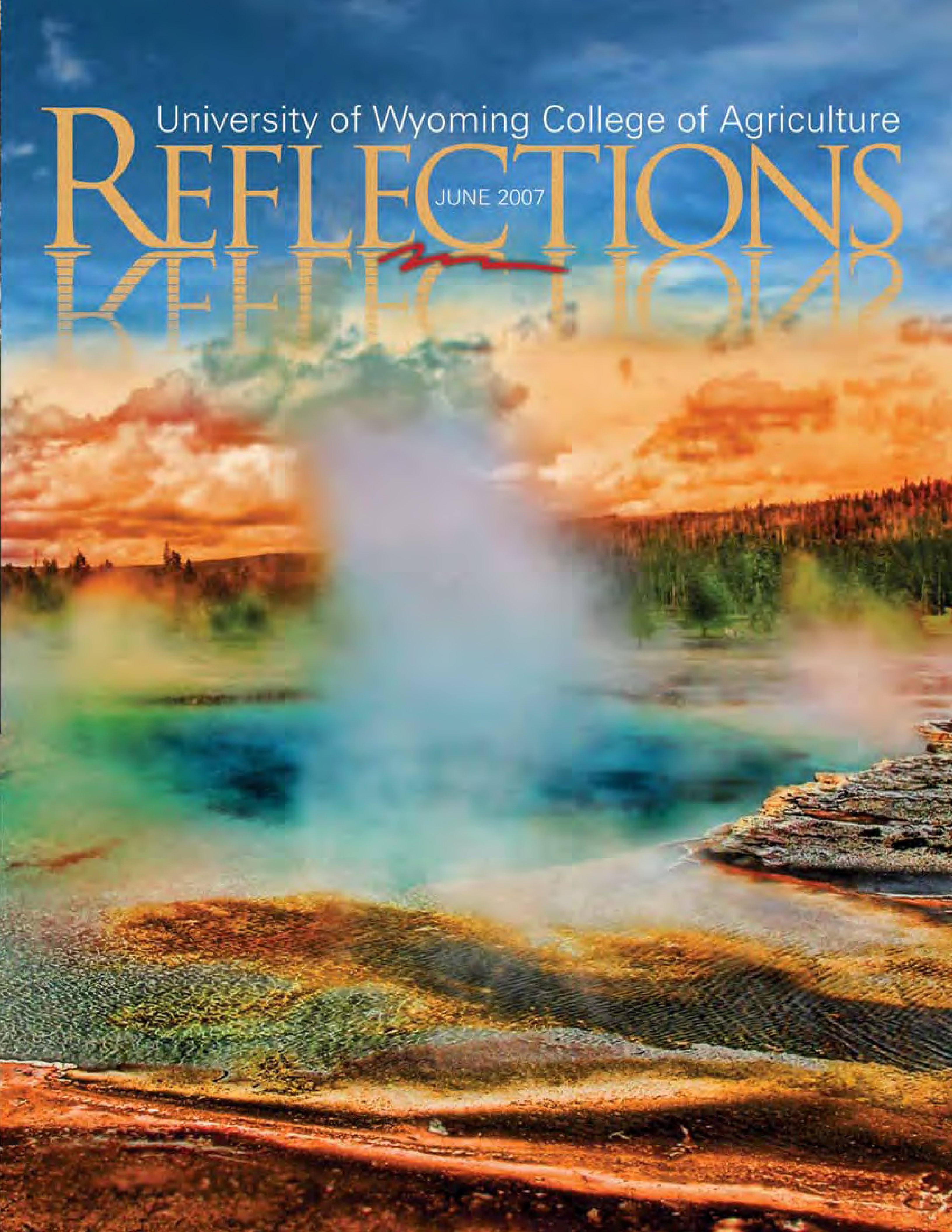
University of Wyoming College of Agriculture

REFLECTIONS

JUNE 2007



“If you don’t know where you are going, any

“Agriculture at the Crossroads” is the theme for this year’s *Reflections*. Mention agriculture and images of fields, crops, and livestock come to mind. The truth is, that’s only a snapshot of the role played by the University of Wyoming College of Agriculture. The big picture is one of the college making a difference in our families and our towns, in classrooms and community centers, and on our farms and ranches.

This issue of *Reflections* includes articles on remote sensing, postpartum depression, locust monitoring, off-road vehicles, mineral content of range grasses, veterinary diagnostics in the 21st century, the northern mixed-grass prairie, insect proteins, small acreages, precision agriculture, brisket disease, and the impact of high fuel and fertilizer prices on profitability.

With eight undergraduate and 20 graduate degree programs, the college’s array of educational opportunities is impressive and designed to give students the ability to find solutions for the complex array of interactions facing agriculture today. The college’s research efforts provide unbiased information for managing wildlife/livestock conflicts, natural resource development, and maintaining profitable and sustainable agricultural production systems.

The college has research and extension (R&E) centers near Laramie, Lingle, Powell, and Sheridan that provide the sites and means to conduct cutting-edge research that discovers, generates, and synthesizes new knowledge for application to meet Wyoming’s emerging technological, scientific, and social needs.

Feel free to visit our campus, extension offices, or the R&E centers to witness faculty, staff, and student efforts firsthand. See how the college’s tripartite mission of instruction, research, and extension/outreach is designed to meet and serve our stakeholder needs. To learn more about the college, please visit our Web site at www.uwyo.edu/UWAG.

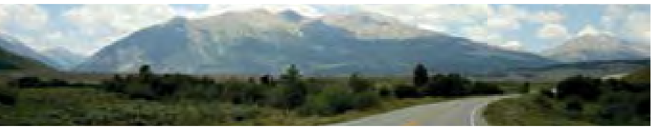
We hope you enjoy this issue of *Reflections* and the assortment of information it provides.

Stephen Miller

Stephen D. Miller
Associate Dean
Director, Wyoming Agricultural Experiment Station

The Office of Communications and Technology in the University of Wyoming Cooperative Extension Service publishes *Reflections*. Members are, from left, Robert Waggener, editor, Dee Bixby, senior office assistant, Tana Stith, graphic designer, Allen Fuller, senior computer support specialist, Barbara Farmer, manager, Randy Anderson, senior computer support specialist, Ronda Whitman, office associate, James Ackerson, computer support specialist, and Steven L. Miller, senior editor.

road will take you there." — *Lewis Carroll*



Reflections

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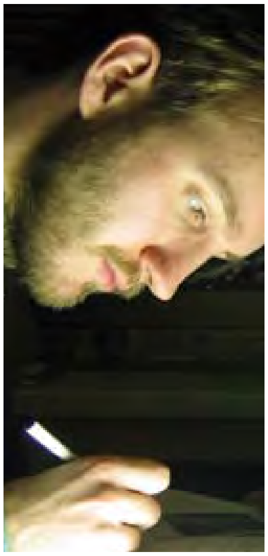

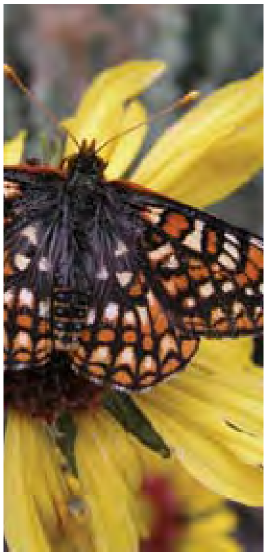

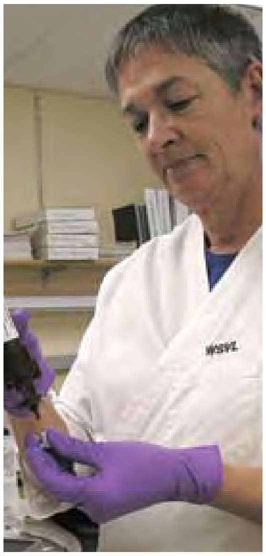

Developing an animal model of postpartum depression

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When you talk about postpartum (depression)…there is a hormonal thing that is going on, scientifically, you can prove that. But when you talk about emotional, chemical imbalances in people, there is no science behind that. *(Tom Cruise)*

I'm going to take a wild guess and say that Mr. Cruise has never suffered from postpartum depression. *(Brooke Shields)*

Notwithstanding the feud in 2005 between Tom Cruise and Brooke Shields, postpartum depression (PPD) is a critical issue for medicine, mental health, families, and society. While many women experience the "baby blues" after childbirth, about 10 to 20 percent suffer the clinical mood disorder designated as PPD. PPD is characterized by pervasive depressed mood, changes in appetite and sleep, lack of motivation, loss of pleasure and, sometimes, thoughts of suicide. These symptoms begin within four weeks of giving birth.

At first glance, the authors may seem an unlikely team. Indeed, we first came together not in the laboratory or even on campus but while trail running. Our talk turned to work, and soon our mutual interest in animal behavior and neurobiology surfaced.

While neither of us was working directly in neurobiology at the time, we both expressed a desire to return to our roots. Thus, the Brenda Alexander-Gail Leedy team was formed, and our first pilot research project soon presented itself, as we noted the program announcement issued by the National Institutes of Health on developing a model of postpartum depression.

This spotlight on PPD is at least partly due to the highly publicized trial of Andrea Yates for the bathtub drowning of her five children in Houston, Texas, in 2001. Yates' putative diagnosis of PPD with psychotic features challenged ideas regarding the legitimacy of a plea of "not guilty by means of insanity." As DePaul University Law Professor Michelle Oberman stated:

> *In many of these cases (PPD)... they're completely psychotic when they kill their children, they get treated, the hormones dissipate and they are totally sane. ...the jury is asked to believe that the sane woman in front of them was absolutely crazy six months before. And that's a hard sell, unless you really understand the process of postpartum psychosis.*

Trying to "really understand the process" of postpartum depression is the basis of work presented here. The inadequacy of rodent models of PPD was easily recognized, but settling on a more valid species was a bit more challenging. We reasoned the ideal animals should be highly social, have an extended period in which they suckle their offspring, and display strong bonding between mother and offspring. Further, the animals should be easy to handle, cost effective, and backed by a large body of knowledge regarding their behavior, physiology, and neurobiology.

Capitalizing on Alexander's animal science expertise, the domestic ewe was chosen.

Finding postpartum ewes for research was not difficult since it was early spring, and the University of Wyoming's commercial sheep flock was just beginning to lamb. Eighteen postpartum ewes were allowed to bond with their lambs for three days.

Knowing stress can precipitate depression in humans and impair maternal behavior in many species, we hypothesized that mild, chronic stress would be effective in inducing depressive-type behaviors in the postpartum ewes. Accordingly, 12 ewes were exposed to a series of mild and unpredictable periods of stress presented every three to four days. The types of stressors included isolation from other sheep, human intrusion into the pen, short confinement to a chute, and the presence of a large, noisy dog. Each stress period lasted for five to 15 minutes with ewes stressed 14 times over a 60-day period. A control group of six animals was not exposed to specific stress.

Postpartum ewes normally exhibit high levels of maternal behavior, are protective of their lambs and, when separated, show significant agitation. We predicted a depressed ewe would demonstrate deficits in such behaviors. To test this, ewes were observed during separation from their lambs and during the subsequent reunion period. During separation, the number of times the ewes bleated (a crying sound and a sign of distress) and the amount of time they spent pacing were recorded. Upon reunification, the number of times the ewes nuzzled their lambs, number of low-pitched grunts, and amount of time they allowed their lambs to nurse was recorded.

As shown in Figure 1, the stressed ewes showed lower levels of agitation and maternal behaviors during the earliest testing periods.

Encouraged by these results, we then tested whether administration of an antidepressant would reinstate normal levels of behaviors. Beginning between two and three weeks postpartum, sertraline (Zoloft®) was administered to six of the stressed animals (Stressed + Sertraline group). We found little evidence of improvement in the behaviors of the treated ewes during these tests (Figure 2).

Sertraline ewes showed an exaggerated cortisol elevation in response to the stress (Figure 3). Anecdotally, the sertraline-treated ewes in the present study were extremely difficult to handle during the first weeks of treatment. Initially, this seems counterintuitive since sertraline is a reliable treatment for depressive disorders, including PPD, and also for anxiety disorders in humans. Interestingly, the therapeutic response to sertraline is known to be delayed for two to four weeks, during which time an increase in agitation, irritability, and even suicide has been reported. It is possible the treated ewes experienced the same type of adverse reaction to sertraline as do humans.

We are excited by the results of this pilot study. The use of mild, chronic stress to induce depressive symptoms in postpartum sheep may provide a breakthrough in the search for a useful model of PPD.

We will now move forward with research to tease out the unique and complex interactions between the hormonal conditions of the postpartum period and the neural circuitry of emotions and mood disorders. We are hopeful that, ultimately, the onset of depression during an intensely emotional time will no longer plague mothers, infants, and families.

So, what can this ewe tell Tom Cruise about postpartum depression? "It's baaad."

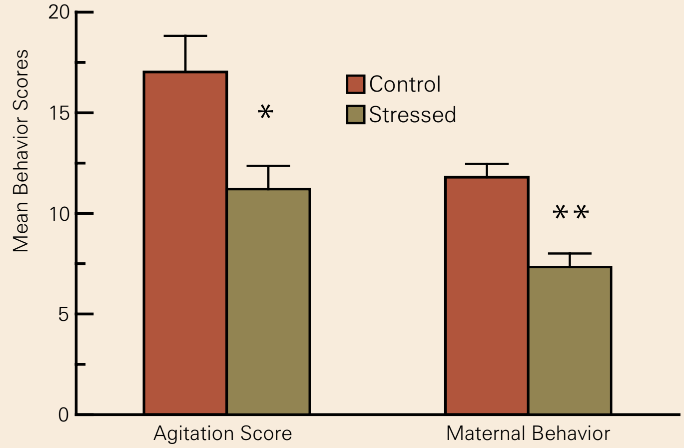


Figure 1: Mean agitation and maternal behavior scores for behavior tests conducted during postpartum weeks two and three.
*$p < .05$ **$p < .01$

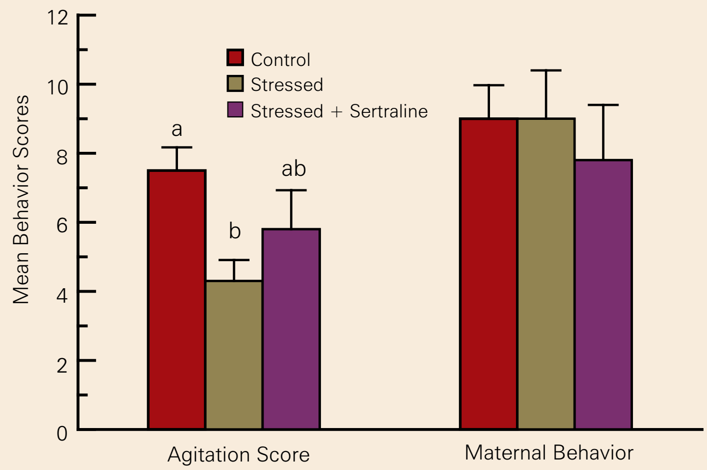


Figure 2. Agitation and maternal behavior scores for four tests, beginning during postpartum week three (antidepressant treatment initiated during week two).
($p < .05$).

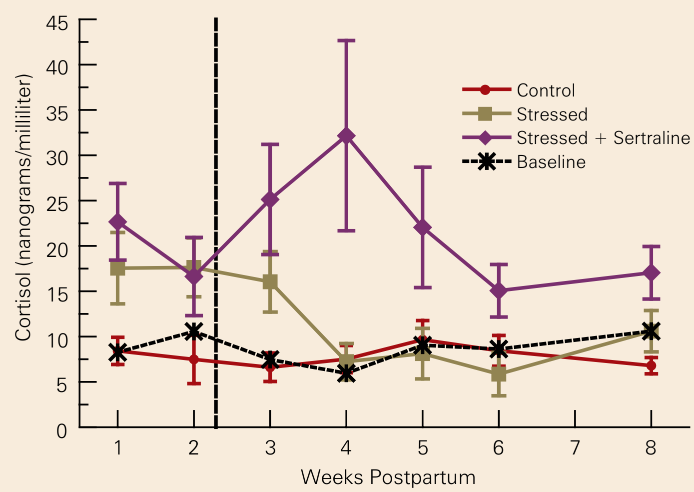


Figure 3. Mean cortisol levels, taken pre- and post-stress exposure, over eight weeks. The vertical dotted line represents the beginning of sertraline administration for the Stressed + Sertraline group. Stressed + Sertraline differs significantly from the Stressed on weeks four and five.

