside invasions

with exotic weed invasions

and the plants in non-affected areas nearby.

"If the exotic weeds can adapt to new environments (such as they encounter when coming to a new continent), you would think that the native plants could adapt to having new neighbors (weeds)," Hild explains. "These perennial weeds can come into the native plant community and stay there a long time. The idea behind the research is that if there are native plants that can hang on and be good competitors, we need to find, collect, and propagate them to develop improved varieties of the native species."

In summarizing their findings so far, Mealor notes:

- Natives persist at reduced levels within old exotic invasions.
- Invaded natives grow larger with target exotics than natives of the same species from non-invaded areas.
- Native genotypes from within weed invasions are more similar to each other than to natives of the same species from just outside the invasions.

Mealor says they are working on the "what if" questions now. "The whys and hows will clear up a lot of the details of topics that we are just beginning to explore," he explains. Hild sees one of the next steps as determining if the offspring of native survivors are also better competitors against exotic weeds. The two researchers will be incorporating more native species in their greenhouse studies, estimating genetic variation in native populations, and using reciprocal transplants in field settings to assess their competitive abilities.

Hild likes the idea of having UW and College of Agriculture colleagues at the forefront of weed research. "What's unique about Wyoming," she says, "is that a lot of other states surrounding us have been overrun by weeds. Because we have a low human population and don't have as many of the kinds of disturbances that could transport weeds into the state, we can sometimes catch these weed invasions when they are fairly new. Other states have been overrun with weeds before they have had the opportunity or the knowledge to fight exotic invasions." The field is "exciting," Hild says, "because we can be on the invasion front for many weed species and can try to avoid new invasions that are knocking at our door."

Vicki Hamende, Senior Editor

Office of Agricultural Communications and Technology

Graduate researcher Brian Mealor waters native grass planted with Russian Knapweed that he is monitoring in an environmental growth chamber. His studies will continue in the college's greenhouse as he tries to determine the characteristics of plants that can compete with exotic weed invasions.

Multi-state involvement enhances research potential

The University of Wyoming's involvement in multi-state research projects offers faculty members the opportunity to collaborate with land-grant teams from throughout the region and the nation to share information and resources to tackle common issues.

More than a third of the faculty members in the College of Agriculture currently participate in 39 federally funded multi-state activities as part of national research support groups, western regional research teams, and coordinating committees that disseminate information in the form of analytical reports to offer ways for producers to meet objectives. In the national and regional projects, common instruments are often developed so that participants in each state can use the same techniques to gather and analyze data.

"Such involvement provides an opportunity for faculty members to get together with others who have interests in the same area and to develop and conduct research projects of mutual benefit agriculturally across the region and the nation," says Jim Jacobs, associate dean and director of the Agricultural Experiment Station for the college.

"From a research standpoint, coordinated efforts ought to make for better designed projects with results that ought to be more applicable and relevant across a wider spectrum," he says.

Collaborative projects involving UW researchers range from basic research in "Reproductive Performance of Domestic Ruminants" and "Genetic Variability in the Cyst and Root-Knot Nematodes" to applied research in "Factors Influencing the Intake of Calcium Rich Food Among Adolescents" and "Benefits and Costs of Resource Policies Affecting Public and Private Land."

Evee George, an undergraduate student, is being trained by Brian Francis on proteomic-diagnostic aspects of W112 research in the Hansen Reproductive Biology Laboratory.

Professor Tod Hansen of the animal science department, who has been involved with his UW colleague Professor Gary Moss and scientists from 13 other states for many years in the investigation of reproduction in ruminants (W-112), sees multi-state cooperation as benefiting newcomers to research projects by providing them with mentors.

"A particular faculty member might be the only person at an institution studying a certain topic. The collaboration offers that person the opportunity to talk to others in the same region who may be encountering similar re-

search problems," Hansen says. In an actual scenario, an Alaskan assistant professor who does not have access to state-of-the-art diagnostic equipment can look to others on his research team to help analyze the blood samples of deer, for example.

