

COLLEGE OF AGRICULTURE AND NATURAL RESOURCES

REFLECTIONS

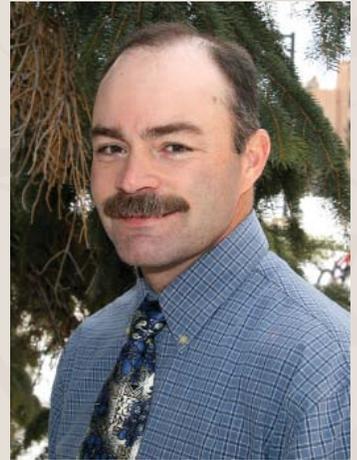
2010

REFLECTIONS

This is my first opportunity to welcome readers to enjoy the creative activities shared by authors in *Reflections*.

I admit I was relieved when I learned “Cultivation” was the theme for this issue. My initial thought was, “Cultivation is a perfect theme for a magazine published by the College of Agriculture and Natural Resources.”

There is a well-established and obvious association between cultivation and agriculture that may lead one to naturally deduce this issue of *Reflections* will concentrate on preparing land to grow crops.



Bret W. Hess

This compels me to caution readers. In fact, one article “Nuts and Roots: The staples of prehistoric cuisine in the Greater Yellowstone Ecosystem,” discusses human dimensions before agriculture even existed. Make no mistake, cultivation in agricultural terms is addressed in this issue, but cultivation in terms of developing new knowledge is the common thread among this issue’s string of fascinating articles.

Cultivation in the sense of developing one’s mind or manners is accomplished by the College of Agriculture and Natural Resources through discovery, education, and training. This issue of *Reflections* covering topics related to all three areas of the college’s tripartite mission of research, instruction, and extension should be no surprise. Although each article does not cover one mission area exclusively, the articles provide a glimpse of the diverse subject matter addressed by the talented people in our college.

Scientific inquiry involves exploration of concepts and leads to new discoveries. Whether gleaning historical lambing records to determine lifetime productivity of ewes born as twins or evaluating the effects of seed scarification and cover crops on establishment of forage legumes, authors in this issue of *Reflections* wisely mention how these discoveries have practical implications that may lead to development of new technologies or management practices.

Investigations into methods to reclaim land disturbed by energy development and adding biohydrogen to Wyoming’s energy portfolio are examples of how researchers in the college are involved in developing strategies to sustain the state’s natural resources. Innovative approaches to investigate market behavior and feed efficiency will help policymakers and livestock producers make scientifically based decisions.

CULTI

There are times to cultivate and create, when you nurture your world and give birth to new ideas and ventures.

Chogyam Trungpa

Cultivating knowledge through innovative approaches is not solely a research endeavor. Associate Dean for Academic and Student Programs Jim Wangberg describes how representatives from the College of Agriculture and Natural Resources are at the forefront of developing methods to meet the challenges of education in agriculture.

“Experiential learning” is one of the terms mentioned in this article that also appears in three other articles discussing how students are engaged in knowledge-cultivating activities. In the capable hands of faculty members, students gained hands-on experience during travels to Ecuador where emphasis is placed on studying caterpillars, and other students have traveled to the hot springs of Thermopolis to gain hands-on experience in understanding microbial ecology. Of course, traveling to and working at those locations was only part of the total experience, and, as described in the article on the student-selected agricultural remote sensing project, students have gained hands-on experience on campus as well.

Transfer of knowledge is another piece of the three-legged stool comprising the college’s mission leading to cultivation of mind and manners. Articles discussing grazing management for sage-grouse habitat and the challenges of organic gardening provide recommendations on solutions for sensitive issues.

Educational programs instituted by members of the Cent\$ible Nutrition Program team help Wind River Indian Reservation residents realize the potential of establishing a local farmers market and provide training for low-income families on how to eat better for less.

I sincerely hope you enjoy reading about the cultivating activities highlighted in this issue of *Reflections*. We are proud of the diverse cultivation partaken by members of the College of Agriculture and Natural Resources. Questions, comments, and suggestions are always welcome. Please feel free to share your thoughts by contacting me at (307) 766-3667 or brethess@uwyo.edu.

Best regards,



Bret W. Hess

Associate Dean for Research and Director of the
Wyoming Agricultural Experiment Station

V A T F



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http://multimedia.uwyo.edu/UWAG_STREAM/reflections/index.html for additional photographs not used in this edition and to interact with the online e-magazine.



Into the cloud



Mist rises over the Ecuadorian forest at Yanayacu station.

forests of Ecuador:

WHERE THE WILD THINGS ARE

*Scott Shaw
Professor of Entomology and
Curator of the UW Insect Museum
Department of Renewable Resources*

For two weeks in June 2009 we set out for the remote cloud forests of eastern Ecuador where the real “wild things” are. Our goal: seek and discover new forms of insect life and gain a better understanding of their ecological roles in this biologically complex misty forest.

Accompanying me on this wet and muddy adventure were 15 people: University of Wyoming botany Professor Greg Brown; two entomology graduate assistants, Guinevere Jones and Jerod Smith; five undergraduate research assistants; five UW honors students; and two public school science teachers (both UW alumni). Together, we set out on a voyage of learning and discovery in the cloud-shrouded, forested-slopes of the eastern Andes Mountains.

My research in Ecuador, currently funded for three years by the National Science Foundation (NSF), centers on the CAPEA project: Caterpillars and Parasitoids of the Eastern Andes. CAPEA is an ongoing, long-term research project dedicated to the inventory of caterpillars and discovery of information about their life history, food plants, and their parasitoids. The goal of CAPEA is to survey and inventory a diverse Ecuadorian community of caterpillars and their associated parasitoids (mostly wasps and flies). We also aim to sample specimens for museum research and gather natural history data documenting plant-caterpillar-parasitoid relationships, development rates, and other life cycle information. CAPEA is a multi-university collaborative project involving several scientists at different institutions. My particular role in CAPEA is to study the diverse microscopic wasps that emerge from many of the caterpillars.

Caterpillars are the Dominant Herbivores

Why study wild caterpillars? Caterpillars (the immature forms of moths and butterflies) are dominant herbivores of forest vegetation in the tropics, literally shaping the distribution and abundance of forest trees. Relationships between parasitoids, herbivorous caterpillars, and their host plants are among the most interesting systems for studying multi-trophic ecological interactions. More than half of all known organisms are involved in plant-insect-parasitoid interactions. These



Slideshow

interactions provide a basis for understanding fundamental issues in ecology and evolutionary biology.

Why study moths and butterflies? The diversity of Ecuadorian Lepidoptera is exceptionally high. Yanayacu is one of the most diverse sites in the entire world for moth species. Situated at the edge of the Amazon Basin, Yanayacu is one of the world's biodiversity hot spots for moth and butterfly species. An average night at the black light sheet may attract hundreds of insect species. Since most tropical moth species were discovered and described based on adult specimens, in many cases the immature forms (caterpillars) and their food plants were previously unknown.

Why study in Ecuador? Ecuador is at the edge of the biological frontier when it comes to our understanding of tropical plants, insects, and their ecological interactions. On the slopes of the equatorial Andes, home for many unique and still-undiscovered species,



Professor Greg Brown finds a remarkably small orchid.



Caterpillar with *Meteorus* wasp cocoons.



Tiger moth caterpillar. The wild silk and Tiger caterpillars are both sometimes eaten by *Meteorus*.

most plant and insects remain poorly studied. Our study site is the Yanayacu Biological Station (YBS), located at 2,200 meters (7,218 feet) elevation in the Quijos Valley, Napo Province, in the Andes Mountains of northeastern Ecuador. Yanayacu is situated just barely south of the equator (00° 35.9'S, 77° 53.4'W) in one of the world's last remaining unexplored swaths of high-elevation cloud forest (www.yanayacu.org). The lichen and moss-covered trees are virtually teeming with mysterious and undiscovered life forms. Biological diversity and habitat complexity increases toward the equator. If you want to be a biologist, the equator is the place to be!

Emphasis is Discovery of New Parasitoid Wasp Species

My research and the graduate studies of Jones focus on the discovery of new species of the parasitoid



Ilatha wasp injecting egg.



Wild silk moth caterpillar.

wasp family Braconidae. Why study Braconidae? Braconidae are one of the most diverse and beneficial families of insects with more than 12,000 named species and thousands of undescribed species. Braconid wasps are parasitoids, resulting in the death of the host caterpillar. The Braconidae are one of the most economically valuable families of insects because of their natural control of potential forest pests. Most species of forest caterpillars have one or more braconid parasitoids keeping their populations in check. Jones' thesis research is targeted at discovering new wasps of the genus *Meteorus*. These Lilliputian wasps are common killers of forest caterpillars at Yanayacu. Parasitism by *Meteorus* is easily recognized since the emerging wasp larva spins a distinctive silk cocoon suspended by a silk thread. We have discovered that *Meteorus* is hyper-diverse at Yanayacu – we have sampled more than 30 kinds of

New insect species

Shaw has discovered and named more than 126 new insect species from 28 different countries. His published suggestion for a Wyoming state insect, Sheridan's green hairstreak butterfly, was adopted by the Wyoming Legislature and signed by the governor in 2009.



Professor Scott Shaw empties catch pans of insect specimens. The yellow color lures to ground level insects that fly at higher levels in the forest.

Meteorus wasps so far, and all of them are new species!

Discovering such new organisms is in some ways more challenging than finding a needle in a haystack – the forest is vast and uncharted, and the microscopic insects we are searching for may be no larger than the lead at the tip of a pencil. So, how do we find them? We are assisted in the search by a research team of undergraduate students and science teachers funded by supplemental NSF-REU (Research Experience for Undergraduates) and RET (Research Experience for Teachers) grants. Searching for caterpillars by hand and eye is quite challenging requiring careful inspection of foliage for feeding damage, silk traces, and frass (insect droppings). The more eyes and hands in the forests, the better the results.