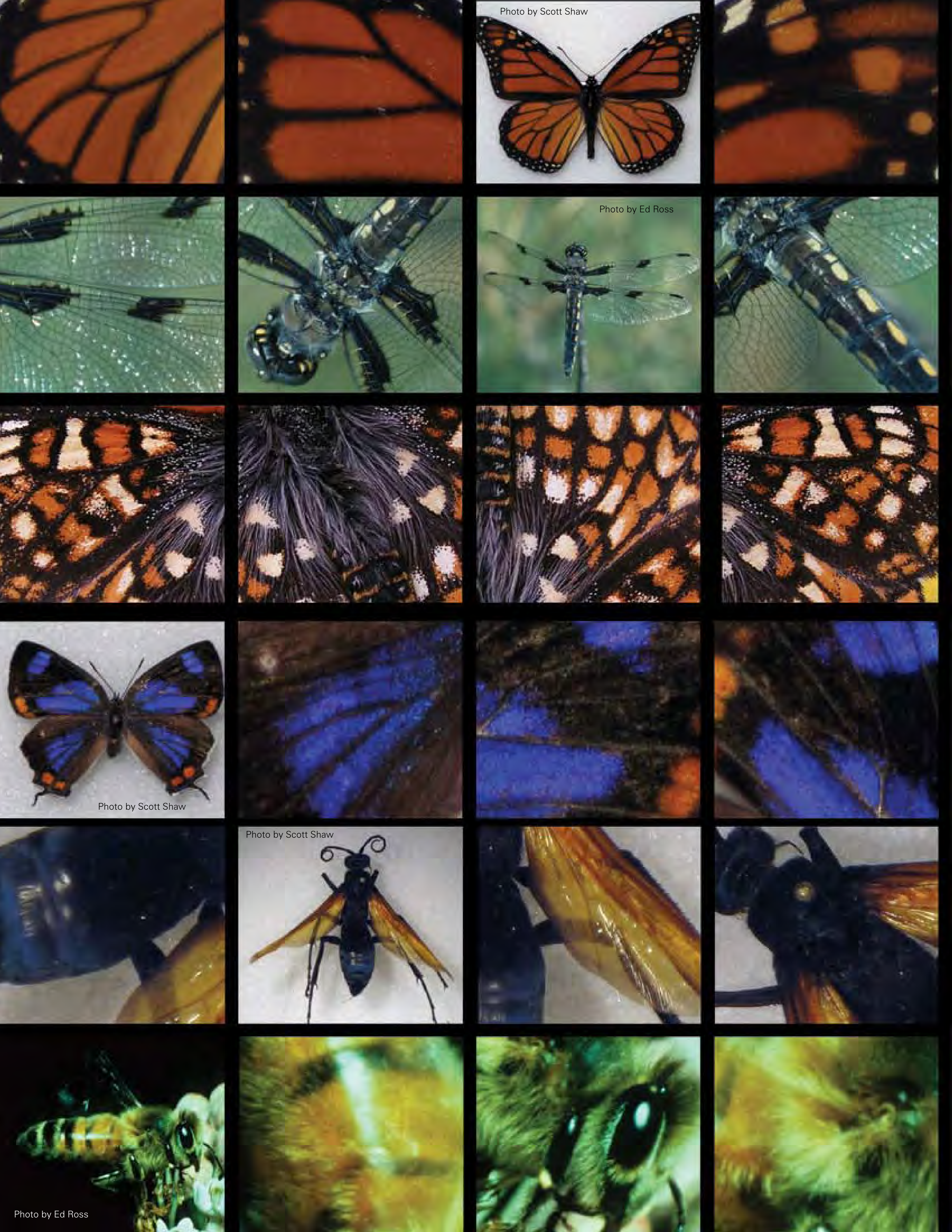


Photo by Scott Shaw
Photo by Ed Ross
Photo by Scott Shaw
Photo by Scott Shaw
Photo by Ed Ross

Would a state insect fly in Wyoming?

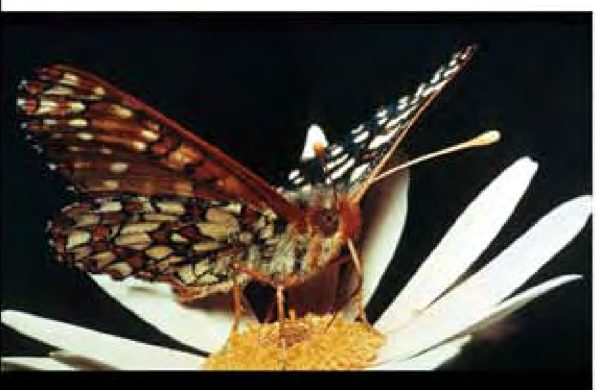


Photo by Ed Ross

Entomology professor ponders whether the Equality State will ever select a suitable insect symbol

Scott Shaw

Professor

Department of Renewable Resources

Forty-two states have designated insects as symbols, either as state insects or state butterflies. Tennessee, arguably the most entomologically inclined state, has declared *two* state insects (firefly and ladybug), a butterfly (zebra swallowtail), *and* an agricultural insect (honeybee)!

Wyoming does not yet have an insect symbol. This article arose from an interest in designating a symbolic insect for Wyoming.

Why designate state insects? Insects are among the most diverse, abundant, and ecologically important organisms on this planet, and we depend upon them for our survival. There are millions of insect species, but only a small fraction of them are pests (less than 1 percent)! The vast majority are beneficial as pollinators, seed dispersers, nutrient-recyclers, food for wildlife, bio-indicators of water quality, and beneficial predators (important to agriculture and forest health).

Plant-feeding insects generate beneficial forest diversity by suppressing dominant plants. Insects are studied as sources of medicines, oils, waxes, scents for perfumes, and silk fibers. Larger insects are attractive and influence our culture by providing inspiration for photographers, artists, novelists, poets, and philosophers.

Designating insects as symbols provides opportunities for students to learn something interesting about nature.

Politically, it's not a bad move, either. The initial expense of the legislation is small compared with the long-term benefits to tourism, advertising, and marketing. A thoughtfully selected state symbol can attract tourists to the region and provide marketing opportunities.

Anicia checkerspot

Designating insects as

How does one go about selecting a suitable symbol? As curator of the University of Wyoming Insect Museum for 17 years, I estimate there are at least 12,000 insect species in Wyoming. Many are rare and can only be identified by direct comparison with specimens. Those can be eliminated – clearly, any state symbol needs to be a common animal, easily identified with a photograph.

Most Wyoming insects are quite small – only a few millimeters long. The smallest insects in Wyoming (fairyfly wasps) are microscopically tiny – just a fraction of a millimeter long. They can be balanced on the head of a pin or inhaled and never even be noticed.

Any state insect will need to be something people find interesting and attractive, something large enough to easily recognize; however, even if the uncommon insects, the pests, and those too microscopically small to be easily seen, are ruled out, there are still many hundreds of large, colorful, interesting insects to consider.

Perhaps history can provide guidance.

Use of insects as symbols is deeply rooted in human history and culture. The ancient Egyptians as far back as 2500 B.C. adopted the dung-rolling scarab beetle as a religious symbol. To the Egyptians, the scarab beetle represented the sun god Khepri, the unseen force that moved the sun across the sky. Ancient Babylonian kings adopted the stinging hornet as a symbol of power and authority. To ancient Greeks, the butterfly became a symbol for the transformation of the human soul.

In America, California was the first state to declare an insect symbol. A state-wide ballot of entomologists in 1929 selected the California dogface butterfly; however, a wave of entomological-enthusiasm didn't sweep the country. From the Depression to the Vietnam War, presumably, legislators had other things on their minds. Finally, in 1972, the California State Legislature officially sanctioned the California dogface. Since 1973, 41 other states adopted insects as symbols.

While some state insects are unique, 16 states have selected the honeybee as a symbol! With 87,000 insect species in North America, one might suppose states could select something original. The honeybee is a lovely insect – by pollination services and honey production it is of enormous beneficial economic impact – but the insect is not even native to the United States.

Of states that have decided to compete over the bee, the most memorable is Utah, because the citizens actually have a good historical reason for picking it: Utah is the Beehive State.

Six states have picked the monarch butterfly – not much of a better choice, perhaps. It's not a permanent resident in any of these states – it's a seasonal migrant. Also, it's a highly toxic organism that makes blue jays vomit – yuck. Eating monarch butterflies could kill a person, but you would probably vomit first because of their taste.

Other duplicated state symbols include ladybugs and yellow swallowtails. The trend of repetitiveness may have something to do with the history of the selection process. Insect symbols became popular in the early 1970s after the environmental movement of the late 1960s. Over the ensuing decades, many insects were selected but, in many cases, the process was symbols provides opportunities for students to learn something interesting about nature.

started by classes of young schoolchildren. They picked familiar insects beloved by children (honeybees, ladybugs, monarch butterflies, etc.).

That's not saying children shouldn't be involved in the process. Far from it – children are wildly enthusiastic about insects, and they can learn a lot from insect studies. I'm just hoping future teachers will do a bit of research and provide students with some thoughtful, original choices.

What sorts of original insect choices might be made? At least 14 states give reasons for inspiration because of their creative ideas. The butterflies of California, Tennessee, and Arizona have not been repeated. Other states selected striking local butterflies as well, including Colorado (Colorado hairstreak), Florida (zebra longwing), Kentucky (viceroy), Maryland (Baltimore checkerspot), and Oregon (Oregon swallowtail).

Photo by Erik Runquist

Sheridan's green hairstreak

Alaska and Washington selected dragonflies. Alaska is a particular favorite – the four-spot skimmer was singled out for its extraordinary flying ability, which reminds Alaskans of the talents of their gifted bush pilots.

Tennessee and Pennsylvania selected firefly beetles. Connecticut and South Carolina tapped praying mantises.

Perhaps the most original pick is by New Mexico, which, in 1989, selected the tarantula hawk wasp. This remarkable wasp catches and stings tarantulas, which it packs into tunnels in the ground as food for its young. This is a sight any tourist to New Mexico will find memorable!

Should Wyoming select an insect symbol? Absolutely! There is already a state flower (Indian paintbrush), tree (plains cottonwood), bird (western meadowlark), dinosaur (*Triceratops*), mammal (bison), fish (cutthroat trout), reptile (horned toad), and even a fossil (*Knightia* fish).

At least two insects might make wonderful symbols for Wyoming.

My first recommendation, as state butterfly, would be Sheridan's green hairstreak, *Callophrys sheridanii*. This lovely insect is distinctive, being one of the few *green* butterflies in our region. It was discovered in 1877 near the location of present-day Sheridan, Wyoming. Both the town and the butterfly are named after Lt. Gen. Philip H. Sheridan, a famous Civil War commander; however, the butterfly was actually named before the town. It occurs widely across Wyoming in mountains and foothills, wherever its foodplant (sulphur-flower) is found. This butterfly flies from March to June and is the earliest butterfly to emerge from a chrysalis in Wyoming. Like the robin in Wyoming and other states, this green butterfly is a symbol of the arrival of spring in Wyoming.

Another great choice as a state insect would be *Euphydryas anicia*, the anicia checkerspot (see photograph page 6). This butterfly also occurs widely across Wyoming. It flies as early as March and as late as August at high elevations. The caterpillar feeds on *Penstemon* plants and Indian paintbrush, so it dines on the state wildflower and is found in the same locations. It's abundant enough to be easily noticed by tourists but not so abundant as to become a pest on the wildflowers. The beautiful butterfly can be easily photographed and would look great on postcards, maps, and T-shirts.

I expect Wyomingites will eventually get around to declaring a state insect. An original choice would be nice, and I certainly hope it's not the honeybee!

Gene expression research could

End result of experiments might be development of a simple blood test to diagnose brisket disease at preclinical stage

Mark Stayton
Associate Professor
Department of Molecular Biology

Richard McCormick
Professor
Department of Animal Science

Altitude or brisket disease is a condition that sometimes occurs in cattle at elevations above 6,000 feet.

Mortality may run about 0.5 to 5 percent among cattle native to high country; however, in lowland cattle brought to higher altitudes or in offspring from untested sires, losses can be as high as 30 to 40 percent.

Cattle show a unique susceptibility to high altitude compared to humans and common laboratory animals. Why is unknown. Among all species tested, domestic cattle show the most extreme response to high altitude exposure. The disease not only has direct economic consequences, but it drastically limits the use of cattle that could provide genetic-based herd improvement.

Development of a simple blood test that diagnoses brisket disease at a preclinical stage would be of great benefit to producers.

Brisket disease occurs when susceptible animals are exposed to a low oxygen, or hypoxic, environment. Lower amounts of oxygen trigger a response in the lung tissue that narrows the small blood vessels of the lung. Such remodeling of the lung vasculature makes pumping blood through the lungs increasingly difficult. The increased pressure required to perfuse the lungs with blood results in a condition known as pulmonary (lung) hypertension, or markedly increased blood pressure, in the arteries feeding the lungs.

As the lung vessels continue to narrow, the heart must work harder to force blood through the lungs. The right ventricle, that portion of the heart that pumps blood into the

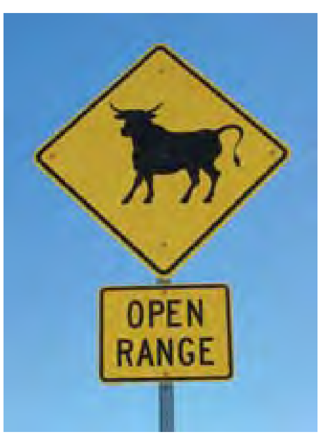
result in simple brisket disease test

lungs, becomes enlarged or hypertrophied. Eventually, this enlargement causes the heart to fail, and the animal dies.

Before heart failure occurs, affected cattle often become visibly ill. Pneumonia, labored breathing, diarrhea, and fluid build-up in the body cavity are often observed. The fluid tends to pool in the brisket region of severely affected animals giving the brisket a swollen, pendulous appearance and the condition its name.

Treatment for brisket disease involves moving sick animals to a lower elevation; this sometimes results in recovery, but often the condition continues to progress and the animal dies.

For more than 20 years, producers, in an effort to raise brisket disease-free herds, have tested breeding stock bulls in particular for a predisposition to developing altitude disease. Some ranchers chose to test their whole herds, although testing just the sire is usually deemed sufficient. The procedure to determine susceptibility involves direct measurement of blood pressure in the pulmonary artery.



Tens of thousands of cattle in the Wyoming-Colorado region have had the pulmonary artery pressure (PAP) test. The routine, voluntary PAP testing of cattle is due almost exclusively to pioneering work of Tim Holt, a veterinarian and assistant professor in the Colorado State University College of Veterinary Medicine and Biomedical Sciences.

While the PAP test can accurately detect animals that have developed pulmonary hypertension, it possesses drawbacks. While PAP testing is done on-site, it involves working and restraining each animal. Since cattle vary in their predisposition to brisket disease, all bulls in high altitude areas should be tested. Further, it is an invasive procedure. A catheter, with a transducer that detects blood pressure, is passed via a large-gauge needle into the jugular vein, through the vena cava, right atrium, and ventricle of the heart on into the pulmonary artery.

Colorado State University (CSU) Assistant Professor Tim Holt prepares the heart catheter as CSU veterinary resident Bambi Jasmin and University of Wyoming beef cattle extension specialist Steve Paisley prepare the steer while UW Associate Professor Mark Stayton (left) films pulmonary artery pressure testing at the University of Nebraska Panhandle Research and Extension Center near Scottsbluff, Nebraska.

Blood pressure values are relayed to an oscilloscope where an average blood pressure value in the pulmonary artery – the PAP score – is recorded. Holt has PAP-tested thousands of cattle in the past 20 years and makes the procedure look quick and easy, but a highly trained and experienced operator is clearly required.

> Altitude sickness in cattle causes up to 40 percent mortality

While the fee for PAP testing an animal is extremely reasonable, it represents still another cost to the producer. Because

ACCACTG AACCCCGTCC CGGACAGTGC CGGTTCATGT
TGATGAT GGGCCACCCA GGGAACCTTG GCAGGGACCA
CTGCCGG TTACCACTGA CCTGCCCAGG CCCCACTCCG
ACGATGT TCTGATGATG CTGTGCCGGC CACCCTGCCC
GCCATCA CTCTGCCGGC TTACCAGTGA CAGCCATCAT

From left, catheterization sterilization solutions and the oscilloscope.

the PAP test detects the response of a calf to high altitude, only cattle that have been at altitude for a number of weeks can be tested. Thus, the PAP test can provide no information about animals that reside at lower elevations and this includes, of course, potential artificial insemination (AI) sires.

The PAP test has proved an effective, if somewhat unwieldy, diagnostic tool. Producers and veterinarians agree a simpler test, one a cattle producer could perform, is desirable.

Within the past few years, the bovine genome has been partially sequenced. Two-thirds to three-quarters of the genes in cattle have been identified. Furthermore, the tools exist to readily identify and measure gene expression changes in any bovine tissue sample, including blood.

