University of Wyoming · College of Agriculture

Reflections

2009

A tree may grow a thousand feet tall, but its leaves will return to its roots.

Chinese proverb

Featured Office
U W C E S

The University of Wyoming Cooperative Extension Service (UW CES) provides lifelong learning opportunities for the people of Wyoming and empowers them to make choices that enhance their quality of life. The UW CES has specialists within the College of Agriculture and educators and staff in all 23 counties and the Wind River Indian Reservation. Members of the administrative office are, from left, Marie Hanson, senior office associate, Cathy Shuster, office associate, Ruth Wilson, associate director, Glen Whipple, associate dean and director, Susan James, federal relations and staff development coordinator, and Duane Williams, associate director.

rooted in research

The theme of this year's *Reflections* is "rooted in research."

You might ask, "Why this theme?" Research in the College of Agriculture is making significant contributions to our tripartite mission of discovery, dissemination, and outreach in Wyoming and around the globe.

Research in the College of Agriculture is blazing new frontiers every day in an effort to improve the profitability of our farms and ranches, ensure that Wyoming agriculture delivers quality products to meet the growing food and renewable energy challenges, protect our environment, understand and provide solutions to climate change, and ensure our communities are better prepared to cope with challenges they face. Our efforts are funded by the state and federal government as well as federal granting agencies including National Science Foundation, National Institutes of Health, U.S. Environmental Protection Agency, National Research Initiative, Sustainable Agriculture Research and Education, Integrated Pest Management, and others.

The articles featured this year will give a glimpse of the work being done in laboratories, field stations, and specialized centers and show you how research is rooted in the classroom as well as outreach programs. This issue of *Reflections* includes articles on the "One Health Initiative," high-resolution aerial images, a trip to Bhutan, hormonal-environmental influences on male sexual behavior, sage-grouse persistence, grasshopper and horn fly control, soils, conservation easements, water quality, date of calving season, and intern programs both domestic and abroad.

The college offers nine undergraduate and more than 20 graduate degree programs all rooted in research and designed to provide solutions to a complex array of issues facing agriculture and natural resource management today. The college's research efforts provide unbiased information for managing wildlife/livestock conflicts and natural resource development, and maintaining profitable and sustainable agricultural production systems.

The College of Agriculture has four research and extension (R&E) centers around the state and extension offices in all 23 counties and the Wind River Indian Reservation that discover, generate, and synthesize new knowledge to meet Wyoming's needs. Feel free to visit our campus, extension offices, and R&E centers to witness faculty, staff, and student efforts first-hand. See how the college's tripartite mission is rooted in research. 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 see how research is rooted in all our efforts.

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Reflections

contents

Conquering the unconquerable HORN FLY

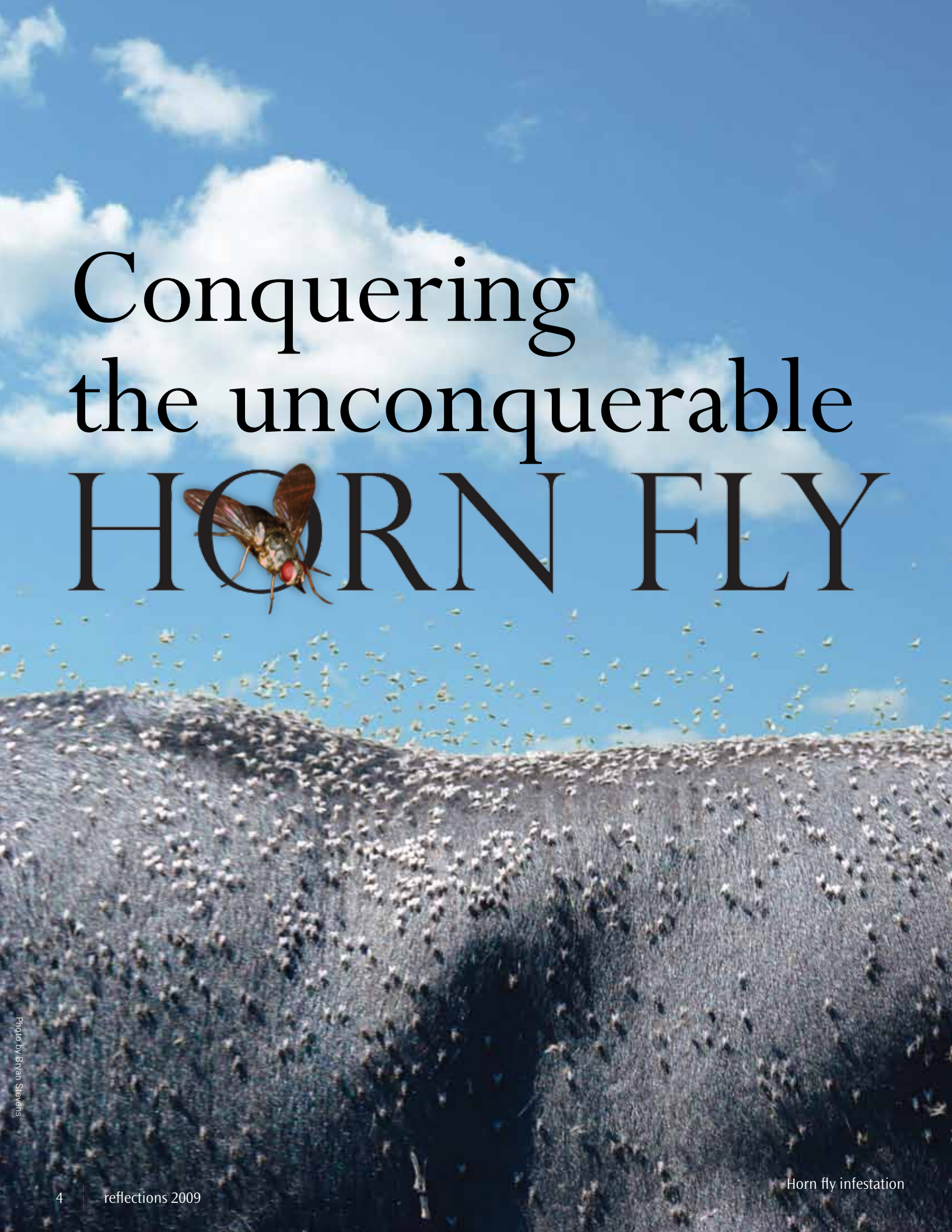

Photo by Bryan Stevens

Horn fly infestation

Bryan Stevens
Entomology doctoral student
Department of Renewable Resources

Roughly 120 years ago, an inconspicuous pest took a ride on a ship from Europe bound for the United States carrying livestock and landed on our Eastern shores.

Today, the little fly has become a top competitor for "major livestock pest of the year." Horn flies have proven to be resilient and an opponent worthy of battle. Traditional methods can offer limited control and only focus on one pest, the horn fly. Our research on Thaler Land and Livestock ranch lands east of Chugwater in southeastern Wyoming seeks to determine whether the same insecticide control for grasshoppers could also be effective against the horn fly.

The original concept of possibly killing two birds with one stone by using a grasshopper treatment to also control horn flies originated in Texas several years ago. After completing a master's of science degree with an emphasis in ruminant nutrition, I contacted Associate Professor Alexandre Latchininsky in the Department of Renewable Resources because I had heard he needed a Ph.D. student. As we discussed the projects he had available, the horn fly project fit best with my background.

Horn Fly First Noticed in 1886

The horn fly (Photo 1) was first noted in Philadelphia between 1886 and 1887. Due to a high reproductive rate and large wings, which allow it to fly long distances, five years later the horn fly was found throughout the Rocky Mountain region from Canada to Texas. Horn flies are a major pest of livestock (mostly cattle) and cost the industry close to $1 billion a year in control and production losses. Several methods of control have been developed; however, success of these methods is short-lived because the multiple generations per year the horn fly has allows them to quickly build resistance.

Photo 1. Horn Fly

Photo 2. Beak

Normal seasonal infestation rates range from 500 to 1,500 flies per animal (see photo page 4). They got their name – horn fly – because they are typically found feeding and resting on heads as well as shoulders of cattle. During the heat of the day, they will move to the mid-line and underbelly of the animal to escape the heat. Being obligate blood feeders, they feed 20 to 30 times a day by using a stout "beak" (Photo 2) that punctures the animal and then sucks up a bellyful of blood.

In attempts to relieve some of the irritation, the cattle use costly energy meant for growth to rid themselves of the flies. Some of the behavioral changes include increased tail whipping, head throwing, bunching with other animals, and rubbing against each other; however, the flies have caught on to these attempts and just merely fly straight up and land right back on the same host.

Cattle behaviors and internal physiology are changed. When exposed to as few as 150 flies, an animal's heart rate, respiration rate, and urinary output increase. As the number of flies rises, the animals increase internal temperature and fecal output and decrease feed consumption and conversion.

Infested heifers and cows give birth to lighter calves and produce, on average, 10- to 12-pound lighter calves at weaning. Animals destined for the slaughterhouse are lighter, which leads to yet another financial loss to the producer.

Spends Life on Single Host

The horn fly's evolution has made it a perfect ectoparasite (lives on the outside of host) for cattle. The flies spend the majority of their lives on a single host. Females are able to mate a couple of days after maturity and then lay their eggs in fresh cow dung. Being able to detect when the animal is going to defecate, they move to the udder and inside hind leg area to wait. As soon

Horn flies are a major pest of livestock (mostly cattle) and cost the industry close to $1 billion a year in control and production losses. They got their name – horn fly – because they are typically found feeding and resting on heads as well as shoulders of cattle.

as the animal defecates, they immediately fly to the patty. Upon arrival, they lay from one to multiple eggs on the underside edge of the pile. Females only spend a few minutes on the patty and then return to the host to continue blood feeding. Larvae take a couple of weeks feeding on the organic matter in the dung to reach maturity. The adult fly emerges from the patty and seeks a host (Photo 3).

Horn fly populations peak in late spring, decrease during the hottest part of summer, then increase again in early fall. Populations die off after the first hard frost so, depending on the region, horn fly populations can linger for a long time. Horn flies overwinter as pupa a few centimeters down in the soil. As the temperature increases in the spring, adult horn flies emerge from their pupal case and go in search of a host.

Over a season, there are multiple generations, which has allowed for the development of chemical resistance to many commonly used insecticides.

Photo by Bryan Stevens

Photo 3. Emergence holes.

Current control methods use insecticide-filled back rubbers, ear tags, and sprays. Each method targets the adult fly and requires the livestock producer to use valuable time and money in maintenance.

The Horn Fly-Grasshopper Connection

Rangelands grazed by cattle are commonly attacked by pest grasshoppers. In a normal year, a grasshopper population can consume as much as 25 percent of the aboveground forage; in an outbreak year, they can consume as much as 100 percent. This puts grasshoppers in direct competition with cattle for available forage.

In the 1970s, a compound called diflubenzuron became commercially available as an insecticide. This product acts as an insect growth regulator (IGR). IGRs are designed to prevent an insect from forming a proper exoskeleton when it molts and leads to deformities and death. As an insect consumes diflubenzuron-treated vegetation, the insecticide acts on the protein matrix that makes up the new cuticle at the time of molting. Adult insects are not affected since they are fully grown and do not molt. Diflubenzuron has been successfully used against grasshopper outbreaks worldwide since the early 1980s.

A question arose as to whether an application of diflubenzuron for grasshopper control could also help with the suppression of horn flies.

Horn fly hosts.

Photo by Bryan Stevens

Thaler Ranch Research

The answer is being examined on the Thaler ranch. A group of 600 cow-calf pairs was grazed from mid-May to mid-August on improved pastures. The pastures were irrigated and contained native grass, orchard grass, and alfalfa. In 2008, horn fly emergence was delayed by an estimated month and a half due to cold and snowy late spring weather. Near the end of June, a sizeable horn fly population finally appeared, and two pastures were aerially treated with diflubenzuron a day before the cattle were brought on to feed. The cattle were rotated between six pastures throughout the summer, feeding about a week at a time on each. Within 24 hours of the cattle leaving a pasture, emergence traps (Photo 4) were placed over 10 fresh manure patties. Eight fresh patties were collected, placed in five-gallon buckets, and brought back to the insect rearing laboratory at the University of Wyoming in the College of Agriculture and placed in an emergence chamber for 10-14 days.

After 30 days in the field, the emergence traps were collected and emerging horn flies counted (Figure 1). The patties from the emergence chamber in the lab were placed in a freezer for later inspection and analysis of emerged flies. Preliminary results are positive that diflubenzuron, when applied for grasshopper control, can also help control emerging horn fly populations.

A lot of nuts and bolts of this research were quite new to me. I had to develop the design of the traps to capture the horn flies emerging from cow dung and the method of extracting the flies' pupae from the collected manure. These were trial-and-error approaches, but, finally, I developed methods that work.

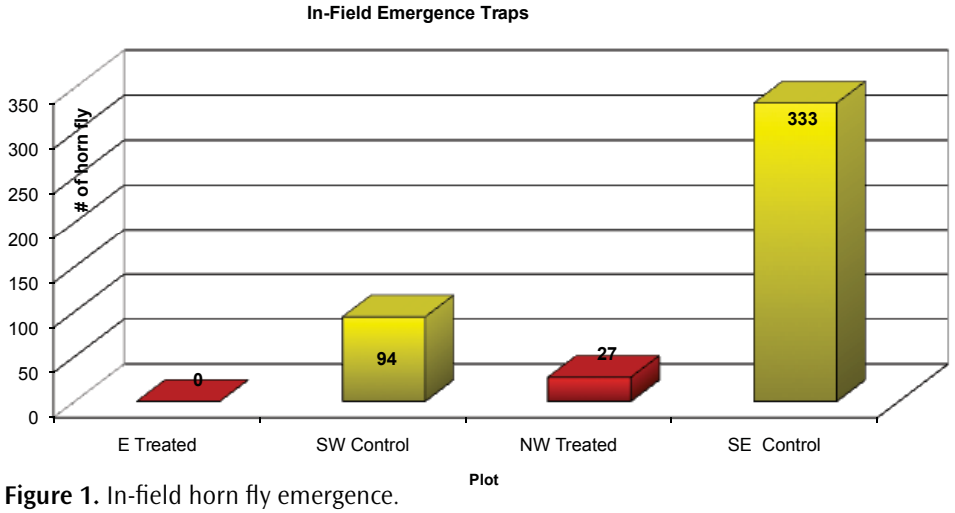

Figure 1. In-field horn fly emergence.

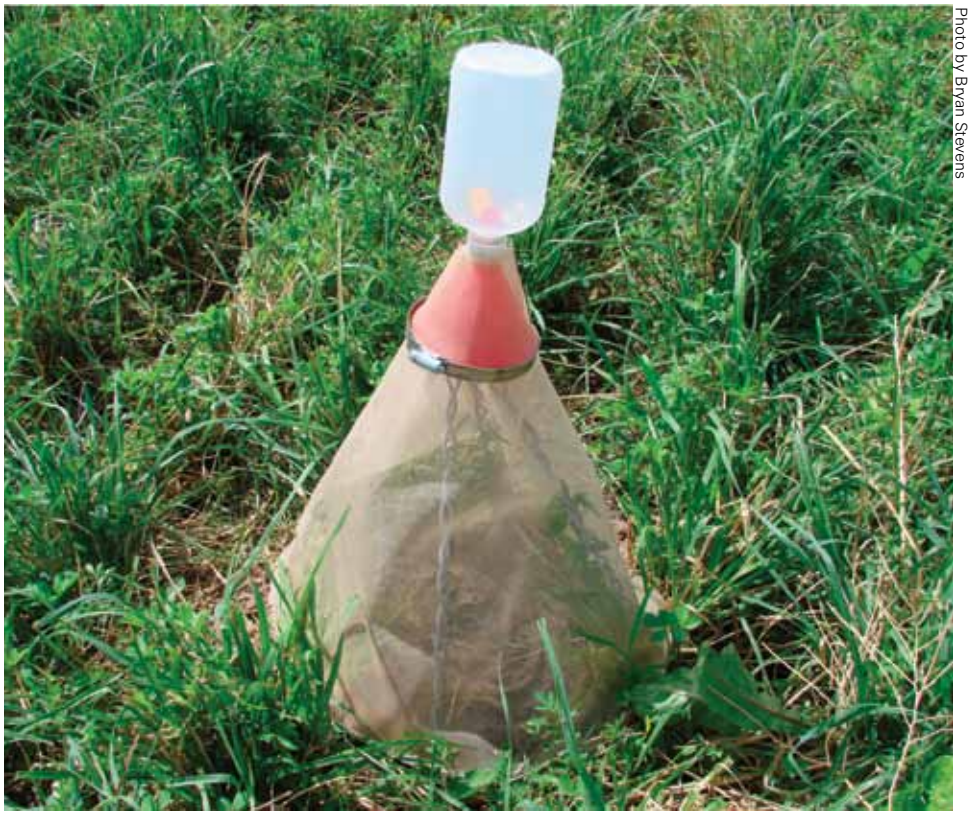

Photo by Bryan Stevens

Photo 4. Emergence trap.

Our experiment brings with it hope that by killing two birds with one stone, a more efficient and environmentally sound strategy to control the evasive horn flies can be developed. We are in the process of determining the spraying's impact on beneficial insects. We know that diflubenzuron can kill any immature arthropod that ingests enough of it; however, the main focus is whether we can gain some control of the horn fly.

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Evaluation of greater sage-grouse population

Christopher Kirol
Graduate student

Jeffrey Beck
Assistant Professor
Department of Renewable Resources

Sage-grouse have become a symbol of the 232,000 square miles of the sagebrush steppe biome, which dominates a significant portion of the West and 38 percent of the land in Wyoming.

The sagebrush biome encompasses 50 percent of its presettlement range (page 11) throughout the West. As the sagebrush biome has decreased in size and become increasingly fragmented, sage-grouse populations, which depend entirely on sagebrush habitats for all life stages and for food, have demonstrated a similar declining trend and are estimated to be 50 percent of presettlement populations. A conservation assessment for greater sage-grouse and sagebrush habitats completed in 2004 by leading sage-grouse researchers concluded that, in Wyoming, sage-grouse populations have declined at an overall rate of 2 percent per year from 1965 to 2003. This rate mirrors population trends in other Western states.

Umbrella Species

Sage-grouse have been identified as an umbrella species. Umbrella species are those representing the health of an ecosystem; therefore, the decline of sage-grouse populations may reflect a decline in the health of the sagebrush steppe ecosystem.

One of our foremost research goals is to generate seasonal probability-of-occurrence maps across our project area on the Atlantic Rim in south-central Wyoming to identify seasonal (breeding, nesting, and brood-rearing) habitats essential for sage-grouse persistence. These outputs can be used by the Bureau of Land Management (BLM), private landowners, and the Wyoming Game and Fish Department (WGFD)

persistence in south-central Wyoming

to protect areas contributing to greater sage-grouse population persistence on the Atlantic Rim. Thus, instead of the somewhat arbitrary buffers that appear to be ineffective in reducing impact to sage-grouse, the BLM could use our research outputs to direct future coalbed methane (CBM) development on the Atlantic Rim (page 12).

Christopher Kirol became intrigued by greater sage-grouse (*Centrocercus urophasianus*) when, at the age of 17, he first saw male birds performing their courtship dance on a lek (or breeding ground) between Cody and Meeteetse in northwestern Wyoming. He still vividly remembers the crisp spring morning air, the deep booming sound produced by the male sage-grouse inflating and deflating its esophageal sacs that carried across the entire landscape, and the intricate posturing and feather displays of the strutting males (Figure 1). Years later, while working as a biologist for an environmental consulting firm, he spent numerous early spring mornings counting sage-grouse on leks in areas being developed for underlying oil and gas reserves. He became even more interested in the plight of the sage-grouse, which ostensibly were showing a downward trend in many areas being developed.

Development-Sage-grouse Connection

Research conducted by the University of Montana and the Wyoming Cooperative Fish and Wildlife Research Unit at the University of Wyoming confirmed this negative relationship between certain levels of development and sage-grouse populations. Kirol resolved to pursue a master's degree to conduct research on sage-grouse. He was directed to Assistant Professor Jeff Beck in the College of Agriculture's Department of Renewable Resources, who has studied sage-grouse and their habitats in Colorado, Idaho, Utah, and Wyoming. He took Kirol on, and, in the spring of 2008, Kirol started fieldwork on the Atlantic Rim sage-grouse study. The study is a collaborative effort between the BLM Rawlins Field Office, Anadarko Petroleum Corporation, WGFD, University of Wyoming School of Energy Resources, Department of Renewable Resources, and many local landowners.

In Wyoming, sage-grouse populations have declined at an overall rate of 2 percent per year from 1965 to 2003. This rate mirrors population trends in other Western states.

Photo by Jamie Martin Young

Figure 1. Male sage-grouse strutting on a lek.

Photo by Kurt Smith

Figure 2. Chris Kirol with radio-marked female sage-grouse ready to be released after capture, spring 2008.

Photo by Chris Kirol

Figure 3. Kurt Smith, a field technician assigned to this project, monitors a radio-marked female sage-grouse in the summer of 2008.