Collection Methods for Sampling Insect Specimens

One very productive sampling method is the “beating sheet” approach. A cloth sheet supported by a wooden frame is held by one person under a branch while another person hits the leaves and branches with a bamboo stick. Caterpillars on that plant are dislodged and fall on the sheet, where they are collected into plastic bags. Returning to the research station with a day's catch of caterpillars, the bagged larvae are coded, tagged, and hung on clotheslines in the Maquina, our caterpillar research building. The Maquina (machine) is the insectary or caterpillar-rearing shed for the CAPEA project. Literally a live caterpillar zoo – the Maquina is the machine that produces specimens, data, and photographs for the CAPEA research project. Each live caterpillar must be kept clean (removing frass and dead plant



Kathleen Meyers examines moths at the light sheet.

material from the bags) and fed new leaves daily, and all changes monitored and recorded until the caterpillar either metamorphoses to an adult moth or



Students return to the research station in 2008 after a productive morning collecting live caterpillars. Each plastic bag contains a live caterpillar and its food plant materials. From left, Arthur Kneeland, entomology graduate student, Sara Selitsky, a member of the undergraduate research team, Guinevere Jones, master's student in entomology and graduate mentor for the research team, and Kathleen Meyers, an agroecology major and now a graduate student in entomology at UW. Selitsky holds the beating sheet, which is used to catch caterpillars dislodged from plants by hitting the branches with a stick. Jones holds the big stick.

Our goal: seek
and discover new
forms of insect life
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complex misty forest.

butterfly or is killed by an emerging parasitic wasp or fly. Whatever the result – whether moth, butterfly, wasp, or fly – the emerging adult insect is preserved and labeled for museum research. So far, more than 30,000 individual caterpillars have been raised and recorded! A carnival-assortment of caterpillars can be viewed at University of Nevada ecologist Lee Dyer's CAPEA Web site (www.caterpillars.org).

In addition to hand-sampling caterpillars, we are using Malaise traps and yellow pan traps to inventory the flying insects along trails. The Malaise

is a passive flight-intercept trap that funnels insects into a barrier of netting and into a sample jar. Yellow pan traps provide an attractive method for getting high-flying insects down out of the forest canopy more than 50 feet above – yellow plastic bowls filled with soapy water placed along the trails. Many insects are strongly attracted to the bright yellow color and literally dive into the pans. By utilizing diverse sampling methods, we are gaining a broader understanding of the entire insect community at Yanayacu.

Adventure Part of UW Honors Program

Last summer, we increased student participation by teaching a new UW study-abroad course: Cloud Forest Ecology in Ecuador. The class provides UW students a unique opportunity to live in the cloud forest, study and participate in on-going tropical research, and experience the thrill of discovering new life forms. HP-4152-1 is a UW Honors Program Senior Seminar, taught for the first time at Yanayacu in June 2009 and scheduled again for June this year. Co-taught with Brown, the experiential-learning class allows UW students to study forest ecology at a high-elevation cloud forest in the Andes Mountains. During travel to the forest study site, students visit the ancient city of Quito, providing cultural experiences for University Studies Program (USP C1 credit). The diverse experiences of last summer's students and teachers have been chronicled by middle school science teacher Jennifer Donovan, who now teaches at the Princeton Review, on the Experiential Science Education for Teachers Web site (<http://yanayacu.weebly.com/>).

As I write this article, it is a frigid 11 degrees F. in Laramie, and the dew-spattered leaves of Yanayacu seem unimaginably distant. Yet, it is somehow comforting to remember that, somewhere near the equator, in that timeless wilderness where day lengths vary less than 20 minutes over the year, at Yanayacu it is still drizzling warm rain, mist drifts over the treetops, and mysterious and undiscovered "wild things" are still flying along emerald pathways. *m*

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Searching for caterpillars on ferns are, from left, Samantha Stutz, a spring 2010 graduating senior in botany, Jahna Locke, a member of the undergraduate research team and now a Fulbright study-abroad student in Spain, and Carlie Miller, a science teacher from Arizona on the science teacher team. Miller is a UW alumna with a bachelor's degree in insect biology.



Experiential Learning

Jennifer Donovan was a middle school teacher when she traveled to Yanayacu. A UW alumna, she wrote about the experiences of last summer's study. Her observations are at the Experiential Science Education for Teachers Web site (<http://yanayacu.weebly.com/>). Information about the project, people, resources for teachers, and published papers from the project are featured. She is now teaching and tutoring for The Princeton Review, a standardized test preparation and admissions consulting company.



FOR YOUR
(PREHISTORIC)
DINING PLEASURE
WE PRESENT:

LOS TRES WICKIUPS

(THREE HUTS)
PREHISTORICALLY CORRECT MENU

What's to eat? If invited to dinner by prehistoric Shoshone friends, here's what might have been on your plate.

APPETIZERS

Tukudika ceviche

Fresh-caught trout with sorrel (*Rumex* sp.) and juniper berries

Parched Mormon crickets (*Anabrus simplex*)

A Los Tres Wickiups favorite! Taste just like crab legs. Parched in a tray with hot coals, you'll savor the crunchy exterior and creamy interior. Served with Lemhi-style dipping sauce.

SOUPS

Bouillabaisse al la Sheepeater

Fresh trout with wild celery (*Lomatium* sp.) in a sage-grouse broth.

Wild Mushroom and Onion Soup

Dried *Boletus edulis* mushrooms and wild chives (*Allium brevistylum*) in rabbit broth. Garnished with sorrel.

MAIN DISHES

Grilled Mountain Sheep

Choice cuts of Big Horn sheep rubbed with juniper berries and wild onion. Grilled over chokecherry coals.

Roasted Elk Marrow with Fairy Ring Mushrooms

A roasted split elk femur topped with sautéed *Marasmius oreades*. Served with a currant and pepperweed (*Lepidium* sp.) reduction.

Bison Pecadillo

A parfleche-sized serving of pounded bison jerky with roasted pine nuts and grouse whortleberries (*Vaccinium* sp.) served on a bed of greens.

STARCHES

Garlic Mashed Spring Beauties

A very popular item every spring. Boiled spring beauties (*Claytonia* sp.) mashed with roasted prairie onion (*Allium textile*).

Creamed Segó Lilies

We boil a generous handful of fresh segó lily (*Calochortus* sp.) buds and serve them in a Big Horn ewe cream sauce. Ask about availability.

Quinoa with Pine Nuts

Mashed quinoa (*Amaranthus* sp.) with toasted whitebark pine (*Pinus albicaulis*) nuts, currants, and honey.

Biscuitroot biscuits with chokecherry gravy

Bannock-style biscuits made from biscuitroot (*Cymopterus* sp.) flour and toasted on a soapstone slab. Ground dried chokecherries are simmered in honey until thick.





NUTS AND ROOTS: The staples of prehistoric cuisine in the Greater Yellowstone Ecosystem

Richard Adams
Ph.D. Candidate
Anthropology
College of Arts and Sciences



Rhoda Schantz
Associate Professor
Department of Family
and Consumer Sciences



For more than two million years, all humans survived by hunting and gathering; it is only within the past 10,000 years there has been any crop production.

Native peoples living in the Greater Yellowstone Ecosystem (GYE) of northwest Wyoming never practiced agriculture and remained hunter-gatherers until contact with European culture. A unique collaboration among the Departments of Family and Consumer Sciences (FCS) and Animal Science in the College of Agriculture and Natural Resources and the Department of Anthropology in the College of Arts and Sciences is exploring the contribution gathered food provided to the diet of prehistoric people in the GYE.

Anthropologists estimate the prehistoric Shoshone Indians inhabiting the GYE procured about 50 percent of their annual calories from gathered foods and 50 percent from hunting. Under the direction of FCS Associate

Professor Rhoda Schantz, anthropology doctoral candidate Richard Adams is studying the gathering part of the hunter-gatherer equation – the part of the equation most commonly associated with women. “The role of women

will remain ambiguous,” points out UW anthropologist and Associate Professor Nicole Waguespack, “until adequate attention is paid to establishing the presence and extent of plant-gathering activities.”

Although there are cases where women hunt and men gather, the traditional stereotype holds because gathering can be interrupted to accommodate nursing and child rearing more than hunting can. Men tend to concentrate on hunting to accrue prestige, increase their status, and attract mates.