In studies involving experimentally induced heart attacks in laboratory animals, our laboratory including the authors and Paul Thomas, a professor in the University of Wyoming Division of Kinesiology and Health, noted that, in addition to large changes in gene expression in the heart itself, the genes in certain blood cells were also affected by the heart attack. We hypothesized the development of brisket disease might also result in measurable changes in blood genes – a tissue sample that is easily obtained.

We identified a herd of 40 half-sibling steers that had a high incidence of brisket disease. Prior to slaughter at 14 months of age, the steers were PAP tested by Holt, and we collected a small blood sample from each. At slaughter, hearts and lungs were collected to confirm brisket disease.

Steve Paisley restrains steer (center) as Tim Holt catheterizes the jugular vein of the steer during pulmonary artery pressure testing at the University of Nebraska experiment station near Scottsbluff, Nebraska.

Based on PAP scores and enlargement of the right ventricle of the heart, a subset of 12 steers was tested for blood gene analysis divided into three groups: normal, early-onset brisket disease, and mid-stage brisket disease.

We measured expression levels for 19,000 genes in white blood cells from each group. In summary, gene expression is induced in response to right ventricular hypertrophy and may permit early diagnosis of the disease.

To complete the study, we will examine the same genes in blood from younger calves near death from brisket disease. Expression of a subset of these genes will be measured in blood samples from production herds to confirm the diagnostic usefulness of the test. The end result could be development of a simple blood test that will diagnose brisket disease at a preclinical stage.

In further studies, we are exploring tests that could be used to predict a beef animal's genetic susceptibility to brisket disease as with AI sires being managed at low elevation.

Harvesting corn silage in the Big Horn Basin.

Photo by Mike Killen

Production decisions and profitability:
Impact of increased fuel and nitrogen prices

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Graduate student

Jim Jacobs
Professor

Dale Menkhaus
Professor

Department of Agricultural and Applied Economics

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Study helps determine effects of higher fuel, nitrogen costs on Big Horn Basin crop profits

Fuel and nitrogen fertilizer prices have increased considerably in recent years, and this is having a major impact on ranchers and farmers in Wyoming and across the country.

The price of ammonium nitrate increased from 28 cents per pound of nitrogen (N) in 2002 to 45 cents in 2005, a 61-percent gain.

In 2002, gasoline and diesel prices averaged $1.41 and 97 cents per gallon, respectively, in Wyoming, but by 2005 they had climbed to $2.21 (57-percent gain) and $2.05 (111-percent gain), respectively.

What implications does this have for producers in northwest Wyoming's Big Horn Basin regarding production decisions and profitability?

The major crops in the Big Horn Basin are malt barley, dry beans, sugar beets, alfalfa, corn for grain, and corn for silage. This study includes ryegrass and alfalfa seed as potential crops in the basin. In analyzing the impact of fuel and N prices on profitability, yield responses to N were estimated to determine the most profitable level of N fertilizer for corn silage, dry beans, malt barley, and sugar beets.

Next, budgets were developed for each of the eight crops to determine return to management, or profit, under alternative prices for fuel and N.

Finally, an economic model was used to determine the impacts of alternative prices for fuel and N on profit and crop mix.

Crop Budgets

Base crop budgets were developed for each of the eight crops using fuel prices from 2000-2002. Additional crop budgets were developed for alternative price increases for fuel and N (Table 1). While all crops are affected by increased fuel and N prices, there is considerable difference in the extent of the impact on profit. For example, when comparing the base budgets with the budget for a $2 increase per gallon of fuel and a 10-cent-per-pound increase in N for sugar beets and corn silage, profit is reduced by $105 and $86, respectively, per acre from base budgets. When making this same comparison for alfalfa seed, profit is reduced by $16 from base budgets per acre.

Increased fuel and N prices impact production expenses of each crop differently because of differences in the number of field operations by crop, amount of N applied, and the crops' response to N. If producers are to maximize profit under rising fuel and N prices, both the level of N applied and crops grown must be considered.

What about the question of how much N to apply?

Table 1. Profit for Alternative Fuel and N Prices

Crop	Alfalfa	Alfalfa seed	Malt barley	Dry beans	Corn grain	Corn silage	Ryegrass seed	Sugar beets
Base Budget	$ (49.57)	$ 857.88	$ (65.32)	$ 94.27	$ (191.80)	$ 63.79	$ 389.89	$ 247.70
Fuel Prices:								
$1 increase/gal	$ (65.82)	$ 851.52	$ (75.21)	$ 76.46	$ (204.16)	$ 36.32	$ 358.24	$ 199.01
$2 increase/gal	$ (82.07)	$ 846.45	$ (85.10)	$ 58.64	$ (216.53)	$ 8.83	$ 349.86	$ 154.83
Fuel & N Prices:								
$1 increase/gal & $0.40 N/lb	$ (65.88)	$ 851.52	$ (73.64)	$ 77.59		$ 34.33	$ 358.24	$ 207.90
$1 increase/gal & $0.50 N/lb	$ (68.11)	$ 847.36	$ (82.19)	$ 59.77		$ 9.72	$ 343.68	$ 185.77
$2 increase/gal & $0.40 N/lb	$ (82.07)	$ 846.45	$ (85.19)	$ 72.00		$ 7.36	$ 349.86	$ 164.13
$2 increase/gal & $0.50 N/lb	$ (84.36)	$ 842.29	$ (92.34)	$ 54.18		$ (22.27)	$ 335.30	$ 142.63

(Parentheses indicate loss)

Table 2. Amount of N Applied (lbs/ac) for Alternative Fuel and N Prices

Crop	Alfalfa	Alfalfa seed	Malt barley	Dry beans	Corn grain	Corn silage	Ryegrass seed	Sugar beets
Base Budget	40	40	120	60	200	200	140	220
Fuel & N Prices:								
$1 increase/gal & $0.40 N/lb	40	40	92	48		193	140	202
$1 increase/gal & $0.50 N/lb	40	40	71	38		117	140	191
$2 increase/gal & $0.40 N/lb	40	40	90	46		180	140	201
$2 increase/gal & $0.50 N/lb	40	40	69	36		88	140	189

Crop Response to N

Yield responses to N were estimated for corn silage, dry beans, malt barley, and sugar beets. The estimated yield response functions for these crops are based on N rate studies at the University of Wyoming's Powell Research and Extension Center. Based on crop yield responses estimated for N, the N applied for alternative price increases in fuel and N is shown in Table 2.

Of the four crops, corn silage was the most responsive to N. For example, the optimal level of N for corn silage decreased by 76 pounds per acre when the price of N was increased from 40 cents to 50 cents

Harvesting sugar beet plots at the University of Wyoming Powell Research and Extension Center.

Photo by Mike Killen

per pound after fuel increased $1 per gallon. In addition, the above price increases for fuel and N resulted in profit for corn silage decreasing by nearly 72 percent.

The optimum N rate for dry beans was not very sensitive to increased fuel and N prices. The optimal amount of N for dry beans decreased 10 pounds per acre when the price of N was increased from 40 cents to 50 cents per pound after a $1-per-gallon increase in the price of fuel. Even with the small reduction in the level of N applied, profit for dry beans decreased by 23 percent for the above increases in the prices of fuel and N. This is one of the main reasons why increases in fuel and N prices impact the profit for each crop differently.

Spreadsheets were developed for each of these four crops to estimate the most profitable level of N to apply. By entering their own crop and N prices along with harvest costs, producers can estimate the most profitable application of N. The sheets can be found at http://agecon.uwyo.edu/farmmgt/Software/default.htm.

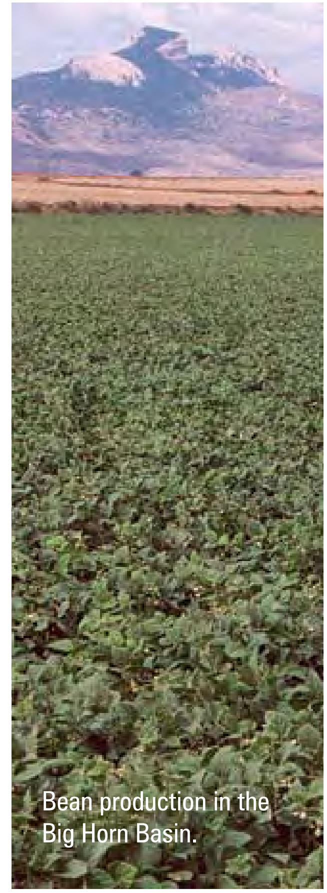
Economic Model

A 600-acre case farm was used to estimate profit for alternative price combinations for fuel, N, and crop mixes. Profit for alternative fuel and N prices for each crop was obtained from the enterprise budgets and used in the economic model under four scenarios.

The first scenario included the major crops in the Big Horn Basin – malt barley, dry beans, sugar beets, corn silage, corn grain, and alfalfa. Scenario two included these same crops, but the acres allowed of the three most profitable crops (sugar beets, dry beans, and corn silage) were increased 50, 30, and 25 acres, respectively. Scenario three included the same crops as scenario one with

Table 3. Acres Allowed, Crop Mix, and Profit

Scenario	1		2		3		4	
Crops:	acres allowed	crop mix	acres allowed	crop mix	acres allowed	crop mix	acres allowed	crop mix
Sugar beets	200	200	250	250	200	200	250	250
Malt barley	200	80	200	0	200	60	200	0
Alfalfa	200	200	200	175	200	200	200	155
Dry beans	70	70	100	100	70	70	100	100
Corn silage	50	50	75	75	50	50	75	75
Corn grain	50	0	50	0	50	0	50	0
Alfalfa seed	0	0	0	0	10	10	10	10
Ryegrass seed	0	0	0	0	10	10	10	10
Return to Management:								
Base budget		44,189						
Fuel price:								
$1 increase		27,789		48,604		41,391		62,018
$2 increase		12,290		30,871		25,955		44,476
Fuel & N price:								
$1incr. & .50N		21,627		41,229		35,181		54,501
$2 incr. & .50N		6,946		24,642		20,569		38,105



Bean production in the Big Horn Basin.

Photo by Mike Killen

10 acres each of alfalfa seed and ryegrass seed included. Scenario four included the same crops and acres as scenario two with 10 acres each of alfalfa seed and ryegrass seed included.

The combinations of fuel and N prices under the four crop-mix scenarios along with the estimated profit are shown in Table 3.

When compared to the base budget, profit under scenario one decreased by 37 percent and 72 percent when fuel was increased by $1 and $2 per gallon, respectively. When the $2-per-gallon increase was combined with N at 50 cents per pound, profit decreased 84 percent compared to the base budget.

By adjusting the level of N applied and the crop mix, producers can reduce the impact of increased fuel and N prices. When compared to the base budget for scenario one, profit under scenario two increased 10 percent when fuel increased $1 per gallon and decreased 30 percent when fuel increased $2 per gallon.

For scenario two, profit decreased 44 percent for the $2-per-gallon increase for fuel with N priced at 50 cents per pound compared to the base budget in scenario one. Scenario two acreages of the three most profitable primary crops – sugar beets, dry beans, and corn silage – were increased. When alfalfa and ryegrass seed production was allowed in scenarios three and four, impacts of increased fuel and N prices on profitability was greatly reduced compared to scenario one. This is largely due to the increased profitability of these seed crops as well as reduced field operations for these crops once established and the reduced level of N applied.

These results illustrate that impacts of increasing fuel and N prices on individual crops are quite different and also vary with the overall crop mix. This means producers must adjust production practices on individual crops and also analyze their crop mixes when faced with rising fuel and N prices if they are to minimize impacts.

The future face of Wyoming's northern mixed-grass PRAIRIE

Jennifer Schomp
Graduate student

David Williams
Associate Professor

Department of Renewable Resources

Higher carbon dioxide levels may change complexion of range

Our atmosphere is changing. Greenhouse gases such as carbon dioxide, methane, and water vapor are increasing in concentration and trapping heat, with consequences for eastern Wyoming's northern mixed-grass prairie.

Plant responses to rising atmospheric carbon dioxide (CO_2) levels are important, as plants utilize CO_2 directly as substrate for photosynthesis and contribute water back to the air through transpiration. The ability of plants to adjust to increases in atmospheric CO_2 levels and moderate feedbacks to the atmosphere affects their persistence and viability on the landscape. In arid and semiarid rangelands, encroachment by deeply rooted woody plants, such as sagebrush, and invasive plants with extensive taproots indicates an availability of water deep in the soil profile.

Ecological theory predicts an increased availability of atmospheric CO_2 will allow plants to assimilate an equivalent amount of carbon through markedly reduced leaf pore openings. By keeping stomates more closed, plants are able to reduce transpiration to the atmosphere and essentially enjoy improved "water status." A rise in surface temperature of soils increases evaporation, but plant water savings promote greater retention at soil depth. The combined result is that more water is stored deep in the soil profile, a feedback favoring plants with long taproots versus native plants with shallow root systems. Understanding the combined effects of various environmental change factors in water-limited ecosystems is complex. Mechanistic explanations must be sought across ecosystems to understand how the physical and biological

Dalmation toadflax is becoming an invasive noxious weed on the northern mixed-grass prairie of southeastern Wyoming and northern Colorado.

Department of Renewable Resources graduate student Jennifer Schomp monitors gas exchange in prairie plants at the U.S. Department of Agriculture's High Plains Grasslands Research Station near Cheyenne.

Jennifer Schomp, left, and Peter Koenig monitor gas exchange data on prairie species.

landscape will respond to atmospheric change. This type of knowledge will be crucial to predicting the future face of a landscape.

The northern mixed-grass prairie of southeastern Wyoming and northern Colorado is dominated by the warm-season grass *Bouteloua gracilis* (blue grama). The prairie also consists of a suite of shallow-rooted, cool-season grasses such as *Pascopyrum smithii* (western wheatgrass) and *Hesperostipa comata* (needle and thread). The northern mixed-grass prairie, however, is fast becoming home to deeply taprooted invasive species such as the noxious weed *Linaria dalmatica* (dalmation toadflax). This perennial forb has bright yellow flowers with elongated spurs and large, clasping, diamond-shaped leaves. A tenacious root system makes it nearly impossible to pull from the ground. The plant spreads mainly by lengthy rhizomes but also drops approximately 500,000 seeds annually.

Invasive species cost ranchers and landowners in the United States billions of dollars annually. Cattle avoid dalmation toadflax due to its alkaloid content, allowing it to spread further across the prairie, displacing native plants. Seedling establishment is facilitated by soil disturbance or overgrazing. Rising CO_2 levels may confer competitive advantage to taprooted, invasive forb species and promote invasions in the northern mixed-grass prairie. Deeply taprooted plants can potentially escape the water limitation imposed upon grasses and other species with shallow root systems during episodes of surface drying.

To begin to understand the effects of atmospheric change upon dalmation toadflax and the native species in the northern mixed-grass prairie, a large-scale experiment has been implemented in the prairie just west of Cheyenne, Wyoming. This experiment is on the High Plains Grasslands Research Station administered by the U.S. Department of Agriculture's Agricultural Research Service (ARS).

Researchers from a number of universities, including the University of Wyoming and Colorado State University, and ARS scientists from Cheyenne and Fort Collins, Colorado, will study the response of prairie plants to elevated CO_2 and to warming treatments for five years.

In 2006, the PHACE, or Prairie Heating and CO_2 Enrichment, project was initiated using Free-Air CO_2 Enrichment (FACE) on the open prairie. This involves delivering elevated (mean of 570 parts per million, or ppm) levels of CO_2 to prairie plants via a system of tubing connected to a tank of pure CO_2. Control plants are exposed to ambient (mean of 370 ppm) levels of CO_2.

Plant physiological responses to the altered atmosphere were measured in the 2006 growing season. Jennifer Schomp, a graduate student in the Department of Renewable Resources, measured stomatal conductance (an indication of the size of leaf stomatal apertures controlling rates of CO_2 uptake and transpiration) and photosynthesis with a portable infrared gas analysis system over the growing season. This plant metabolic information will help in understanding whether elevated CO_2 will allow plants to reduce stomatal conductance,

David Williams administers a pulse of precipitation on the PHACE experimental site.

Jennifer Schomp conducts leaf photosynthesis measurements at the PHACE experimental site.

increase photosynthesis, and conserve water in a moisture-limited system as has been observed in other ecosystems.

Gas exchange measurements focused on the grasses blue grama and western wheatgrass, the native forb fringed sage (*Artemesia frigida*), and dalmation toadflax. Plant water potential, a measure of soil and plant water balance, was measured 13 times during the growing season to track plant water relations. Soil water content, soil and canopy temperatures, and specific leaf area were monitored during the growing season. Dalmation toadflax was monitored under ambient conditions for the 2006 study; its response to elevated CO_2 and warming will also be examined during this five-year experiment. UW ecology graduate student Peter Koenig investigated the biochemical responses of these species to precipitation events under elevated and ambient CO_2. UW botany graduate student Sarah Bachman monitored photosynthesis and respiration of the entire plant community to elevated CO_2.