Hansen's multi-state group meets annually, often at locations where research is currently being conducted. "It's a chance for us to get together to give station reports describing what we did over the last year and to outline objectives for the next year," he explains. Having from 20 to 40 meeting participants as opposed to 200 or more as is the case with some professional gatherings allows for easier networking and productivity, Hansen says.

He and his fellow ruminant researchers in the project submit annual reports, have written hundreds of collaborative publications, and have already worked through two critical five-year renewable reviews. "It's important for us to make progress and show collaboration and show how we are helping each other," Hansen says.

While his team began by primarily studying the fertilization efficacy of beef cattle and sheep through the use of sophisticated reproductive technologies, its research has expanded to include exotic but domesticated ruminant species such as bison, white-tailed deer, muskoxen, reindeer, elk, and caribou. The management and efficient reproduction of these species has added a new component to the original mission of the project.

An additional challenge to livestock producers in western states is the changing demographics of the region, according to information posted on the World Wide Web by Hansen's multi-state research group.

Issues like air and water quality, waste management, production efficiency, and resource stewardship are becoming increasingly important as the interface between rural and urban communities expands. Another issue of concern in western states, the Web site reports, is the need for improved animal welfare as well as improved productivity.

Leading reproductive biologists from states as far northwest as Alaska, as far north as Minnesota and Michigan, and as far south as Texas have joined the W-112 project. Work groups are currently studying components of the reproductive process (follicular maturation, ovulation and fertilization, embryo development, implantation, maternal recognition of pregnancy, and maintenance of luteal integrity) that can limit fertility.

Web information reports that research team members are also examining the role of stress and nutritive status on folliculogenesis and ovulation in ruminants. Clinical colleagues are developing vaccines and immunologic strategies to lessen the incidence and severity of diseases that reduce the fertility of domestic species in the western states.

Hansen says he views multi-state research as "a really important functional U.S. Department of Agriculture support effort." He adds, "It's one of the better research groups I am involved in."

Vicki Hamende,
Senior Editor

Office of Agricultural Communications and Technology

College looks to individual a

Steve Williams studies forest fires. He has examined them as far away as Mongolia and Australia and as close as California, New Mexico, and Wyoming. His goal now is to help revitalize collaborative efforts aimed at evaluating the importance of fires, especially to forested ecosystems, and at balancing the interests of private landowners with the concerns of governmental entities.

Williams, a soil biologist and professor in the renewable resources department, is one of several biologists, chemists, historians, and other researchers who studied and are still studying the aftermath of the 1988 Yellowstone fires. Some of his work has been done at the University of Wyoming-National Park Service Research Center on Jackson Lake, a facility which is administered by UW's Office of Research.

"Fires are important large-scale processes in ecosystems," Williams says. "If fire has historically been a feature in a wild system, and if you want to retain a full spectrum of wilderness characteristics, you have to have fires. At one level, the life cycles of many plants are dependent on fire. On another scale, the entire nutrient cycle is dependent on fire."

Accelerated soil erosion is a frequent outcome of fires. "Soil on slopes is stabilized by plants and their roots. After a fire, the dead roots decay," Williams explains. Water from snow or rain soaking into these soils increases the soil weight and provides lubrication. Together these result in increased erosion, sometimes at massive scales.

There is often a "flush of biological activity," Williams says, after a fire. Fire results in surface soils being recharged with available nutrients, and it often breaks the dormancy of seeds that have been accumulating sometimes for many decades in soils or in cones in the forest canopy. "When moisture comes and air temperatures are right, there can be an explosion of plant life the season after a fire. This can be followed by increased activity and an abundance of other biota from fungi to voles to elk."

During the early and experimental years of land management, Williams says, "fires were viewed as bad and therefore something to be eliminated. Now fire is viewed as a land management tool and often looked at favorably. Still, if you are a cabin owner in a forest, it is difficult to consider a fire bearing down on your place in the context of enhanced nutrient cycling and biological diversity. How do you handle fires in a forest and also have summer homes there?"

Complicating the situation, Williams says, is the "mixture of management styles which comes from the different missions of land management agencies." For example, the U.S. Forest Service focuses on multiple use and the National Park Service on "preservation for the en-

and governmental concerns in fire and ecosystem research

joyment of the people." The sometimes conflicting interests of the Fish and Wildlife Service, the timber industry, producers, and sportsmen can also clash. "How do you interface a cattle ranch with wildlife habitat that accommodates predators?" He adds, "How do you manage a fire being pushed by 60 mile-per-hour winds from a federally managed wilderness area onto a privately owned commercial forest?"