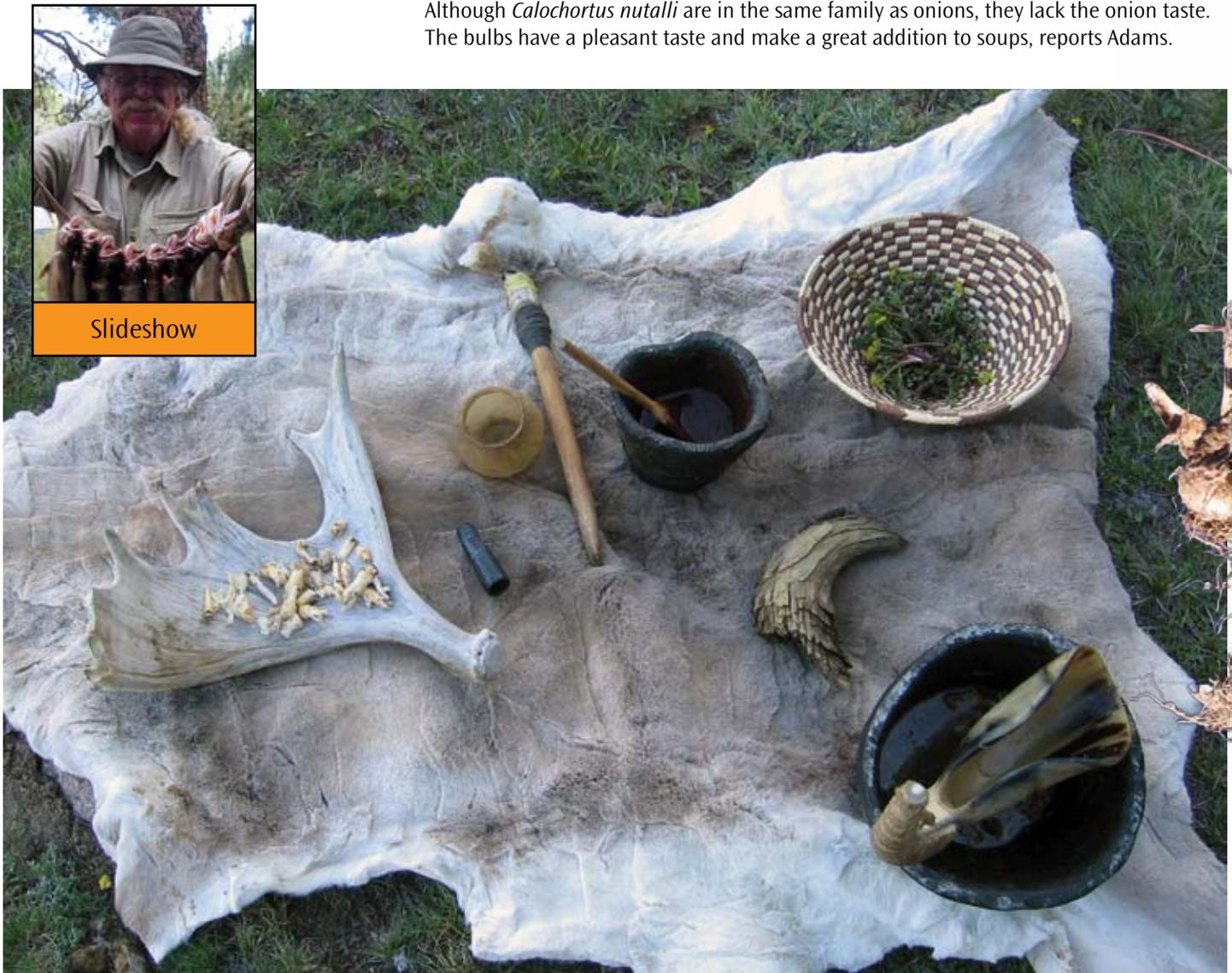


Richard Adams grinds *Cymopterus* roots with a mano and metate prior to making biscuits.

Stone Tool for Grinding Nuts, Roots, Spurs Curiosity

As an anthropology graduate student in 1989, Adams was on the crew that unearthed a 9,000-year-old mano at a high-altitude archaeological site in a whitebark pine forest near Dubois. A mano is a stone tool used to grind nuts and roots to improve their digestibility. Adams remembers the excitement of his mentor, UW Professor Emeritus George Frison, over the discovery. Frison, whose work on prehistoric hunters in Wyoming is known worldwide, considered the mano to be evidence pine nuts may have been a more important prehistoric food resource than realized.

Although *Calochortus nutalli* are in the same family as onions, they lack the onion taste. The bulbs have a pleasant taste and make a great addition to soups, reports Adams.



Examples of prehistoric cuisine are spread out on the sheepskin. There are peeled, fresh biscuitroot on the moose antler. The smaller of the soapstone bowls (left of the basket) has chokecherry gravy. The larger soapstone bowl, with the horn spoon resting on top, has Sheepeater bouillabaisse (trout, wild chives, biscuitroot tops). The basket has biscuitroot tops that season the bouillabaisse. There is a digging stick in the top middle of photo to dig the biscuitroot, a soapstone pipe, a bison horn, and a bowl made from a bladder.

Pine nuts, unlike most other gathered vegetable foods in Wyoming, contain a large amount of fat. Fat is one of the most efficient forms of storing energy, and pine nuts store more fat than any other prehistorically utilized vegetable food in the GYE. Whitebark pines (*Pinus albicaulis*) grow in the GYE near tree line; whitebark pine nuts are only slightly smaller than pine.

Fourteen years after the discovery, Adams teamed with UW anthropologist Ruth Shepherd (now with UW's International Programs) to examine

pine nut use in prehistoric Wyoming. Shepherd was on the same archaeological crew the year the mano was found and, at Frison's urging, had written her 1992 master's thesis on the role of manos in a whitebark pine nut subsistence system at high altitudes in north-west Wyoming. They proposed that, if teams of Shoshone Indians spent several weeks in high-altitude whitebark pine forests harvesting pine nuts and then transporting them down to winter camps along river valleys, they could feed every individual in camp more than 1,000 calories per day from the end of the pine nut harvest in October

until the first spring root crops blossomed in mid-March. The storage of these fat-laden nuts let a family group stay in one place for the winter with a degree of security and safety.

Analyze Nuts, Roots Suspected to be Part of Prehistoric Diet

Curious about the nutrient value of other gathered prehistoric foods, Adams approached Schantz. Her research interests were piqued by a desire to be informed about Wyoming foods. Schantz and Adams chose to focus on a few gathered nuts and roots that, because of firsthand accounts by



Although there are cases where women hunt and men gather, the traditional stereotype holds because gathering can be interrupted to accommodate nursing and child rearing more than hunting can.

Euro-American eyewitnesses, were suspected of being dietary staples: whitebark pine nuts, biscuitroots (*Lomatium* sp, *Cymopterus* sp.), and sego lilies (*Calochortus* sp.). Pine nuts were known to be the main source of calories in the winter diet of other prehistoric Shoshone Indians who lived in Nevada and California. Meriwether Lewis described the first specimens of biscuitroot and their importance to Shoshone and Flathead Indians. They are some of the first plants to grow in the spring, and they can be harvested by the bushel in good years. The harvest season in Wyoming begins with the first biscuitroot appearing before the snow has completely melted in mid-March and lasts until mid-October when the last of the pine nuts are collected.

Starting late March, and armed with a prehistorically correct digging stick made from a 65-centimeter length of juniper whittled to a point at one end and fitted with a T-shaped handle at the other that is similar in

appearance to museum specimens, Adams dug root crops in the Laramie Range and the Shirley and Great Divide basins keeping track of the harvest rate, or how many roots can be dug in a given time. Multiplying harvest rate by the caloric value of the harvested food provides the return rate (kilocalories/hour). But the caloric value of many prehistorically

important gathered foods had not yet been determined. With laboratory time donated by the Department of Family and Consumer Sciences, Schantz conducted proximate analyses of whitebark pine nuts and those listed above. In a proximate analysis, the food value (calories) and composition (carbohydrate, protein, ash, and moisture content) of foods are determined. These values are the building blocks of dietary analyses.

Proximate analyses were a cooperative effort among several departments. Yihua Yu, a graduate student in the FCS food science and human nutrition program, processed samples for proximate analysis. The late Venerand Nayigihugu, research scientist in animal science, performed the fat analysis. Kelli Belden, manager of the Soil Testing Lab in the renewable resources department, performed the mineral analysis.

Feed a Family of Four Half the Year

After calculating several return rates, the researchers combined their data with the return rates of



New Yorker. Used with permission.

“I hunt and she gathers—otherwise, we couldn’t make ends meet.”





Easy to dig, *Claytonia lanceolata* are also known as fairy spuds. Once peeled, the corms are best boiled and served with butter. They are as good as a new potato, notes Adams.

other edible species gleaned from published sources and then averaged the sample. In the future, they hope to conduct proximate analyses of other important plant foods such as spring beauties (*Claytonia lanceolata*) and bistort (*Polygonum bistortoides*).

Preliminary results show the average return rate for gathered vegetable foods in Wyoming is about 1,000 kcal/hour, which means that, in just one eight-hour day in the summer, a prehistoric gatherer could collect enough vegetable food to feed four to six people. Schantz and Adams determined if one gatherer focused only on the most caloric and easily harvested foods, a woman could accumulate enough surplus over the course of a harvest season to feed a family of four for half the year. The conclusion that prehistoric Shoshone women could work for the seven-month growing season and then feed their families for the next several months with stored nuts and roots may seem startling to modern Americans working long hours just to make ends meet every month.



Using a chipped stone knife mounted in a sheep horn, Adams cuts a piece of grilled Big Horn sheep. In the back of the frying pan are sauteed *Boletus edulis* mushrooms.

The archaeology of prehistoric hunters in Wyoming is well-known thanks to the work of Frison, but he says survival would not have been possible if gathered food products had been subtracted from the diet of prehistoric hunter-gatherers.

In this study, proximate analysis of prehistorically correct foods is combined with ethnographic and actualistic data and on nut and root harvesting to calculate the upper limit of how many

calories a prehistoric woman could gather during the harvest season.

It turns out that it is 50 percent of a family of four's yearly calories. This half of the diet consistently supplied prehistoric families with enough calories, carbohydrates, vitamins, and protein to survive and reproduce. *m*

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Beyond the Classroom and into hot water:

Student research at the Thermopolis Hot Springs

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As the menacing green creature undulated toward its prey, students gathered around the screen watched closely. One or two provided a running commentary, anticipating the creature's next move.

As the prey succumbed, there were cheers and boos from students.

They were not watching last summer's hottest horror flick, but, rather, the natural history of creatures too tiny to be viewed with the naked eye.

The screen was connected to a microscope in a teaching lab on the Central Wyoming College (CWC) campus in Riverton that magnified the algal mat specimen 1,000 times allowing a sneak peek into the teeming microbial world of the Thermopolis Hot Springs.