The Atlantic Rim extends from Rawlins south approximately 50 miles to Baggs. A control area was also established northwest of Rawlins just south and west of Bairoil. The Atlantic Rim study area encompasses 422 square miles and contains 89 known sage-grouse leks – a density of one lek per every 5 square miles. Few locations in Wyoming contain such a high density of sage-grouse leks. The study area near Bairoil was selected as a control because it has a viable population of sage-grouse, has similar vegetation communities to the Atlantic Rim, and is not currently being influenced by oil and gas development. The control area contains 15 sage-grouse leks and encompasses 316 square miles with a lek density of one lek per every 21 square miles.

Capturing Started in 2008

Kirol began fieldwork in mid-April 2008 with the start of the capturing season. Sage-grouse are captured at night with the aid of all-terrain vehicles, spotlights, and long-handled hoop nets, quick feet, and a little luck. Efforts focus on female grouse because they provide a wealth of information including demographic rates (nest success, brood productivity, and adult female survival) and habitat selection patterns important to understanding nesting and brood-rearing habitats. The majority of the females are captured around leks where, in the spring, they congregate to select the most desirable males to breed with. Captured were approximately 50 females, 25 of which were in the control area while the remainder were in the Atlantic Rim study area. The captured birds were collared with necklace-mounted radio-transmitters (Figure. 2), weighed, age determined, and quickly released to reduce stress. The Rawlins BLM had collared several female grouse in 2007, so the study had approximately 120 female grouse.

The 120 collared birds were then monitored at least once a week with the use of radio telemetry for the remainder of the summer and into the fall and are monitored on a monthly basis by fixed-wing aircraft throughout the winter.

Monitoring female sage-grouse throughout the breeding, nesting, and brood-rearing season is essential for our research. First, we can determine fitness over the breeding, nesting, and brood-rearing season by evaluating demographic responses including nest success and brood survival.

Second, this enables us to gather seasonal occurrence data (female sage-grouse locations throughout the season). Occurrence data allows us to evaluate habitat characteristics at locations or habitats female sage-grouse select during critical nesting and brood-rearing stages. These habitats will be analyzed at landscape (macrohabitat) and microhabitat scales through a combination of field measurements and remote sensing data. We collected

Photo by Chris Kirol

Figure 5. Transect established at a hatched sage-grouse nest to measure habitat characteristics.

Oil and gas development has been identified by many researchers across the West as one of the major causes contributing to sage-grouse population declines.

micro-scale vegetation measurements at nests and early and late brood-rearing locations in addition to an equal number of random locations within each study area to describe and compare the characteristics of used (grouse locations) and available (random locations) habitats (Figure 5).

Habitat Characteristics Measured

Some of the habitat characteristics measured at these locations include slope, topographic orientation of the site, shrub canopy cover, shrub density, visual obstruction, herbaceous ground cover, cover of sage-grouse food-forbs and non food-forbs, perennial and annual grass cover, and grass height. These data will provide an understanding of microhabitats selected during critical life stages.

Oil and gas development has been identified by many researchers across the West as one of the major causes contributing to sage-grouse population declines. Compounding the issue is the fact many of the mineral reserves, especially CBM, directly underlie a large portion of the current sage-grouse range. Direct habitat loss occurs when native vegetation is converted to access roads, well pads, pipelines, and other features. Indirect habitat losses can occur when sage-grouse are displaced or avoid areas near infrastructure because of increased levels of human disturbances (e.g., traffic, noise, pollution, human presence).

Mitigation Measures

On lands under the authority of the BLM, mitigation measures are used to protect sage-grouse breeding and nesting habitat. These mitigation

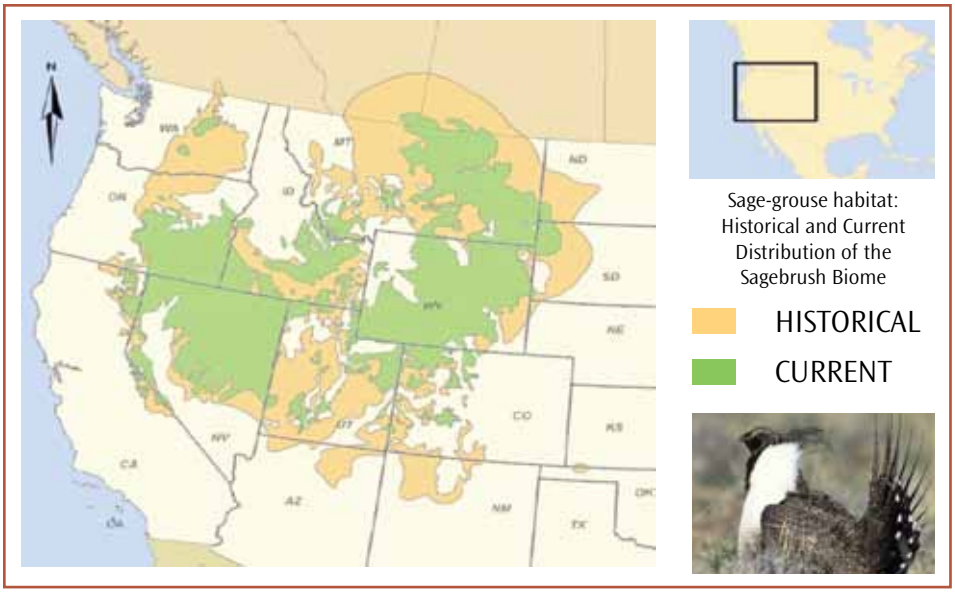

Figure 6. Current and historical distribution of sage-grouse.

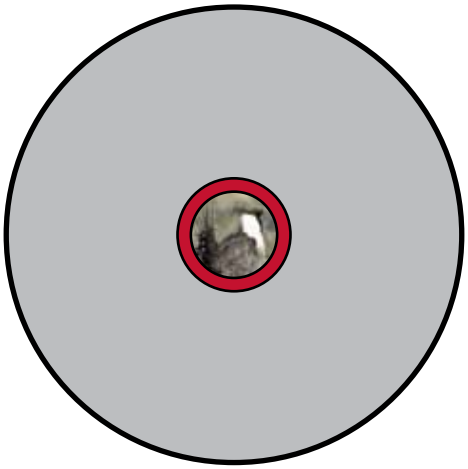

Figure 7. Current nesting habitat mitigation measures utilized by the BLM. The sage-grouse in the center represents a lek, the red circle represents the 0.25-mile no-occupancy buffer, and the gray circle represents the 2-mile seasonal buffer.

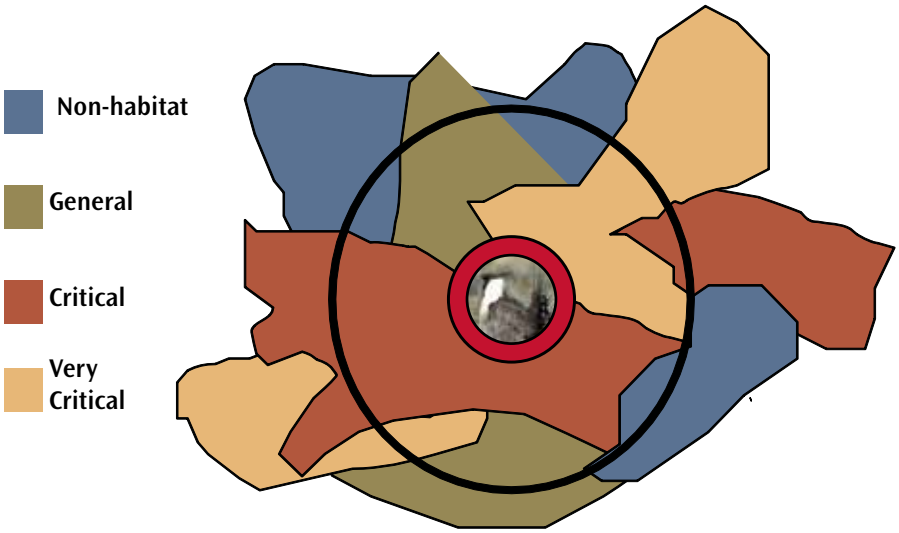

Figure 8. Conceptual output representing nesting or brood-rearing habitat categories. The outer circle represents the currently used 2-mile buffer, the inner circle represents the 0.25-mile buffer, and the sage-grouse in the center represents the lek. The various polygons represent habitat areas and possible distribution of these habitats.

measures are based on earlier research and management recommendations that suggest protecting a 2-mile radius (buffer) around a lek site to maintain nesting habitat. The BLM commonly employs this 2-mile buffer; however, this is a seasonal stipulation and only prohibits activities in these areas during the breeding and nesting season from March 1 to June 15. Additionally, the BLM commonly employs a 0.25-mile buffer around each lek prohibiting any surface disturbance (Figure 7).

A recent empirical review of multiple sage-grouse studies throughout the West by Beck showed that current BLM mitigation measures do not appear to be effective in mitigating negative sage-grouse population responses to energy development. Consequently, the Atlantic Rim sage-grouse study seeks to identify alternative sage-grouse management options in a developing CBNG field. Specifically, the objectives of our study call for identification of habitats critical for sage-grouse population persistence. These are areas that, if protected, have the highest potential to maintain viable sage-grouse populations within the project area (Figure 8).

Our study seeks to link ecological conditions on the Atlantic Rim to both sage-grouse occurrence (habitats that animals are likely to use) and population fitness (number of offspring produced that survive to reproduce) to understand and manage for population persistence (Figure 9).

Our study was designed to provide crucial information to prudently develop the CBNG field in the Atlantic Rim while maintaining critical habitats for sage-grouse to persist. Field data collection will continue through 2009, and our project will likely be completed in 2010. If successful, our approach to identifying areas for population persistence could be implemented in other areas where oil and gas reserves and greater sage-grouse populations overlap.


Photo by Aimee Wiese

Occurrence
Habitats that animals are likely to use.


Photo by Chris Kirol

Fitness
The number of offspring produced that survive to reproduce

Figure 9. Linking occurrence to fitness is important in identifying habitats contributing to population persistence. The photograph on the left shows an area a large number of sage-grouse are using. The photograph on the right shows an adult female sage-grouse with one of her chicks. Brood productivity is one of the parameters we are estimating in the Atlantic Rim and the control area. These estimates provide critical information as to the ability of habitats to promote population persistence.

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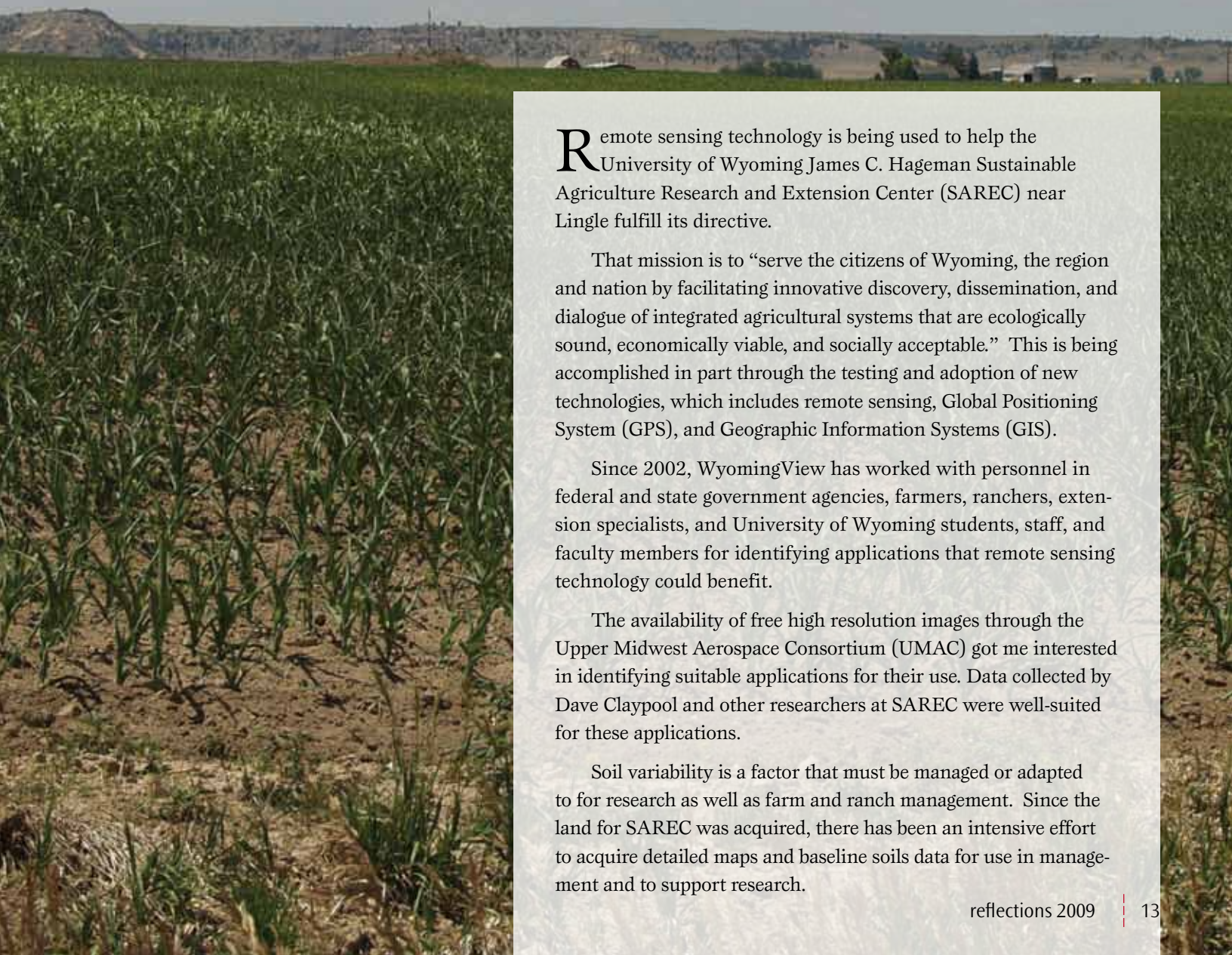
High resolution, color infrared aerial images for mapping crops and pastures at SAREC

Ramesh Sivanpillai • Remote Sensing Scientist • Wyoming Geographic Information Science Center and Department of Botany
David A. Claypool • Master Technician in Crop Science • Department of Plant Sciences



Remote sensing technology is being used to help the University of Wyoming James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC) near Lingle fulfill its directive.

That mission is to "serve the citizens of Wyoming, the region and nation by facilitating innovative discovery, dissemination, and dialogue of integrated agricultural systems that are ecologically sound, economically viable, and socially acceptable." This is being accomplished in part through the testing and adoption of new technologies, which includes remote sensing, Global Positioning System (GPS), and Geographic Information Systems (GIS).

Since 2002, WyomingView has worked with personnel in federal and state government agencies, farmers, ranchers, extension specialists, and University of Wyoming students, staff, and faculty members for identifying applications that remote sensing technology could benefit.

The availability of free high resolution images through the Upper Midwest Aerospace Consortium (UMAC) got me interested in identifying suitable applications for their use. Data collected by Dave Claypool and other researchers at SAREC were well-suited for these applications.

Soil variability is a factor that must be managed or adapted to for research as well as farm and ranch management. Since the land for SAREC was acquired, there has been an intensive effort to acquire detailed maps and baseline soils data for use in management and to support research.

Mapping SAREC Fields

Mapping the fields and facilities at SAREC with GPS has been completed, and crop yield maps were collected in 2003. Apparent electrical conductivity (EC_a) data has been collected for all of the irrigated and dry land farmland. Soil samples on a 2.5-acre grid for all the farmland have been obtained and are being analyzed by the UW College of Agriculture Soil Testing Laboratory. All of this data is being consolidated in a GIS and is available to UW personnel. At the time of this writing, the data are being used for developing an experimental design for a long-term research project – just one of many possible uses.

Another method being used to map field and pasture conditions and vegetation variability at SAREC is remote sensing, which consists of digital images acquired with aircraft or satellites. Remote sensing is not a new technology, but, historically, its use for farm management has been limited by cost, availability, appropriate resolution, and timeliness.

Acquiring high spatial resolution aerial images is expensive, and repeated acquisitions during a growing season can be cost prohibitive.

Through UW's participation in the UMAC (www.umac.org), high spatial resolution (1-meter), color, infrared, aerial images of SAREC were obtained at no cost between June and September of 2005 through 2008 using AEROCam (Airborne Environmental Research Observational Camera). Further details on AEROCam can be found at www.umac.org/sensors/aerocam.

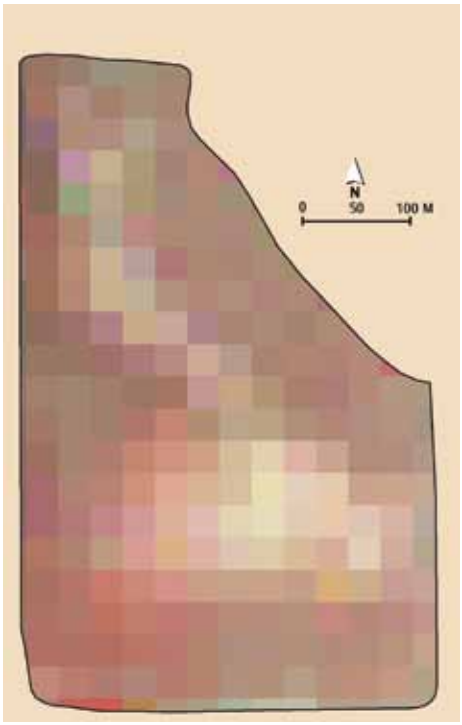


Figure 1. Landsat (30-meter resolution) image of one field at SAREC.

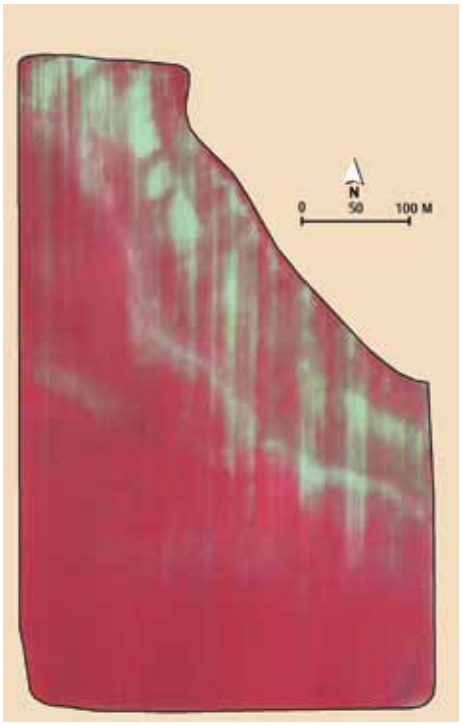


Figure 2. AEROCam image (1-meter resolution) of a field at SAREC. Effect of soil variations on crop growth are apparent based on different shades of red.

Spatial resolution refers to the level of detail on an area basis – the pixel size. Spectral resolution refers to the wavelengths of light recorded.

Moderate spatial resolution (30-meter) images collected by the Landsat satellite are useful for detecting patterns over hundreds of acres but are limited for identifying variations within small fields (Figure 1). Each pixel in the Landsat image records information for every 900 square feet. The 1-meter AEROCam image records information for every 9 square feet, which makes subtle variations in crop growth easily identifiable as well as features such as the edge of the field and roads (Figure 2). Bright shades of red (see explanation at left) correspond to areas of high crop vigor, and dark shades correspond to low crop vigor.

This level of detail makes AEROCam imagery useful not only for farm management but also as a research tool for small-plot studies.

Color infrared (CIR) images are routinely used in agricultural applications due to their ability to detect subtle differences in vegetation growth. The amount of infrared (IR) radiation reflected by vegetation is related to its growth and health. Healthy vegetation reflects relatively more IR and appears bright red in these images, while vegetation with moderate or poor growth appears in darker shades of red. Numerous federal and state government agencies, private consultants, and agricultural producers in certain states use these images acquired by satellites and airplanes.

Wealth of Information Available

High spatial resolution aerial images contain a wealth of information for agricultural applications. If these images

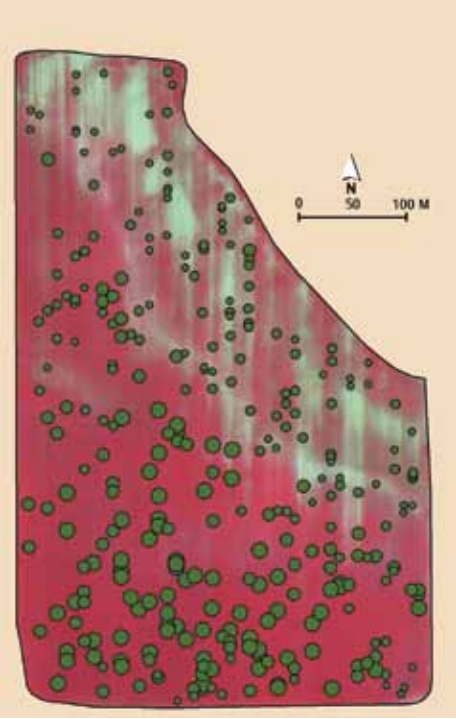


Figure 3. Randomly selected yield monitor data superimposed on AEROCam image. Size of the circles is proportional to yield.