Williams points out that "fire doesn't recognize" political boundaries. "In Wyoming almost 50 percent of the state is owned and managed by the federal and state governments. No matter where you are in the state, there's government-owned land that adjoins private land. The governmental management goals are often vastly different from the goals of private landowners."

Williams sees an important role for UW and the College of Agriculture in the continued exploration of the post-fire Yellowstone ecosystem and the multiplicity of other fire issues as well. "Federal land managers are looking more and more for cooperative arrangements with private individuals, agencies, and universities to help with land management research and with extending that research to the public through informal and formal educational avenues," he says. "The Greater Yellowstone-Teton Ecosystem (GYTE) and the state as a whole represent a crucible of land management issues that can be shared with our students and can provide blueprints for similar issues regionally, nationally, and around the world."

Williams emphasizes that the GYTE is "the most recognized park and forest zone on the planet. It has unparalleled natural beauty and unique geological and wildlife resources. Its designation represents hallmark decisions and legislation in land classification, use, and management."

The GYTE, he adds, "is squarely in the political, cultural, economic, and ecological front yard of Wyoming. The University of Wyoming and all of its colleges, including agriculture, will continue to work cooperatively and with land management agencies to expand research, outreach, and educational opportunities related to this fabulous resource for our state, national, and world citizens."

Vicki Hamende,
Senior Editor

Office of Agricultural Communications and Technology

Studies show bison do not transmit deadly disease

Researchers have long known that bison suffering from Malignant Catarrhal Fever (MCF) have likely been infected from virus particles shed by sheep. A study recently completed by the College of Agriculture at the Wyoming State Veterinary Laboratory (WSVL) has concluded that the opposite is not true – infected bison do not spread the disease to non-carrying sheep.

In a collaborative effort involving funding from the U.S. Department of Agriculture (USDA), the Throlson American Bison Foundation, and several state associations, and with buffaloes provided by producers in California and Colorado, the Department of Veterinary Sciences spent several months researching the effects of exposing MCF-infected bison to healthy, specially bred sheep. Much of the work was completed by UW graduate student Joe Monfre of Casper under the leadership of Donal O'Toole, head of the state lab and of veterinary sciences at UW.

These pens housed MCF-infected bison while they were tested with non-infected sheep.

With MCF the "leading acute disease of bison," according to O'Toole, studies conducted in several laboratories during the past couple of years generally concluded that a bison with clinical MCF does not serve as a source of the virus in infecting other bison in a herd. Infected sheep remain the primary culprits.

While sheep do not succumb to the virus, bison victims face death since there is currently no treatment, vaccine, or cure for MCF. Of the approximately 300,000 buffaloes being raised in the U.S. for their unique, low-fat meat, an estimated 25 to 35 percent are infected with the devastating MCF disease. The UW research results can at least assure bison producers that their herds will not spread MCF to sheep that could in turn cause expansion of the virus in their bison herds. "Hopefully this will help alleviate some of the fear and stigma associated with the disease," O'Toole says.

"A lot of bison producers have had major outbreaks of the disease and have suffered financial losses," Monfre says. MCF can also strike other ruminant animals such as cattle and deer.

The herpes-type virus is difficult to detect in bison, Monfre says, because the animals can be infected but not show any symptoms for a long period of time. Also, sheep can inadvertently shed the virus, mainly from their nasal secretions, from miles away. Most adult sheep are infected, O'Toole says, but some of them only shed for very brief periods of time and then no longer appear to pose a threat. Once bison suddenly show the signs of high fever, a runny nose, a custard-like discharge, bloody diarrhea, and cloudy eyes, they can die within 24 to 48 hours.

In the WSVL study, four donated buffaloes infected with MCF

This is one of four buffaloes infected with Malignant Catarrhal Fever that was used to research whether the disease could be transmitted to sheep.