Preliminary results suggest the northern mixed-grass prairie responds to elevated CO_2, as has been shown in other ecosystems. The physiological response of cool-season grasses and forbs is typically more dramatic than their warm-season counterparts due to a greater biochemical constraint under ambient CO_2 levels. The abundant warm-season grass blue grama displays less of a direct response to elevated CO_2, as it has a CO_2-concentrating mechanism favoring efficient photosynthesis under warm temperatures and low ambient CO_2 levels. Because lowered stomatal conductance contributes to soil moisture storage in all species under elevated CO_2, warm-season species enjoy an indirect benefit of enhanced plant water status. The deeply rooted forbs fringed sage and dalmation toadflax maintain higher plant water status relative to grasses late in the season, when water is most limiting, even without the indirect soil moisture benefit of elevated atmospheric CO_2. Further analysis of how elevated CO_2 affects plant attributes such as water-use efficiency and forage quality will be important in comprehending possible effects of atmospheric change upon the sustainability of native plant communities and rangeland agricultural productivity.

Understanding the physiological responses of dominant range species is important in efforts to predict the future face of this beautiful, productive, and economically important ecosystem. Shifts in typical patterns of resource partitioning by various species on the landscape have the potential to alter the balance of plant species composition over the long-term. If the inherent perennial taproot advantage in the semiarid ecosystem is amplified with direct effects upon photosynthesis as well as with indirect effects of increased soil moisture savings under elevated CO_2, then taprooted, invasive perennial species may have enough of a competitive edge in the long-term to dramatically alter the landscape.

Increasing our understanding of plant physiological responses to single and multiple atmospheric change factors will help us to gain a mechanistic view of the prairie landscape, upon which predictions regarding the future face of the northern mixed-grass prairie can be built.

To follow the progress of the PHACE study in Wyoming, visit www.phace.us.

Veterinary diagnostic laboratories in the 21st century

Donald L. Montgomery[a]
Associate Professor

Donal O'Toole[b]
Professor and Department Head

Department of Veterinary Sciences

[a]*Don Montgomery has worked in veterinary diagnostic medicine as a board certified pathologist since 1982.*

[b]*Donal O'Toole is past president of the American Association of Veterinary Laboratory Diagnosticians.*

Veterinary diagnostic laboratories (VDLs) such as the Wyoming State Veterinary Laboratory (WSVL) face formidable challenges in the 21st century as VDLs attempt to fulfill service roles to citizens. The WSVL, in West Laramie, is managed by the College of Agriculture's Department of Veterinary Sciences.

Higher salaries in private industry and approaching retirement present continual challenges involving hiring and retaining personnel for VDLs. Rocketing price tags of laboratories and equipment are daunting. Financial and technical support for required, up-to-date information technology is not readily available, and accreditation and international acceptance are major challenges.

Given the number of commercial private veterinary laboratories, asking how WSVL benefits the state and why the university underwrites a VDL is reasonable.

WSVL, established by statute in 1947, was operated by the Wyoming Livestock Board until 1978. WSVL was transferred to the University of Wyoming with a specific charge to research and report on causes of contagious, infectious, and communicable diseases found among livestock in the state. The mission has expanded to include diagnosis of companion animal and wildlife disease and testing for state- and federally regulated diseases. Support provided by public service VDLs goes beyond diagnosing disease in individual animals.

Organization, Staffing, and Testing Provided by Publicly Supported VDLs

VDLs are organized differently. Some, such as the WSVL, are in veterinary science departments. Many are housed in universities inside colleges of veterinary medicine. Others are under the office of the state veterinarian or operated by state departments of agriculture. For most state-supported VDLs, financial assistance reflects a combination of test fees and contributions from public funds.

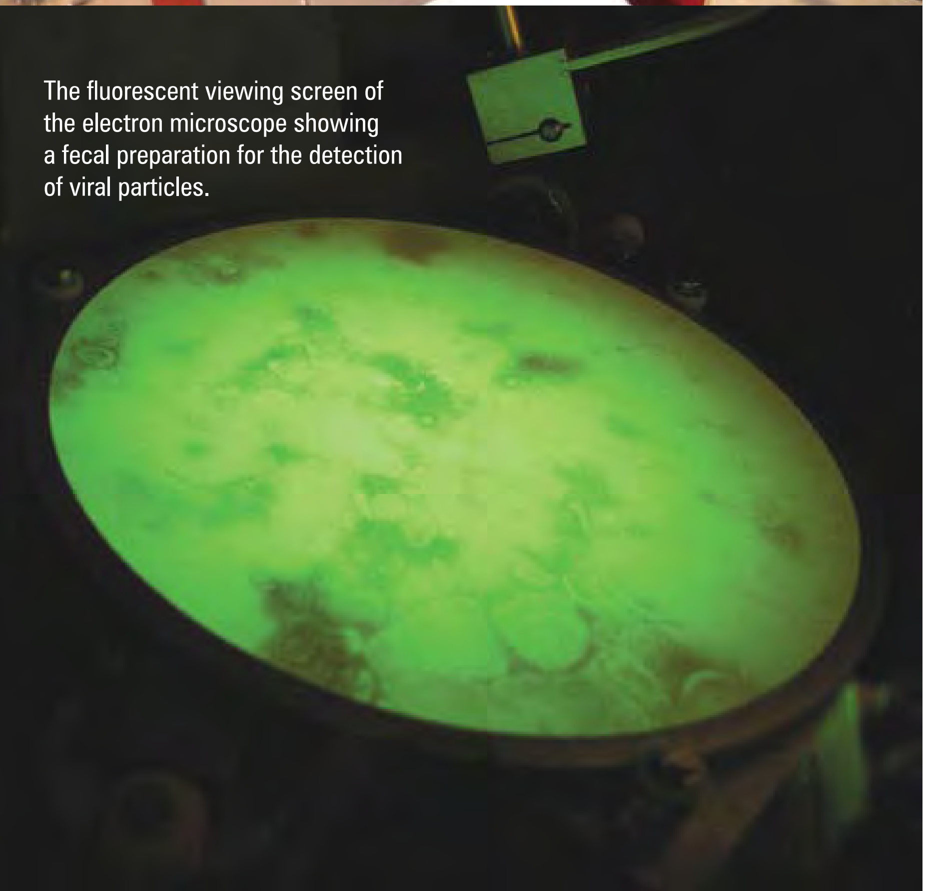
VDLs are staffed by professionals having doctor of veterinary medicine degrees (DVMs) and advanced training, DVM/Ph.Ds, or Ph.Ds in some field of diagnostic veterinary medicine. Disciplines represented are listed in Table 1 on page 20. Testing provided by VDLs includes an exhaustive array of procedures for diagnosing diseases in animals (Table 1).

Missions of Public Veterinary Laboratories

Support

Support to practicing veterinarians and animal owners in the diagnosis of animal disease has been a focus of VDLs since their inception. Most VDLs are full-service, providing support for production and companion animals and wildlife. Even the minimum diagnostic support for the various animals requires an array of tests, many being species-specific. Although a large private-enterprise veterinary laboratory industry exists, it focuses on profitable testing, most involving companion animals.

Carol Hearne, electron microscopist, inserts a specimen into the electron microscope.



The fluorescent viewing screen of the electron microscope showing a fecal preparation for the detection of viral particles.

Competition, staffing, retirement, information technology part of stresses to Wyoming State Veterinary Laboratory as it continues to provide services to public

Recognition and discovery

Recognition and discovery of new animal diseases frequently occurs. During the careers of current WSVL personnel, several new diseases have emerged. These include canine parvovirus (1970s), chronic wasting disease in elk, deer and moose (recognized as a spongiform encephalopathy by the late Professor Beth Williams at the WSVL during the 1980s), bovine spongiform encephalopathy, also known as mad cow disease (1980s), canine influenza, strains of highly pathogenic avian influenza causing human deaths, and many others. VDLs are often the first to recognize and characterize these diseases.

Surveillance for diseases

Surveillance for diseases of importance to animal industries is critical for the economic viability of production animals and wildlife. They include brucellosis, equine infectious

Table 1. Current staffing* and testing at the Wyoming State Veterinary Laboratory

Diagnostic Discipline	Purpose
Pathology (3)	
Gross Pathology (necropsy)	Gross dissection and evaluation of deceased animals to determine cause of death; collection of samples for other testing
Histopathology	Microscopic examination of tissues collected from necropsy; also includes examination of surgical specimens (biopsies) from live animals
Clinical pathology	Examination of blood and body fluids and other samples from live animals for evidence and type of disease
Microbiology	
Bacteriology/mycology (1)	Culture and other procedures for the diagnosis of disease caused by bacteria and fungi
Virology (1)	Isolation and other procedures for the diagnosis of disease caused by viruses; includes electron microscopy and serology
Parasitology (1)	Identification of internal and external parasites causing disease
Toxicology (1)	Identification of poisons as the cause of animal disease
Epidemiology (1)	Characterize the incidence and spread of animal disease

**Number of professional staff members in each discipline given in parentheses. Does not include the many dedicated technical staff members who are professional in their own right, often having bachelor's and master's degrees and technical certifications in their area of expertise. Also, does not include the many student workers who contribute greatly to the mission of WSVL, many of whom matriculate to careers in medical microbiology and veterinary medicine.*

Table 2. Some diseases of animals transmissible to humans that occur in Wyoming.

Disease	Causative Organism	Species Affected
Q-fever	*Coxiella burnetii*	Mainly goats and sheep – abortion
Chlamydiosis	*Chlamydophila abortus*	Mainly sheep – abortion
Brucellosis	*Brucella abortus*	Cattle, elk, bison – abortion
Rabies	Rabies virus	All mammals susceptible – encephalitis
Plague	*Yersinia pestis*	Wildlife, cats, dogs – septicemia, localized infection
Tularemia	*Francisella tularensis*	Wildlife, occasionally other species – see plague

anemia, bluetongue, equine viral arteritis, chronic wasting disease, scrapie, and bovine virus diarrhea, among others. Some have now been largely eliminated due to cooperative state-federal regulatory programs. Reservoirs of diseases, like brucellosis and tuberculosis, persist in wildlife at the wildlife-livestock interface requiring heightened and costly surveillance testing.

Interstate and international shipment of production animals and related commodities requires surveillance testing. Not least is the specter of high-impact foreign animal diseases entering the United States. WSVL is one of multiple VDLs approved to test for high-impact exotic diseases. WSVL personnel are approved for testing foot-and-mouth disease, classical swine fever, highly pathogenic avian influenza, and Newcastle disease.

Surveillance for zoonotic disease

Surveillance for zoonotic disease is a highly important function of VDLs. Some diseases in animals (Table 2) are zoonotic, i.e., transmissible from animals to humans. Many have the potential to cause serious human illness or death.

Education and research

Education and research are integral services offered by VDLs. The service commitment of WSVL faculty members varies from 50 to 70 percent, leaving little time for formal classroom or laboratory teaching and research. Instruction is often invisible to the university and general public. It occurs one-on-one in discussions with practicing veterinarians and animal owners regarding specific diseases. WSVL personnel present many hours of formal continuing education to veterinarians at state meetings. Research is often applied: developing new diagnostic tests, epidemiological studies of disease in a given locale, and defining the nature of recognized or newly discovered diseases. As Lynn Woodard, WSVL's director from 1986 to 1999, said, applied research in VDLs is often the cheapest and most effective in veterinary medicine. In 2006, personnel in the Department of Veterinary Sciences submitted or published approximately 50 scientific articles (http://wyovet.uwyo.edu/Newsletters.asp. Click on Volume 7, Issue 4), most based on diagnostic material. Presentations at scientific meetings for 2006 run into dozens.

Challenges for the 21st Century

Accreditation and international acceptance

Accreditation and international acceptance will be a major challenge. "Do the best job possible" is no longer acceptable for VDLs. The American Association of Veterinary Laboratory Diagnosticians is the official accrediting body in the United States. For full accreditation, VDLs must provide services to multiple animal species and meet all assurance and quality-control requirements, including time-consuming and costly documentation and validation of existing and new tests offered to the public. Testing for official state and federal programs must be conducted in approved laboratories.

Professional and technical staff members must meet minimum standards for education, training, and certification. WSVL was first accredited in 1989 and has been continuously accredited, most recently in 2005. Accreditation is for five years.

Information technology

Information technology will be crucial to VDLs. Efficient, timely delivery of results is imperative. No ideal data management system is available to meet the needs for all tests. WSVL's data management system is not perfect but is utilitarian. As communication with clients enters the 21st century, electronic transmission of laboratory reports will be expected – a service not currently available. Efficient retrieval of information on disease incidence in Wyoming, a need recognized by the hiring of WSVL's first epidemiologist, Assistant Professor Kenji Sato in 2004, will require modifying the existing system. These goals necessitate financial and technical support not currently available.

Laboratory facilities and equipment

Laboratory facilities and equipment are important issues. Many laboratories are crowded with no room for expansion. Testing is more sophisticated and automated, providing accurate, reproducible data on larger numbers of animals. With sophistication comes the need for additional laboratory equipment. This instrumentation is the same as in human laboratories. New instrumentation reflects the rising costs of human medical care; no price breaks are given for veterinary applications. The same is true of reagents to perform these tests. The life expectancy of laboratory equipment is short and typically is depreciated in five years or less.

Staffing issues are the most pressing and critical for VDLs, and this is true at the WSVL. Qualifications for professional diagnosticians entail four years of undergraduate education, four years for the DVM degree, and four to six years of specialized training in a diagnostic discipline. Educational programs have not adapted to attracting and increasing the number of students in several disciplines. Additionally, veterinary graduate education tends to focus on basic research, not service or applied research.

Certified histotechnologist and lab supervisor Paula Jaeger prepares the automated instrument for chronic wasting disease immunohistochemical staining. This instrument can stain 80 slides per run.

Failure of training programs to keep pace with demand and that downplay the value of diagnostic service have contributed to a critical manpower shortage. There is keen competition for personnel in all disciplines between academia, VDLs, and industry. The brightest new graduates and seasoned veterans of diagnostic service are attracted to industry in increasing numbers. Many are lured by modern, up-to-date facilities and by salaries and benefits that approach twice those of academia and VDLs.

VDLs attempt to offset manpower shortages by offering training programs, but there is no assurance these individuals will remain in diagnostic service after training. A goal of the WSVL is to establish one training slot for a veterinary diagnostician. There is also competition between VDLs for key diagnostic personnel. VDLs with the most up-to-date, well-equipped facilities likely will attract the best candidates. WSVL has outdated necropsy facilities. We conducted almost 700 necropsies in 2006. Our specimen receiving area is inadequate, and many labs are crowded with minimal to no room for expansion. WSVL is well-equipped with instruments.

Using a rotary microtome, certified histotechnologist Mercedes Thelen prepares tissue sections for chronic wasting disease (CWD) staining. In 2005, the pathology laboratory prepared 10,037 CWD slides for the pathologists to examine.

Retirements may account for approximately 70 percent of the anatomic pathology vacancies between 2008 and 2011. Five of nine professional staff members at WSVL will reach retirement age in five to six years.

Who will staff VDLs when these individuals retire? WSVL offers two externships to junior and senior veterinary students. One goal of the program is to encourage students to consider diagnostic medicine as a career.

Competition from private diagnostic laboratories

Competition from private diagnostic laboratories will be an issue. Private laboratories typically provide diagnostic services only for companion animals. Necropsies and in-depth workups are seldom offered. In some states, publicly funded VDLs have decided to limit testing to only food animals and horses leaving private labs to provide services for companion animals. Private labs leave gaps in testing deemed important by full-service VDLs. By not performing necropsies and comprehensive testing on companion animals, new diseases may remain unrecognized and surveillance for zoonotic diseases may not be accomplished. Plague and tularemia cases in cats in Wyoming in 2005-2006, for example, alerted physicians that both diseases were possible in the human population – as they were. The picture that emerged over both years in cats and wildlife would likely have been missed by private laboratories. Testing by private laboratories deprives state laboratories of cost-effective tests – tests that have often been developed and validated in the public sector. These tests generate net income for state laboratories and subsidize others that could not be otherwise offered. Few private laboratories will invest in the secure containment facilities required to work safely with biosafety level 3 (BSL-3) pathogens, those that may cause serious or potentially fatal diseases. WSVL is seeking a modular building so that such work can be done. In January 2007, the state of Wyoming requested letters of interest from architectural firms to design two BSL-3 facilities in accordance with the final report of the state's Biosecurity Laboratory Task Force. The task force proposed two state-owned facilities: one in Cheyenne to meet public health needs and a second at the University of Wyoming to meet the needs of the state's VDL and the Wyoming Game and Fish Department.