Figure 4. Mosaic of AEROCam images of SAREC near Lingle.

can be acquired several times during the growing season, researchers can track changes in growth. By comparing yield values with imagery, researchers can correlate crop growth conditions at a given time with yield at the end of the growing season (Figure 3). Identifying areas in a field or pasture with consistently high or low plant vigor is possible by comparing images acquired over several years. Several UW students have been using AEROCam images in their research projects throughout Wyoming (see right).

The AEROCam image data can be used in conjunction with soils or yield data, but, first, the images must be georeferenced, which means each image is oriented to specific locations on the ground. Georeferencing of aerial images is an essential and critical data processing step to integrating this information with ground-based data. Rajeswari Siloju, a UW Department of Computer Science student, has taken on the task of georeferencing several years of images, and the project is expected to be finished this summer.

Researchers at UW can obtain either individual georeferenced AEROCam images at SAREC or mosaics of several images. Individual images are suitable for comparison to field measurements since they retain the original brightness values recorded by AEROCam. These images can be opened in several image-processing and GIS software without any format conversion. These images can be uploaded to Personal Digital Assistants (PDAs) connected with GPS enabling researchers to navigate to locations in a field or pasture. Photo mosaics (Figure 4) can be used to assess overall field conditions and to aid in site selection for future experiments.

It is satisfying to see when remote sensing technology can provide reliable information for managing Wyoming's crop and range lands. More information about educational activities involving AEROCam data can be found in "High resolution, no-cost AEROCam data promotes undergraduate remote sensing research in Wyoming," in the April 2008 edition of *Photogrammetric Engineering and Remote Sensing,* available online at http://www.asprs.org/publications/pers/2008journal/april/index.html.

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UW graduate and undergraduate students have been using AEROCam images in their research on rangeland, shrub land, forest, and cropland. The authors are currently working with a graduate student who is using AEROCam images to analyze the growth of corn over three years in two fields. One field is irrigated using a center pivot, and the second field is furrow irrigated. We are relating certain ground measurements to crop vigor recorded by these photographs and assessing whether AEROCam images can pick up growth patterns in both irrigation methods.

Is fall calving a viable alternative to spring

Brian Strauch
*Former graduate research assistant **

Larry Held
Professor

Dannele Peck
Assistant Professor

Department of Agricultural and Applied Economics

We began studying the economics of fall calving following an informative senior-thesis presentation by an outstanding agribusiness student in 1999. The student's work was based on the experience of her father, a cattle rancher in Wyoming, who successfully switched from spring calving to fall calving.

** Now an educator with the University of Nebraska-Lincoln Extension*

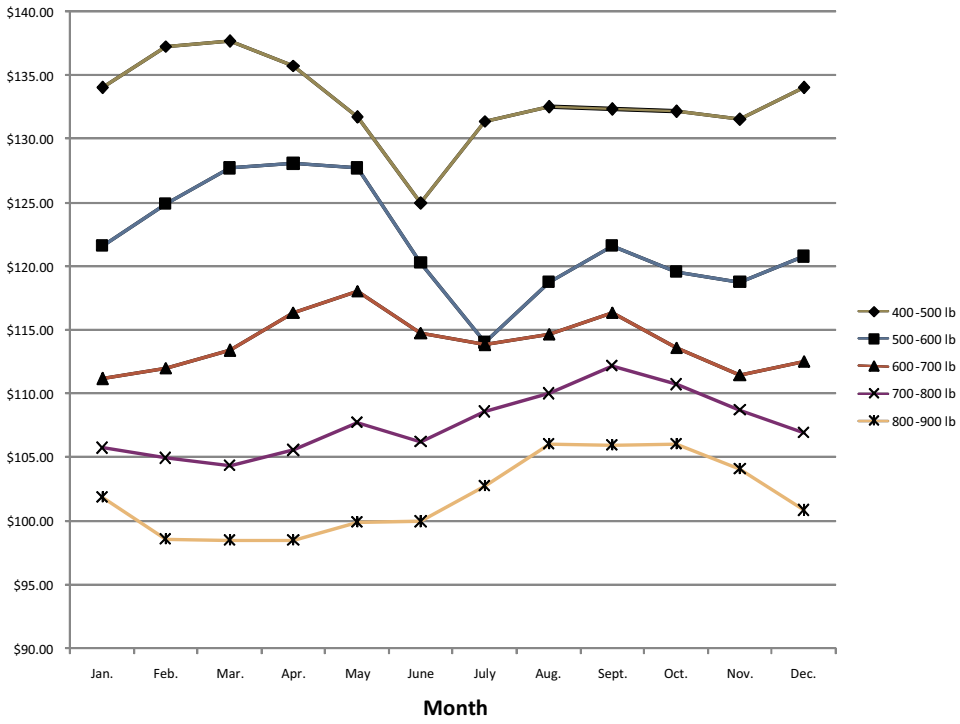
Given her father's apparent success with fall calving, we wondered why it was not a more common practice in Wyoming.

Most cow-calf ranches in Wyoming are spring-calving operations, with calves typically born in March or April. Because many ranches calve during the same time of year, many also send calves to market at the same time of year, typically in October. When large numbers of calves are on the market at one time, the price received (i.e. the feeder cattle price) tends to be lower than in periods when fewer calves are on the market.

The seasonal pattern of Wyoming feeder cattle prices is shown in Figure 1 for various weight classes. The price received per hundred-weight ($/cwt) for feeder cattle tends to be higher at the beginning of the year than in the fall, particularly for animals in the 400- to 700-pound weight classes (i.e. calves and "short" yearlings).

Figure 1 indicates calves can potentially be sold at higher prices in the spring than in the fall. The question therefore arises, "Could cow-calf operators increase profits by calving in the fall (August/September) and selling those calves in early spring (March/April), rather than calving in the spring and selling them in the fall?" This article reports results from a recent thesis project by Brian Strauch (M.S., 2008) that estimates the profitability of fall versus spring calving in Wyoming.

Figure 1. Twenty-one-year average steer prices by month for various weight classes (1987-2007).



Source: U.S. Department of Agriculture Agricultural Marketing Service, Torrington, Wyoming.

calving in Wyoming?

Economic Analysis

Budgets and linear programming models were developed for two model ranches representing spring versus fall calving operations in Wyoming. Both model ranches were assumed to have identical feed resources, including hay production and animal unit months (AUMs) of seasonal grazing on deeded and leased lands. A variety of performance factors that differ between fall-calving and spring-calving operations were incorporated within the respective ranch models. Differences in performance factors were identified through surveys and interviews with five fall-calving operators in northeast and north-central Wyoming; most had run spring-calving operations at some point before switching to fall calving.

Operators identified several advantages from calving in the fall, including higher prices for fall-born/spring-marketed calves, lower labor requirements, and higher rates of calf survival at birth. Lower labor requirements and higher calf survival are largely due to more favorable weather conditions when calving in the fall.

Some differences between spring and fall calving have potentially important, but less obvious, effects on profitability, such as monthly forage needs. Fall-calving herds require more winter forage because cows are lactating, and calves must be fed hay. An economic analysis was needed to account for whether the advantages of fall calving (i.e. higher feeder cattle prices when calves are sold in early spring) outweigh some potential drawbacks (e.g. higher winter forage requirements).

It was difficult to objectively compare some performance factors for fall versus spring calving due to a lack of data. Labor requirements were particularly challenging to compare. Participating operators consistently indicated labor requirements were less for fall-calving operations; however, detailed records were not available to objectively quantify the labor savings. A 33-percent reduction in labor costs for fall-calving operations was assumed in this analysis to reasonably account for the labor savings indicated by fall-calving operators. If actual labor savings are less than 33 percent, our results overestimate the profitability of fall calving as compared to spring calving. Given the uncertainty surrounding labor savings, operators who are considering a switch to fall calving should consult fellow producers and attempt to estimate labor savings for their specific operation.

Fall-Born Calves Bring Higher Prices

Fall-born calves, when sold in April, commanded a higher average price ($128.08 per cwt) than spring-born calves sold in October ($119.61 per cwt on average). When combined with other performance factor differences between spring and fall calving (including lower labor, utility, and veterinarian expenses), annual net income appears to be higher under fall calving than spring calving. The apparent net income advantage of fall calving should be viewed with some skepticism, however, due to a great deal of uncertainty about the true magnitude of cost savings associated with fall calving. If cost savings are smaller in reality than those

Table 1. Summary of select performance measures for spring versus fall calving.

	SPRING-CALVING, 521 cows				FALL-CALVING, 454 cows			
Activity	Month of Sale	Sale Price ($/cwt)	Sale Weight (lbs/calf)	Calves Sold (head)	Month of Sale	Sale Price ($/cwt)	Sale Weight (lbs/calf)	Calves Sold (head)
Sell Steer Calves	OCT	$119.61	550	234	APRIL	$128.08	525	213
Sell Heifer Calves	OCT	$110.88	500	182	APRIL	$122.21	475	148
Annual Revenue [1]				$298,567	Annual Revenue[1]			$288,188
Annual Costs[2]				$286,722	Annual Costs[2]			$264,872
Annual Net Income[3]				$11,845	Annual Net Income[3]			$23,316

[1] Annual Revenue includes calf sales as well as the sale of excess hay ($10,680 in the spring calving operation, and $13,052 in the fall calving operation) and cull cows ($33,047 in the spring calving operation, and $45,997 in the fall calving operation).
[2] Annual Costs include all costs except operator's management and interest on owned land.
[3] Annual Net Income represents the amount of income left over, after paying annual costs, to cover the cost of the operator's management and interest on owned land.

assumed in this study, fall-calving's net income advantage may be much smaller, or even non-existent. More accurate cost comparisons of spring versus fall calving are needed before a more definitive conclusion about relative net income can be made.

Although the fall-calving herd is smaller (454 vs. 521 cows), due to differences in their seasonal forage requirements, a higher sale price and lower operating costs more than offset the reduction in number of calves sold.

Fall Calving not Guaranteed to Increase Profit

Prior to this study, it appeared higher seasonal prices might guarantee an economic advantage for fall calving. It may be tempting to conclude from Table 1 (above) that fall calving is more profitable than spring calving; however, this must be viewed with some skepticism given uncertainty about the true extent of labor savings on fall-calving operations.

This study's results do not show a sufficiently large difference in annual net income between fall and spring calving to conclude that either practice has a clear economic advantage over the other; therefore, fall calving appears to be a viable alternative to spring calving but not necessarily more profitable to any large extent. Higher seasonal prices for fall-born/spring-sold calves are an important factor to consider, but they alone do not justify switching to fall calving. The extent of cost savings from fall calving (e.g. labor savings) is equally important and must be sufficiently large for fall calving to be a viable alternative.

Because the economic performance of fall calving depends heavily on the extent of cost savings, interested cow-calf operators should conduct their own economic analysis to capture the unique resource base and operating costs of their ranch. The model ranches developed in this analysis were based on aggregate production and resource data (i.e. a combination of data from multiple ranches), so this study's results do not represent the climatic, resource, and production characteristics of any individual ranch.

The management skill, climatic environments, and seasonal feed resources of a specific operator's ranch may cause fall calving to be more or less profitable than what is suggested here or observed on other ranches. Although most operators surveyed for this study seem pleased with their switch to fall calving, their ranch's climate may be particularly conducive for fall calving, or they may have above-average management skills, or they may be more willing than most to take risks associated with major operational changes. These factors, along with the potential extent of cost savings on an operator's specific ranch, should be carefully examined before switching to fall calving.

Consideration should also be given to potential cash-flow shocks during the transition from spring to fall calving. Rather than converting an entire herd to fall calving in a single year, it may be necessary to convert one-third of the herd over a three-year period, or perhaps one-half of the herd over a two-year period, to maintain adequate cash flow.

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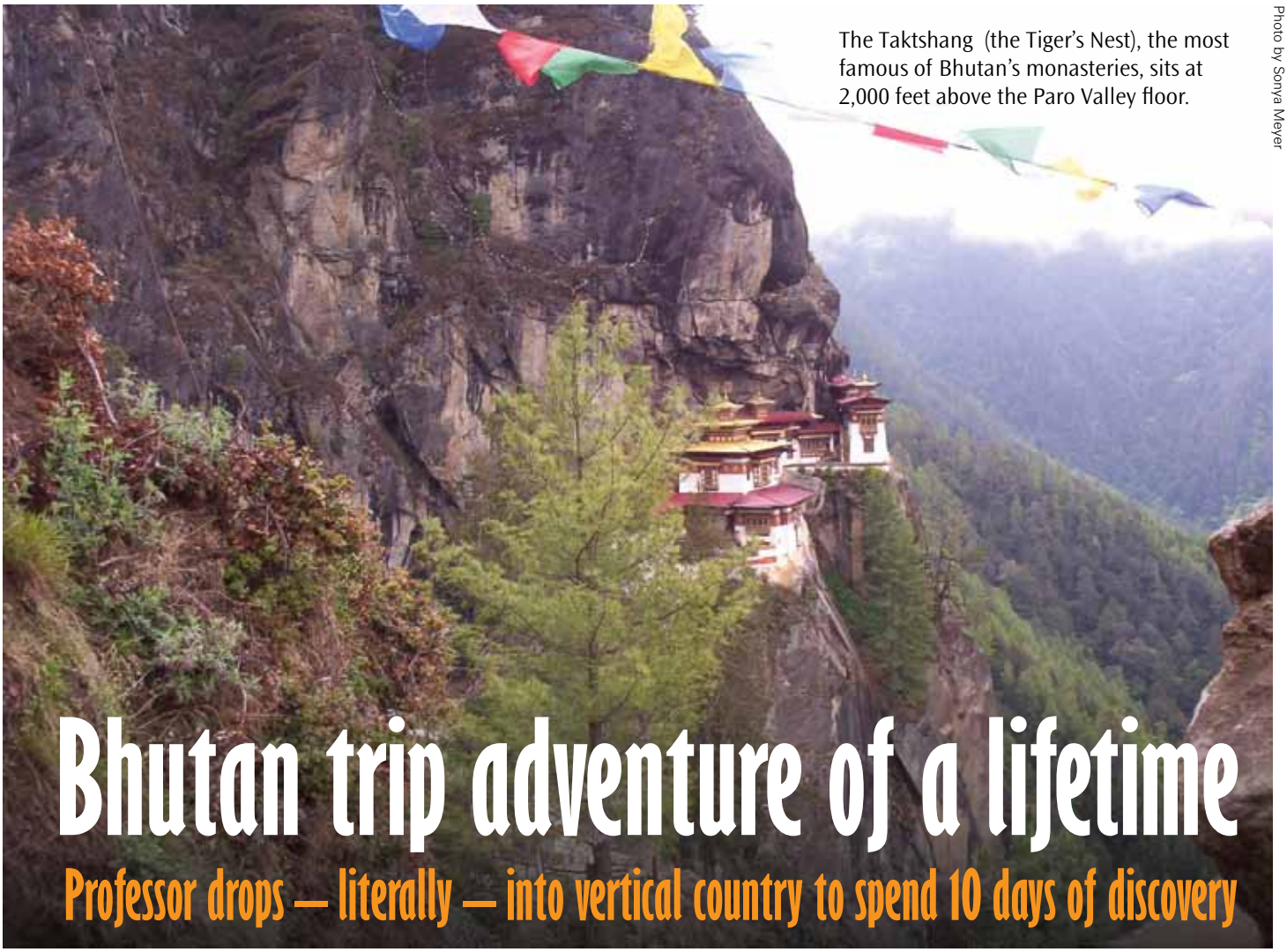

The Taktshang (the Tiger's Nest), the most famous of Bhutan's monasteries, sits at 2,000 feet above the Paro Valley floor.

Photo by Sonya Meyer

Bhutan trip adventure of a lifetime

Professor drops – literally – into vertical country to spend 10 days of discovery

Sonya Meyer
Associate Professor
Department of Family and Consumer Sciences

Imagine my excitement and maybe a bit of trepidation when offered the opportunity to make my first trip to Asia, especially when told we would be flying into a country with one commercial airline, one "international" airport with one runway, and only a few pilots with the training and license to make the landing and take-off.

And, the government as well as the population view Gross National Happiness (GNH) to be more important than Gross National Product.

I was invited to be part of a university faculty study tour organized through Colorado State University focusing on Buddhism and textiles. The generous support from my department, family and consumer sciences, the University of Wyoming College of Agriculture's Global Perspectives program, and UW's International Programs Office made it possible to accept the invitation. We spent 10 days in May 2008 in the Himalayan Kingdom of Bhutan.

Bhutan? I might have heard a reference made to the country in a documentary of black neck cranes, or it might have been on a Public Broadcasting Service program referencing the traditional dress of ghos (go) for men and kiras (key rah) for women still worn. Bhutan was one of the most amazing travel adventures I have experienced.

The government as well as the population view Gross National Happiness (GNH) to be more important than Gross National Product.

Big Verticals

Bhutan has been called a vertical country. That became quite evident as we started our sideways vertical decent into Paro, in the western part of the country and the location of that one "international" airport. The capital of Bhutan is Thimphu, a two-hour drive east of Paro; however, the airport is in Paro because it has the only valley wide enough and long enough for a runway.

We seemed to have landed on a movie set or in an elaborate theme park. With the exception of the security guards, all Bhutanese airport employees were in traditional dress. The buildings were very ornamental with intricate, brightly painted designs; we later realized these were all Buddhist symbols. The landscape is dotted with dzongs (zong) – government administrative centers, monasteries, and prayer flags. The homes in the central region, which runs west to east, somewhat resemble Swiss chalets but with Buddhist symbols painted on the exterior. Everything seemed to have a very clean, neat, and tidy appearance.

Associate Professor Sonya Meyer on the hike to Tiger's Nest.

This surreal feeling continued when we checked into our first resort. There were no golf courses, riding trails, swimming pools, spas, etc., but all the resorts we stayed at were in beautiful settings, and the service was exceptional. At some point on our journey, several of us felt we had discovered the Shangri-La of Hilton's *Lost Horizon.*

That feeling stayed with us throughout our 10 days; however, underneath the beauty appears to be a country with Old World methods scrambling to catch up to the modern world. For example, road repairs were completed with gravel made by a hammer and chisel on the spot.

This method was not limited to road repair. Bhutan recently crowned its new king. Preparations included building a stadium for the coronation ceremonies and later to be used for soccer, as well as new hotels and repair and upgrade of many shops. Gravel for these projects also appeared to be made with hammer and chisel.

Bhutan Undergoing Fast Changes

Some say there have been more changes in Bhutan in the last 50 years than in the previous 400. Satellite television became available in 1999. The number of cell phones has outnumbered land lines in recent years. The only traffic light we encountered was in Thimphu, and I understand it was installed in anticipation of increased traffic for the coronation of the new king. I recently heard that, since the coronation a few months ago, the traffic light has been removed, and the citizens of Thimphu are once again relying on the main traffic circle with a gazebo-type structure and traffic officer to maintain traffic flow.

Hydroelectricity, exported primarily to India, provides roughly 32 percent of the government revenue. Yet, there are numerous homes without any form of electric power. Many of the resorts we were in had Internet access as well as cable television. Thanks to CNN, we knew about the tornadoes that struck Windsor and Wellington, Colorado, as well as the one in Laramie; however, it was also good to be away from technology throughout much of our trip, to have the realization there are populations around the world not aware of the day-to-day events happening around them. By not processing so much information, I had the opportunity to better appreciate and process my surroundings and the experience.

Gross National Happiness

Although change is occurring rapidly in Bhutan, the Bhutanese are very proud and protective of their unique culture and pristine environment – both part of the basis of GNH. The foundation of GNH is four-fold: sustainable economic development, maintaining the pristine environment, preserving cultural identity and heritage, and good governance.

My interest in GNH lays more with Bhutan's ability to maintain its pristine environment and preserving

cultural identity and heritage; however, without good governance and sustainable economic development, the other two factors would be difficult.

The per capita income is among the world's lowest but one of the highest in South Asia – $470 in 1999 to $760 in 2004 (Source: The World Bank in Bhutan, 2006). Tourism is the country's third largest provider of foreign exchange and may prove to be a lesson to the rest of the world in sustainable economic development.

Bhutan's tourist industry is a model for controlled growth. They do this through a daily tourist tariff fixed by the government. We were charged $200 per person per day during our trip; we heard the cost would be doubling. This tariff includes accommodations, food, ground transportation, the services of guides, and a tax used by the government. The tax goes toward supporting the infrastructure, education, health, and other programs. In addition to the daily tariff, all tourists in Bhutan are required to book through an approved tour agency, and visas are required.

Maintaining this level of control over tourism allows the country to preserve its environment and cultural identity. Accommodations are built to blend with and take advantage of the environment.

A Model for Ecotourism

The Bhutanese may also prove to be a model for ecotourism. One of the nicest hotels we were in is in the Black Mountain/Forest National Park where the black neck cranes winter. The hotel runs on solar power, and we were told to plan on the electricity in our rooms to be available only from 6-9 p.m. There are no power lines running through this valley meadow; there are no power lines for the cranes to become tangled in. The meadow streams are off limits for the locals to fish while the cranes are there, as are the track roads running through the meadow. Tourism is encouraged during the time the black neck cranes are there, but the safety and well being of the cranes is a priority.

Women hike steps going to work at Trongsa Dzong dressed in kiras and carrying supplies in baskets strapped to their backs.