Veterinary Sciences Livestock Manager Rod Rogers bleeds a buffalo to help determine its viral condition.

shared water troughs and adjacent living quarters with non-infected sheep. "The animals were fairly closely confined," Monfre says. "We could get to them a lot sooner than the average producer could. We got to know the animals and could look for viral changes and symptoms."

O'Toole and Monfre shared their preliminary findings at an MCF symposium in Colorado that was attended by prominent researchers from throughout North America. They have also partnered with MCF experts Hong Li of the USDA Agricultural Research Service, Tim Crawford of Washington State University, and a network of producers and collaborators around the country. O'Toole's involvement actually began in the early 1990s following an MCF outbreak in cattle.

With Wyoming following closely behind North Dakota, South Dakota, and Colorado in terms of the number of bison being raised, Monfre notes that "we have immediate access to the producers." He adds, "We also have one of the few facilities where it's still cost effective to do these kinds of large animal studies. We have the resources to do it."

O'Toole says the work has really just begun. "We know where the virus is coming from. The next study that we will probably do is to attempt experimental reproduction of the disease using some of the fluid of these shedding sheep," he explains. "One reason why this disease has been such a pain is because experimental reproduction has been so difficult. If we can use material from these high-shedding sheep, it will give us a better idea of what the disease does on its miserable track."

Bison infected with MCF and healthy sheep shared a water trough in the College of Agriculture study.

Vicki Hamende,
Senior Editor

Office of Agricultural Communications and Technology

Renewable resources department links with

To tackle the critical importance of water in Wyoming and the western United States, a water resources option for graduate students is offered in the Department of Renewable Resources, which includes the entomology, soil science, and rangeland ecology and watershed management programs.

Established in cooperation with other departments throughout the University of Wyoming, the water resources curriculum offers students and faculty members the opportunity to work collaboratively with a variety of agencies, communities, and individual producers.

These graduate students are all involved in research projects through the water resources program.

Jason Peel, left, and Rich Jackson, both graduate students in the water resources program, work on a nitrate project in Seminoe Park near Rawlins, Wyoming.

Encompassing courses in civil engineering, geography and recreation, geology, math, economics, law, botany, and zoology in addition to a large selection of College of Agriculture offerings, the water option provides multi-disciplinary expertise in various aspects of hydrology, law/natural resources economics, and water quality.

"We have a number of disciplines, and we are leaders and in the forefront of water resources research," says K. J. Reddy, assistant professor of renewable resources and the water resources program faculty adviser.

About 20 graduate students and a group of faculty members from several different departments are currently involved in water resource research related to drought, coal bed methane product water, water quality issues associated with irrigated agriculture and grazing, and surface coal mining.

Working with local ranchers, the Natural Resources Conservation Service (NRCS), industry representatives, the Environmental Protection Agency, and water quality agencies, UW researchers are studying

collaborative teams to study water issues

the characteristics of coal bed methane-produced water in disposal ponds and channel systems in the Powder River Basin.

"We are looking closely at the water quality with respect to salinity, sodicity, and trace metals," Reddy says. Beneficial uses of the water, he explains, must be weighed against environmental issues.

At the site of the Kendrick irrigation project near Casper, UW is working on selenium issues and helping to develop sound management practices to minimize the natural input of selenium into agriculture drainage water and tributaries. Another example of water quality research involves trying to develop an innovative technology to control acid mine drainage from surface coal mining activities. Students and faculty members there are interacting with local farmers, conservation districts, the Wyoming Department of Agriculture, industry, and water quality agencies.

A third focus for the water resources program involves issues pertaining to nitrate ground water quality in Goshen County. Local farmers, the city of Torrington, the NRCS Water Quality Division, the state engineer's office, U.S. Geological Survey representatives, and faculty members from Eastern Wyoming College are collaborators in that research. "We are creating a steering committee that will include all of these working partners," Reddy says.

The outcome of a national congress on non-point source water pollution that Reddy attended in Baltimore, Maryland, was that the nation is facing a shortage of trained professionals in water resources research, particularly pertaining to water quality. Employment opportunities, he says, are plentiful for students completing the water resources curriculum, and he sees that as one of the reasons for growing interest in the program.