Financial support for public VDLs is a critical issue. Nationally, public financial support has tended to decline, resulting in a steady increase in fees levied for tests, compounded by the added expense of offering more sensitive and specific – but expensive – molecular assays. Public VDLs attempt to offset this by identifying profit center tests and by offering fees-for-service testing to the USDA for diseases of national concern, such as highly pathogenic avian influenza and mad cow disease. States will have to balance financing with the level of support required for the service they expect.

In diagnostic medicine, there will always be dedicated professionals who consider service a rewarding career. Despite challenges, diagnostic laboratories will continue to be service-oriented and provide a valuable, tangible commodity.

Getting a handle on ORVs

Question: For which recreational pastime did 37 percent of Wyoming households spend more than a million user days and almost $339 million in 2005?

Answer: ORVs, or off-road vehicles. About 92 percent of registered ORVs are ATVs, or all-terrain vehicles.

Thomas Foulke
Associate Research Scientist

David "Tex" Taylor
Professor

Department of Agricultural and Applied Economics

ORV use being big in Wyoming may come as no surprise.

A U.S. Forest Service (USFS) study put Wyoming second in the nation after West Virginia in ORV use. Yet, even though ORV use is perceived to be big, no one had much information on how big. This left a gaping information hole for public land managers and the state. Compounding this are growing calls for ORV regulation on public lands by conservation groups and counter calls from some hunting groups and trail users to keep regulation out of the equation.

New information is available with publication of a report by a group of researchers from the Department of Agricultural and Applied Economics. The group included Assistant Professor Chris Bastian, interim department head and Associate Professor Roger Coupal, Associate Research Scientist Thomas Foulke, Temporary Assistant Research Scientist Desiree Olson, and Professor David "Tex" Taylor.

The project was funded by the Wyoming State Trails Program (WSTP), a unit of the Wyoming Department of State Parks and Cultural Resources. WSTP has administrated the state's ORV permit program since its inception in 2002 (Figure 1). ORV users who want to ride on enrolled roads and trails (those designated by public land managers and county government) must register and purchase a $15 decal for their

Figure 1. Number of Wyoming ORV permits sold, 2002 to 2005

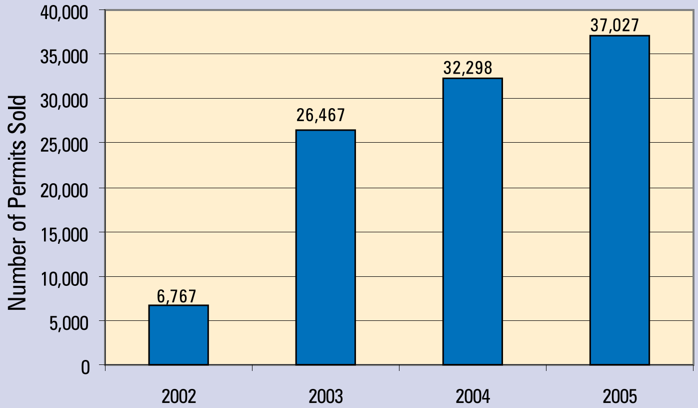


Figure 2. ORV usage by month – resident and non-resident.

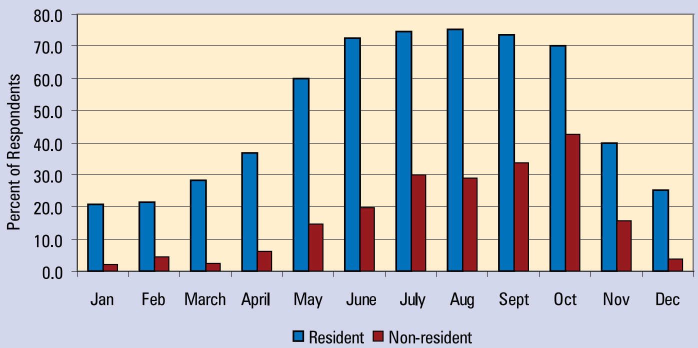


Figure 3. Destination by percent of trips – resident and non-resident.

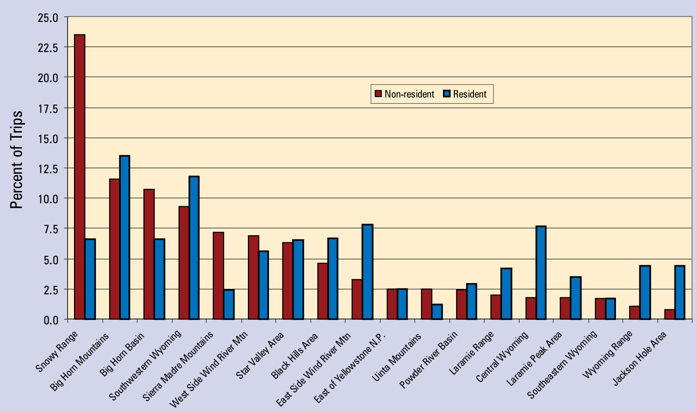
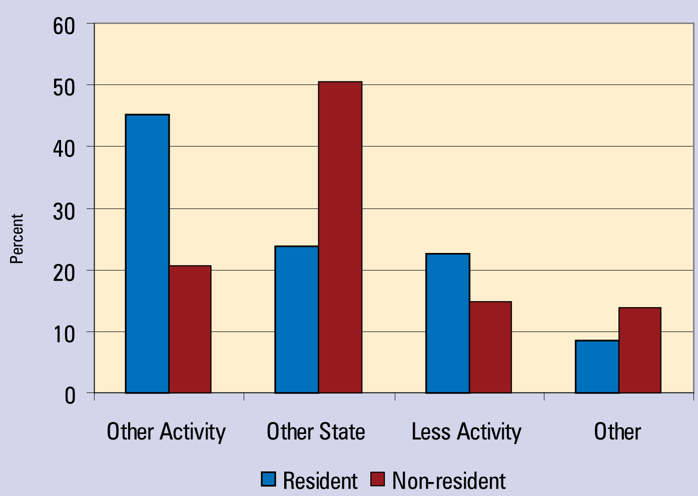


Figure 4. Other outdoor activity if unable to ride ORVs for recreation in Wyoming



ORV (see text box, page 25 for Wyoming's definitions of ORVs).

WSTP uses the money to establish and maintain trail systems, print maps, improve safety programs, and work with interest groups and public land managers on behalf of trail users. There are approximately 1,500 miles of trails in the system. About 98 percent are on USFS and Bureau of Land Management lands.

WSTP officials wanted to know how many ORVs are in the state, the number of jobs created by ORV use, and income impacts on Wyoming's economy. Also, they sought information on where people like to ride, how often, how much it costs to travel there, and how many times a year they go.

Researchers were charged with conducting a survey and analyzing results. Two surveys were used. One, the *2005 Off-Road Vehicle Survey,* was sent to about 1,900 residents and non-residents who purchased a 2004 Wyoming ORV permit. Its purpose was to collect demographic and trip expenditure data.

The first survey only addressed those who register their ORV (since they purchased a permit). The researchers commissioned another short survey of their own through the Wyoming Survey & Analysis Center (WYSAC). WYSAC conducted a random telephone survey to determine what proportion of state residents own or ride ORVs.

The study comes at an opportune time for more than just the WSTP. There is very little research available on ORV numbers and use in Wyoming and, as their numbers have mushroomed in the last decade or so, land managers are struggling with questions of use and overuse. ORV use has become a hot-button issue, especially in the West, where there is a significant amount of public land. There have been similar studies in Colorado and Utah but nothing for Wyoming.

The results contained interesting surprises. The multipurpose nature of ORVs means they are ridden throughout the year.

Non-residents tend to come to Wyoming to recreate on ORVs just one or two months of the year, concentrated in late summer and fall. Resident use peaks in August, which is part of a broad plateau of summer and fall use; however, ORVs are ridden throughout the year with no month having less than 20 percent riding at least once during the month (Figure 2).

The multi-use nature of ORVs also lends them to other activities. People use them not just to ride for riding's sake but also to access areas they may not normally be able to for activities including hunting, fishing, and camping.

Non-residents led residents in the hunting category. Residents led in the ORV riding category. This is not surprising since residents have more opportunity to ride whereas non-residents have to plan what may be a single trip to Wyoming and may include several activities.

Residents tend to be more dispersed in geographic use, primarily the result of place of residence. Residents tend not to travel more than two hours and about 150 miles from home to recreate with ORVs. Non-residents tend to travel 250 miles or more and showed a preference for the Snowy Range in southeastern Wyoming followed by the Big Horn Mountains in north-central Wyoming and, to some extent, southwestern Wyoming locations (Figure 3). Both residents and non-residents showed a preference for USFS lands.

About 64 percent of resident ORV riders spent at least one night away from home while recreating, compared to almost 92 percent of non-residents. This was obviously related to the distance traveled to recreate.

Survey respondents were asked what they would do if they were unable to ride ORVs in Wyoming. Less than 25 percent of residents responded they would start recreating in other states. More than 80 percent of non-residents responded they would not recreate in Wyoming (Figure 4). This represents a potential loss of tourism dollars to the Wyoming economy.

Non-residents coming to Wyoming to ride ORVs are bringing vacation dollars and spending them in the local economy. These are the dollars measured as economic impact. For ORVs, the project estimated that non-residents spent $44.8 million in Wyoming in 2005, and these expenditures are associated with 679 jobs and $17.6 million in labor earnings. Residents are estimated to have spent $338.9 million from owning and recreating with ORVs during the same period.

ORV riders add to government revenues, too. Sales taxes, gasoline taxes, lodging taxes, and permit registration fees add up. Residents contributed an estimated $16.4 million per year and non-residents about $2.1 million for a total of about $18.5 million per year.

The telephone survey, a short, random survey of the state used to calculate how many people own and ride ORVs, provided the biggest surprise. It estimated about 150,000 ORVs in the state and that about 37 percent of Wyoming households own one. The survey also estimated there is an average of 2.4 riders and two ORVs per participating household.

The margin of error for this survey is plus or minus 5.6 percent.

Since the mail survey only accounted for those who register ORVs, the telephone survey was vital in estimating what proportion of the total population engages in this recreational activity.

To download the complete, 85-page report, go to the Wyoming Economic Atlas at http://agecon.uwyo.edu/EconDev/ORVs.htm

What is an ORV?

Wyoming law differentiates off-road vehicles (ORVs) into three types:

Type 1: A recreation vehicle primarily designed for off-road use that is 50 inches or less in width, has an unladen weight of 900 pounds or less, and is designed to be ridden astride upon a seat or saddle and travel on at least three low-pressure tires.

Type 2: Any unlicensed motorcycle having an unladen weight of 600 pounds or less designed to be ridden off road with the operator astride upon a seat or saddle and that travels on two tires.

Type 3: Any multi-wheeled, motorized vehicle not required to be licensed and is designed for cross-country travel on or over land, sand, snow, ice, or other natural terrain and that has an unladen weight of less than 900 pounds.

Wyoming Statute 31-1-101 (a) (xv) (K)

Figure 1. Asian migratory locust.
Photo by Scott Schell and Alex Latchininsky, UW.

Eye in sky peering at Central Asian habitat

Satellite technology provides giant leap forward in lowering manpower demands, increasing information available to those planning management strategies

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Project Leader "Sustainable Locust Management in Central Asia"

Locusts – the ancient enemies of men

Locust swarms since biblical times have been a nemesis to agriculturists.

Swarms, often consisting of millions of locusts, can wipe out vegetation over large geographic areas in a few days. Even in the 21st century, locust management remains a costly and environmentally hazardous venture: expenses to control the recent desert locust plague in West Africa in 2003-2005 exceeded $90 million, with 32 million acres treated with broad-spectrum insecticides. Yet, during peak locust outbreaks, farmers on all continents still can lose the fruits of their labor in a matter of hours.

National and international agencies are working together to prevent or minimize the impact of locust outbreaks not confined within national boundaries.

This is particularly true for Central Asia, where locusts thrive on vast and sparsely populated areas. One of the most notorious pests is the migratory locust *Locusta migratoria* L. (Figure 1), which inhabits stands of common reed along rivers and lakes but, as its name suggests, can travel long distances until it finds crop fields to devour. Its biggest breeding area is situated in the Amudarya River Delta near the Aral Sea, 300 miles east of the Caspian Sea (Figure 2).

Locust monitoring and control

The Amudarya delta provides favorable wetland conditions for the migratory locust survival and reproduction. The sandy river banks serve as egg-laying sites, while the reed stands

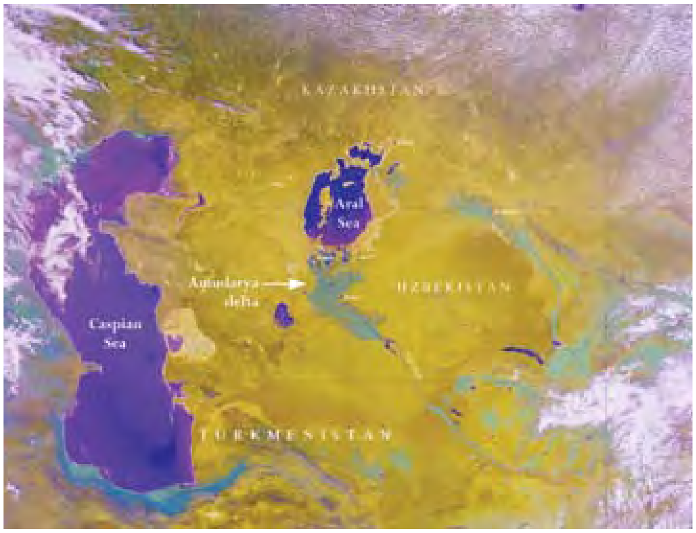


Figure 2. Study area.

helps UW researchers ease locust monitoring

furnish food and shelter for hoppers and adults (Figure 3). The outbreaks occur at irregular intervals, last for several years, and devastate nearby irrigated crops.

Locust swarms can disperse in different directions covering more than 700 miles. Usually, the outbreaks follow abnormally dry years when larger areas emerge from flooding, expanding the habitat suitable for egg-laying. The primarily grass-feeding migratory locust is admirably adapted to the reed monoculture and plays a major role in the cycling of nutrients; however, it becomes a ruthless agricultural pest when the swarms fly out of the reed beds. Thus, the principal goal of locust control is to prevent the development of the dense swarms capable of emigration flights out of the reeds into the crop areas.

Despite the contraction of the locust habitats caused by the desiccation of the Aral Sea, traditional ground surveys remain extremely difficult. Furthermore, recent changes in the hydrological structure resulted in the increase of water flow into the sea. The subsequent expansion of the reed beds in the Amudarya delta enlarged the areas of locust habitats and increased the risk of locust infestations.

Accurate and timely survey became a necessity for efficient locust management under rigorous financial constraints.

According to guidelines for the ground survey, the average daily area inspected by a professional scout is between 250 and 375 acres. This means that, for a team of 20 scouts (the number of locust personnel working in the Amudarya delta), 11 to 16 months are needed to survey the entire delta, which occupies 2.5 million acres. In the real world, the nymphal survey period is limited to three weeks.

Taking into account the paucity of resources combined with difficult accessibility and a poor road network in the delta, the traditional ground survey methods are obviously inadequate for efficient locust management. Finding locust-infested areas becomes guesswork. As a result, vast wetland areas of more than one million acres a year become blanketed with broad-spectrum insecticides, which aggravate the negative impact on the fragile wetland ecosystem. On the other hand, locust swarms often escape control from the remote delta areas wreaking havoc to nearby wheat and cotton fields. Identification of reed areas as potential migratory locust habitats is the key to successful management of this pest.

Photo by Evelin Kirkilionis-Wilps (GTZ).

Figure 3. Reed beds in the Amudarya delta.

Satellite images: An effective solution?

While finding reed-covered areas is tedious from the ground, University of Wyoming scientists developed a different approach. They used the omnipresent eye in the sky, or remotely sensed data from satellites. Certain satellites like NASA's Moderate Resolution Imaging Spectroradiometer (MODIS) – http://modis.gsfc.nasa.gov/ – collect information daily, and the data are free of charge. Satellite technology uses different reflectance from ground features, particularly in the infrared waves invisible to human eyes. Each feature like water, soil, or vegetation has a unique "signature," which a satellite sensor stores in a digital format (Figure 4).

A "raw" satellite image represents a mosaic of pixels, like a digital photograph. In a MODIS image, each pixel corresponds to an area 300 by 300 yards on the ground and is assigned a certain number depending upon the "spectral signatures" from the land cover features, which the pixel contains.

Different types of vegetation also create different spectral signatures. Knowing these signatures, researchers can assign the pixel to a particular land cover class like water, sand, or even vegetation type. The processed image contains meaningful information regarding features on the land surface (Figure 5). Satellites periodically collect new data, which can then be used to update the maps.

Figure 4. Spectral signatures of different ground classes obtained from a satellite.