A controlled tourist population also helps to preserve Bhutan's cultural identity. A tourist economy not only depends on the cost of accommodation, food, transportation, and other amenities, it also relies heavily on the sale of gift items and novelties. What struck me was the authenticity of most of the items found in the gift shops. Absent were the souvenir trinkets found in many tourist communities. Items we saw related to Bhutan's culture and traditional crafts, and the prices led me to believe the people recognized the monetary value of the skills used to create the items. We found this to be true even with the "trail side" retailers. Seeing someone "setting up shop" along the side of a road to sell their merchandise is not uncommon in many tourist areas.

> At some point on our journey, several of us felt we had discovered the Shangri-La of Hilton's *Lost Horizon.*

Rinzin Wangmo, left, and her mother, master Aum Leki Wangmo, present a natural dye workshop for the tour group. Tour members stayed at the family guest house during their stay in Jakar.

Woman Seeks to Be Master Weaver and Dyer

Our stay in Jakar was in the guest house of Aum Leki Wangmo, a Bhutanese master weaver and dyer. Aum Leki Wangmo and her daughter, Rinzin Wangmo, have attended the International Folk Art Festival held annually in Santa Fe, New Mexico. Aum Leki teaches weaving and dying to women from the surrounding villages. Rinzin explained she is somewhat of a rarity in Bhutan – a highly educated woman learning to become a master weaver and dyer. She explained those who weave cannot read and write, and those who read and write cannot weave. Her goal is to become famous in Bhutan for being able to do both. She explained that, in Bhutan, women either weave from the heart or they weave for sale. In their workshop, she and her mother teach and weave from the heart. This might explain why they start weaving at 6 a.m. and continue until 10 at night stopping for lunch and tea and short rest breaks.

Maybe the "from the heart" work ethic is at the center of Bhutan's GNH. The Bhutanese struck me as not just a happy people but proud – pride in their country and in their uniqueness; however, as the country becomes less isolated, it will be interesting to observe if their traditional dress and customs will be maintained or if they will experience the change that has occurred in so many other Asian countries.

My hope is they will maintain their uniqueness, and maybe, just maybe, they can serve as a GNH role model for the rest of the world.

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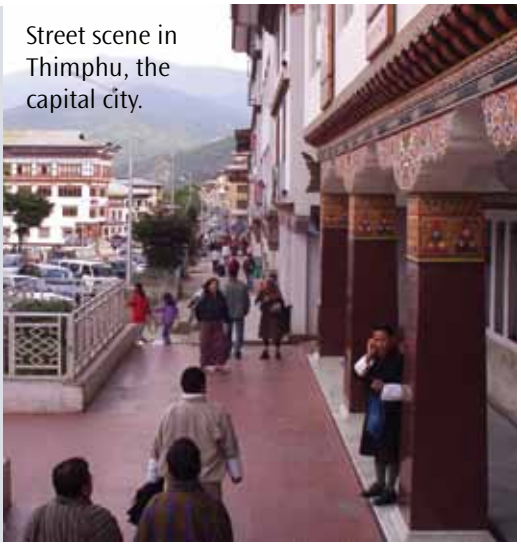
Visit leads to UW course, collaborative study-abroad program

Sonya Meyer also visited Cambodia and Thailand during her trip. Since her return, she has incorporated information on Bhutan's housing into a lecture for the Department of Family and Consumer Sciences' housing course and, combined with the experiences in Cambodia and Thailand, developed a special topics course on Eastern dress and textiles taught this past spring. Time spent in Thailand allowed her to make contacts for student visits during a collaborative study-abroad course with Colorado State University this fall with travel over winter break to Hong Kong and Thailand.



Street scene in Thimphu, the capital city.

Village woman dressed in her kira, the traditional dress of women in Bhutan. Her sleeping child is carried in a back sling.

Government requires workers in traditional dress

The obvious outward symbol of Bhutan's preservation of its unique cultural identity and heritage is through the government mandate of traditional dress. The traditional dress mandate appears to apply to those employed in government agencies, financial institutions, and the tourist industry.

The school uniforms in Bhutan are also traditional dress. We became very accustomed to seeing men wearing ghos and women in kiras and jackets, and young boys in a gho and young girls in an immaculate kira and jacket on their way to and from school. It quickly became apparent Western culture and dress had reached this isolated kingdom. Blue jeans and T-shirts on the streets at the close of the workday were not unusual, especially among young people. Western influence of ready-to-wear clothing was especially evident in the shops in Thimphu. The mannequins used for display were Western in appearance.

Traditionally, the ghos and kiras were made in the home from handwoven fabric; however, with the demand for readily available and more affordable traditional clothing, shops are selling ready-to-wear ghos manufactured in India. We also saw fabric imported from India in shops for making ghos. We did not see ready-to-wear kiras. This may be because construction of the kira is much less complex than the gho. Weaving one kira panel can take three months to weave; it takes three panels to make one kira. Depending on the fiber and the intricacy of the design, one panel can cost around $400. Women's jackets do appear as ready-to-wear. The beautiful silk jackets are manufactured in China.

Handwoven fabrics seem to play a major role in Bhutan's past. Fabric was once considered a commodity many used to pay their taxes. There was also a hierarchy of gift giving associated with a gift of fabric. Only certain fiber combinations and designs were acceptable as gifts to members of the royal family, while others were acceptable as wedding gifts. There are some woven patterns considered traditionally Bhutanese, while others identify specific regions within Bhutan.

Weaving was always the role of the women. Tailoring/sewing is the job of men especially for anything associated with a Buddhist temple or festivals.

Even though handwoven fabrics still play a major role in Bhutan's cultural identity, there are no major textile manufacturing facilities. There is concern this art might be dying. The lure of a career in the city has more appeal than staying in the village and weaving.

Fabrics made in Bhutan are still handwoven using a technique called supplemental weft. These beautiful fabrics are made on a vertical loom, a backstrap. We visited one weaving workshop in Thimphu that could be considered somewhat of a manufacturing facility; however, rather than the mechanized looms found in most factories, these looms were all backstrap. There were several looms all with fabrics in various stages of production. There was also a small gift shop where their work was sold. Observing these women at work, it was easy to appreciate the prices associated with the products. Many handwoven kiras can start at $1,000. A handwoven belt could start around $100.

Researcher studies sugar

Dennis Odero
Post Doctoral Research Associate
Department of Plant Sciences

Weeds need to be controlled in sugar beets because they negatively impact yield. In addition, they produce abundant seeds that remain dormant in soil for extended periods of time and become a source of re-infestation in subsequent years.

These factors make the management of weeds very important.

In 2003, many sugar beet growers within northwestern Wyoming's Big Horn Basin and some parts of southern Montana started noticing an increase in the abundance of annual broadleaf weeds Venice mallow, lanceleaf sage, wild buckwheat, and redstem filaree.

Growers were interested in knowing the ideal herbicide program for management of these weeds. We initiated management and competition studies to answer grower concerns. These weeds were unique compared to weed species commonly found in cultivated fields in this region – they are low stature and prolific seed producers. We were astonished when visiting infested fields that these weeds, despite their smaller size, completely crowded out and choked sugar beets.

The competition studies were conducted in 2006 and 2007. During the course of the project, we noticed these weeds emerged with sugar beets at the same time and were relatively slow growing but still managed to outcompete sugar beets, especially where occurring in high densities.

Competitive Forces Develop

Weeds will certainly compete with sugar beets for soil nutrients, soil moisture, and light resulting in up to a 95-percent loss in yields if no control measures are carried out; however, in irrigated production systems where soil water is sufficient and nutrients are abundant, light becomes the main factor around which competitive forces develop. Infestations of weeds also increase sugar beet protection costs because they harbor several insect and disease pests.

The most competitive weeds against sugar beet are annual broadleaf species that grow tall and shade the sugar beet canopy. Consequently, as the density of these weeds increases, light becomes more limited resulting in root yield reduction. Based on the growth form and habit of these weeds, it was unclear if they would be detrimental to sugar beet.

Sugar beet yield responses to various densities (18, 36, 54, 72, and 90 plants/10 feet of sugar beet row) and duration of competition from these weeds was determined. For the duration of competition, 54 plants/10 feet of sugar beet row of each species was allowed to compete with sugar beet for 2, 4, 6, 8, 10, and 12 weeks before removal. The lowest densities of these weeds that would result in yield reduction as well as the length of time they

Wild buckwheat in competition with sugar beets.

beet-broadleaf weed scuffles

would compete with sugar beet before yield reduction based on the cost of chemical control was also estimated. The chemical cost for managing these weeds in conventional sugar beets was $152.04, $125, $169.03, and $124.29/acre for Venice mallow, lanceleaf sage, wild buckwheat, and redstem filaree, respectively.

Effect of Season-long Competition on Sugar Beets

Sugar beet root yield decreased as weed density increased for all weed species. Root yields were reduced from 20 to 49 percent, 17 to 49 percent, 17 to 58 percent, and 18 to 63 percent for Venice mallow, lanceleaf sage, wild buckwheat, and redstem filaree, respectively, as their densities increased from 18 to 90 plants/10 feet of sugar beet row. The aboveground biomass of these weeds increased with density illustrating they exhibited strong interspecific competition against sugar beets despite their low stature. Competition from these weeds similarly reduced sucrose yield as their densities increased.

It was estimated yield equivalent to the chemical cost of control would be lost if 12, 10, 14, and 7 Venice mallow, lanceleaf sage, wild buckwheat, and redstem filaree plants/10 feet of sugar beet row, respectively, were allowed to compete with conventional sugar beets season-long.

Why is this important to estimate minimum densities that would reduce yield?

An understanding of the competitive relationship between weeds and sugar beet provides a basis for planning effective weed control strategies. To achieve this goal, growers need to know the lowest density of specific weeds or weed complexes that will reduce sugar beet yield so appropriate management strategies can be implemented to maximize returns.

Sugar Beet Response to Length of Weed Competition

Similarly, sugar beet root yield decreased with increasing lengths of competition for all the weed species. Root yields were reduced 4 to 39 percent, 7 to 42 percent, 2 to 41 percent, and 14 to 42 percent as the duration of competition increased from 2 to 12 weeks for Venice mallow, lanceleaf sage, wild buckwheat, and redstem filaree, respectively. Competition from these weeds likewise reduced sucrose yield as their densities increased.

The time required to manage Venice mallow, lanceleaf sage, wild buckwheat, and redstem filaree before root yield equivalent to the chemical cost of control was lost in conventional sugar beet was approximately 6, 5, 6, and 4 weeks, respectively.

Sugar beet growers in the Big Horn Basin and other sugar beet production regions in Wyoming have adopted Roundup Ready sugar beets. This presents growers the opportunity to have broad spectrum weed control using glyphosate and no carryover restrictions like herbicides used in conventional sugar beets – thus allowing flexible crop rotations. The use of this technology is credited with lower cost of weed control at $52.99/acre when compared to conventional sugar beets.

Consequently, the effect of these weeds was also determined on glyphosate-resistant sugar beets. The lowest density these weeds would compete

> Weeds will certainly compete with sugar beets for soil nutrients, soil moisture, and light resulting in up to a 95-percent loss in yields if no control measures are carried out.

Venice mallow

Lanceleaf sage

Redstem filaree

based on the chemical cost of control before yield reduction in glyphosate-resistant sugar beet was 21 plants/10 feet of row for Venice mallow, lanceleaf sage, and wild buckwheat, and 12 plants/10 feet of row for redstem filaree.

The minimum duration of time they would compete before yield reduction based on the chemical cost of weed control was four weeks for Venice mallow and three weeks for lanceleaf sage, wild buckwheat, and redstem filaree. The lowest density as well as the duration of time these weeds would interfere with sugar beets before yield was reduced in glyphosate-resistant sugar beets was less than for conventional. This was attributed to the cheaper cost of managing these weed species in glyphosate-resistant sugar beet.

Based on these results, management of these weeds in glyphosate-resistant sugar beets should be implemented at low densities and earlier in the season because of their low management cost.

One of the weed species we studied – wild buckwheat – has been shown to have some natural tolerance to glyphosate for chemical weed control. This means there will be a shift to weed species that are tolerant to glyphosate such as wild buckwheat in sugar beet fields. We know that wild buckwheat will negatively affect sugar beet yields, and, based on these assertions, we will be studying wild buckwheat dose response to glyphosate. This will give us an idea of what rate of glyphosate to use where wild buckwheat infestations are high in sugar beets.

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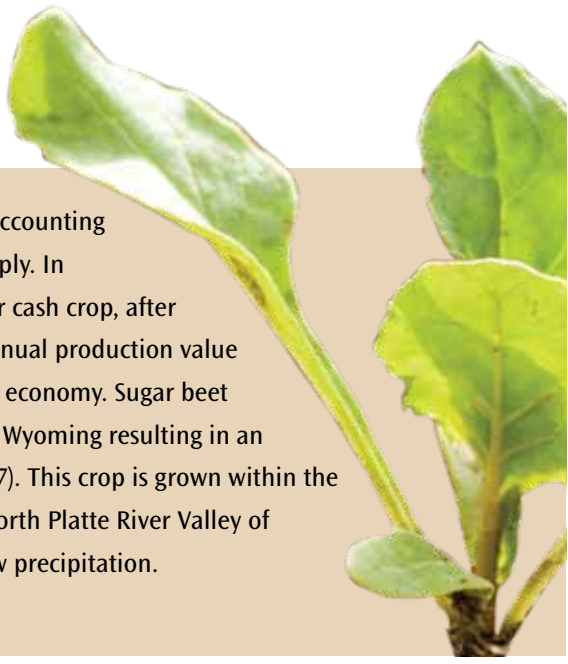
The most competitive weeds against sugar beet are annual broadleaf species that grow tall and shade the sugar beet canopy.



Sugar beet is a globally important crop accounting for 37 percent of the world's sucrose supply. In Wyoming, sugar beet is the second major cash crop, after alfalfa and other hay, contributing an annual production value of $37 million (2006 figure) to the state's economy. Sugar beet is grown on 30,800 acres (2007 figure) in Wyoming resulting in an average root yield of 21.8 tons/acre (2007). This crop is grown within the Big Horn Basin, Wind River Basin, and North Platte River Valley of Wyoming under irrigation because of low precipitation.

Think swine research will become important in Wyoming when pigs fly?

Well, they've just departed for the runway...

Researcher examines which genes in swine affected by aflatoxin-contaminated feed

Kristi Cammack
Assistant Professor
Department of Animal Science

One does not normally associate pigs with the rangelands of Wyoming; however, in 2007, the number of swine in the state was estimated at 107,000 head at 150 operations.

My interest in swine started while growing up on a small farm in eastern South Dakota. We raised pigs for a number of years. While working on my Ph.D. at the University of Missouri, I was involved in a number of swine studies. Although the swine industry is not necessarily prevalent here in Wyoming, the swine industry is definitely a big player in U.S. agriculture.

One of the challenges for sustaining a profitable swine operation is the availability of a cost-efficient feedstuff. The rise in the number of ethanol plants has led to an increased incorporation of ethanol by-products into swine diets. The most common commercial by-product is distillers dried grains with solubles (DDGS). Distillers grains are by-products of the fermentation process to produce ethanol. Surplus solubles from the fermentation process and distillers grains are combined prior to drying to produce DDGS.

Photo 1. Amanda Kaiser (left), a senior in the Department of Animal Science, and master's student Sheila Rustemeyer conduct laboratory analyses on samples collected during the swine study.

Historically, there has been limited use of DDGS in swine diets in part due to variability in quality and nutrient content, low protein content, poor amino acid digestibility, and high fiber content; however, recent studies have shown DDGS produced by newer ethanol plants compared to older plants have a higher nutrient content and digestibility, making these DDGS better suited for swine diets. These higher nutrient DDGS are considered a potential cost effective alternative for corn, soybean meal, and dicalcium phosphate in swine diets. Current research suggests DDGS can be included in swine diets during all phases of production, varying from 5 percent of the diet for young pigs up to 50 percent for mature sows and boars.

Liver Primary Target

One concern regarding the inclusion of DDGS into swine diets is that corn used to produce these by-products is susceptible to molds that produce toxins, collectively called mycotoxins, which are concentrated during the ethanol process. Aflatoxin is one such toxin and is not destroyed during ethanol production but instead concentrated by three to four times resulting in potentially high levels in the DDGS produced. A low level of aflatoxin present in DDGS may cause aflatoxicosis (toxicosis caused by aflatoxins) in swine consuming the contaminated feed, resulting in reduced feed efficiency and growth rate, liver damage, and immune suppression.

The liver is the primary target organ of aflatoxins. Pigs are particularly sensitive to this toxin, more so than cattle and sheep, and immature animals are typically more sensitive than adults. Currently, the most feasible treatment for aflatoxicosis is the removal of the affected individual from contaminated feed, and the most proven method of prevention is stringent and frequent testing of feedstuffs.

Finding a Solution

To better treat or prevent aflatoxicosis in swine, researchers need to improve their understanding of how aflatoxins affect the liver.

One approach is to determine which genes, especially in the liver, are affected by consumption of aflatoxin-contaminated feed. Identification of these genes may help researchers determine how aflatoxins affect the pig and, as a result, lead to the development of therapies to treat individuals with aflatoxicosis or even prevent aflatoxicosis in swine-fed, aflatoxin-contaminated feedstuffs. Researchers also need a better understanding how the incidence and severity of aflatoxicosis varies with the amount and duration of aflatoxin fed.

I really enjoy working with graduate students, and I believe this research has many practical applications for swine producers in Wyoming and beyond, and that is something I hold in very high regard. The research fell into place quickly. My Ph.D. adviser, Bill Lamberson, has been involved in swine research at the University of Missouri for a number of years. I visited with him about the idea, and he was very receptive to working together on the problem. We started visiting with David Ledoux, a mycotoxin expert at the University of Missouri, and a plan was developed. Swine health and alternative feedstuffs are a priority for the National Pork Board (NPB). The three of us applied for a competitive grant from the NPB and were successful. We initiated a collaborative research project that features the use of genomic technologies to better understand how aflatoxins directly affect the pig liver and how that translates to aflatoxicosis in pigs. The research project has since become the thesis project of a Department of Animal Science master's student, Sheila Rustemeyer (Photo 1), originally from Jefferson City, Missouri, and a recent graduate of Truman State University in Kirksville, Missouri.

The animal portion of the research was conducted at the University of Wyoming College of Agriculture's Livestock Farm. Dave Lutterman, supervisor of the UW Swine Unit, was instrumental in this part of the research. A study was designed in which 90 Duroc x Yorkshire crossbred young barrows (Photo 2) were fed a diet containing a high level of aflatoxin (500 parts per billion -ppb), a low level of aflatoxin (250 ppb), or no aflatoxin for a period of 7, 28, or 70 days (Table 1). Feed intake was recorded daily, and pigs were weighed

Table 1. Design of the experiment.

	No Aflatoxin	Low Aflatoxin	High Aflatoxin
7 days	10 pigs	10 pigs	10 pigs
28 days	10 pigs	10 pigs	10 pigs
70 days	10 pigs	10 pigs	10 pigs

Photo 2. Duroc x Yorkshire barrows.

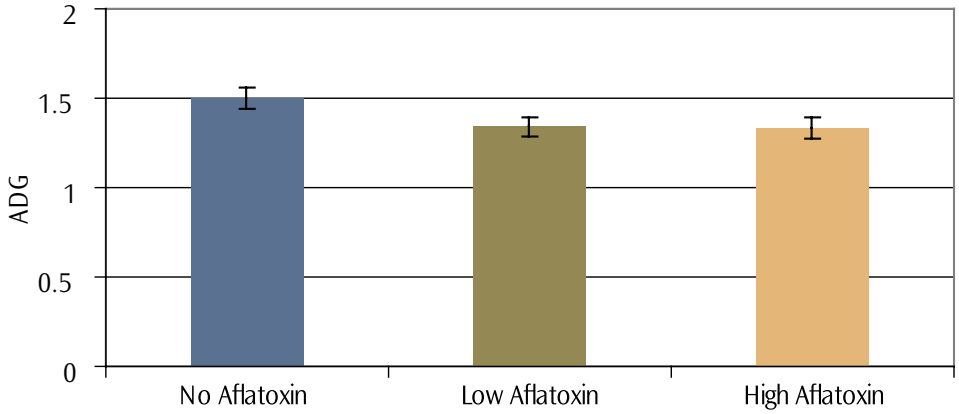


Figure 1. Average daily gain (ADG) in pounds of barrows consuming a diet with no aflatoxin, a low level of aflatoxin, or a high level of aflatoxin. Consumption of a diet contaminated with aflatoxin, at either a higher or more moderate level, results in decreased ADG. We found ADG was more quickly affected by the high aflatoxin diet, but it was also affected by the low aflatoxin diet over a longer period of time. This would suggest diets with low concentrations of aflatoxin could affect the growth of an animal if fed for a lengthy period (70 days in this study).

and blood sampled weekly. Pigs were closely monitored for clinical symptoms of aflatoxicosis, including feed refusal, depressed intake, and weight loss. Liver, pancreas, and kidney tissues were collected from pigs on their last treatment day (7, 28, or 70).

Preliminary evidence from this study suggests consumption of either a high or low level of aflatoxin for a short period of time (seven days) does not affect weight gain or average daily gain of growing barrows; however, a longer term consumption of an aflatoxin-contaminated diet (28 days) does appear to inhibit weight gain and average daily gain (Figure 1), regardless of level of aflatoxin. Similar results are expected in pigs consuming the aflatoxin-contaminated diets for 70 days.