The average visitor to Thermopolis enjoys the recreational benefits of the Big Spring, which issues mineral-laden water at a temperature of 127°F. Much of this water is diverted through channels to several bathing establishments, but some of it follows a different path over terraces formed by decades of mineral deposition and microbial growth. The curious visitor can tour these terraces along a system of boardwalks, but only a few probably guess at the abundant and diverse microbial life forms underfoot.

Thermopolis Hot Springs Understudied

While the thermophilic (heat-loving) microbial communities of Yellowstone National Park are famous and well characterized, the microbial diversity of the Thermopolis springs is relatively understudied. Researchers at CWC in Riverton have begun to study this intriguing site with support from the INBRE (IDeA Network for Biomedical Research



(Photo Michelle Sait)

UW postdoctoral fellow Blaire Steven, standing, assists UW students Shane Severs, left, and Alice Brantz in collecting water samples from the source of Big Spring, Thermopolis.

The students enjoyed a continuum of hands-on research experience from microbial ecology fieldwork to molecular approaches for analysis of community structure and function.

Excellence) program. Equipment purchased with INBRE funds has allowed project investigators Professor Suki Smaglik and Assistant Professor Steve McAllister to introduce molecular biology techniques into CWC biology and microbiology teaching labs.

The transfer of a CWC student to the University of Wyoming in 2007 forged a link between the CWC Thermopolis project and Assistant Professor Naomi Ward's research lab in the Department of Molecular Biology at UW. Sage McCann, an INBRE transition scholar, worked as an undergraduate researcher in Ward's laboratory after transferring to UW and also transferred with him his interest in the Thermopolis project. When Ward was tinkering with the idea of adding a field trip to an upper-level microbial physiology and metabolism class, Thermopolis was an obvious choice. The springs provide an ideal environment for field-based learning in the areas of microbial physiology, ecology, and evolution. The springs also readily allow demonstration of the interdependence of biology, chemistry, geology, and the ways in which microbial activity is both influenced by, and influences, physical and chemical aspects



(Photo: Michelle Sati)

UW students Gavin Lawlis, left, and Latha Chungath extract DNA from Thermopolis spring samples in the Central Wyoming College teaching labs in Riverton.

of the habitat. The study of microbes in such extreme environments also has relevance to astrobiology – the search for life elsewhere in the universe. Lastly, Thermopolis provides students an opportunity to perform hands-on research likely to yield novel findings.

UW, CWC Students Take Samples

With generous support from the Beyond the Classroom program and INBRE, we were able to take 10 UW students for a three-day field trip to the springs in early October 2009, and, to our knowledge, this was the first field trip organized for UW molecular biology and microbiology majors. We were also able to involve six CWC students.

Prior to the field trip, UW students were introduced in Ward's class to key concepts in microbial ecology, physiology, and evolution. On day one,

students carried out physicochemical measurements and microbial sampling of different locations within the spring and associated pools. This involved taking temperature and pH measurements with a portable probe and careful transfer of algal mat specimens into sterile plastic sampling tubes. The sampling equipment must be sterile to ensure no contaminating bacteria are detected by the sensitive molecular techniques used in the analysis. They also received an on-site introduction by Smaglik to the geological history of the spring.

On day two, we traveled to the CWC campus in Riverton, and students performed DNA extraction and microscopy on samples collected the previous day. The DNA extraction procedure is one used by researchers all over the world for many different kinds of natural samples. In brief, it involves

breaking open the microbial cell walls by physical agitation of the sample in a tube with tiny sand-like particles. DNA released from the broken cells is recovered by passing the resulting solution over a column that binds the DNA and not other cell components (proteins, membranes, etc.). The purified DNA is released from the column by addition of a particular buffer, and the final product is then ready for analysis by DNA sequencing.

Back in Laramie, a post-trip lecture for the UW class by Ward included a debriefing in which all students were introduced to the molecular methods being used by the collaborative UW-CWC team to analyze the Thermopolis microbial communities. These approaches differ from the cultivation-based methods familiar to the general public through the work of Louis Pasteur and other famous microbiologists.

We now know that growing microbes on agar in Petri dishes, while invaluable for medical diagnostic and industrial purposes, can capture only a tiny minority (0.1 to 1 percent) of microbes present in natural environments such as hot springs.

DNA Sequencing for Microbial Identification

An alternative method involves identification of microbes through DNA sequencing using a gene that is universally distributed due to its essential role in encoding 16S rRNA, the RNA component of the ribosome (the cell's protein factory). Starting in the early 1980s, this cultivation-independent approach has revolutionized our understanding of the evolutionary relationships of bacteria and the diversity of the microbial world. We have already obtained high-throughput 16S rRNA gene sequencing data for the



(Photo Michelle Sait)

Filamentous and unicellular microbes in hot spring mat material observed using light microscopy.

Thermopolis samples, and interested students will have the opportunity to carry out analysis of the sequence data in the Ward lab. This work constitutes a real research experience – a valuable addition to the more scripted laboratory experience students encounter during formal lab classes.

We believe the trip enhanced the student learning experience in a number of ways. They gained a better understanding of the interactions between biology, chemistry, and geology in shaping microbial communities. They were introduced to extremophilic microbes, their adaptations to environment, and their relevance to astrobiology. The students

enjoyed a continuum of hands-on research experience from microbial ecology fieldwork to molecular approaches for analysis of community structure and function. They also gained experience in disseminating the research results: two UW students elected to use the Thermopolis field trip as the basis for a poster presentation in a cell biology class, and the work was presented at the UW Undergraduate Research Day last spring. This research presentation involved a third UW undergraduate student, who will also be included in future journal articles describing the work.

The students also enjoyed informal interactions with members of the Ward research group who accompanied the trip as support staff members, assisting with camp setup, and other logistics. A chance to interact with researchers at different stages of their careers gives undergraduates insight into research career paths. *~*

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(Photo Michelle Sait)

From left, UW students James Bergene, Shane Severs, Quintin Davis, Blaire Steven, and Daryl Domman.



Sheridan scientists

Chicken on insect patrol.

Research and Extension Center apply organic solutions to pest problems

Adrienne Tatman
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(Photo by Adrienne Tatman)

Onion tops eaten by grasshoppers.

Organic farming has recently increased in popularity across the nation and in Wyoming. Organic growers range from large-scale commercial farms to backyard gardeners.

According to the U.S. Department of Agriculture Economic Research Service, the number of commercially farmed certified organic acres across the nation has increased from 1.3 million in 1997 to more than 4 million in 2005. In Wyoming, only one grower with 75 acres of cropland was certified organic in 1997. By 2005, organic production had grown to 31 producers with 100,592 acres of crop, pasture, and rangeland (www.ers.usda.gov/data/organic/).

The Sheridan Research and Extension Center (SREC) has established a half-acre organic garden where methods acceptable for use in organic production are implemented. Current research includes improving soil fertility, extending the growing season, and controlling insects, weeds, and disease.

Organic Bindweed, Skeletonleaf Control

Annual weeds are abundant and reasonably easy to control with tillage and hand weeding. Perennial weeds are not as few control options are available for organic production. Each year, patches of field bindweed (*Convolvulus arvensis* L.) and skeletonleaf bursage (*Ambrosia tomentosa* Nutt.) grow larger in the SREC garden. Skeltonleaf bursage can reproduce by seed or vegetatively. Tillage is not an option. Neither thermal nor hand weeding were successful. Flame weeding, a type of thermal weeding, uses propane to produce a constant flame on the end of a hand wand applied to the target weed. The flames burnt down the leaves, but re-growth was fast, and the leaves were greener than before. This was repeated every two weeks during the growing season of 2008, and no bursage reduction was noticed. The same rapid re-growth occurred with hand weeding.

A 12-foot by 10-foot bursage patch was covered with a dark-colored tarp during the entire growing season of 2009. This prevented the plant from using the sun for photosynthesis, blocked moisture from penetrating the soil, and generated heat under the tarp. When uncovered in October, the bursage was found stressed but alive.



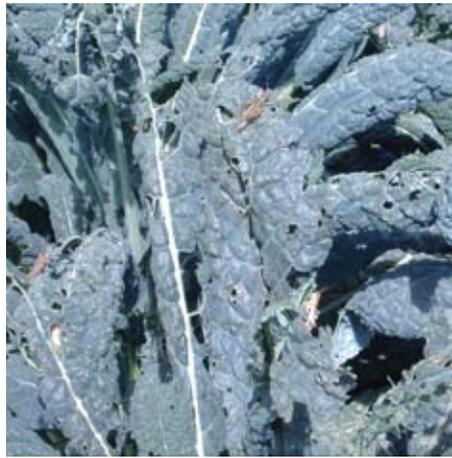
(Photo by Adrienne Taiman)

Colorado potato beetle larvae eating eggplant with diatomaceous earth on leaf.

The patch was to be covered again this growing season. Another control method attempted on bursage was household vinegar. Bursage around the outside edge of the tarp was sprayed with distilled vinegar diluted with water to 5 percent acidity. The weeds were temporarily burnt to the ground with re-growth shortly following.

Similar to bursage, field bindweed can reproduce by seed or vegetatively. Bindweed has a long taproot, and any piece can start a new plant. Hand weeding was the initial control method on two raised beds. Despite

Using organic methods can require more time, management, and labor than conventional strategies. Solutions are not always found easily, but there are many reasons to seek out the organic alternatives.



(Photo by Adrienne Taiman)

At least six grasshoppers can be seen eating Kale leaves in this photo.

the effort taken to remove all pieces, the bindweed rapidly grew back from the tap root. Vinegar of 5-percent acidity was applied at 5-percent (full rate), and 2.5-percent (half-rate) strength. Full strength performed best with 90 percent of the aboveground plant parts burned down while the half-rate proved unsuccessful. The re-growth was comparatively slow, but, in three weeks, the plants regenerated the density that had been present before the vinegar application. Vinegar with a stronger acidity from 10-20 percent is available and will be used this year. At this point, we are unaware of vinegar changing the soil pH; soil samples will be analyzed for confirmation.