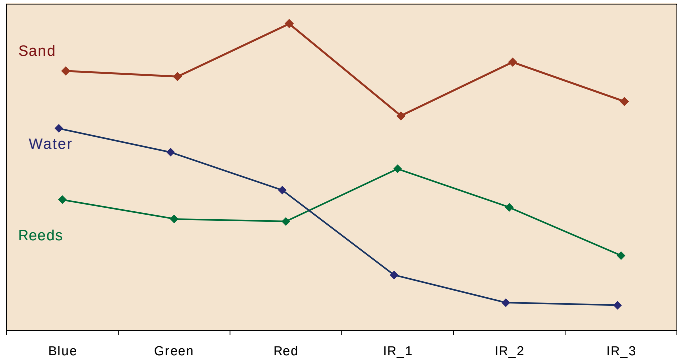


Figure 5. Classified MODIS satellite image of the study area near the Aral Sea.

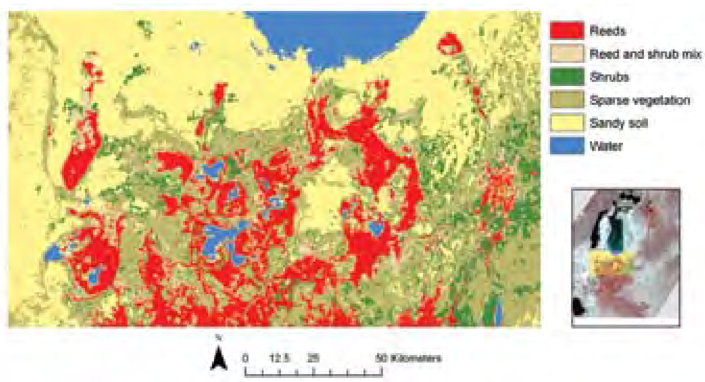


Table 1. Areas of land cover classes found in the study zone near the Aral Sea based on the MODIS satellite image and associated risk of locust infestation.

Land cover class	Area in acres (% of total)	Risk of locust infestation
1. Reeds	986,598 (18%)	High
2. Reed and shrub mix	340,264 (6%)	Medium
3. Shrubs	204,612 (9%)	Medium/Low
4. Sparse vegetation	505,607 (22%)	Low
5. Sandy soil	2,216,859 (39%)	Low
6. Water	322,796 (6%)	Low

International collaboration: A key to success

Mapping locust habitats in the Amudarya delta using satellite imagery is an international project funded by the German Agency for Technical Cooperation (GTZ) and NASA via the Upper Midwest Aerospace Consortium (UMAC). UW is an active member of UMAC. The project is coordinated by the Association for Applied Acridology International, a virtual consortium of locust specialists from 21 countries that operates under the auspices of UW.

Our field work in Uzbekistan was conducted in collaboration with GTZ and Uzbek Plant Protection Services. We also conducted two aerial reconnaissance missions to survey remote areas near the Aral Sea, which could not be accessed from the ground.

Using MODIS satellite images and combining them with field data, we generated a map portraying reed distribution within the delta. We identified large areas of reed beds throughout the delta and estimated areas of various features, such as reeds, other vegetation, water, and bare ground (Table 1). Through this process, we were able to provide the percent area occupied and location of reeds within the delta. Plant protection specialists are now using this information to seek out areas for locust surveys and to improve the efficiency of their locust monitoring program.

Instead of blanketing the entire delta with poisonous insecticides, they are able to target control operations only to the areas of reed stands, which occupy less than 18 percent of the Amudarya River Delta. The result of such targeted treatments is an obvious win-win situation from economic and ecological aspects.

What's next?

Migratory locust is one of several locust species threatening agriculture in Central Asia. Satellite technology proved a useful tool in locust monitoring, and we expanded our expertise to different geographic areas and different locust species. We are working with scientists from Novosibirsk State University (Russia) and personnel from the Plant Protection Services in Kazakhstan to map the Italian locust habitats along the Russia-Kazakhstan border. We are also working with GTZ and Uzbek Plant Protection Services personnel to map the Moroccan locust habitats along the Uzbekistan-Afghanistan border. Through these collaborative efforts with several national and international agencies, UW is emerging as a leader in generating locust habitat information using satellite images for Central Asia.

To learn more about these projects:

Sivanpillai R., Latchininsky A.V., Driese K.L., & Kambulin V.E., 2006. "Mapping locust habitats in River Ili Delta, Kazakhstan, Using Landsat Imagery." – *Agriculture, Ecosystems & Environment* 117: 128-134.

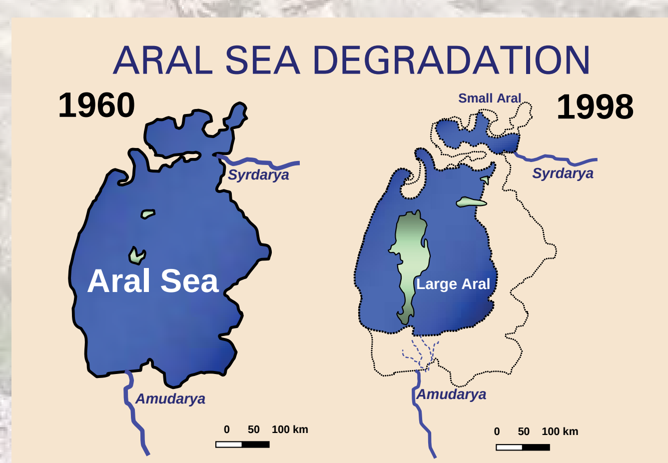
Sivanpillai R. & Latchininsky A.V., 2007. "Mapping locust habitats in the Amudarya River Delta, Uzbekistan, with multi-temporal MODIS imagery." – *Environmental Management* 39: 876-886.

Ecological disaster: The dying sea

Land-locked in the heart of Asian semi-deserts, the Aral Sea is a huge, saltwater lake. It does not have outlets, and it is fed by only two tributaries, the Amudarya and the Syrdarya rivers. Until the 1960s, the Aral Sea was the fourth largest lake on the planet. Three decades later, it has lost 85 percent of its volume and 60 percent of its area and moved down to eighth place on the list of world's largest lakes.

The rapid and irreversible desiccation of the Aral Sea is one of the most dramatic ecological catastrophes on Earth. It was triggered by the increasing diversion of water from its tributaries for agricultural needs. Whereas at the beginning of the 20th century, only about 5 percent of the total river flow was used for agricultural purposes, the rapid expansion of the irrigated area from 14 to 21 million acres led to an almost total extraction of the average annual river flow by the end of 1980s. As a result, the shoreline receded by 80 miles and exposed 9 million acres of the former sea bottom.

The emerged soil remained devoid of any vegetation and became a salty desert. The desertification was accompanied by a dramatic decrease in biodiversity. Fifty plant species went extinct in the Amudarya River Delta. The number of nesting bird species fell five times, and the number of mammal species dropped from 30 to 10. Because of the three-time increase in water salinity, all 24 native species of fish have been lost. The fishing industry died out, and the formerly thriving fishing port of Muynak is now 30 miles from the shoreline. Frequent dust storms aggravated the severe soil erosion.



Aral Sea in 1960 (left) and 1998.

Rusting fishing vessels on the former Aral Sea bottom near Muynak. Photo by Evelin Kirkilionis-Wilps (GTZ).

Precision agriculture can reap

Precision herbicide application study finds higher rates of return on larger fields

Larry Held, Professor • Matthew Fleming, Graduate Student
Department of Agricultural and Applied Economics
Stephen Miller, Professor • David Claypool, Master Technician
Department of Plant Sciences

The controls on a precision crop sprayer, including the rate controller, field computer, boom controls, and Global Positioning System receiver.

Adopting a precision herbicide application (PHA) system for controlling skeletonleaf bursage (SB) in winter wheat can be an economical choice – even in a series of drought years – for Wyoming producers pondering whether to use blanket applications.

They could reap savings through lower herbicide costs.

The Department of Plant Sciences and Department of Agricultural and Applied Economics conducted field studies from 2001 to 2003 exploring the use of PHA technology to control bursage (*Ambrosia tomentosa* Nutt.) in southeast Wyoming. Bursage, also known as burr ragweed, is an aggressive, creeping perennial weed closely related to ragweed. Native to the Great Plains, the plant is difficult to eradicate because of its extensive horizontal root system and tolerance to many herbicides.

PHA uses electronic controls plus Global Positioning System to spray only infested areas of a field instead of blanket applications across entire fields, or a whole-field application.

SB is a good candidate for PHA because it is a perennial, tends to prefer soil types where water collects, and grows in dense patches rather than being randomly distributed. These characteristics make its location predictable from year-to-year and easier to map than an annual weed that may appear randomly in a field.

The Department of Plant Sciences' precision agriculture sprayer uses commercially available components assembled to meet the needs of research.

Reducing herbicide costs would help winter wheat producers with this weed problem achieve better profit margins. Yields are generally expected to increase when weeds are controlled; however, severe drought persisted during the years of the field study, and there was no yield advantage from herbicide applications.

The economic benefits of PHA presented here are from reduced herbicide costs. In this context, the analysis of the cost of adopting this technology and resulting herbicide cost savings are a worst-case scenario in which a farmer utilizes the technology and an unfavorable weather condition, such as drought, follows.

Economic Analysis

Rates of return on investment (RRI) is a method to compare returns to an alternative investment such as a certificate of deposit or the stock market. RRI is the return after all expenses have been subtracted.

The economic analysis used equipment costs required to convert an existing sprayer to a PHA system ($13,428) plus extra maintenance required ($281 per year). Herbicide cost at the

herbicide cost savings

Bursage

time of the field studies was $11.19 per acre for Curtail®, which was selected because it was the most economical herbicide giving effective control of SB at the time. Cost savings of PHA compared to whole-field application would be the herbicide cost of the unsprayed fraction of the field.

All costs and benefits for this study were computed on a real 2004 dollar basis. This method, rather than adjusting for inflation, was used because real interest is more predictable than inflation.

Many field sizes of dry land wheat were considered in Laramie County in southeast Wyoming, representative of the High Plains in the three corners area of Wyoming, Nebraska, and Colorado. Typical SB infestation rates ranged from 1 to 40 percent, although higher rates were included to test the sensitivity of the RRI method.

Results and Discussion

Table 1 summarizes RRI realized from investing and using precision application technology for different field sizes in combination with alternative field infestation rates ranging from 10 to 80 percent. Positive rates of return from PHA are shown for all combinations of field sizes and infestation rates.

A consistent pattern of high return rates are observed with larger fields because more acres reap the benefits of herbicide savings from PHA compared to whole-field application.

Fields with higher infestation rates show lower rates of return because herbicide requirements move closer to that of whole-field application.

If covering the whole field is necessary, there is little reason to incur the extra cost of PHA technology, and there is little or no saving in herbicide usage or cost. Table 1 also indicates that, given all field sizes, there is less incentive to adopt PHA if bursage infestation rates equal or exceed 50 percent of field acreage. Fields should be greater than 600 acres to realize high rates of return if adopting precision applications in this scenario.

Conclusions

Adopting a basic precision herbicide application system for controlling bursage in winter wheat can be an economical choice due to savings in herbicide cost even in a series of drought years.

This is especially true if infestation rates are low in combination with large fields. Adopting PHA on smaller fields having very high infestation rates (60 to 80 percent) would not be economical. The size of the field and the scale of a weed problem must be examined when considering using precision herbicide weed control technology.

This project was limited to analyzing the adoption of PHA technology to control one weed species. Because the equipment can be used for all herbicide applications, the conversion to this technology may have the potential to be more profitable than shown here. Because PHA is a rapidly changing technology, a producer must always use current prices and equipment when making the decision to adopt it.

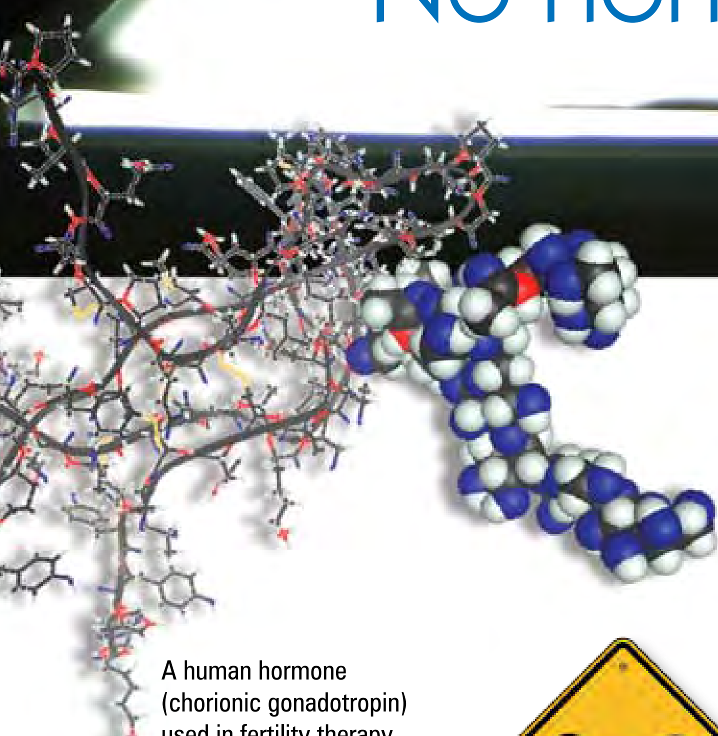
Table 1. Rates of return on investment from adopting precision herbicide application, based on a 6-percent interest rate, given alternative field sizes and infestation rates.

Infestation Rate (%)	Rates of return (%) -------------- Field size (acres) --------------			
	600	900	1,200	1,500
10	18.7	23.6	27.2	30.1
20	17.3	22.2	25.8	28.6
50	11.9	16.6	20.0	22.7
60	9.5	14.0	17.3	20.0
80	2.1	6.4	9.5	11.9

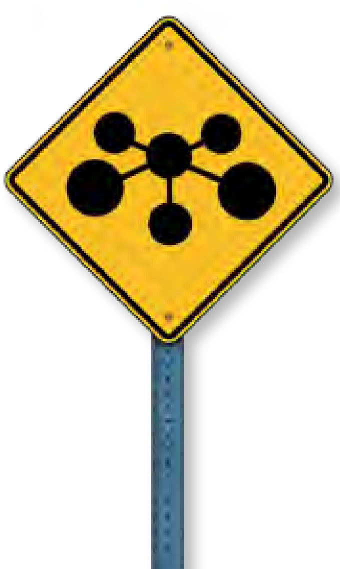
Christoph Geisler identifying exposed spots on X-ray film that indicate the presence of a gene in a corresponding bacterial virus.

The buzz in these researchers' laboratory is all about using insects to produce marvels beneficial to mankind

No honey, just glycans — getting the sugars



A human hormone (chorionic gonadotropin) used in fertility therapy. The large structure in the bottom right is the glycan; the rest is the protein part. Glycans are comparable in size to the protein they are placed on, and there may even be more than one of them.



Christoph Geisler
Department of Molecular Biology Graduate Program

Most people connect sweetness with honey and then honey with insects.

In the molecular biology laboratory operated by Professor Don Jarvis, that connection is quite different. Here, insect cells are modified to become more human-like and make proteins with sugar groups that could be used to diagnose or cure diseases.

Such proteins are used for research purposes or could be vaccines to help combat diseases. Since the early 1980s, scientists have used insect cells for this, as the properties of proteins produced by these cells are very similar to those of proteins found in humans.

One way to produce enough purified protein is identifying the gene that encodes the protein and putting it into a harmless insect virus. Insect cells that keep dividing and multiplying can be grown in large numbers under the right laboratory conditions. These cells are suspended in a milky solution and are shaken gently around the clock in the laboratory by machines. When these insect cells are then infected with the virus, they are reprogrammed to make the desired protein in large amounts.

Unfortunately, there are subtle differences between proteins coming from humans and those produced by insect cells. Some proteins have sugar groups called glycans on their surface. These must have a specific structure when the proteins are to be used as drugs. The glycans on proteins from insect cells are shorter than those on the same proteins found in humans.

right in insect cell-produced proteins

The machinery needed to make large, human-like glycans is simply not present in insect cells. As a result, protein drugs made in insect cells would quickly be broken down in the human body and would not work well. This is why many protein drugs are not made in insect cells, even though insect cells can churn out larger amounts than other cell types. The Jarvis lab began to modify insect cells to make human-like glycans to harness their production capability.

Insects: Not very sweet

In insects and humans, glycans are made in several steps: first, a large precursor structure consisting of 14 sugars linked together is put on a new protein. Next, some of these sugars are removed until a core of six sugar groups is left. In humans, the path then turns around and different sugars are added to form larger structures (Figure 3).

Much work has been done in the Jarvis laboratory to engineer insect cells to produce human-like glycans. Initially, this involved discovering the genetic differences between insects and humans. Insects are very different from people, but most of these differences disappear at the molecular level. When looking at the DNA sequences that encode the makeup of an organism, insects and humans are actually quite similar.