To investigate the genomic effects of aflatoxicosis on the liver, an advanced tool called a microarray chip will be used. Thousands of target genes are present on a single microarray chip. RNA is a precursor of DNA and is used for genomic assessment. For this study, the RNA from each liver sample will be isolated in the laboratory and then used in conjunction with the microarray chip to determine which genes are affected by consumption of aflatoxins.

If the gene is present in the liver sample, the corresponding target on the microarray chip will fluoresce; if the gene is not present, the corresponding target will not fluoresce. The fluorescence of each target gene is measured, and the fluorescence differences between pigs receiving no aflatoxin, a low level of aflatoxin, and a high level of aflatoxin will help identify those genes that play an important role in the response to aflatoxins.

The microarray (gene) analysis will be conducted this summer at the University of Missouri. Rustemeyer will spend her summer there, working with Bill Lamberson's lab in finishing this portion of the research. Additional lab analyses will be conducted in our laboratory in the Department of Animal Science upon Rustemeyer's return.

What This Means to Swine Producers

As the nutrient value of ethanol by-products improves, producers are increasing the use of DDGS in swine diets to improve the economic viability of their operations; however, the increased use of DDGS is paralleled by an increased risk of aflatoxicosis. It may be difficult for swine producers to diagnosis aflatoxicosis in their herds, as the symptoms can be non-specific, such as suppressed appetite and lower gains.

Although DDGS are considered a cost-efficient alternative feedstuff, the economic implications associated with aflatoxicosis can more than offset potential cost savings of feeding DDGS. For swine producers to take full advantage of the DDGS market, the effects of feeding an aflatoxin-contaminated feedstuff needs to be more fully understood, and novel treatment and improved prevention strategies need to be developed. We hope that taking a genomics approach will help determine how aflatoxins affect the physiology of the pig and that this knowledge can be used as a first step in developing those strategies.

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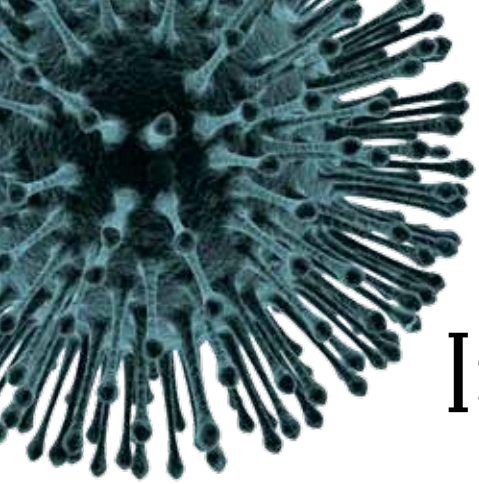


Is the global 'One Health'

Donald Montgomery
Head, Department of Veterinary Sciences and Director, Wyoming State Veterinary Laboratory

'One health' is a concept that embraces the complex interrelationships between the environment, animal health, and human health.

"The convergence of people, animals, and our environment has created a dynamic in which the health of each group is inextricably interconnected," says Lonnie King, a veterinarian and director of the National Center for Zoonotic, Vector-Borne, and Enteric Diseases, Centers for Disease Control and Prevention, Atlanta, Georgia. King goes on to say that, of the recognized infectious diseases in humans, approximately 60 percent are caused by multi-host pathogens able to be transmitted across species lines. "…over the past three decades, approximately 75 percent of new emerging human infectious diseases have been zoonotic," i.e. transmitted from animals to humans.

Exemplary is the global concern regarding highly pathogenic avian influenza virus (type H5N1) that has caused 385 human infections and 243 deaths (these numbers continue to increase).[2] "If an avian influenza virus, such as the H5N1 subtype virus, acquires the ability to undergo efficient and sustained transmission among humans, a pandemic would be inevitable," according to Terrence M. Tumpey in proceedings of the 59th Annual Meeting of the American College of Veterinary Pathologists.

Additional players in this dynamic, including global, national, and local economies, population increases, energy exploration, and climactic change, whether or not you believe in it, are relevant to Wyoming.

Should we be concerned only with pandemics? The overview of the "one health" initiative may seem to focus only on the new, emerging, or pandemic diseases that impact human health; a focus, yes, but not the sole reason for the initiative. Although we must be vigilant regarding emerging and pandemic infections, what of the diseases that currently exist in Wyoming? What changes will alter the environmental-animal-human health dynamic? "One health" may become an imperative for Wyoming, not just an initiative. The College of Agriculture and others throughout the university and state are positioned to provide direction and leadership for Wyoming.

What are the challenges for Wyoming?

The demand for Wyoming's rich mineral resources is great; the potential economic benefit is tremendous. According to a flyer from the Wyoming Reclamation and Restoration Center, in the College of Agriculture, "No one agency knows how much land has been disturbed because of energy development." Along with mineral exploration and energy development has been an increase in the state's population. In the Christmas Eve edition of our local newspaper, an article stated revised census estimates rank Wyoming No. 7 in the rate of population increase.

With continued energy development and expansion of the Wyoming populace into rural and semi-rural areas disrupting and displacing wild and domesticated animals, there is the potential for infectious diseases at the wildlife-domestic animal-human interface to be more prevalent.

Rabies, plague, tularemia, Q-fever, and brucellosis are only some of the infections of wildlife and domestic animals in Wyoming that can be transmitted to humans. Other multi-host pathogens include antibiotic resistant *Staphylococcus aureus*,

Initiative right for Wyoming?

Campylobacter jejuni, salmonellosis, and various parasites.

Anthrax cases occurred in livestock and wildlife during the 1950s in Wyoming and recently in surrounding states. Anthrax spores can survive in the soil and persist in the environment for decades; there is a potential for future outbreaks. The deaths of a National Park Service wildlife biologist in Arizona in 2007 from plague and a Missouri man from rabies in 2008 illustrate the real potential for serious human illness. Of added concern to all is the specter of new, emerging infections such as the H5N1 strain of avian influenza already mentioned.

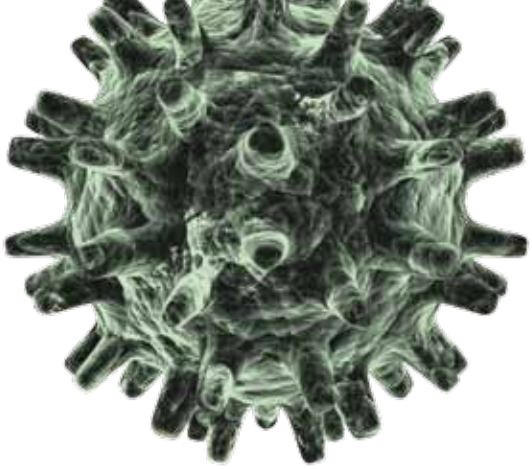
"The convergence of people, animals, and our environment has created a dynamic in which the health of each group is inextricably interconnected."

Lonnie King, DVM

Disease and Human History

At the recent annual meeting of the American College of Veterinary Pathologists, Brad Bolon, veterinary pathologist and historian, gave an excellent address entitled *Plagues and Politics: Disease as the Etiology for Human History*.[3] Excerpts from his presentation are pertinent.

- "A renaissance in historical scholarship during the last few decades has begun to restore the public's appreciation of disease as not only an individual inconvenience but also the key etiology in directing how human civilization has, is, and will unfold."
- "Current thinking is that almost all major human epidemic diseases first began as animal infections, which later jumped to man and evolved to accommodate a human-to-human mode of transmission…"
- "The key is obviously greater contact time between humans and animal-derived pathogens and their vectors…"
- "Epidemics may be more contained in the future, but they are here to stay. Therefore, society … must take effective steps to deal with future disease outbreaks."
- "A primary lesson of history (that) underpins the current 'One World, One Health' initiative is that the medical community will always be slow to recognize new medical crises in time to actually prevent a pandemic from occurring."
- "The veterinary profession … is well-placed to fill a key role in optimizing society's response to future pandemics."
- "This aptitude stems from the emphasis placed … on identifying and treating infectious diseases, and from the routine veterinary mindset of approaching such conditions as a herd health problem rather than as an isolated or individual illness."



What are Wyoming's assets?

Disease surveillance and timely recognition are cornerstones of the "one health" initiative. Wyoming has the infrastructure to effectively monitor the health of the environment, animals, and humans. Wyoming is blessed with conscientious, knowledgeable livestock producers and wildlife managers who are excellent stewards of the state's natural resources and have a keen awareness of animal health issues.

The health professions, veterinary and human, are strong, but it is increasingly difficult to attract practitioners to the state, and there are areas of Wyoming underserved. These individuals are the first line of defense against disease, whether the disease affects only individuals or larger populations.

Further, the Wyoming Department of Health has been proactive in surveillance for multi-host pathogens and has established a system of regional veterinary coordinators who provide feedback regarding such infections in animals.

There are also diverse players in the College of Agriculture and University of Wyoming as well as in state agencies who could provide needed infrastructure for a "one health" initiative for Wyoming.

The Wyoming State Veterinary Laboratory provides testing necessary to detect infections by multi-host pathogens as well as surveillance for new or emerging diseases such as the H5N1 strain of avian influenza. The diagnoses of high-impact animal or multi-host pathogens, those capable of causing severe illness and death as well as economic harm or human illness, are then communicated to health officials at the Wyoming Department of Health and Wyoming Livestock Board.

At the other end of the spectrum, mitigating the effects of climatic change, such as drought, as well as energy and mineral exploration and development, are within the purview of the Wyoming Reclamation and Restoration Center and the Department of Renewable Resources in the College of Agriculture. Only a few of the potential participants are named here; some are obvious, but virtually anyone could play a role.

Many of the assets are in place to make a "one-health" initiative for Wyoming a reality. Acceptance and leadership are a must; there is, however, no single entity that could or should dominate the effort required to make this happen. The challenges are to educate the general public, to work together, and to recognize and appreciate the diversity of disciplines that contribute to the health of the environment, people, and animals.

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[1]Lonnie J. King, et al: Executive summary of the AVMA One Health Initiative Task Force report. *JAVMA* 233(2):259-261, July 15, 2008.

[2]Terrence M. Tumpey: Mutations that affect the transmissibility of influenza A viruses. Proceedings of the 59th Annual Meeting of the American College of Veterinary Pathologists, pg 188-189, Nov. 15-19, 2008.

[3]Brad Bolon: Plagues and Politics: Disease as the etiology for human history. Proceedings of the 59th Annual Meeting of the American College of Veterinary Pathologists, pg 182-185, Nov. 15-19, 2008.

Animal science researchers find maternal hormone environment influences development of male sexual behavior

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Department of Animal Science

The expression of male sexual behavior is intriguing. Sexual interest or libido as well as fertility and the ability to copulate are required for the successful reproduction of most animals.

Brenda Alexander was a research associate in the College of Agriculture's Department of Animal Science when she began to notice different sexual behaviors expressed by rams. Some rams stood around feigning indifference to the estrous ewes patiently waiting for their stillness to be noticed while other rams would make a direct beeline to any ewe, all ewes, and would have the ewes in estrus identified and mounted in less than a minute. Outside of the barnyard, the same male behavior in other species could be observed. It made a person wonder why there is such a difference. What controls sexual interest and expression? Is it developmental?

Neural pathways that control expression of male sexual behavior are established during fetal development. This process of sexual differentiation of the male brain includes both defeminization and masculinization. Defeminization alters the response of the hypothalamus to the gonadal steroids so a surge release of luteinizing hormone (LH – necessary for ovulation in the female) is no longer possible. Masculinization of the central nervous system is a less well-defined process and includes development of male-specific behaviors. These behaviors, although not expressed until adulthood, differentiate during the fetal period primarily in response to hormones secreted by the fetal testes and may also be influenced by other steroids in the fetal environment.

Progesterone's Effects

What role progesterone, known and named for its pro-gestational role in the female, has in the development and expression of male sexual behavior is what interests Alexander now.

Progesterone is mostly known as a female hormone required for the maintenance of pregnancy. This steroid hormone is synthesized during pregnancy by the maternal ovary and is secreted in abundant quantities by the placental membranes. In the male, progesterone

is synthesized by the testes and is required for the synthesis of testosterone. Progesterone is a derivative of cholesterol and freely diffuses across the cell membrane to influence brain development and behavior by binding to specific steroid receptors that alter DNA transcription and translation.

The role of progesterone in the development of male sexual behavior is gaining research interest since progesterone, a hormone generally regarded as innocuous, is increasingly being used for treatment of at-risk pregnancies thus exposing the developing fetus to unnatural concentrations of the hormone.

Neural pathways controlling sexual behavior are established during fetal development and are sensitive to the fetal steroid environment.

Circulating concentrations of progesterone are similar among male and female laboratory rats and mice during the period of sexual differentiation; however, the male brain is more sensitive to progesterone because of the increased expression of progesterone receptors within regions of the developing brain necessary for neuroendocrine function and expression of male sexual behavior.

Rat Model Useful

The rat is a useful animal model to study the development of sexual behavior because it is born relatively undeveloped, and sexual differentiation of the nervous system occurs postnatally. The rat fetal gonad differentiates just prior to birth with normal sexual differentiation of the nervous system occurring during the first five days of life. Because of this postnatal differentiation and early sexual maturity of the rat, the steroid environment during this critical period of differentiation can be manipulated to determine its effect on the expression of male sexual behavior by 10 weeks of age.

For these experiments in the College of Agriculture, male rats were treated on postnatal day one through five with either progesterone, a specific progesterone antagonist (RU486), and compared to vehicle treated controls. Animals were weighed frequently to monitor growth. Following sexual maturity, rats were exposed to receptive females and sexual behavior was monitored.

Treatment with progesterone or the progesterone antagonist did not influence growth or the number of mounts achieved when exposed to estrous females. Therefore, progesterone may not be important for the development of sexual interest or libido in the rat; however, treated rats did decrease number of intromissions (vaginal penetrations; Figure 1) and ejaculations (Figure 2).

It may seem unusual for an agonist (activates a receptor to induce a response) to have a similar response as the antagonist (blocks the receptor); however, high levels of an agonist can often act like an antagonist by down-regulating expression of the receptor.

Progesterone Influence in Sheep

Influence of progesterone on the development of sexual behavior is not unique to the rat. In the sheep, sexual differentiation of the brain occurs early at approximately days 65-100 of pregnancy; however, in the ram lamb, there is a second period of sexual differentiation that occurs postnatally from four to eight weeks of age. During this postnatal period, there is an increase in testosterone synthesis coinciding with an increased expression of sexual play in the ram lamb. Rams castrated prior to this developmental period do not

express sexual behavior with hormone treatment contrary to rams castrated after this critical period.

Rams are usually selected based on phenotypic or production characteristics and are rarely evaluated for sexual behavior even though the desire and competence to mate are obligatory for the incorporation of superior genetics into a flock. Research by Ed Price at the University of California, Davis, in the 1980s determined that, if ram behavior was evaluated, as many rams would be culled for poor libido that are currently culled for structural defects or semen limitations. Although a lot has been learned about male sexual behavior since the 1980s, there are still rams that express poor sexual behavior in the field.

Recent research at the University of Wyoming treated ram lambs with RU486 or a control solution. Treatment of rams with RU486 from four to eight weeks decreased serum concentration of testosterone at 6 months of age. It is not known whether treatment had a long-term effect on testosterone synthesis or if treatment simply delayed the attainment of puberty. At six months of age, treated rams showed an initial decrease in the number of investigatory behaviors suggesting an influence on sexual interest in the ram, but, contrary to the rats, numbers of mounts and ejaculations achieved in these young, post-pubertal males were similar. Although this period of development is necessary for the expression of adult sexual behavior, mounting behavior *per se* is likely established during fetal sexual differentiation.

For males to be reproductively successful, sexual interest (libido) as well as fertility and the ability to copulate is required. Neural pathways controlling sexual behavior are established during fetal development and are sensitive to the fetal steroid environment. Since expression of male sexual behavior can be influenced during this developmental period, the long-term effect of exogenous hormones must be determined so we do not inadvertently affect the males' reproductive success.

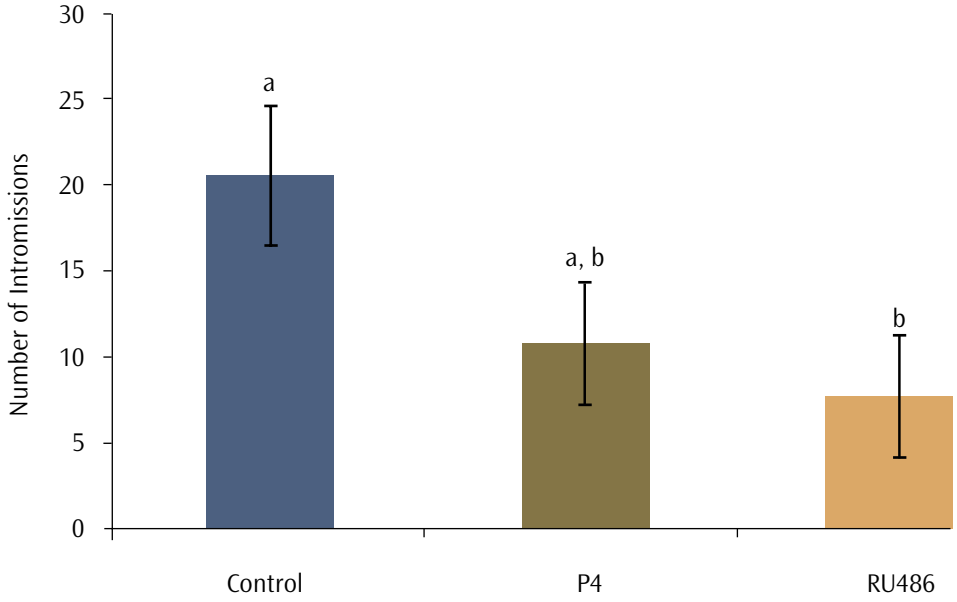

Figure 1. Number of intromissions (vaginal penetrations) achieved during a 30-minute test period in rats treated with either progesterone (P4), a progesterone antagonist (RU486), or a vehicle control from days one through five of life. Differing subscripts differ ($P < 0.05$).

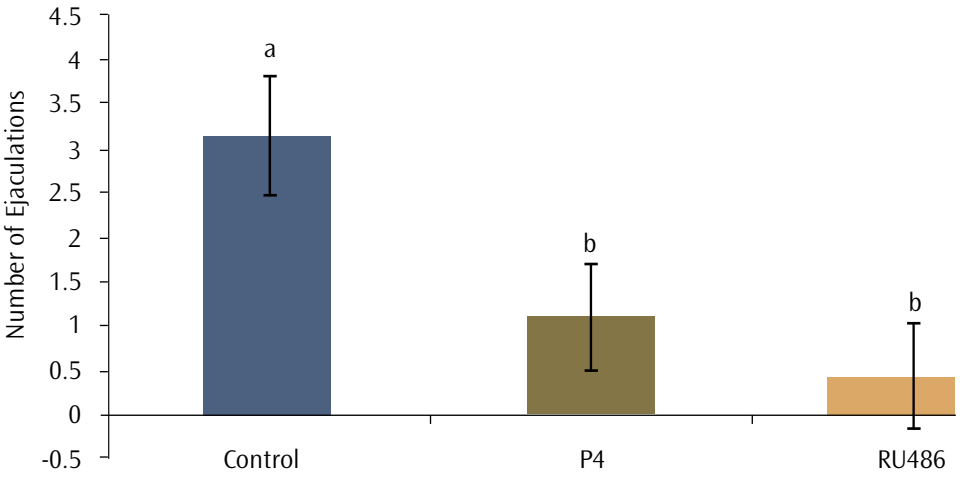

Figure 2. Number of ejaculations achieved during a 30-minute test period in rats treated with either progesterone (P4), a progesterone antagonist (RU486), or a vehicle control from days one through five of life. Differing subscripts differ ($P < 0.05$).

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Can conservation easements help

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Rural communities in the West are experiencing an unprecedented rate of growth and development pressure.

This is forcing communities and landowners to make trade-offs between residential development and the rural amenities provided by agricultural lands. These amenities include arable lands, open space, wildlife habitat, air and water quality protection, and recreation opportunities.

How can rural communities keep their "rural" amenities? Conservation easements are one tool that helps preserve agricultural lands and the rural amenities they provide. Landowners keep their land but give up their rights to turn all, or part, of their land into residential housing, oftentimes for tax benefits and/or other compensation.

The impetus for our work was Wyoming governors Stan Hathaway's, Mike Sullivan's, Jim Geringer's, and now Dave Freudenthal's interest in the fate of rural/agricultural lands and the importance to Wyoming of our open spaces. Subsequent research led to several departmental master's theses and important collaboration with the Ruckelshaus Institute of Environment and Natural Resources Open Space Advisory Committee.

The issue that seemed to resurface: agricultural landowners manage many

keep the 'rural' in rural communities?

important resources. Those lands and the activities on them are important to rural economies and communities. The question then becomes what did these landowners think about refraining from residential housing development on their agricultural lands?