Organic Grasshopper, Potato Beetle Control

Insect populations are partly determined by the number of eggs surviving to hatch in the spring. Consistent crop monitoring is vital for organic insect control because many methods require more time to be successful. At SREC, two insects are a challenge: the Colorado potato beetle (*Leptinotarsa decemlineata*) and grasshoppers.

In early June of 2009, Colorado potato beetle larvae were spotted on



(Photo by Adrienne Taiman)

Damage on cabbage from grasshoppers.

potatoes in the garden. They heavily feasted on the leaves and stems of eggplant and potato. An application of diatomaceous earth was applied because of its success observed during previous growing seasons. Diatomaceous earth consists of ground, hard-shelled algae. This powder can be absorbed into the insects' exoskeleton causing them to dehydrate. If ingested, it will shred their insides (www.ghorganics.com/DiatomaceousEarth.html). Unfortunately, the diatomaceous earth did not noticeably decrease their population. By late June, the beetle infestation threatened the entire potato crop and many eggplants.

In 2008, a moderate grasshopper population was noticed in late July. Migrant geese helped keep the grasshopper population in check; however, many eggs were laid before the killing frost in early October. In June of 2009, the grasshopper population was increasing at an alarming rate. Once the grasshoppers moved into the garden, they quickly destroyed most of the cabbage crop (upper right). As the grasshopper population exploded, so did destruction throughout the entire garden.

With the early onset of the large grasshopper population and the migratory geese not yet arrived, hopes of a productive growing season were dwindling and searches for organic grasshopper control desperate. One way to control grasshoppers organically is with bait containing grasshopper-specific fungus. Once eaten, the fungus causes a disease in which infected grasshoppers eat less and die. The disease spreads to healthy grasshoppers through cannibalism. This method works best at younger stages of grasshoppers when they are 1/4-1/2-inch long. Unfortunately, this bait was not an option. We had grasshoppers longer than 1 inch.

Battling Grasshopper Population

Total vegetable destruction was inevitable if action was not quickly taken. Eco-bran, wheat bran coated with carbaryl, was applied outside the garden fence to attract grasshoppers away from garden produce. Grasshoppers will travel up to 50 feet to feed on the bran coated with the systemic insecticide. Inside the garden, a buffer between the fence and the rows of vegetables varied between 10-50 feet. The grasshopper population did not noticeably decrease. By August 6, the grasshoppers had either partially or completely eaten the onion tops on yellow, white, and red onions. The sweeter red onions were favored. Many of the red bulbs were bitten into while the yellow and white escaped with minor damage. Potato, lettuce, and herb leaves were completely stripped. Winter squash and kale leaves were also eaten entirely or left holey. Remaining pieces of devoured ripe tomatoes were left hanging on the vines.

Poultry Called Upon for Control

Organic control methods for the grasshopper invasion were discussed with farmers in the area. It was universally advised poultry could be the solution. Opinions differed on the specific type of poultry as turkeys, chickens, geese, and ducks all have a reputation for controlling insects. On August 18, twenty-six chickens were rented from a local farmer. Once released into the garden, the hens immediately were seen eating the grasshoppers and other garden insects. After only one week, there was a drastic visual decrease in the grasshopper population. Ten days later, the grasshopper population decreased to a point the chickens had nibbled on some vegetables. This damage was minute compared with damage from grasshoppers. The hens were fenced out of the main garden and into the tree nursery for 11 days.

While there, the chickens reduced the weeds by 90 percent from their pecking and scratching. The hens were let back into the garden for nine days to eat more grasshoppers before being returned to their owner. Not only did chickens save the garden from total destruction by insects, but also eliminated weeds! Using organic methods can require more time, management, and labor than conventional strategies. Solutions are not always easily found, but there are many reasons to seek out the organic alternatives.

SREC will continue working on organic methods that can be implemented across Wyoming on farms and gardens of every size. *~*

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(Photo by Adrienne Tatman)

North half of garden. Back to front: high tunnel, winter squash, cabbage, kale (kale leaves re-growing from previous grasshopper damage).



AGRICULTURAL MARKETS, policies, and economic behavior in the laboratory and beyond

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Our research team has undertaken a challenging assignment: assess the economic impact of agricultural policies, some of which have not yet been implemented. Our investigation of agricultural markets, policies, and market behavior has taken us places that agricultural economists do not routinely venture – into the laboratory and the field.

As part of a three-year cooperative research project funded by the USDA, the Department of Agricultural and Applied Economics is collaborating with the USDA Economic Research Service developing experimental markets to analyze how farmers, ranchers, and other agricultural professionals make economic decisions in response to different market conditions and agricultural policy treatments.

Frontier research in experimental economics has recently received many favorable nods, including an article in the journal *Science* touting the increasing use of experimental methods in the social sciences, particularly in economics and policy development (www.sciencemag.org/cgi/reprint/326/5952/535.pdf). Laboratory markets provide a valuable means to test proposed policies while avoiding costly trial and error. Our results inform national-level policymakers, further our understanding of market behavior, and refine experimental methods for further policy work.



Students versus Professionals as Subjects in Lab

At 3 o'clock on a Wednesday afternoon, eight university students take their seats in the economics laboratory on the second floor of the south side of the College of Agriculture building. Students offer an obvious pool of participants for market experiments conducted on the UW campus. But do university students behave the same way as seasoned agricultural professionals?

A common issue raised regarding experimental results is the impact of the experience and background of students versus real-world subjects. Experienced professionals are more difficult to recruit for experiments, but their backgrounds may be more consistent with the population of interest for industry policy development. This implies experiments with professional subjects may offer more credible results.

After discussions with USDA collaborators, we decided to run additional field sessions to address the question of appropriate subjects in our laboratory experiments. We began the process of recruiting agricultural professionals for experimental sessions in December 2008 and conducted sessions through July 2009.



Agricultural professionals receive instructions from Assistant Professor Chris Bastian, above, and negotiate trades, lower right, in a laboratory market designed to investigate subsidy payments. Professor Dale Menkhous, lower left, recruits volunteers at the James C. Hageman Sustainable Agriculture Research and Extension Center near Lingle.



Taking the Show on the Road

“Hi. This is Amy Nagler from the University of Wyoming ag economics department. I was given your name as someone who might be interested in a market experiment we’ll be conducting in your area in December...” Ever-polite, potential recruits often busy at their jobs or with their families listened to my spiel. A woman making supper gave me her husband’s cell number – he

was out feeding their pigs. He thought a market experiment sounded interesting and asked me to call back to his wife on the landline to check his calendar. High school football finals, frozen stock ponds, cut hay waiting in the field: agricultural professionals are busy people!

Slowly, though, enough generous farmers, ranchers, bankers, and farm hands said “Yes” and our sessions filled. Our research crew packed a

mobile laboratory of eight linked laptop computers and headed down the road to see what we could learn from this new group of participants.

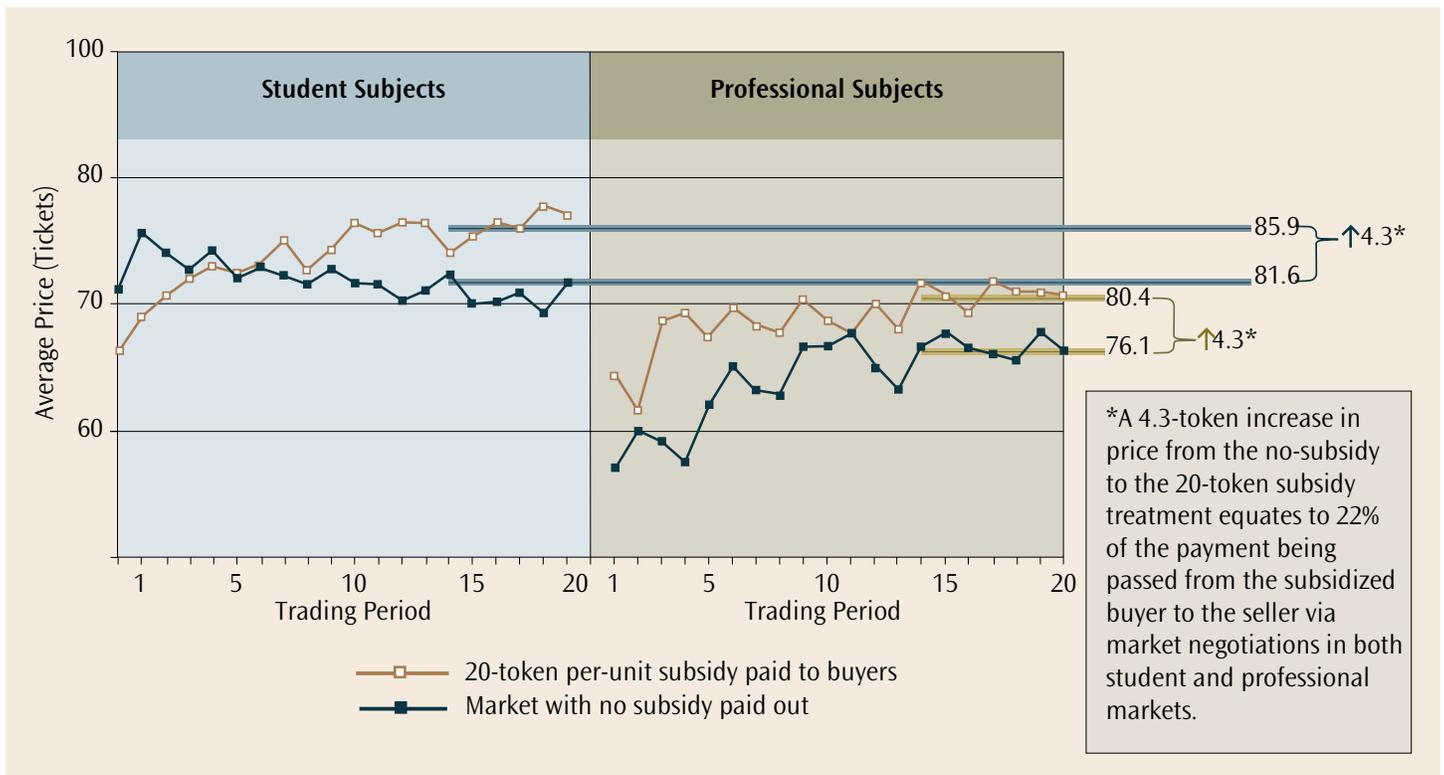
The Elements of Experimental Market Design

A well-designed experimental market is simple and specific. Ideally, it should capture market behavior in response to the specific variable researchers are interested in while avoiding any confounding influences or complicated procedures.