To ensure continued success, faculty members from the renewable resources department meet regularly with colleagues from departments all over campus to revitalize the program to maintain its appeal and importance.

Vicki Hamende,
Senior Editor

Office of Agricultural Communications and Technology

UW students conduct research on water quality at the Kendrick irrigation project near Casper.

Involvement gives College of Agriculture a national

The Office of Academic and Student Programs helps the College of Agriculture maintain a significant national profile. "We are definitely a player," says Jim Wangberg, associate dean and director of the office.

Key committee and task force assignments, election to leadership positions, sponsorship of special conferences, visibility in peer-reviewed publications, and the acquisition of education grants for teaching improvement and enhanced student learning all thrust Wangberg, his office, and thus the college into the national conversation about the importance of sharing information about academic programs.

"Our national presence is captured in many ways," Wangberg says. The college's avenue into the agenda comes largely through the National Association of State Universities and Land-Grant Colleges (NASULGC). Wangberg attends NASULGC meetings and has served as a member of the group's Academic Committee on Organization and Policy (ACOP) and as the secretary, vice chair, and chair of the Western Academic Programs section. "It's significant that we have a role in overseeing NASULGC academic programs," Wangberg notes, adding that "it is an honor and a distinction." UW hosted one of the group's Western Regional Teaching Improvement workshops.

As co-chair of a NASULGC Academic Summit Task Force, Wangberg says he hopes to help establish "a national academic summit to determine where we want our academic programs to be 10 years from now, what we want our graduates to have learned, and what we think employers will be looking for."

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Jim Wangberg promotes the college's national involvement.

Wangberg's other national council and committee assignments include involvement with the National Academic Programs Planning and Futuring Committee and a three-year Advisory Council membership for the Leadership Development Program of the Experiment Station Committee on Organization and Policy (ESCOP)/ ACOP. He is also a member of an Impact Statement Committee.

In terms of national review panels, the Office of Academic and Student Programs has been involved with the U.S. Department of Agriculture (USDA) Cooperative State Research, Education, and Extension Service Multidisciplinary Graduate Education Grant Training Program and also oversees the USDA Excellence in College Teaching Awards Program.

Wangberg and college faculty members co-authored an article entitled "A Collaborative Faculty Approach for Improving Teaching of Writing and Critical Thinking Across Disciplines: A Wyoming Case Study" for the National Association of Colleges and Teachers of Agriculture (NACTA) Journal. The college sponsored and hosted a National Conference on Student

voice

Writing and Critical Thinking in Agriculture in April in Jackson, Wyoming, that was made possible by a USDA Higher Education Programs Challenge Grant. Wangberg serves as principal investigator for the grant and for another one that focuses on Excellence in College and University Teaching in the Food and Agricultural Services. The college has had two regional grant winners.

His office also makes annual contributions to the Food and Agricultural Education Information System Web site, a national database with information about enrollments, graduates, and academic programs.

Wangberg is proud of the college's national presence. "It represents a pretty significant level of activity for one office," he says. "Some of it is visible, and some of it is behind the scenes. It is part of what we do."

Vicki Hamende, Senior Editor

Office of Agricultural Communications and Technology

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Frank D. Galey — Dean

Jim Jacobs — Associate Dean and Director,
Agricultural Experiment Station

Kathleen Bertoncelj — Office Associate, Senior,
Agricultural Experiment Station

James K. Wangberg — Associate Dean and Director,
Office of Academic and Student Programs

Glen Whipple — Associate Dean and Director,
Cooperative Extension Service

Editor
Vicki Hamende — Senior Editor,
Office of Communications and Technology

Design and Layout
Tana Stith — Graphic Designer,
Office of Communications and Technology

Cover Photo
Ed Reeve

Back Photo
Orlando Hiller (trees)
Jim Gores (aspen leaf)

Departments
Agricultural and Applied Economics: (307) 766-2386
Animal Science: (307) 766-2224
Family and Consumer Sciences: (307) 766-4145
Molecular Biology: (307) 766-3300
Plant Sciences: (307) 766-3103
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UNIVERSITY
OF WYOMING
College of Agriculture
P.O. Box 3354
Laramie, WY 82071-3354