Existing research suggests much had been done on what the public wanted in open space preservation, but there was a void as to what was affecting landowners and land trusts when entering into easements. As this amounted to both potential suppliers and demanders of easements, we chose to apply for a grant to study this from a market perspective. A group of researchers from the University of Wyoming College of Agriculture's Department of Agricultural and Applied Economics and Colorado State University's Department of Agricultural and Resource Economics received a $388,200 grant from the U.S. Department of Agriculture. The proposal was among 10 percent of the proposals received nationally to be awarded funding. The funding was for studying what might impact landowners' decisions to participate in conservation easements and affect the organizations offering conservation easements. Understanding potential issues and preferences related to conservation easements should provide information that could improve the use of conservation easements and help small communities keep their "rural" nature.

Researching Landowner Preferences

Little research has been conducted in the West on landowner preferences for conservation easements. Researchers conducted focus group interviews with agricultural landowners and land trusts over a two-year period, meeting with more than 100 people to discuss relevant issues and topics before conducting survey research. Interviews took place at national meetings of the Washington, D.C.-based Land Trust Alliance in Madison, Wisconsin, as well as with groups from the Wyoming Stock Growers Association, Colorado

Understanding potential issues and preferences related to conservation easements should provide information that could improve the use of conservation easements and help small communities keep their "rural" nature.

Photo by Christopher Bastian

Department of Agricultural and Applied Economics Associate Professor Don McLeod (foreground) takes notes during a focus group session at the National Land Trust Alliance meetings in Madison, Wisconsin.

Photo by John Hewlett

Agricultural lands such as this provide scenic Wyoming vistas and other amenities many rural residents enjoy.

Farm Bureau, and Colorado Cattlemen's Association. The outcomes identified a number of issues used to develop a survey subsequently mailed to nearly 5,000 landowners in Wyoming and Colorado.

The What

Wyoming landowners more strongly agree on the following than Colorado landowners:

- they have a responsibility to conserve their land and the resources upon it;
- their families' livelihood is dependent on their land's economic productivity; and
- their future livelihood is dependent on personal control of their land.

Wyoming landowners more often indicated their land provides habitat for a range of animals, particularly big game species. Wyoming landowners responded they manage an average of 71 percent of their land for wildlife habitat compared to 48 percent for Colorado landowners.

Even though Wyoming landowners seemed more committed to conserving wildlife habitat, they were less likely to have conservation easements on their property than Colorado landowners. Colorado landowners more often replied they were knowledgeable about conservation easements and thought land trust organizations would protect their interests compared to Wyoming landowners.

Colorado landowners who thought land trusts would protect their interests had 41 percent of their household income coming from farming or ranching; Wyoming landowners who thought land trusts would protect their interests had 44 percent of their household income from production agriculture.

Colorado landowners who did not believe land trusts would protect their interests had 42 percent of their household income coming from agriculture. Wyoming landowners who did not believe land trusts would protect their interests had 50 percent of their household income coming from agriculture.

The results indicated landowners who were more dependent on their

land for income from agriculture were more skeptical of conservation easements. Lack of trust by landowners appeared to be a deterrent to entering into a conservation easement. This might be due to the potential loss of control over their land that conservation easements sometimes may require.

Implications: Wildlife

In a 2004 study, Associate Professor Roger Coupal and colleagues at the University of Wyoming found that big game species in Wyoming depended heavily on private land for habitat. Their results indicated all species except bighorn sheep had larger amounts of winter habitat on private land than spring-summer-fall habitat. This suggests residential development on private lands threatens seasonal habitat of big game species.

The results given here additionally indicated Wyoming landowners felt a greater responsibility to the big game species in their state; however, the results also showed Wyoming landowners were less likely to consider placing a conservation easement on their land. These outcomes suggested a possible cause of this inconsistency might be Wyoming landowners' unfamiliarity with the benefits of conservation easements. The responsibility to big game species felt by Wyoming landowners identifies an opportunity for policymakers attempting to implement future conservation easement programs. Wyoming policymakers might benefit from informing landowners of the threats development poses for big game habitat and further educating landowners on the opportunities conservation easements offer.

Land Preservation Efforts by State

As of 2008, Colorado had 32 Land Trust Alliance member groups operating locally and four Land Trust Alliance members operating statewide. Wyoming had seven Land Trust Alliance members operating locally and two operating statewide.

As of June 2004, Colorado had a number of fundraising mechanisms in place to help pay for conservation easement programs, including the Colorado Nongame and Endangered Wildlife Fund, Great Outdoors Colorado lottery grants, the Colorado Conservation Easement Tax Credit Program, and the Native Species Conservation Trust Fund. As of November 2002, Wyoming depended largely on hunting and fishing licenses as well as the Wyoming Wildlife and Natural Resource Trust (also partially funded by the sale of hunting and fishing licenses) and private donations to help fund conservation easement programs.

Photo by Robert Waggener

Wyoming agricultural lands, such as this northeast of Laramie, provide for rural communities open space, scenic views, wildlife habitat, and livestock grazing.

The limited conservation easement programs in Wyoming, at the time the survey was conducted, may be another factor explaining the differences between Wyoming and Colorado responses.

Tax Incentives

Permanent conservation easements are considered charitable contributions and can be used as income tax deductions on federal returns as long as the easements meet certain requirements. An income tax deduction is calculated by subtracting the market value of the land when a conservation easement is in place from the market value of the land prior to the conservation easement.

Colorado offers tradable state income tax credits for landowners putting their land in a conservation easement. Since Wyoming landowners are not subject to state income taxes, they might not be influenced by the same incentives as Colorado landowners. This added opportunity might also increase Colorado landowners' willingness to enter into conservation easements.

These preliminary results offer potential explanations as to why Colorado landowners are more likely to consider conservation easements than Wyoming landowners. These results suggest improved program education and better tax incentives might increase the willingness of landowners in Wyoming to enter into conservation easements. Such steps might improve the likelihood conservation easements can help keep the "rural" in rural communities.

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Feeding and protecting the soil

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How Wyoming cropping systems are affecting the soil's biological, physical, and chemical properties could be used as lessons for others in the world to achieve long-term ecological sustainability of crop production, especially in dry, cold climates.

Our research involves working with nine wheat farmers in the Slater and Albin areas of southeastern Wyoming and five sugar beet producers near Powell in northwestern Wyoming. These producers are using a diversity of cropping systems and irrigation methods, including organic agriculture, no-till, minimum till, conventional, and others.

Our project tracks the long-term effects of using these different systems on the soil properties, soil organic matter and nutrient dynamics, emission of greenhouse gasses, and carbon sequestration – in short, the ecological and the economic sustainability of production in the long-term. The farmers are very enthusiastic about the work and actually demand seasonal results from our research team. They want to know how their activities are affecting the soils and the environment, and if what they are doing makes economic sense.

Photo by Eusebius Mukhwana

A typical wheat field near Chugwater with a wheat phase (plowed) and fallow.


Photo by Eusebius Mukhwana

Using a small wheat harvester to compute wheat yields, moisture, and protein content on a farm near Slater.

A key objective for this project is to determine whether the low rate of adoption of conservation tillage in Wyoming is an agronomic issue – is it too dry or otherwise too unproductive to realize the benefits of conservation tillage in soil and water conservation? Or is it an extension problem – are we just not getting the word out as well as other states? This is because earlier studies by the Conservation Technology Information Center (2004) indicated that, by 2004, only 20 percent of wheat acres in Wyoming were grown using any conservation cropping system (with 5 percent using no-till). And yet, in many respects, the United States is a world leader and pioneer in the development and use of no-till and other conservation cropping systems. No-till is used on one-third of all American wheat acres. While in many parts of the world no-till is used mostly to control soil erosion, in the U.S. it is used to reduce production costs and improve moisture-use efficiency.

One would think Wyoming, with its dry growing conditions (precipitation of about 11.8 to 15.7 inches per year), potential for severe wind erosion and extremely cold winters (frost period of 83-157 days in a year), would benefit immensely from the use of no-till and other conservation cropping systems. Hence, the low adoption rates of these systems in the state puzzles researchers.

In southeast Wyoming, much soil is lost through wind erosion in conventional crop-fallow wheat farming. No-till is known to reduce erosion and conserve enough water that crops can be grown every year. In the Big Horn Basin, farmers typically apply twice as much nitrogen fertilizer as soil tests call for. Nitrogen fertilizer is made from natural gas, so this is a huge waste of natural resources (and expenses), and the excess is lost as greenhouse gases or as pollution to ground and surface waters.

Our Ancestors Hit the Ground Running

The first agricultural use of land in Wyoming and the rest of the Northern Great Plains was for cattle rearing. But when the federal homestead law was passed in 1862, large portions of land

secures our future

Eusebius Mukhwana, a Ph.D. student in soil science, downloads data from automated moisture and temperature sensors installed in different cropping systems. The system collects moisture and temperature information at five soil depths every 30 minutes.

moved into private hands as more and more farmers moved in from the East.

As farmers pushed west, they discovered crop production became more erratic and precarious. Many early conservationists warned of the erosion on the extensive flat landscapes coupled with the effect of winds in the Northern Great Plains if land was cultivated. In spite of these warnings, large tracts of land were broken up for farming, and the number of erosion problems, especially caused by wind, became unbearably high. This, coupled with scarcity of water, easily degradable soils, the difficulty with which trees grow (meaning one cannot easily grow trees to control wind erosion), and acute water scarcity, would make one think farming in Wyoming and surrounding areas was an over-ambitious activity. It is now known that Great Plains soils have lost 30-60 percent of soil organic matter that accumulated during millennia of grassland cover since intensive tillage systems started being used in the early 1800s.

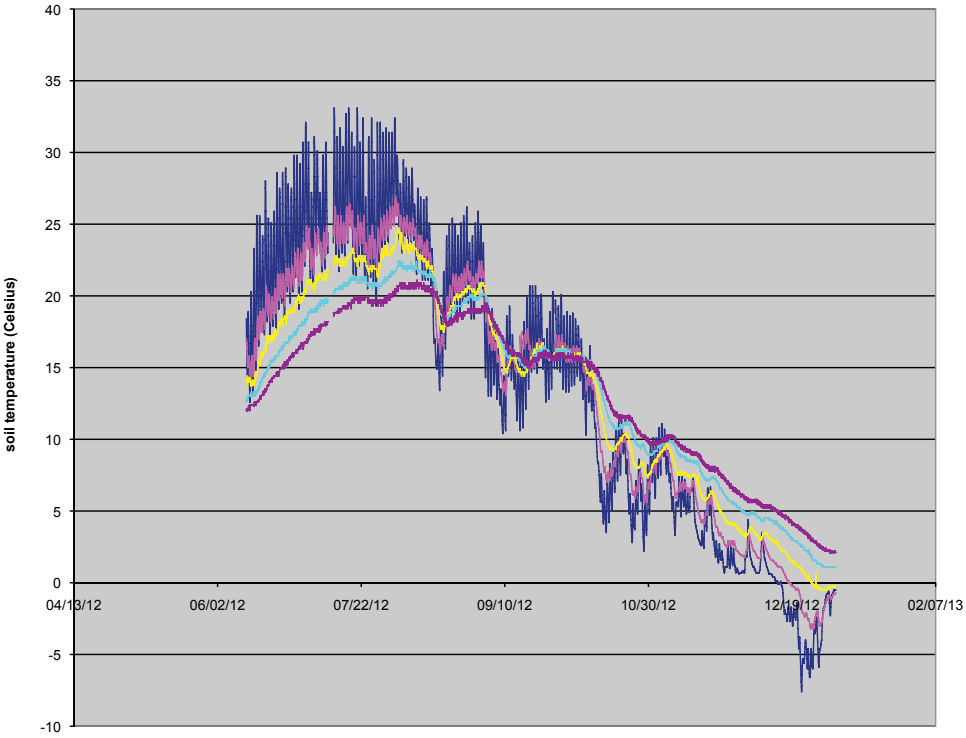
Producers used crop fallow systems to help stabilize crop yields during droughts. Over time, producers, with the help of researchers, have perfected management practices that retain greater quantities of surface residues during the fallow period to increase soil water storage, soil organic matter, and improve erosion control. Growth of corn-based ethanol production is expected to have ripple effects by increasing crop prices, and this could lead to intensification of production and the reduction of the fallow period for many of these crops. Prices of wheat and other non-biofuel crops have been increasing as producers switch to corn and wheat replaces corn for livestock feeding.

Crop Rotations that Became Mono-cropping

In most cases, the selected crop rotations under dry land conditions in the Northern Great Plains had a specific order on how crops followed each other in the fields, and crop diversity was quite limited. Over time, it evolved into a fixed-cropping system with one or two crops plus annual fallow that gave it characteristics of a virtual monoculture.

More recently, researchers and farmers have found subtle weaknesses in this fixed-cropping system as there was a buildup of weeds, disease, and insect pests. The system has been found nonresponsive to a variety of important stresses such as weather, and

Harvesting and weighing sugar beets near Powell.



Graphical representation of data collected from temperature sensors installed at 10, 30, 50, 70 and 90 cm in each of the different wheat cropping systems. The information enables the research team to assess how different cropping systems are affecting soil moisture and temperature dynamics.

it was not ecologically or economically sustainable. Consequently, farmers have been striving to adopt and implement dry land cropping systems with more diverse crops and less fallow per unit of time (so instead of growing one crop in two years, they grow crops two out of three years) to make more efficient use of precipitation lost to evaporation during fallow. Recent studies have found 75 percent or more of annual precipitation is typically lost to runoff, evaporation, deep percolation, and weeds.

To develop and perfect these intensive systems that work in the long term, producers need information about how soil properties and nutrient dynamics are affected by these systems as well as the yield and economics of different cropping systems being used by farmers and their long-term ecological sustainability.

An Interdisciplinary Research Team

Starting in 2008 and for the next three years, our interdisciplinary team of soil scientists is working with producers to help gather information and data to document the effects of intensive cropping systems on soil properties, nutrient dynamics, and the yield as well as economics of dry land winter wheat and irrigated sugar beet production in Wyoming. Team members, who are mostly from UW, include Assistant Professor Jay Norton, specializing in soil fertility; Adjunct Assistant Professor Urszula Norton, soil microbiology and ecology; Assistant Professor Thijs Kelleners, soil physics and hydrology; Professor Jim Krall, cropping systems and adoption issues; Assistant Professor Dannele Peck, Department of Agricultural and Applied Economics; and Ph.D. graduate student Eusebius Mukhwana from Kenya.

The team is collecting data on how different cropping systems affect soil moisture and nutrient dynamics, soil organic matter, microbial biomass, inputs into each system, and resulting yields, and it is also carrying out an economic analysis for each. The study will establish the effects of using each of the cropping systems on the economic and ecological sustainability of dry land winter wheat and irrigated sugar beet production in Wyoming. The team hopes to generate information that will be used by producers to improve the productivity of both crops in Wyoming while conserving and enhancing the environment.

The results of this research will be used to develop and share University of Wyoming Cooperative Extension Service messages with producers on how to improve farming systems for long-term sustainability. Clearly, the team has established that conservation cropping systems have beneficial effects on soils, crop yields, and nutrient dynamics.

Research insights have come when talking with the producers. Small puzzles are identified by looking at the data, and most of them are quickly solved by visiting with the farmers.

Collection of gas samples for analysis of greenhouse gas emissions (carbon dioxide, nitrogen dioxide, and methane) in different sugar beet cropping systems in the Big Horn Basin.

The process of sharing results with producers and discussing why the data looks as it does has been very rewarding. It involves melding two very different perspectives: a generic, scientific one that tries to apply observations very broadly, and a local-knowledge one that attributes specific site and practice characteristics to explaining observations.

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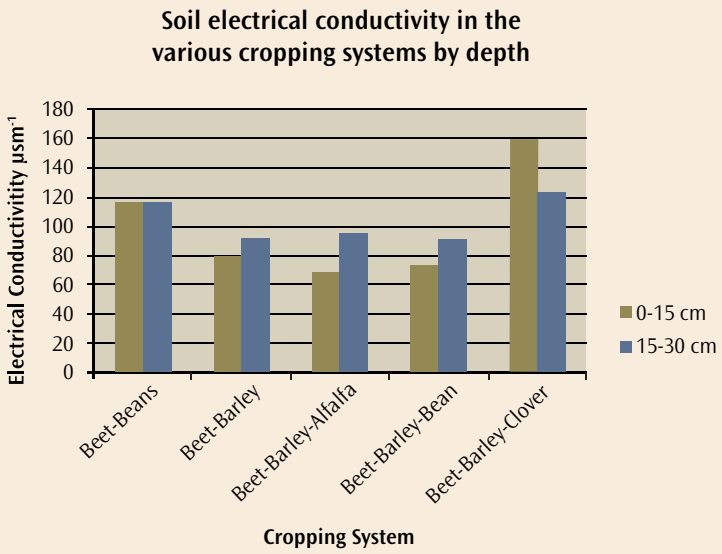
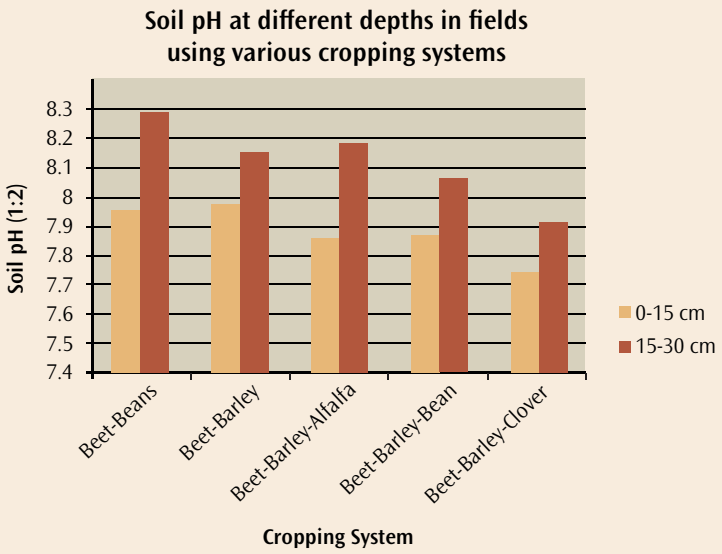
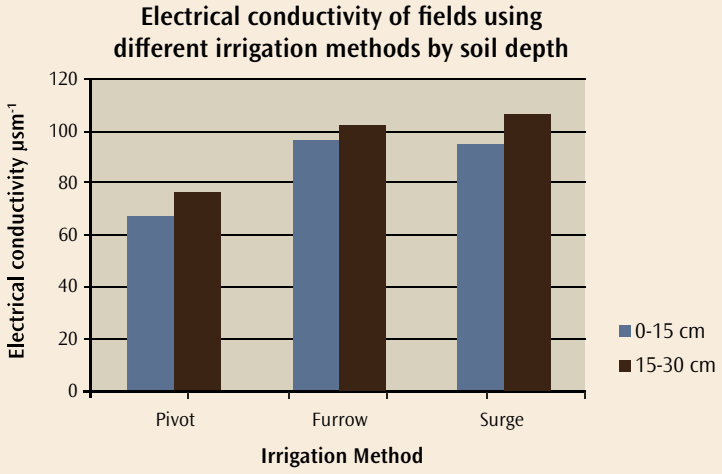
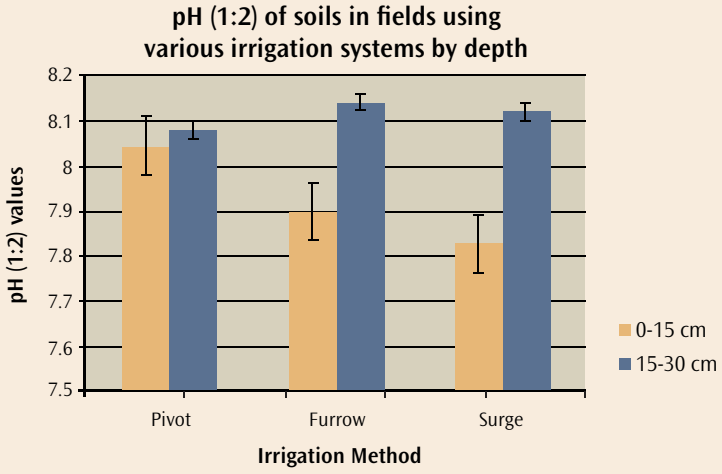
The team is evaluating effects of using different irrigation methods (surge, furrow, and pivot sprinkler) on soil properties, organic matter, and nutrient dynamics, and the ecological and economic sustainability of sugar beet production in the Big Horn Basin.









Some of the soil properties in the Big Horn Basin as affected by irrigation method and sugar beet cropping systems.

Searching for

Scott Schell
Assistant Extension Entomologist

Alexandre Latchininsky
Extension Entomologist
Department of Renewable Resources

Stefan Jaronski
Pathologist Researcher
U.S. Department of Agriculture-Agriculture Research Service-Northern Plains Agricultural Research Laboratory

Reducing pest grasshopper populations while at the same time minimizing harm to the environment, including killing beneficial insects such as bees, with the method chosen is the goal of all involved in pest management.

"It's not easy being green," as the old song goes, and it is especially true if you're a grasshopper being turned green from the inside out by *Metarhizium anisopliae*, a fungus used to control pestiferous insects.

In a time when the word "green" has come to mean more than just a color, perhaps it is appropriate an organism that has great potential to be a good alternative to synthetic pesticides turns its targets green.