Paying out real earnings to motivate market decisions, anonymity, and standardized recruitment and laboratory procedures can control for social biases. These basic design elements are important to ensure observed behaviors are motivated by incentives in the market, and extraneous behaviors that stem from a desire to please the experimenter or to live up to what a participant believes other subjects expect from them are mitigated.

An Experimental Land Rental Market

The experimental market we used to look for similarities or differences between student and professional subjects was constructed to capture the impact of a subsidy in an agricultural land rental market. In this case, we wanted to know how much of a subsidy



Average Prices for Student and Professional Participants by Policy Treatment in an Experimental Land Rental Market

Recent and ongoing research topics investigated using the College of Agriculture and Natural Resources experimental economics laboratory

The effect of alternative redemption values in an English auction

Asymmetry in buyer/seller sizes on trading partner choice in private negotiation

Impact of subsidies and taxes on private bargaining with applications to carbon sequestration markets

Subsidies without common knowledge in private negotiation

Coupled and decoupled subsidies in land rental markets

Uncertainty in supply and demand (contracting for product outside of spot markets) with food safety implications

(Many of these studies have received primary funding from the Paul Lowham Research Fund.)

given to a tenant farmer might be passed on to the landowner via market negotiations over land lease contracts. Since most contracts to rent agricultural land are privately negotiated between a prospective renter and landowner, our laboratory market paired buyers (tenants) and sellers (landlords) to make offers and counteroffers until they agreed on price and a contract or trade was made. In our experiments, participants trade units of land using a currency of tokens. Tokens are cashed in at a rate of 100 tokens to a dollar at the end of the session. The simple motto “buy low, sell high” sums up how to make profitable trades. Participants earned \$30 to \$50 in addition to a show-up fee of \$7 for students and \$50 for professionals for the sessions, which lasted about an hour and a half.

In half of the sessions, tenant buyers were paid a 20-token subsidy for each unit of land they rented by trading in the market. This stylized subsidy is

a simple alternative to the no-subsidy scenario. The purpose is to investigate how much of the 20 tokens is negotiated away from the buyer to the lease seller in each of the two subject pools.

As buyers and sellers sit typing in bids and offers and make trades, our computerized market collects data that will tell us how traders act in response to a policy treatment. Computer programming required to create the virtual market is done in-house by current and former UW computer science students. Price, trades, and earnings data are averaged across several replications and analyzed graphically and using a model that provides estimated convergence levels over 20 trading periods that can be compared for statistical differences.

Results, Conclusions, and Insights

Laboratory results with both student and professional subjects provide the same answer to our initial policy research question: How much of a

per-unit subsidy given to the buyer is passed on to the seller via market negotiations? In markets with both subject groups, a price increase of 4.3 tokens in subsidized over no-subsidy policy treatments equates to 22 percent of the buyer subsidy passed on to sellers via higher negotiated prices. This treatment effect is of interest in potential policy analyses. In general, our results are similar to other empirical findings that indicate land prices and rents respond significantly and positively to government support. As we might expect, landlords benefit from renting to a subsidized tenant.

Moreover, the similarity between students' and professionals' response to policy treatments validates the use of student subjects in similar experiments. The convenience of student subjects continues to make them accessible and valuable subjects in laboratory markets.

How does this result compare to other studies? We are not the first to collect data from a non-student population using market experiments. Experienced public accounting firm partners, commodity and options pit traders, lobbying professionals, and wool buyers all have been lured into the lab and their behavior compared with that of student participants. Results from these diverse subject pools vary depending on the groups and markets studied. No single study can provide a definitive answer to whether students are representative of real market players. This relationship depends on specific research goals, populations of interest, and market attributes.

Taking our economic laboratory on the road allowed us to compare students' and professionals' market behavior in a controlled setting. Knowing how these groups compare can be important when trying to understand



Agricultural professionals receive payments from Menkhaus for tokens they earned in a laboratory market.

how new policies may affect economic impacts on communities, land values, or other markets related to agriculture.

Further laboratory sessions using student participants in a similar market

setting are underway. These experiments expand the basic market with alternative market conditions and policy treatments to investigate the impact of trading partner selection, limited knowledge of subsidies, as well as different subsidy types. Results from these treatments have applications to energy markets as well as agricultural land markets. *m*

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DO IT YOURSELF: A Behavioral Economics Experiment

Try this experiment with two people you know: Give ten \$1 bills to the first person. Instruct that person that they may hold onto their newfound loot or give a portion of this money to the second person – with one stipulation. If the second person is not happy with the amount passed on to them, neither player gets to keep any of the money and the entire \$10 must be handed back to you. What you will find is that neither player is likely to act like a model of classic economics. If both players were purely rational and self-interested, the smallest portion possible would always be given out and this tiniest portion would always be accepted. What actually happens? The person you just endowed with some free money hands over \$4. We humans are self-interested, yes, but we are also generous. Now watch what happens if the first person is a bit less generous and only hands over a dollar. The recipient of this amount irrationally rejects this piddling amount, giving up a perfectly free dollar to leave both players with nothing. Why? Humans, apparently, are self-interested, rational, generous, and we have expectations of fairness and punishment that also drive how we behave.

In our experimental market, a subsidy payment given to the buyer changed expectations and affected how prices were negotiated. Behavioral experiments such as this “ultimatum game” are another tool economists use to further understand how and why social and cultural expectations influence economic decisions in a market.





Grazing management in Wyoming

SAGE-GROUSE

D Declining sage-grouse numbers in the Western U.S. in recent years have prompted concern about the impact of various land uses on their habitats.

Livestock grazing is probably the most widespread land use across the big sagebrush (*Artemisia tridentata*) ecosystem. Sage-grouse habitat is tied closely with the presence of sagebrush in foothill and plains environments.

Of the three subspecies of big sagebrush, Mountain big sagebrush (*A. t. vaseana*) in its lower elevation distribution, and Wyoming big sagebrush (*A. t. wyomingensis*) across much of the Wyoming Basin, provide sage-grouse habitat.

In response to concerns, a committee was commissioned and developed an assessment of habitat ecology and grazing effects related to sage-grouse habitat needs. The publication,

Grazing influence, objective development, and management in Wyoming's greater sage-grouse habitat, with emphasis on nesting and early brood rearing, B-1203, is available for free viewing from the University of Wyoming Cooperative Extension Service. Go to <http://ces.uwyo.edu/> and click on Publications and enter B-1203.

Vegetation Ecology, Grazing Response

Understanding the vegetation ecology and responses to grazing is essential to addressing grazing effects in these habitats. The ecological sites typical of sage-grouse habitats in Wyoming are defined by the Natural Resources Conservation Service (NRCS) in major land resource areas (MLRAs) 32, 34A, and 58 (see map page 30). These are characterized by sandy or loamy soil textures and depths that include shallow (less than 20 inches) and deeper (greater than 20 inches) soil.

The important plant communities for sage-grouse are Sagebrush/Bunchgrass, and Sagebrush/Rhizomatous Wheatgrass-Bluegrass.

Sagebrush/Bunchgrass provides the best diversity of grasses, forbs and shrubs, overhead cover, and herbaceous screening cover for nesting. Chicks can use the forbs and insects during early brood rearing.

The Sagebrush/Bunchgrass Plant Community develops over time from a bunchgrass-dominated state of low value to sage-grouse after disturbances such as fires to a more desired sagebrush-dominated state. Bunchgrasses become less vigorous and lower in

Although potentially a concern, livestock grazing may be one of the lesser problems faced by sage-grouse and one easily managed.

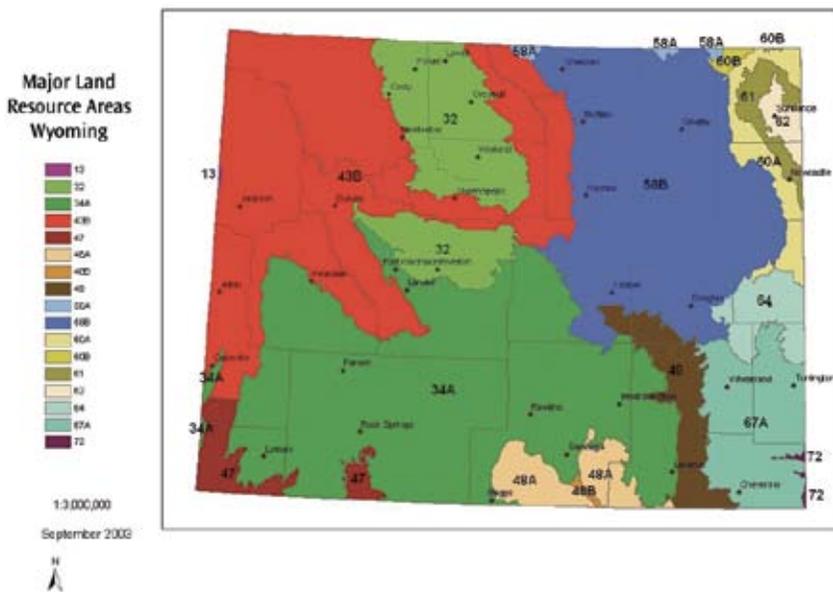
production due to competition from increasing sagebrush cover. At this late successional state, the bunchgrasses are vulnerable to excessive grazing and provide less cover for nests.