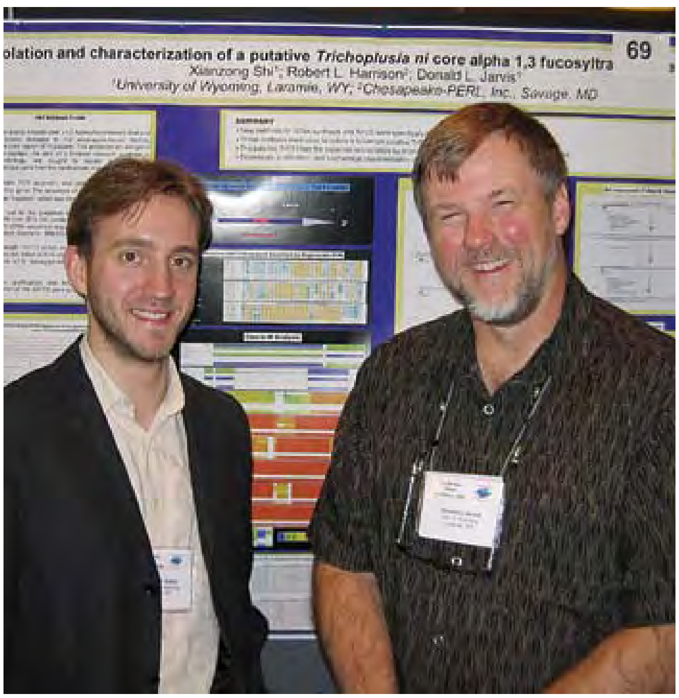
The complete DNA sequences or genomes of 12 insect species, including the silkworm, the malaria mosquito, and the honeybee, have been decoded.

Scientists can determine if a specific gene is present in a species. Using the genome of the fruit fly, which was the first insect genome to be decoded, researchers discovered that insects have all the genes needed to make the glycan precursors and put them on proteins. But, while insects have all the genes needed for the trimming reactions, they lack the genes for making the human-like structures.

Making insect cells more human-like

To make proteins with human-like glycans, insect cells need to have the genes that, in humans, are involved in enlarging them. The Jarvis group set out to do this in the 1990s. First they built a toolkit to allow human genes to be expressed in insects. This involved identifying the human genes that encode for the enzymes that extend the glycans. It also involved identifying stretches of DNA, called promoters, which allow the insect cells to read and actually use the human genes.

Promoter-gene combinations were then put into insect cells to create new, transgenic (containing a



Professor Don Jarvis, right, and graduate student Christoph Geisler at the Society for Glycobiology meeting in Los Angeles, California, November 2006.

gene from another species) insect cells with the human enzymes needed to make more human-like glycans. By using this approach for several human genes needed to make the largest and most complex N-glycans, the Jarvis lab created transgenic insect cells that can be used to manufacture proteins with sugar structures identical to those found in humans.

Knocking out genes: Less is more

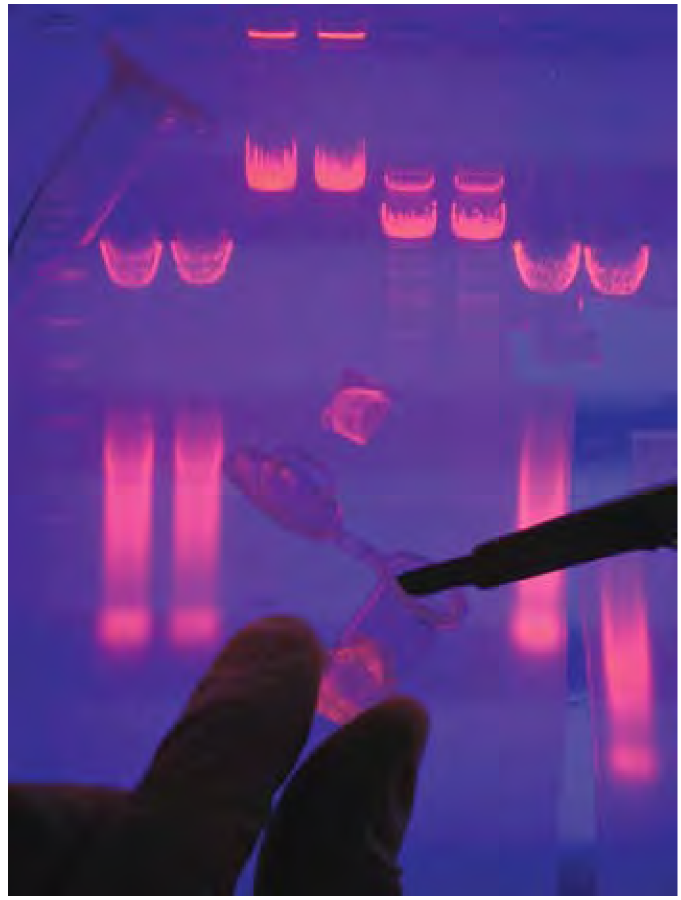
Insects not only lack the genes humans have to make large and complex glycans, they also have genes absent in humans. Some of these cause cells to make glycans not present in humans. These unnatural glycans can cause allergic reactions if insect cells are used to make protein drugs for use in humans. Thus, to ensure that protein drugs produced in insect cells are safe, the genes responsible for these glycans must be eliminated.

Recently, one of these insect genes was identified in the Jarvis lab. This gene codes for an enzyme that adds a single sugar called fucose to the glycan to produce a structure not found in humans.

Another recently identified insect gene is responsible for a glycan trimming step that does not occur in humans. By knowing the DNA sequence of such genes, it becomes possible to eliminate the products they encode. This can be done through a process called RNA interference, a process plants, animals, and humans use to turn off certain genes. Two U.S. scientists discovered the mechanism behind this and received the 2006 Nobel Prize in Medicine for their research. By including this approach, insect cells can be made that produce protein drugs or vaccines with human-like glycans even more efficiently.

Currently, the first influenza vaccine made in insect cells is on its way to be approved by the U.S. Food and Drug Administration. The Connecticut company Protein Sciences Corporation developed a method to manufacture some parts of the influenza virus in insect cells to replace the old process, which involved growing the virus in chicken eggs.

Growing live virus to produce a vaccine makes its production more complicated as additional safeguards are needed to ensure the vaccine cannot cause an infection. As insect cell-produced vaccines are made without live viruses, they are inherently safer. Even if not stated on the label, chances are that in the future your flu vaccine will be made utilizing insect cells.



Isolating DNA from an agarose gel. Here, DNA coding for a human transporter gene involved in glycan biosynthesis is isolated. Ultimately, this gene will be expressed in insect cells, making them more humanlike.

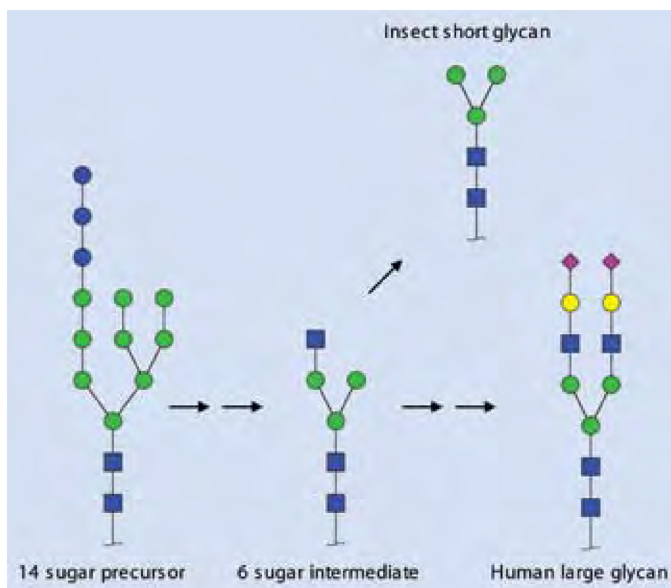


Figure 3. Insect glycan synthesis compared to the human process. The first half of this pathway is the same in humans and insects; however, insects produce only short, trimmed structures, whereas humans have larger and elongated glycans.

UW study recommends ranchers sample range grasses for mineral content

Grasses sampled on four Wyoming ranches didn't always provide sufficient levels of needed minerals

Blaine Horn
Big Horn Mountain extension educator (Johnson and Sheridan counties)
University of Wyoming Cooperative Extension Service

The health and well-being of their livestock is a top priority for Wyoming ranchers. Healthy livestock have higher conception rates and weight gain. A small increase in either or both can help a ranching operation remain sustainable and thus maintain the wide open spaces we all appreciate in Wyoming.

Range livestock ranchers want to lower costs of production to help keep operations viable. A subject some Wyoming ranchers have become interested in that affects animal health and production costs is the mineral content of native rangeland grasses their livestock must eat.

Minerals are important in the health and production of livestock. If grasses have inadequate mineral levels, ranchers can provide cattle and sheep appropriate levels in a custom mineral mix and possibly at a lower price than a standard mix. In addition, standard mixes might not provide right amounts of the lacking minerals or more than what is needed of other minerals.

A research project was conducted in 2002, 2003, and 2004 on four Johnson County, Wyoming, ranches to determine how much of the macro minerals calcium, phosphorus, potassium, magnesium, and sulfur, and micro minerals iron, zinc, manganese, and copper native range grasses contained between May and November. Macro minerals are needed in the tissues in larger amounts than micro, or trace minerals. Mineral levels found in these grasses were then compared to the amounts required by a beef cow and sheep ewe.

Although knowing mineral content of range grass throughout the year would be desirable for ranchers whose cattle and sheep graze native range year-round, funding limits prevented obtaining this data, except

Reservoir pasture of the Willow Creek Ranch May 16, 2003. Grass samples were clipped from 10 randomly placed 2½-square-foot hoops along a 300-foot transect.

for in March 2004. Because alfalfa and grass hay is the main source of forage for many range livestock during winter and early spring, knowing their mineral content may be more important than knowing that of range grass during this period.

Participating ranchers were Dave and Don Hall, who ranch along French Creek northwest of Buffalo; Don and Peter Meike, who ranch in the Sussex area east of Kaycee; Jim Moore, whose ranch lies in the very southeast corner of Johnson County; and Gene Vieh, who owns the Willow Creek Ranch at the Hole-in-the-Wall southwest of Kaycee.

Current year's growth of leaves, stems, and seed heads of western wheatgrass, needle and thread grass, prairie Junegrass, Sandberg's bluegrass, bluebunch wheatgrass, slender wheatgrass, green needlegrass, and threadleaf sedge (a grass-like plant) were periodically harvested by clipping from pastures of the above ranches.

Although grass mineral levels were generally similar among the ranches, grasses at the Vieh ranch usually contained higher amounts of calcium, magnesium, iron, and manganese and lower levels of phosphorus and copper compared to grasses from the other ranches.

Concentrations of phosphorus, potassium, magnesium, sulfur, and zinc in the grasses were highest in the spring and declined as the plants matured and went dormant in the fall; however, calcium, iron, and manganese levels increased during the growing season, but the March 2004 samples indicated that concentrations of these minerals declined with the death and winter weathering of leaves and stems. Thus, producers may want to sample range grass at least in February, May, August, and November – especially if these times coincide with the following production stages – to provide the right amount of minerals.

A beef cow's and sheep ewe's mineral needs change with their stage of production. Their needs are lowest after weaning and highest, especially for phosphorus, calcium, potassium, and magnesium, during the first few months of lactation. For beef cows, sampling range grasses for mineral analysis should occur at the start of calving, two months following calving, at weaning, and during the seventh month of pregnancy. For ewes, sample at the start of lambing, at weaning, at flushing, and during the third month of pregnancy if their main source of forage is from range grasses during any of these times.

Ranchers may also want to sample hay for mineral analysis as it is often the main forage source for livestock during winter but does not necessarily contain adequate amounts of required minerals. University of Wyoming Cooperative Extension Service (UW CES) offices around the state can assist in how to take a hay sample, and many have hay probes for taking samples.

The only minerals within the grasses that were at adequate levels for livestock were calcium and iron. Potassium content was sufficient, except in late fall and in the March 2004 samples. Many Wyoming ranchers begin calving and lambing in late winter. The potassium requirement of cows and ewes is highest at this time because of milk production, but during this period the potassium level in range grass is low. Providing cows and ewes with additional potassium through supplements or hay in late winter, when they are nursing, ensures their feed consumption remains at a level for them to maintain, if not gain, weight. Reduced feed intake is a sign livestock are not obtaining enough potassium in their diet.

The grasses generally contained a sufficient amount of phosphorus to meet the needs of a cow only in the spring at the Hall, Meike, and Moore ranches but did not contain enough for a ewe because sheep require a higher concentration of phosphorus. A phosphorus supplement may be warranted on a year-round basis for both cattle and sheep, but an analysis of grass phosphorus content would determine if this were so.

Zinc was the only mineral never at sufficient levels, and generally it was at half the recommended level. Zinc was also deficient in alfalfa hay raised on the Hall and Meike ranches and in hay purchased by the Moore and Vieh ranches from the Clearmont (southeastern Sheridan County) and Riverton (central Wyoming) areas, respectively. Soils of Johnson County, and possibly other areas of Wyoming, may be low in soluble zinc for plants to absorb as similar research by the author in southeast Colorado found range grasses there generally contained adequate amounts for cattle and sheep. The provision of a zinc supplement might improve livestock weight gains and possibly reproductive performance. Further study in this area is needed to determine if zinc supplementation would improve animal performance.

Magnesium levels in range grass were below the needs of cows and ewes, except in the fall at the Vieh ranch. This was a result of the grasses at the Vieh ranch not declining in magnesium in the fall and the lower requirements of the cow and ewe due to weaning of their offspring. Ranchers generally provide livestock a magnesium supplement, especially in the spring when the potential for grass tetany is high. Grass tetany is caused by too much potassium in the diet of ruminants compared to the amount of calcium and magnesium. Results of this study confirm the need to provide cattle and sheep a magnesium supplement in the spring but also indicate year-round supplementation may be warranted.

In 2002 and 2004, a beef cow and sheep ewe would have obtained an adequate amount of sulfur from the grasses to meet their needs but only in spring 2003. Summer and early fall precipitation amounts may account for this difference. Adequate precipitation was received for grass growth during this period in 2002 and 2004, but dry conditions in the summer and early fall of 2003 may have caused the grasses to go dormant resulting in low sulfur. This may have also been true for calcium, iron, and manganese.

Grasses at the Hall, Meike, and Moore ranches did not contain enough manganese for a beef cow and sheep ewe, except for in the fall of 2002 and 2004. Grasses at the Vieh ranch contained adequate amounts of manganese on all sampling dates and averaged twice the amount compared to the other three ranches. Soils of the Vieh ranch apparently contain significantly more soluble manganese than the other ranches.

Because sheep require less copper in their diet compared to cattle, grasses met the needs of a ewe more often than they did that of a cow. Compared to cattle, sheep are more sensitive to too much copper in their diet. More care has to be taken when giving a copper supplement to sheep to avoid copper toxicity.

Based on the results of this study, range livestock producers in northeast Wyoming and southeast Montana may want to consider periodically sampling their range grasses for mineral content and then use the information to develop custom mineral supplements. A sample containing a good mixture of grasses the livestock are eating should provide reliable results for the development of a custom mineral mix.

Some range beef cattle nutritionists recommend ranchers sample grasses monthly for at least three years to determine nutrient supplementation needs. Results of this study indicate that monthly sampling may not be necessary at least with respect to minerals; however, sampling the same time of year over a three-year period would be recommended.

Mineral analysis can cost $15 or more per sample so the fewer the samples needed to develop a custom mineral mix the better.

Ranchers can learn how to sample range grasses for quality analysis and obtain information about livestock nutrient needs through their UW CES county office. Consulting livestock nutritionists about custom mineral mixes based on livestock needs and mineral content of range grass and hay is recommended.

Funding for mineral analysis of the grasses in this study was provided by the Wyoming Private Grazing Lands Team, and mineral analysis was performed by the University of Nebraska Soil and Plant Analytical Laboratory. There are many public and private labs that conduct quality analysis of feeds and forages, and UW CES offices can provide assistance in locating one that will provide the services a rancher needs.

Grass on the Hall ranch northwest of Buffalo on May 12, 2003.

Small acreages– Large issues

an effort to help rural residents manage their resources

Small acreages are the fastest growing land parcels sold in Wyoming. The Small Acreage Issue Team provides information to owners new to the land

Cole Ehmke

Extension Specialist

University of Wyoming Cooperative Extension Service

Lee and Saunda Phillips had a problem. As new residents on a small acreage near Gillette, they'd discovered 13 inches of annual precipitation couldn't sustain lush landscapes and that significant planning was needed to provide forage for their draft horses. To overcome the challenges of living in the country and creating a healthy property, they needed insights on small-acreage living – insights many others need, too.