To provide a background on how and why University of Wyoming Cooperative Extension Service entomologists in the Department of Renewable Resources have become involved in the search for the perfect insect fungal pathogen, a little history is needed. Everyone is probably familiar with the phrase "plague of locust." These locust creatures, which are actually certain grasshopper species that exhibit physiological and behavioral changes such as wing length and swarming in response to high population densities, are infamous and have been giving people problems ever since humans started farming.

Before agriculture, we probably just ate the locusts instead of the wild plants when given the opportunity; however, when farmers have to grow food not only for themselves but for people in towns specializing in other occupations, a plague of locust can have severe consequences. Even now, locusts still cause problems. Efforts of 22 countries to combat a 2003-2005 outbreak of the desert locust in Africa cost about half a billion dollars. More recently, reports of the locust plagues eating crops and vineyards in Australia appeared in November 2008 news.

In North America, we are fortunate our only locust species, the Rocky Mountain locust, probably went extinct in the early 1900s. At least it hasn't been seen or collected since, and the widespread starvation, deprivation, and hardship it caused to the early settlers have not reoccurred; however, we still have grasshopper problems in Wyoming and 16 other Western states where these pests cause economic losses to crops and rangeland.

Small Grasshoppers Swarm into Big Problem

It may be hard to fathom how a grasshopper, which at its heaviest may only weigh 1/28 of an ounce, can out compete a 1,000-pound cow for food, but it can. The grasshoppers' strength is in numbers. At economically damaging population densities, the biomass of pest grasshoppers can easily exceed 100 pounds per acre. A large species like *Melanoplus bivitattus* would have that weight at 15 grasshoppers per square yard. For some of the small species, it would require densities more than 40 per square yard. The grasshoppers can eat the plants to the surface of the ground and/or clip

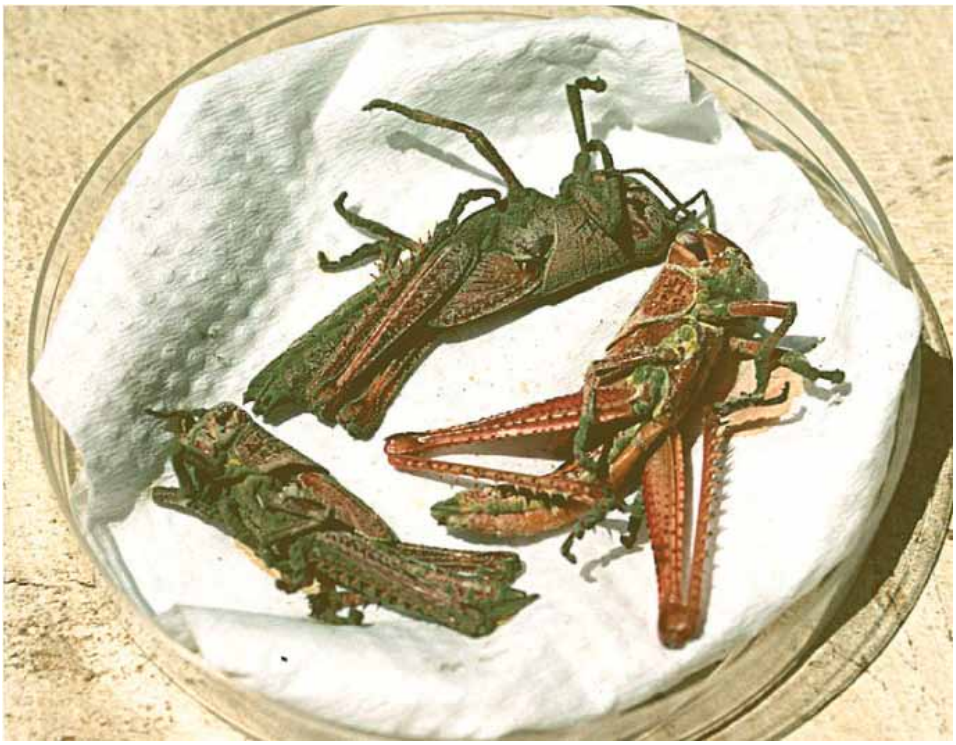
a fungus among us

stems off making them unavailable to other herbivores. Ranchers confronted by severe, multi-year grasshopper outbreaks face the choice of either trying to reduce grasshopper populations or liquidating herds.

Reducing pest grasshopper populations while at the same time minimizing harm to the environment, including killing beneficial insects such as bees, with the method chosen is the goal of all involved in pest management. To that end, Australian and British researchers found a pathogenic fungus, *Metarhizium anisopliae*, that could be used as a biological insecticide.

The strain of this fungal pathogen they found in Australia and Africa was so effective at killing just grasshoppers and locusts, members of the insect family Acrididae, it was named variety *acridum*. *M. anisopliae* var. *acridum* could also be propagated on substrates like rice and does not require a living insect host to produce spores. This is unlike an earlier bioinsecticide, the protozoan *Nosema locustae,* which showed initial promise but was difficult to produce commercially in great quantity.

These *M. anisopliae* var. *acridum*-based products are called Green Guard and Green Muscle. They are currently used in Australia and various African and Asian countries, and they are being evaluated by Mexico and Canada. In the United States, the



Dead grasshoppers with green *Metarhizium anisopliae* spores showing.

introduction of an exotic insect disease organism, like *M. anisopliae* var. *acridum*, that could theoretically permanently affect native insect fauna, would have many regulatory obstacles that may take years to overcome.

Looking For Right Fungus

Stefan Jaronski, an insect pathologist researcher with U.S. Department of Agriculture's (UDSA) Agriculture Research Service-Northern Plains Agricultural Research Laboratory in Sidney, Montana, and Professor Don Roberts in the Department of Biology at Utah State University have been prospecting for native *M. anisopliae* varieties with the properties of being both lethal only to insects and easy and cheap to propagate.

They found a candidate variety called DWR346 to test on pest grasshoppers. Jaronski has done extensive tests in his lab with DWR346 and had gotten to the point he needed to test this strain in the field under tough, real-world conditions. This is where the UW CES and College of Agriculture comes in as southeast Wyoming is known for consistently having grasshopper infestations.

This long-billed curlew in the early morning mist is one of the many bird species that feed on grasshoppers at the field trial location. Leaving a healthy amount of non-pest insects behind after reducing grasshoppers to non-economically damaging levels is a goal of integrated pest management.

With our working relationships with friendly, helpful, grasshopper-plagued Wyoming ranchers, county weed and pest control folks, USDA's Animal and Plant Health Inspection Service insect scouts, plus our knowledge, equipment, and eager graduate students, we could help Jaronski do the first field trial of the DWR346 biopesticide.

June is a wonderful time of year to be working on the prairie of Wyoming. The bird, insect, and plant activity is at its peak if adequate moisture is available. Fortunately, June is also the time when most grasshopper control work is done. Research in Montana grasslands has found grasshopper population densities as low as 14 grasshoppers per square yard will remove 30 percent of the vegetation over the spring and summer in a normal year.

In drought conditions, which favor the development of grasshopper outbreaks, the percentage of forage consumed or destroyed is even greater. During outbreaks, grasshoppers can commonly reach densities ranging from 25 to 50 per square yard over thousands of acres and in localized areas more than 100 per square yard. At extreme densities, grasshoppers that would normally benefit other wildlife as food become a detriment as they consume all available vegetation. Bird species that can utilize grasshopper nymphs as food for their young but require plant cover and/or seed production to survive the rest of the year end up having to leave the infested area or starve. Rodent populations and other types of insects that depend on plant food also decline.

Currently, grasshopper infestations are controlled with the Reduced Agent-Area Treatment (RAAT) strategy developed at the College of Agriculture in the late 1990s. RAAT works by utilizing reduced rates of insecticide agents, appropriate for the small, early life stages of the grasshoppers, and by taking advantage of the grasshopper's tendency to roam. We found we could treat as little as 33 percent of an infestation and still get adequate control. This reduces the amount of insecticide used, saving money and reducing the impact on the environment. In 2003, the strategy was applied to 400,000 acres in Wyoming and saved ranchers about half a million dollars.

RAAT is the best way for reducing grasshopper populations back to non-damaging levels and minimizing the impact on non-target fauna; however, even with RAAT and the least toxic synthetic insecticide currently registered for use on grasshoppers on rangeland (Dimilin 2L), there is no product available for ranchers growing beef organically.

In 2004 near Lander, we conducted large-scale field tests with a different insect fungal pathogen, *Beauveria bassiana,* that already had suitable registration – suitable for rangeland/improved pasture without a post-treatment grazing restriction; however, the pathogen failed to provide sufficient levels of control to warrant its high price, so a new biopesticide like DWR346 would be a valuable tool.

Test Plots Near Lusk

On a ranch near Lusk in extreme eastern Wyoming in June of 2008, we found grasshoppers with densities well above the economic injury level. Densities averaged more than 30 grasshoppers per square yard in the pasture. An experimental design that allowed for replication and statistical analysis of the treatments within the constraints of the regulations that govern

the use of unregistered products like DWR346 was developed.

Small plot sizes are a real handicap with grasshopper field experiments as grasshoppers are very mobile creatures, and most biopesticides take time to work. Treated and untreated grasshoppers could move in and out of the plots confounding results, so a way to account for that was included in the design. The applications of sprays were made under ideal conditions – calm winds and sunny skies – and provided great experience for the graduate students helping with the field trial. Students gained practical experience in setting up a field experiment and applying a pesticide safely and accurately.

Results after 14 days showed the greatest decline in the grasshopper population density, from 29 to 10 per square yard, was observed in the three plots treated with the highest rate of DWR346. We never aim for 100-percent control, but, when compared to the untreated plots that showed some natural population decline, we only achieved 48-percent mortality. That level of control would not be sufficient in really high grasshopper densities, but it is a good start.

A wise man once said the best definition of research is "repetitious searching." The DWR346 variety of *M. anisopliae* may not end up being the "green" grasshopper control product we are looking for, but we will never give up the search.

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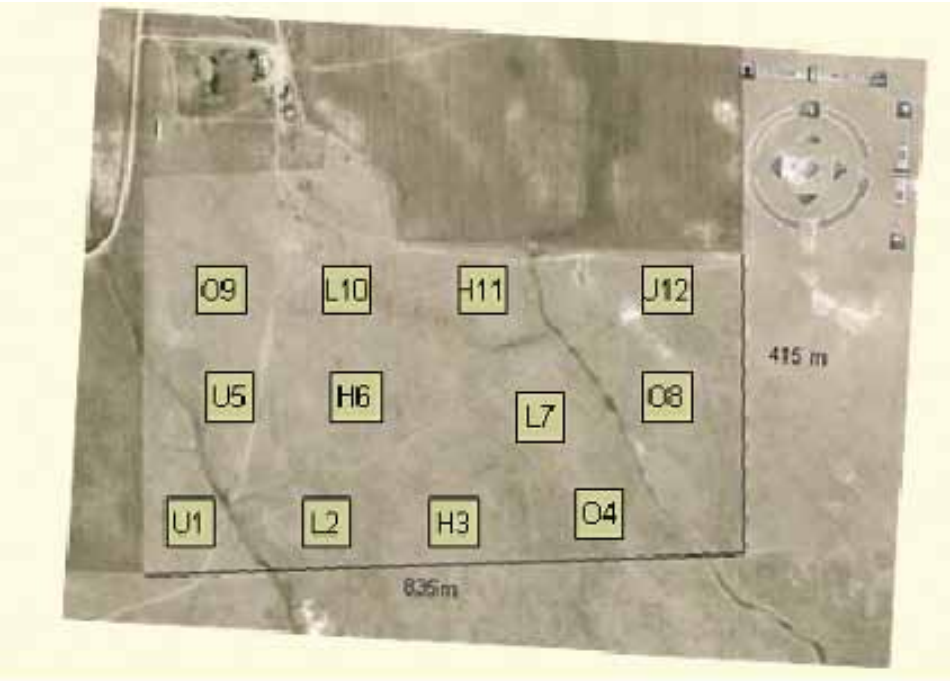

Map of test plots near Lusk. The total area treated with *Metarhizium anisopliae* DWR346 could not exceed a total of 10 acres. To test two different DWR346 rates applied in three replicates meant each plot could only be 1.65 acres in size. Another three plots were treated with just the carrier fluid without DWR346 fungal spores, and three were completely untreated.

University of Wyoming graduate students Travis Gilchriest, left, Arthur Kneeland, on all-terrain vehicle, and Jerod Smith, in the distance, apply *M. anisopliae* DWR346 spores with precision using an ATV-mounted sprayer.

Potential disturbances in relation to greater sage-grouse lek persistence in the Big Horn Basin

Jennifer Hess
Graduate student

Jeffrey Beck
Assistant Professor
Department of Renewable Resources

Greater sage-grouse (*Centrocerus urophasianus*) is a species of concern across the West. Populations have been declining throughout its range in response to habitat loss and fragmentation.

These disturbances to sagebrush (*Artemisia* spp.) communities are largely related to wildfires, agricultural development, urbanization, invasion of exotic species, and intensive burning programs. The quality of sage-grouse nesting and early brood rearing habitats have the greatest impact on sage-grouse populations by influencing nest success and juvenile survival.

The route to my research started when I began working with the University of Montana with greater sage-grouse in northeastern Wyoming's Powder River Basin in 2003. I immediately fell in love with the Big Horn Mountains, which are home to blue and ruffed grouse, and I also became fascinated with sage-grouse, which occupy the sagebrush-covered lowlands. I was introduced to rocket-fired nets and spotlighting during the capture seasons. I had left a job in Minnesota working with wolves, deer, and lynx – I thought trapping deer in Minnesota was exciting, but then I was in charge of rocket-net crews and found out how adrenaline really worked! Just imagine waiting at a lek (a sage-grouse breeding area) with a rocket-net set ready to fire. The grouse start appearing at about 4:30 a.m. You begin seeing more and more birds as they start moving toward the net. Before you know it, you're given a signal to fire. The rockets fire, the net shoots, birds are jumping, and you start running from your vehicle carrying blankets to lay over the captured birds to calm them down. You then start removing grouse from the net and begin the processing (weighing birds, applying radio collars, and collecting feather samples).

I began looking for a master's project, and I contacted Assistant Professor Jeff Beck in the College of Agriculture's Department of Renewable Resources. Beck had been funded to initiate a project to evaluate sage-grouse habitat enhancement treatments in the Big Horn Basin in north-central Wyoming (Figure 1, page 50). After initiating my master's fieldwork to evaluate these treatments, we began brainstorming how various sagebrush treatments that have been implemented to enhance sagebrush might possibly affect lek attendance in the Big Horn Basin. Even though these treatments are meant

to improve grouse habitats, could the treatments themselves be affecting the attendance of male sage-grouse on leks during the breeding season?

My project, started in May 2008, focuses on looking at Bureau of Land Management (BLM) treatments (prescribed fire and mechanical mowing) on sagebrush in relation to sage-grouse habitat in the Big Horn Basin. Finding out how habitat management is working and what portions of the management needs improvement is essential in effectively promoting future populations of grouse, among other species.

Impacts of Disturbances on Lek Persistence

Many studies have shown sage-grouse avoid agricultural developments. Attendance of males at breeding grounds has also been shown to decline in relation to increased expansion of cultivated fields. Hens with chicks tend to avoid areas close to cultivated cropland or urbanized developments.

Road development is normally associated with human activity, fragmenting sagebrush communities and sage-grouse habitats. Increased human activity can lead to higher frequencies of wildfire, which can lead to large habitat losses for sage-grouse. Roads have been found to accelerate the dispersal of exotic plant species, thereby lowering production of native plant species selected by sage-grouse for food and cover.

The BLM, working with the Wyoming Game and Fish Department (WGFD), private landowners, and others, is using fire in the Big Horn Basin to improve habitat for sage-grouse and other wildlife. These fires are in old, decadent stands of sagebrush and areas with juniper. Although fires may increase grass or forb production, big sagebrush (*A. tridentata*) recovery to preburn status is long (25-100 years). Burning may also increase the establishment of invasive plant species such as cheatgrass (*Bromus tectorum*). Cheatgrass competes with native grasses for soil and water following fire and depletes it faster than areas without cheatgrass. Fire frequency increases with cheatgrass invasion and causes substantial competition with native shrub-steppe species. Although short-term improvements of forb and grass production following fire in mountain big sagebrush (*A. t. vaseyana*) have been documented, this outcome has limited temporal benefit for sage-grouse inhabiting these communities. Consequently, burning Wyoming big sagebrush (*A. t. wyomingensis*) can be detrimental to sagebrush obligate species such as sage-grouse (Baker 2006 and Beck et al. accepted). Wyoming and mountain big sagebrush are both found throughout the Big Horn Basin.

Many studies have shown sage-grouse avoid agricultural developments. Attendance of males at breeding grounds has also been shown to decline in relation to increased expansion of cultivated fields. Hens with chicks tend to avoid areas close to cultivated cropland or urbanized developments.

Photo by Cindy Lindstrand

Photo 1. Greater sage-grouse lek with males displaying and females examining potential mates.

Figure 1. Map of the Big Horn Basin region in north-central Wyoming. Map modified from Wyoming Geographic Information Science Center.

Mechanical treatments, such as mowing, are seen as possible alternatives for sagebrush enhancement techniques to lower dense stands of sagebrush and allow for other native plants to establish and flourish. The effects of mowing may be less detrimental than prescribed fire, because mowing does not kill all sagebrush plants and allows for quicker recovery than prescribed fire.

Breeding Grounds are 'Leks'

Sage-grouse breed on areas called "leks," which are open, flat areas that have low sagebrush cover (Photo 1); for instance, prairie dog (*Cynomys* spp) colonies are commonly selected by grouse for lekking grounds. These open areas make it possible for grouse attending leks to easily observe one another and to detect predators. Males display and compete for female attention during the spring of each year on these lekking grounds. Females arrive, choose a dominant male and eventually mate. Enumerating the numbers of males on leks is the most common way to monitor trends in sage-grouse populations.

By comparing lek occupancy to long-term changes in the landscape, one can effectively identify patterns in lek persistence.

Detecting the disappearance of active leks is an efficient way to determine large declines in populations. There are 286 known leks in the Big Horn Basin, which allows for thorough investigation of what is potentially influencing lek attendance. By evaluating sagebrush community disturbances at a landscape scale, we can assess how these variables may impact lek persistence. Our project does not examine lek counts due to the likelihood of high observer error inherent in the probability of detection when surveying leks. We examined, however, leks that are occupied or unoccupied in the Big Horn Basin.

By using WGFD descriptions, we categorized leks in the Big Horn Basin as either occupied or unoccupied (Figure 2). Unoccupied means males are no longer attending the lek. We summarized the area of each disturbance factor: agricultural development, road development, wildfire, and treatment (prescribed burn or mowed) around each lek (5-kilometer buffer) in the basin. Our 5-kilometer buffer shows the typical distance a nesting female travels from her breeding ground to her nesting site. We also summarized the area of sagebrush cover around each lek. These summarizations provided us data to identify habitat characteristics that may be leading to the decline in occupied leks in the Big Horn Basin.

After thorough investigation and removal of leks with missing data, we retained 177 (62 percent of total leks in the basin) to examine. The criteria we used to identify leks unsuitable for our analysis include (1) leks where only one survey was conducted for a decade, (2) leks with missing data extending beyond one decade, and (3) leks where only one survey was conducted in a decade, which resulted in designating the lek unoccupied. Of the 177, we identified 146 occupied leks (82 percent) and 31 unoccupied leks (18 percent).

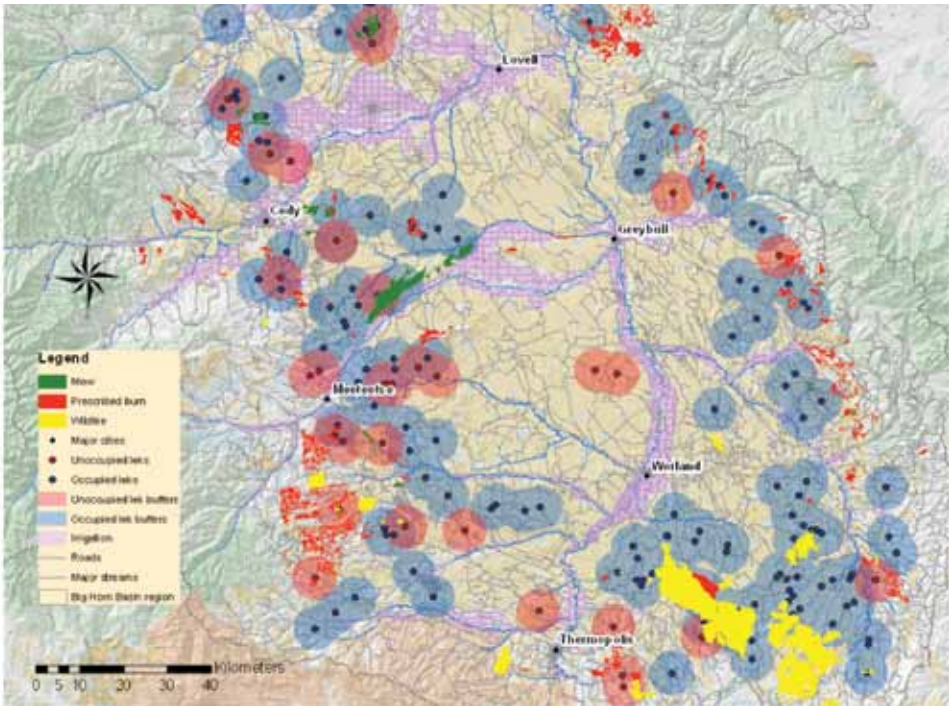

Figure 2. Map of Big Horn Basin, Wyoming, showing 177 leks (31 unoccupied and 146 occupied) with treatments, wildfires, roads, and agricultural development. Layers obtained from Cody Bureau of Land Management Field Office and Wyoming Geographic Information Science Center. Map created by Jennifer Hess.