Excessive grazing will push the Sagebrush/Bunchgrass State across a threshold into the Sagebrush/Rhizomatous Wheatgrass-Bluegrass State. This state is more resistant to grazing pressure but provides less, but still adequate, sage-grouse nesting cover if properly grazed. The Sagebrush/Rhizomatous Wheatgrass-Bluegrass State usually will not recover to the Sagebrush/Bunchgrass State through

HABITAT

Mike Smith, Professor,
Extension Range Management Specialist, Department of Renewable Resources





changing grazing management; additional management input is usually required to at least remove sagebrush and give competitive advantage to any residual bunchgrasses.

Abusive grazing of the Sagebrush/Rhizomatous Wheatgrass-Bluegrass State, such as around water areas in season-long grazed pastures, can result in a sagebrush-bare ground state that offers little chance of recovery without reseedling.

Moderate Grazing is Best

Grazing management has two objectives: the long-term management of plant health and the annual management of residual forage for sage-grouse cover and soil surface protection.

Experience shows moderate grazing is best for plant health, maintaining plant community states, providing sage-grouse habitat, and is defined using the landscape appearance method in the Wyoming rangeland monitoring guide (www.wy.nrcs.usda.gov/technical/rangemgt/range.html). This level of grazing results in 40-60 percent utilization of dominant bunchgrasses and 10 percent or less of the not-preferred forage species. Repeated spring grazing

can be detrimental to bunchgrasses.

In general, the management objective for sage-grouse nesting habitat would be to optimize overhead and screening cover by moderate grazing and manipulating sagebrush in the Sagebrush/Bunchgrass State. Under natural conditions, the Sagebrush/Bunchgrass State would be renewed by periodic wildfire removing sagebrush and invigorating the bunchgrasses remaining; however, in the current situation of precarious sage-grouse populations and fragmentation of sagebrush habitat from many sources, prescribed burning may be the least desirable method. Its complications include the uncertainties as to the size that may be treated and especially the length of time before sagebrush re-establishes and the area becomes useful for sage-grouse.

Effectiveness of Alternatives Not Clear

Research into the effectiveness of other alternatives, such as the targeted grazing of sagebrushes, mowing, or thinning sagebrush with herbicide, has not been completed. These treatments would reduce sagebrush canopy cover

and provide greater competitive advantage to bunchgrasses. Management treatments, such as thinning sagebrush with herbicide and herbicide treatment of smaller areas within dense sagebrush stands, suggest that increasing sage-grouse populations may result.

Although potentially a concern, livestock grazing may be one of the lesser problems faced by sage-grouse and one easily managed.

Many other disturbances in the sagebrush ecosystem affect sage-grouse use of potential habitat. These include:

- Energy development and transportation corridors that create non-native vegetation, noise, activity, and overhead objects such as power lines and wind turbines,
- Invasion of non-native species, such as cheatgrass,
- West Nile virus has also reduced sage-grouse in some areas.

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These may also minimize impact on sage-grouse

Additional livestock grazing management practices that help minimize the impact on sage-grouse:

- Minimizing fences near leks
- Putting visible markers on the top wire of fences to prevent sage-grouse from flying into the wires
- Installing escape ramps in livestock watering troughs to prevent drowning
- Not grazing lek areas during breeding
- Not using high livestock densities in nesting areas

Engineered strain of *Rhodobacter sphaeroides* with produced hydrogen.

BIOLOGICAL HYDROGEN

A new addition to Wyoming's energy portfolio?

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Undergraduate Student

Min-Hyung Ryu
Ph.D. Student

Mark Gomelsky
Associate Professor
Department of Molecular Biology

Wyoming's rich history of being critical to this nation's supply of natural resources is well-known. Fossil fuels, which are the basis for Wyoming's energy industry, are essentially irreplaceable. We need to look elsewhere for energy sources as these supplies continue to be depleted; however, with the push for cleaner alternatives to fossil fuels, the question arises where will Wyoming stand in the coming years?

With the Environmental Protection Agency's (EPA) December 2009 declaration that carbon dioxide (CO₂) is a public endangerment and pollutant, we envision stricter government control.

A promising alternative energy considered worldwide is hydrogen (H₂). An important attribute of hydrogen as a fuel is that its burning generates nothing but water. In addition, hydrogen can be produced in many ways, but, equally important, it is a renewable and clean energy source.

Hydrogen is obtained from water by using electrolysis or from fossil fuels by using heat — a process called thermolysis. Both methods require significant investment of energy and generate carbon dioxide or monoxide as waste products. Fortunately, several microorganisms, working in a consortium, can generate hydrogen in a renewable fashion with no





Mutant strain of *R. sphaeroides* with higher hydrogen production capacity.

pollution. Some fermentative organisms clean existing pollutants from the environment in the process of generating hydrogen. Since the bacterium uses the volatile components such as acetate in the waste water, it processes these components into H_2 and CO_2 .

Bacteria Generating Hydrogen Hold Promise

Three biological processes of hydrogen generation have been extensively studied in the international community. The first involves the use of photosynthetic green algae or cyanobacteria.

These organisms use solar energy in the process of photosynthesis to break down water (H_2O) into molecular oxygen (O_2) and can be engineered to also produce hydrogen. This promising method faces several significant obstacles, primarily because hydrogen-generating systems are readily inactivated by oxygen. This is due to an enzyme critical in the production of hydrogen; exposure to even minute amounts of oxygen will deactivate this enzyme thus ceasing all hydrogen production.

The second biological way to generate hydrogen is by using fermentative

bacteria to break down organic material, e.g., waste water or plant biomass, and produce hydrogen and volatile fatty acids (VFA) as products. One of the questions with this technology is how to dispose of the VFAs. VFAs are pollutants that lower the pH of water, thereby making it inconsumable, while they are also toxic to plants and contaminate soil.

Another biological process of hydrogen generation, and the focus of research in the laboratory of Associate Professor Mark Gomelsky in the Department of Molecular Biology, might hold the answer. Gomelsky's laboratory has been studying photosynthetic bacteria called purple non-sulfur bacteria (PNSB), focusing primarily on *Rhodospirillum rubrum* (*R. sphaeroides*). PNSB are common inhabitants of freshwater lakes and ponds. *R. sphaeroides* uses solar energy in photosynthesis and also converts VFAs into hydrogen and carbon dioxide; however, most of the carbon dioxide is then used for cell biomass, whereas hydrogen is excreted. Using fermentative bacteria and PNSB appears to be a winning combination of producing hydrogen in a renewable fashion, generating essentially no pollution and, potentially, cleaning wastewater in the process.

Bacteria Have Advantageous Relationship

Interestingly, fermentative bacteria and PNSB naturally coexist in wastewater treatment ponds. Fermentative bacteria and PNSB are in a beneficial relationship to one another. As the fermentative bacteria produce VFAs, PNSB bacteria uses those compounds to produce H_2 ; it is a cycle that allows both bacteria to thrive together. Both fermentative and PNSB bacteria are naturally occurring in the environment; therefore, no new invasive species are being introduced into the environment to produce a beneficial product.

UW Lab Genetically Engineers Bacteria

The approach Gomelsky's laboratory has taken is to genetically engineer *R. sphaeroides* to maximize its hydrogen producing potential. The laboratory has identified multiple pathways in the genetic makeup of the bacteria that can affect the capacity of the producing hydrogen while still keeping the integrity of the bacteria. We have engineered mutations to knock out auxiliary reductive pathways so more resources may be diverted to the production of hydrogen. When combined, these mutations increase hydrogen yield by more than three-fold compared to the wild-type strain (Figure 1). All mutations are created in such a way that they do not leave antibiotic gene markers, so the strain remains environmentally friendly. Min-Hyung Ryu, molecular biology Ph.D. student, is the main *R. sphaeroides* engineer. One of the unanticipated drawbacks of the mutant is that it precipitates down from the culture at a much higher rate compared to the original strain. It is possible the bacteria are now secreting an extracellular substance that is causing cell aggregation and precipitation. We are working toward an answer to this unexpected presentation. Because of the precipitation, cells don't fully use the sunlight and don't produce hydrogen at the maximal rate. We are now using genetic engineering to solve this unexpected problem.