"The rise of the small-acreage owner is something we're seeing in the West," says Michelle Cook, manager of the Campbell County Conservation District. The latest federal Census of Agriculture (2002) shows the number of land parcels of 10-49 acres in Wyoming increased more than 27 percent since 1997. Campbell County is one of the fast movers. For Cook, a large part of helping the Phillipses of the West is her work with the Small Acreage Issue Team, a multi-organization group in Wyoming striving to educate small-acreage managers about land stewardship.

What's at Stake

"The issue is that many new landowners don't understand how to manage a property," says Cook. Their expectations may not fit sustainable management of the land, and they may end up causing environmental and social problems. "That means the health and well-being of blocks of Wyoming are at stake. This is not being done maliciously but instead due to a lack of knowledge of rural living," she says.

To serve small-land managers, the University of Wyoming Cooperative Extension Service (UW CES) partnered with other organizations in 2004 to form the Small Acreage Conservation Education and Outreach Project. This group created attractive and popular methods of reaching its audience, including the popular maga-

zine *Barnyards & Backyards: Rural Living in Wyoming,* regional workshops, and one-on-one consultations.

Getting Started

In recent years, natural resource professionals were seeing an increasing number of small-acreage properties (typically 10 to 160 acres). Many were exurban residential subdivisions near some Wyoming cities including Cheyenne and Casper, and many were beginning, limited-resource, and smaller enterprises. A drive through the country increasingly showed overgrazed pastures, poor animal health, infestations of weeds (including noxious weeds), soil erosion, and other problems.

Typical educational programs had long targeted commercial properties. Additionally, the audience wasn't familiar with the traditional organizations that could help them, such as UW CES, the federal Natural Resources Conservation Service, and local conservation districts. The educational effort was going to require starting from scratch.

Survey Says . . .

Education isn't successful unless it provides something an audience wants. To find out what information small-acreage managers wanted, when they needed it, and the most convenient delivery method, the group conducted a survey in 2004 of small-acreage landowners across Wyoming.

"The results clearly showed this group wanted 'how-to' information, especially when it came to weed control, gardening, and pastures," says UW CES Educator Tom Heald, one of the project initiators.

"Although various delivery methods (tours, Web sites, workshops) were acceptable to this group, what really came across strongly was the need to have this 'how-to' information in a printable form. They were telling us they wanted solid information but wanted it when they had the chance to look at it."

Heald says the group knew a holistic approach to educational outreach was needed.

"The results formed the platform of our program," he says. "We designed efforts that were media-oriented and hands-on, and provided plenty of one-on-one assistance. Moving across town is challenge enough, but starting a new life in the country means learning about water wells, septic systems, building fences, and managing acres of pasture, to name just a few of the challenges a rural landowner must contend with. Our job is to provide the best information available to their needs and in a way that is meaningful to the individual landowner."

Calvin Strom, a University of Wyoming Cooperative Extension Service educator, suggests plant species that make the best use of available resources.

Group Background

With the survey in hand, project members started testing their approach and building partnerships. Over time, the collaboration has grown to 11 diverse organizations. Current members include Audubon Wyoming, Historic Trails Resource Conservation and Development Council, Montana State University Extension, Natural Resources Conservation Service, UW CES, Wyoming Association of Conservation Districts, Wyoming Department of Environmental Quality (DEQ), U.S. Environmental Protection Agency (EPA), Wyoming Private Grazing Lands Team, Wyoming State Forestry Division, and Wyoming Weed and Pest Council.

To guide efforts, they developed the following vision: to create a culture of stewardship among small-acreage land managers by promoting sustainable practices that enhance the ecological, economic, and social aspects of the land and its people.

Start-up funding came from a Section 319 Information and Education grant from the Non-point Source Task Force administered through DEQ with money from the EPA. The program aims to increase the health of impaired watersheds. Better management of the upland vegetation, on which many small acreages lie, is a factor in improving water quality.

Educational Approach

The project's content delivery emphasizes attractiveness and accessibility for today's media-oriented audience. The approach has three thrusts.

Barnyards and Backyards: Rural Living in Wyoming. The hallmark component is an invitingly designed and award-winning quarterly

magazine. It contains articles introducing small-acreage managers to subjects ranging from landscaping, grazing management, and animal care to soils, enterprise development, and gardening. Each issue features landowners who exemplify practices discussed in the magazine, emphasizing the challenges faced and the strategies used. Reader comments particularly praise this personal element. Though written for Wyoming rural landowners, this magazine has subscribers from across the United States. A selection of articles is available at www.barnyardsandbackyards.com.

Two years into the project, paid subscriptions approach 3,000, with total copies printed each quarter ranging from 5,000 to 7,000. The additional copies are distributed through team member offices and at small-acreage educational events.

Most paid subscriptions are from organizations, such as conservation districts, offering the magazine as an educational resource to clientele. One county planning board bought a subscription for every new rural resident in the county. Apart from subscriptions, partners circulate the magazine at locations such as realty offices, county planning offices, farmer's markets, and libraries. An individual subscription costs $6 per year.

"The magazine is a tremendous tool for any land manager," Cook says.

One-on-One Consultations. Recognizing this audience is not familiar with land management professionals, the project uses teams of two interns to take the program into targeted exurban areas. The interns connect landowners with resource professionals who can help address issues and provide landowners with needed information.

Workshops. Regionally focused workshops give landowners the opportunity to attend expert-led sessions and discuss issues with peers. Workshops focus on land and livestock management topics. During the spring and summer of 2006, nine workshops were held throughout Wyoming with 326 participants attending – a notable success. The team created a framework for delivery and advertising material and assisted local hosts with delivery.

The workshops have proven effective at helping people change their behaviors. When asked what types of practices they would implement, comments included:

- Reseed my dead lawn in September utilizing soil test results.
- Pasture rest from overgrazing and possible area reseeding.
- I will contact the conservation district for help on planting a windbreak.
- I will not pull my Canada thistle since it will just resprout – I'll use a herbicide.

One Laramie County attendee said, "All small-acreage owners should be required to attend the workshops and implement what they learn."

Final Comment

The small-acreage project is leading the effort to educate new land managers across Wyoming and the West. The project's successful methods of reaching out to this growing segment of the rural-urban interface have proven popular. The magazine is recognized as a valuable educational tool. Workshops and work by interns provide useful, personal connections. The directors of participating workshops note the publicity generated and the knowledge gained by both clientele and project members.

A combination of education and outreach methods, coupled with a high degree of interagency collaboration, extend the reach of this project. It addresses a relevant issue facing many Wyoming communities and others across the West and has the potential to visibly improve the condition of our lands and resources.

WORKSHOP RESULTS

Average self-reported participant percent knowledge gain	30 percent
Overall workshop score (5-excellent 1-poor)	4.62
Did the workshop answer your questions (5-very much so, 1-not at all)	4.38
Will you use the information to change what you do on your property (5-very much so, 1-not at all)	4.57

Aerial views yield producer news

Remote sensing reaps data for farmers, ranchers

Images rich with Wyoming information available to anyone through center's service

Ramesh Sivanpillai
Assistant Research Scientist

Kenneth Driese
Associate Research Scientist

Wyoming Geographic Information Science Center

Wyoming's juxtaposition of rivers, valleys, rangelands, forests, lakes, fields, and snow-capped mountains creates a tapestry of colors, textures, patterns, and shapes.

The same breathtaking scenery captured in imagery from an airplane or satellite can be useful for understanding Wyoming's landscape. Such photos or images are called remotely sensed data, and they reveal valuable information often less obvious when seen from the ground.

Using these images, a farmer or rancher can identify areas of uneven crop growth in a field, and remedial measures can be taken if the problem is spotted early.

A range manager can identify areas with adequate forage or areas that are overgrazed and susceptible to erosion. Periodically collected satellite images can monitor forest fires and map burned areas (Box 1) or assess vegetation responses to drought.

Acquiring aerial photos and using the information is not new. During World War II, through aerial reconnaissance missions, countries eyed each other's troop movements, selected valuable targets for a bombing mission, and assessed damage following aerial raids.

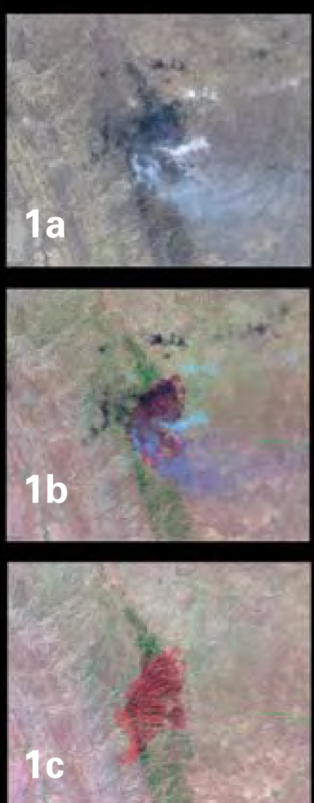
Invention of infrared (IR) photos in the early 1950s opened a new era in vegetation monitoring and mapping. The IR region of the spectrum is not visible to the human eye; however, vegetation reflectance in the infrared is much stronger than for many other materials. IR photos capture subtle changes caused by growth differences, diseases, or water content changes in the leaves.

Identifying impending problems early is one major advantage of IR imaging technology.

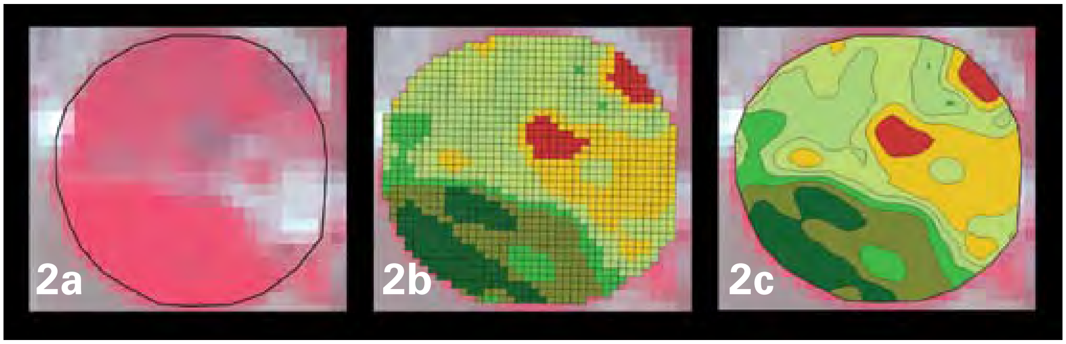
Many government agencies use IR imaging technology to identify pine trees infested with bark beetles. Damage is invisible with standard color photography, thus slowing response and increasing the risk of damage to adjacent trees.

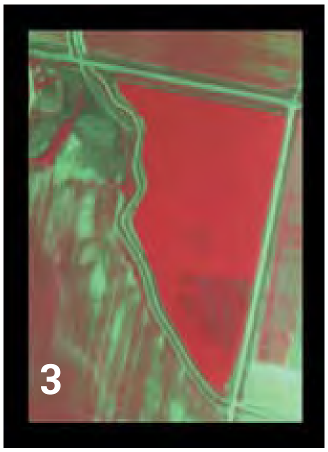
Realizing the value of IR images, especially for vegetation monitoring, the United States, France, India, and a few other countries have launched satellites to

Box 1: Wildfires of summer 2006



Wyoming witnessed several forest fires during the summer of 2006 and, with the help of satellite images, the area burned and the severity of burns can be mapped. Figure 1a shows last summer's wildfire burn area on Casper Mountain as it would appear to a human eye. In figure 1b, the same information is shown in an infrared combination with a higher level of detail. Figure 1c shows the scars after the fire was extinguished. Landowners and management agencies can use these image to assess the extent of damage. Images obtained subsequently for this area (every 16 days) can be used to monitor vegetation recovery and mitigate future risk to forest fires.





acquire these images. Since the early 1970s, these Earth-observing satellites have been collecting information about the land, rivers, and oceans. These images illuminate the magnitude of deforestation in South America, the cataclysmic destructions of the 2004 Asian tsunami, and large-scale crop failures throughout the world due to drought.

Large collections of remotely sensed data are archived at various locations throughout the world; however, these images are not widely used by everyone. Most users are in government agencies and universities.

Several agencies initiated programs to promote the widespread use of these images. WyomingView is such a program; it is funded by the U.S. Geological Survey (USGS). The Upper Midwest Aerospace Consortium (UMAC) is another, funded by NASA. Both programs in Wyoming are hosted at the Wyoming Geographic Information Science Center (WyGISC) with offices in the University of Wyoming College of Agriculture.

Through UW participation in WyomingView and UMAC, Wyoming citizens have access to a large collection of satellite and aerial images. These free data are available in ready-to-use format and require only minimal training to download and view on a computer.

Since 2002, WyGISC has provided more than 1 terabyte – or 1,024 gigabytes – to a wide range of users and continues to identify new users through outreach activities.

Three examples show how these data can be used to understand and manage Wyoming's agricultural, range, and forestry resources.

Figure 2a is an IR image acquired by a Landsat satellite showing a farm near Casper during the middle of a growing season. Areas of dark red indicate crops with high vigor, and lighter shades of red to grey correspond to relatively lower vigor. With the help of specialized software, this image can be converted to a map (Figure 2b) highlighting the differences in crop growth. The same software converts the image into a zone map (Figure 2c) that can be either printed as a map or put into a hand-held computer and taken to the field to identify the reasons for poor growth.

This technology has been applied at UW's James C. Hageman Sustainable Agriculture Research and Extension Center near Lingle. IR aerial photos for this area were obtained the past two years through a free UMAC program called AEROCam, short for Airborne Environmental Research Observational Camera. Using these images, scientists in the UW Department of Plant Sciences are mapping both the dry land and irrigated croplands. Figure 3 shows cropland, and the intensity of red highlights areas of high and low crop growth. Crop specialists use this information and collect soil samples to understand factors affecting yield.

Aerial images typically show more detail than satellite images and are collected by UMAC based on requests from users every year.

These infrared images are also useful for monitoring forage availability or identifying overgrazed rangelands or for monitoring vegetation recovery after a prescribed fire. Figures 4a and 4b show the same rangeland in a normal and drought year, respectively. Less intensity in red color could be related to decreases in forage availability.

Outreach and Training Activities

To promote this technology among Wyoming agricultural producers, farmers from North Dakota using these methods for managing their farms were invited to conduct workshops in Worland, Powell, and Casper. Wyoming farmers and ranchers got firsthand information on how North Dakota producers benefited from these images. WyomingView in collaboration with UMAC trained the farmers in the use of imaging software, and manuals were provided with instructions on how to download and analyze data.

Recognizing that not all users have fast Internet

Photo by Ken Driese

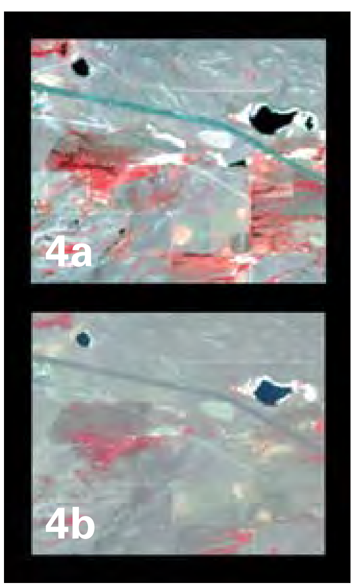
Santhosh Seelan of the Upper Midwest Aerospace Consortium describes the benefits of satellite data for farming and ranching applications during a workshop in Casper. Seelan is a professor with the Department of Space Studies at the University of North Dakota.

connections for downloads or computers for viewing images, UMAC will be providing computers to several UW Cooperative Extension Service (UW CES) offices and Wyoming Agricultural Experiment Station (AES) research and extension centers. Images for the counties or Wyoming agricultural regions, such as the Big Horn Basin, along with the software to view these images, are on these computers. Users can visit these offices and view the images for their area of interest. Copies of the instruction manuals are also there.

In 2005-06, computers were provided to UW CES offices in Worland and Casper. In 2006-07, computers will be provided to the Powell Research and Extension Center and the UW CES Goshen County office in Torrington. Computers and data will be provided to other AES and CES offices in Wyoming as long as funding is available.

These are a few examples of how remotely sensed data can be used for monitoring and mapping Wyoming. Other applications include vegetation mapping in rangelands and non-cultivated lands, forest-type mapping, habitat analyses, and mapping water levels in reservoirs and land surfaces. New satellite images will be added to the online archive as they become available and funding for WyomingView continues.

This data archive is a valuable resource for those intending to use imagery for monitoring a small piece of agricultural land or large areas. Programs like WyomingView and UMAC are examples of how services from UW benefit the citizens of Wyoming.



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