Male sage-grouse displaying on a lek.

Photo by Jennifer Hess

Road Development Impact

Our study indicated road development has had the most influence on lek occupancy in the Big Horn Basin (Figure 3). We are not certain whether newly developed or existing roads have had the greatest influence on lek persistence. A detailed time scale of disturbance is needed to understand when and where the greatest disturbances have occurred. We also intend to create models that consider other factors of disturbance such as energy and housing developments.

The western region of the Big Horn Basin – areas around Cody, Meeteetse, and Thermopolis – has been affected by oil development since the 1920s. This region is also where lek abandonment has increased, according to the WGFD lek database. We would like to examine whether this disturbance has led to an increase in anthropogenic disturbances leading to a decline in occupied leks in the Big Horn Basin.

More work will be completed in the following year as additional coverages are acquired to match our temporal scales of interest. Updated sagebrush coverage layers through Geographic Information Systems will be available this year through the Wyoming Geographic Information Science Center. Oil and gas well information will be acquired through the Wyoming Oil and Gas Conservation Commission Web site (http://wogcc.state.wy.us). With further investigation, we intend to pinpoint major influences concerning road development over time as well as more closely examine the rate in which leks are abandoned.

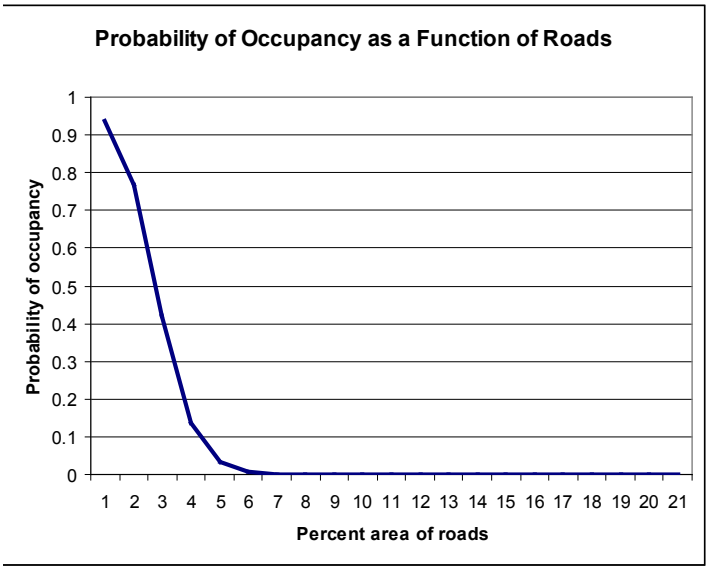

Figure 3. The probability of lek occupancy as a function of roads in the Big Horn Basin, Wyoming, during the last 26 years (1980-2006).

Our model can be used to identify leks in the Big Horn Basin that have been persistently used by breeding sage-grouse. We can also use these results to help managers decide what areas of the region should not be altered in relation to suitable lekking grounds for sage-grouse.

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Study-abroad opportunities prepare,

Ed Bradley
Associate Professor
Department of Agricultural and Applied Economics

American society constantly engages in discourse regarding how best to prepare its youths to live and work well in the world in which they will graduate. This discourse never ends because the challenges confronting society change over time.

Increasingly, businesses and governments have to operate effectively across national boundaries and overseas to be successful.

Both the University of Wyoming and the College of Agriculture have long committed resources so interested students could learn about foreign cultures, ideas, and perspectives. Faculty members offer numerous on-campus courses as well as faculty-led, study-abroad courses overseas for students to develop international skills and understandings.

On-campus courses allow some students to understand cultural differences and similarities, yet many students merely wonder why they should learn or care about this or anything else foreign. Most students have the ability to explore foreign material deeply rather than superficially and to develop sufficient skill and confidence to work overseas. Nevertheless, I have noticed students who do develop such skill and confidence usually have studied abroad.

Agricultural communications major Natasha Wheeler, left, in France in 2008.

Study-abroad Courses Motivate Students

Based upon my experience, faculty-led, study-abroad courses prepare and motivate students to work internationally far better than on-campus instruction alone. The ongoing study-abroad program with which I have firsthand experience is a four-week food and agriculture study-tour in France. I and other UW faculty and staff members have cooperated with counterparts at the *Ecole Supérieure d'Agriculture d'Angers* (ESA) (http://foreigner.groupe-esa.com/article441.html) for 20 years to recruit and take interested UW students overseas.

The professional careers of the 80 UW students who have participated in this foreign-study tour, in which students reside with host families, are exceptional. The former student participants or alumni include successful lawyers, doctors, farmers, and ranchers, and several are professionals employed by multinational companies and international-oriented government agencies.

Alumnus Touts Program

Marty Winchell, 1995 graduate in agribusiness and 1994 participant in the study-tour in France, recently wrote, "The University of Wyoming provided me with the fundamentals to live and compete in the global world." This former Torrington resident has been working on Asian logistics issues for more than 10 years. He claims the

motivate ag students

university is quite capable of producing leaders not only for Wyoming but also for the world. For the past five years, he has lived in China, where he manages 600 people in 22 locations for a division of Schneider National Inc. based in Green Bay, Wisconsin.

What empowers young Americans to venture into such challenges?

Good health, character, and work skills matter, yet what will be of value to graduates in the near future includes a large set of skills and knowledge. Knowledge of the arts, sciences, and technical professions are assets along with good communication, quantitative, critical thinking, and life-long-learning skills. No one wants to shortchange the preparation of American youths (preschool, K-12, and postsecondary students), so curriculum ought to be modified to reflect Americans' additional needs in an increasingly competitive and interdependent world community.

Many educators believe more students ought to study abroad to earn credits within their degree programs. For example, the National Association of State Universities and Land-Grant Colleges (now called the Association of Public and Land-Grant Universities) strongly supported establishment of the Senator Paul Simon Study Abroad Foundation. The goal of this proposed foundation would be to quadruple the number of U.S. students that study abroad within 10 years by providing students with small grants for gaining international experience.

Generous Donors Fund Programs

At the University of Wyoming, similar programs were established with the generosity of donors, most notably Lynne and former Vice President Dick Cheney. In just the past several years, the number of UW students studying abroad has quadrupled to about 400 annually.

As a country, the United States (long an economic, political, and military superpower) may maintain its capacity as a force for good in the world community, but it faces many challenges. International relations have been strained by global problems that require bringing people together across borders to solve. An increasingly large number of American professionals in many fields will be needed to address global environmental, economic, and security issues, for example.

Working across cultures requires an appreciation for one's own and other people's cultures, plus a good understanding of multiple interests and viewpoints. It is hard to find negotiated solutions that allow multiple parties to benefit if you neither understand the role of culture in problem solving nor merge or synthesize ideas of different people.

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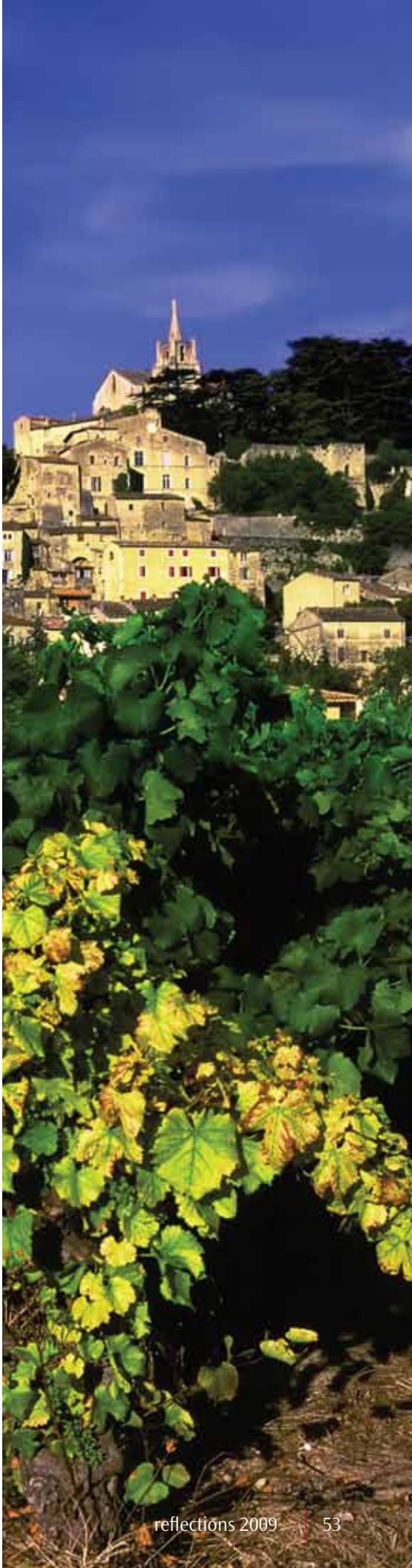

Annie Morabito during her 2008 summer internship in central Washington at a raspberry, blackberry, strawberry, and grape vineyard. Morabito, of Chicago Park, California, is a senior majoring in agroecology.

Dynamic agroecology internships prouide method for success

By David Wilson
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The agroecology internship program in the Department of Plant Sciences is nearing its 20th birthday.

The number of requests for interns far outweighs the number of available students. The myriad of employers offering internships is an attractive aspect of the program for students. Many companies and governmental entities return year after year in hopes of luring another student into the programs.

Typical government entities with internships include the Natural Resources Conservation Service, U.S. Forest Service, Bureau of Land Management, and Wyoming weed and pest control districts. But private businesses make up the bulk of the opportunities. Golf courses, greenhouses, landscaping businesses, seed producers, chemical companies, and crop consulting firms are just a few in the highly varied group of internship sponsors.

Since many companies offer the intern a permanent position after graduation, many of the employers are actually College of Agriculture graduates themselves. For instance, there are at least four previous students who are either managers or assistant managers of golf courses in Wyoming, and two of the largest western crop consulting companies employ two or more College of Agriculture graduates.

Approximately 30 to 130 internship offers come through the Department of Plant Sciences each year along with more than 30 full-time employment opportunities for graduates. There are usually six to 15 student interns a semester. This gives students who have an idea of the type of job they would like after graduation a chance to gain on-the-job experience. Maybe more importantly, the varied opportunities allow students who are undecided on a specific career a chance to try different career fields. Spending three months to discover a certain job is not what you want to do as a career can be as valuable as finding out that it is exactly what you want to do the rest of your life. Another huge advantage for students is they usually get a job offer before graduation, either from the company they interned with or from references and job experience, which helps them acquire a similar position with another company.

When the internship program began, some students were resistant to the idea. Many wouldn't consider positions outside of Wyoming or even Laramie. But, gradually, students heard from other students about how much they had learned on their internship and, in some cases, how much they earned.

Salary has been one of the key departmental requirements for internships in agroecology. Requests for student interns without financial offers are not posted unless from non-profit organizations. Students typically get three credits for a summer internship and usually earn $12 to $20 an hour. Many even pick up overtime and bonuses, which can boost their salary to more than $10,000 for a 15-week period. Occasionally, students take volunteer internships in nature conservation or with wildland refuges or small organic production businesses. But, these credit-only internships are rare and by choice.

Beyond the actual job experience, students are required to keep a log of daily activities and write a paper about their learning experience. Students from outside the agroecology degree program occasionally enroll in an agroecology internship. This is generally because their degree program lacks an internship program. Although an internship program could be a component of every degree program, it can be difficult to develop a working program, especially if the program of study has low employment potential. For these programs, students will need to look for volunteer positions and accept credit in place of salary. In these cases, students may receive a credit per week of internship, rather than one per five-week period. Regardless, a student with a degree and job experience will usually out-compete individuals lacking either one of these.

You may see many new internship programs in other degree areas over the next few years. It is a major goal of the College of Agriculture to provide all students with internship experience. After all, internship programs truly support the College of Agriculture motto – "Students, the reason we're here!"

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Researchers update water quality guidelines for Wyoming livestock, wildlife

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Quality of water naturally available to livestock and wildlife and, in many cases, water released in the course of resource development, has increased concerns whether the recognized standards of water quality are adequate to protect the health of livestock and wildlife.

Reviews of research literature leading to these existing standards are decades old. Complicating things even further, there are literally thousands of Web sites and extension documents that have uncritically hashed, rehashed, and "mis-hashed" these old papers without recourse to the current biomedical knowledge base or providing any sort of track record of where their recommendations came from.

These issues led to a project funded by the Wyoming Department of Environmental Quality (WDEQ) to review the available literature pertaining to common potential toxicants in Wyoming's water. A team of three faculty members and three graduate students conducted the literature review.

Wyoming water quality standards have clouded with time. Many of the regulatory standards used were actually based on hearsay.

Water quality varies geographically, and development has moved into areas of higher mineral contents in the water. Coal-bed methane (CBM) development has released much water of dubious quality, raising awareness among publics and regulators. The issue of largest interest was the release water of high sodium levels that would have largely affected irrigators. Many ranchers found the water desirable for livestock, largely assuming the water was not going to be toxic to livestock. CBM water has not been a livestock issue of any magnitude. Other water releases, mostly oil well drilling fluids, have periodically affected relatively isolated locales.

The WDEQ is in the process of revising the standards for released waters.

Results from this extensive study are available in the 94-page bulletin B-1183, *Water Quality for Wyoming Livestock & Wildlife: A Review of the Literature Pertaining to Health Effects of Inorganic Contaminants*, available from the University of Wyoming Cooperative Extension Service in hard copy or by download. See http://ces.uwyo.edu/PUBS/B1183.pdf.

Subsequent to the publication, we have been funded to examine, through literature review, nine additional chemicals that are of potential toxicity and that occasionally occur in water – boron, cadmium, chromium, copper, lead, mercury, zinc, uranium, and iron.

Summary of selected elements and compounds

Here is a thumbnail summary of the review of various elements and compounds in B-1183.

Materials covered in this publication include arsenic, barium, fluoride, molybdenum, nitrate and nitrite, pH, selenium, sodium chloride, sulfur, and total dissolved solids.

Water is the single most important nutrient for livestock and big game wildlife species. While animals can survive for a week or more without food, death is likely in a matter of days without adequate water intake. Water is involved either directly or indirectly in virtually every physiologic process essential to life.

Obviously, an adequate supply of clean water is necessary to the health of all animals, including human beings. Poor-quality water has resulted in acute illness and death. It also robs producers via decreased performance (primarily growth and reproduction).

The amount (dose) of any waterborne toxicant ingested by a given animal is determined by the concentration of the substance in water, by the amount of water the animal drinks, and the amount contained in feedstuffs.

Although there are many ways of expressing measurements regarding water quality and toxicology, we have chosen to use the following conventions. The dose of a toxicant that causes some particular effect is expressed in milligrams of substance per kilogram of body weight or "mg X/kg BW". The concentration of a substance in water is expressed as milligrams of substance per liter of water or "mg X/L". If the substance is ionized, and the ion is important in terms of toxic effects, it will be described with the standard scientific abbreviation for the ion, e.g. nitrate, "NO_3^-" Similarly, the concentration of a toxicant occurring in dry feedstuffs will be described in terms of parts per million or ppm. Single elements are abbreviated with the standard chemical symbol (e.g. "Se" for selenium).

Arsenic

Arsenic (As) is a metalloid that occurs naturally in water and soil. It is also released from a number of human activities. Assuming negligible As in feedstuffs, 5 mg As/L in drinking water will provide the minimum toxic dose of 1 mg As/kg BW to grazing animals in warm weather. Assuming a "no observed adverse effect level" (NOAEL) of 0.5 mg/kg BW/day and allowing for these small forage concentrations, we recommend drinking water for livestock and wildlife not exceed 1 mg As/L.

Barium

Barium (Ba), an alkaline earth element, oxidizes easily when exposed to air and is found as the Ba^{2+} ion in water. Much more research needs to be done with Ba in ruminants, but, given the current state of knowledge, soluble Ba^{2+} concentrations should be held to well below 23 mg/L to avoid acute toxicity. We do not recommend using water containing more than 10 mg Ba^{2+}/L even for short periods. Until there is better data, it is impossible to make any recommendations regarding chronic exposure.

Fluoride

Fluorine (F) is the most electronegative and reactive of known elements. It rarely occurs free in nature, chemically combining to form fluorides. Fluorides are widely distributed throughout the environment in various anthropogenic and natural forms. We recommend water for cattle contain less than 2.0 mg/L F^-. By extension, these waters should also be safe for sheep, cervids, and probably horses.

Molybdenum

Molybdenum (Mo), an essential trace element required for nitrogen fixation and the reduction of nitrate to nitrite in plants and bacteria, is widely distributed in nature. Surveys have identified extensive areas of forage containing potentially toxic concentrations of Mo (10-20 ppm) in at least five Western states, including Wyoming. The ruminal interaction between Mo, sulfate (SO_4), and copper (Cu) is responsible for the greater sensitivity of ruminants than monogastrics to Mo. We recommend

that, in the absence of other data, drinking water for livestock and wildlife contain less than 0.3 mg/L. If dietary Mo is higher, which is not unusual in this region, water Mo concentrations should be adjusted downward accordingly.

Nitrate and Nitrite

The nitrate (NO_3^-) and nitrite (NO_2^-) ions are intermediates in the biological nitrification cycle and the primary source of nitrogen (N) for plants in the soil. Nitrate in water is additive with NO_3 in feedstuffs, with a given dose in water being somewhat more potent than in feed because it is consumed more rapidly. Assuming negligible forage NO_3 concentrations, a water NO_3 concentration of 500 mg NO_3^-/L (measured as NO_3^- ion) would provide 100 mg/kg BW, which would provide a two-to-three fold margin below the 200-250 mg/kg BW lethal dose. If forage concentrations are higher (not a rare occurrence in the Great Plains), the permissible water concentration should be adjusted downward. Based upon the existing knowledge base, 100 mg NO_2^-/L (as the nitrite ion) should not cause poisoning in livestock.

pH

pH is defined as "the negative log of the hydrogen ion (H^+) activity," although "concentration" is often substituted for "activity" in a working definition. Feedlot ruminants are often marginally acidotic as a metabolic consequence of the high soluble carbohydrate rations they receive. In this case, acid water might be sufficient to trigger a crisis. We suspect the commonly touted acceptable ranges for drinking water pH (a low of 5.5-6.5 and a high of 7.5-9.0) are excessively conservative from a strictly animal health standpoint, at least on the acid side, but there are not sufficient experimental and/or clinical data to offer a specific alternative.

Selenium

Selenium (Se), a metalloid, can be present in soil at levels sufficient to cause toxicity or low enough to result in deficiency in grazing animals. Either outcome can result in serious economic losses to livestock producers and illness and/or death in wildlife. Experience at several regional diagnostic labs indicates horses may be poisoned while ruminants using the same forage and water remain unaffected. Water safe for horses should be safe for other livestock and ruminant wildlife species. In areas where forage Se concentrations are higher, or if horses are receiving dietary supplements that contain Se, safe water concentrations will have to be adjusted downward, but, under normal conditions, 0.1 mg/L should not cause problems.

Sodium Chloride

Sodium chloride (NaCl), or salt, was one of the first nutrients to be identified as essential to life. Sodium (Na) and chlorine (Cl) are rarely found in elemental form in nature; however, most of the toxic effects of NaCl are due to Na. If the only water available is also the major source of dietary Na, long-term impacts will occur at lower dosages. Assuming water consumption typical of a rapidly growing steer and only background feed Na concentrations, the no-effect level would be about 1,000 mg Na + /L or 2,500 mg NaCl/L. Serious effects, including death, become likely at 5,000 mg Na + /L. We recommend keeping drinking water Na concentrations at less than 1,000 mg/L, although short-term exposure to concentrations up to 4,000 mg/L should be well-tolerated.

Sulfur

Sulfur (S) occurs in nature as free S or combined with other elements in sulfides and sulfates. Concentrations safe in ruminants should provide adequate protection for horses. Assuming normal feedstuff S concentrations, keeping water SO_4^{2-} concentrations less than 1,800 mg/L should minimize the possibility of acute death in cattle. Concentrations less than 1,000 mg/L should not result in any easily measured loss in performance.

Total Dissolved Solids (TDS)

Total dissolved solids (TDS) are defined as all inorganic substances contained in water that can pass through a 2-micron filter. In general, TDS is the sum of the cations and anions in water. We do not recommend relying upon TDS to evaluate water quality for livestock and wildlife; however, if no other information is available, TDS concentrations less than 500 mg/L should ensure safety from almost all inorganic constituents. Above 500 mg/L, the individual constituents contributing to TDS should be identified, quantified, and evaluated.

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