NASA Looks at Biohydrogen Production

Last summer, the Wyoming NASA Space Grant Consortium awarded Hull an undergraduate research scholarship to metabolically engineer *R. sphaeroides* for increased biohydrogen production. Why is NASA interested in hydrogen and PNSB? Long-term space expeditions would generate a lot of human

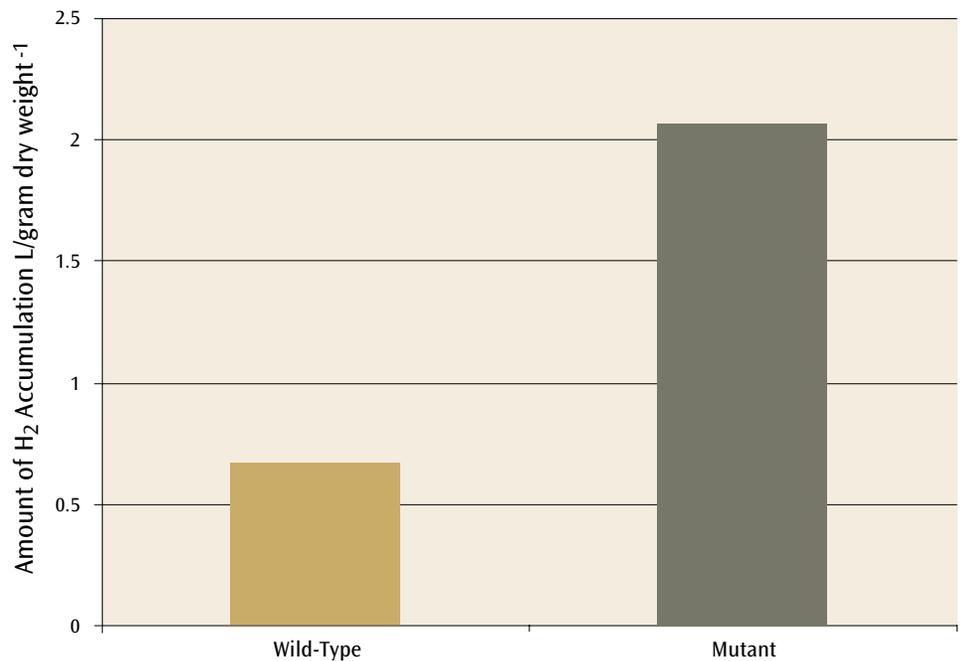


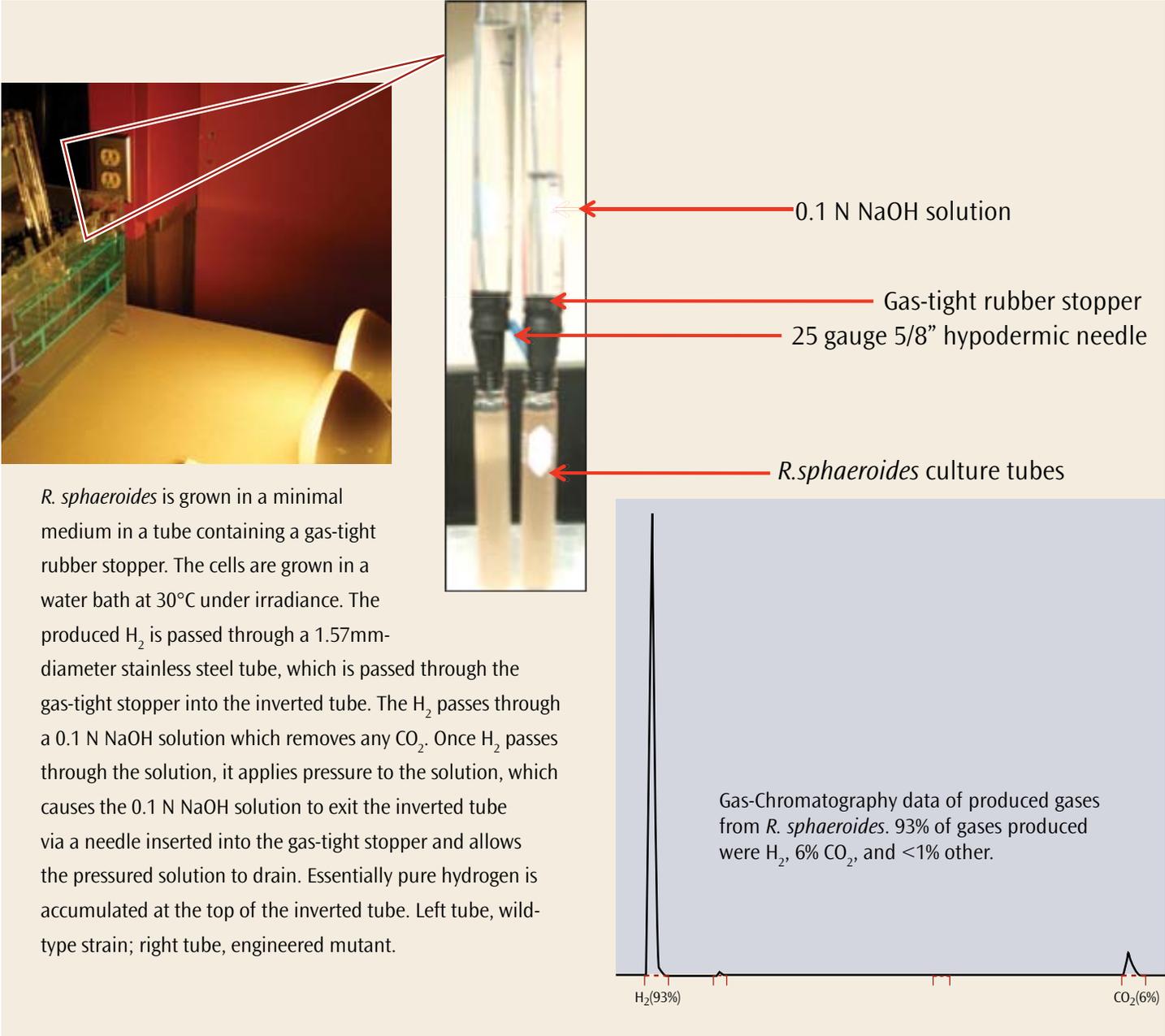
Figure 1. Difference in Hydrogen Production between the Original (Wild-type) Strain and the Mutant

waste and might need a way to recycle wastewater. NASA has a manned mission to Mars planned to occur around 2031. The crew of six is estimated to produce 12,200 pounds of organic solid waste during its 30-month mission. The current system utilizes resources such as fuel and a vehicle to ship that waste back to the orbit of Earth where it will be received by the International Space Station or similar orbital vehicle at a later time. Since Earth would be the closest planet, and most feasible to the Mars mission (~37,000,000 miles), shipping the waste back to Earth would be more cost effective than any other possible location. Obviously, this will come at a significant cost, which has yet to be determined due to the evolving nature of the mission. During long-term space expeditions, *R. sphaeroides* could be part of the solution by detoxifying waste with the added benefit of the generated hydrogen that can be used as a clean energy.

Biohydrogen — Step in Right Direction

Biohydrogen obtained from *R. sphaeroides* would be a step in the right direction to substitute for fossil fuels. With ideas exchanged at the Copenhagen Climate Conference at the end of 2009, there are bound to be changes in the countries that produce the highest amounts of greenhouse gases. Similarly, with the EPA declaring that CO₂ is a public danger, there will only be more pressure to change to clean fuels.

The U.S. has attempted to make changes by incorporating alternative forms of energy, but there will be no quick fix for our enormous consumption of fossil fuels. Since wastewater treatment plants already have a plethora of organic acids that can support *R. sphaeroides*, as well as a large amount of solar energy available, it seems a logical relationship for the bacteria and treatment plants; therefore, the cost of retrofitting these plants for a hydrogen



R. sphaeroides is grown in a minimal medium in a tube containing a gas-tight rubber stopper. The cells are grown in a water bath at 30°C under irradiance. The produced H₂ is passed through a 1.57mm-diameter stainless steel tube, which is passed through the gas-tight stopper into the inverted tube. The H₂ passes through a 0.1 N NaOH solution which removes any CO₂. Once H₂ passes through the solution, it applies pressure to the solution, which causes the 0.1 N NaOH solution to exit the inverted tube via a needle inserted into the gas-tight stopper and allows the pressured solution to drain. Essentially pure hydrogen is accumulated at the top of the inverted tube. Left tube, wild-type strain; right tube, engineered mutant.

collection receptacle would be reasonable. On a larger scale, a combination of fermentative bacteria and PNSB can be used to produce hydrogen from plant biomass. Retrofitting wastewater treatment plants would require an installation of an *in-situ* bioreactors to grow *R. sphaeroides*.

The University of Wyoming is at the forefront of trying to bridge the

gap of the alternative energies needed to wean this country off dependence on fossil fuels. With Wyoming being a large, energy-rich state, it is imperative we generate new resources to keep this state competitive with regard to alternative fuels. This research is one promising step in that direction.

The authors would like to thank the School of Energy Resources

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How far will that pound of feed take you?

UW examines feed efficiency

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Improving the feed efficiency of a herd or flock can mean big savings for producers. A 5-percent improvement in feed efficiency could have an economic effect four times greater than a 5-percent improvement in average daily gain

If picking out your next car, one you would drive for the next seven years, what type of car would you choose? Would you pick a large SUV that averages 9-13 miles per gallon or a four-door sedan that averages 24-30 mpg?

In essence, livestock producers are faced with similar decisions with their animals. Feed prices are unpredictable at best, prone to rumors and speculation associated with the ethanol industry as well as the whim of Mother Nature. In general, feed prices will continue to rise, linked inevitably to fuel and fertilizer prices. Most producers' immediate response is to reduce spending. An additional tactic used by both seedstock and commercial producers is to select for more efficient animals – those that require less feed while still remaining productive.

Feed efficiency is universally agreed to be an important trait, but it has also been an elusive trait to monitor.

Why?

Measures of feed efficiency require the ability to measure individual feed intake — something not easily or feasibly done by producers; however, improving feed efficiency can reduce overall winter feed costs and improve profitability.

Feed is a major expense for livestock producers. Feed costs account for 60-65 percent of total production costs for beef cattle producers and 50-70 percent for sheep producers. Since cattle and sheep are managed to maintain body condition and weight, selecting more efficient animals that have lower maintenance requirements (energy requirements for normal metabolic processes) can have a dramatic effect on reducing feed inputs.

In the past, researchers had to pen each particular animal to record individual feed intake. This was an expensive and time-consuming process that required weighing each animal's daily feed allotment while also measuring the amount of feed remaining at the end of the day.

Installation of GrowSafe Feeding Systems

Over the past five years, many universities and research facilities have installed GrowSafe feeding systems. Two such systems have been installed at UW research facilities: one beef cattle system at the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC) near Lingle, and one sheep system at the Laramie Research and Extension Center Livestock Farm



Beef cattle GrowSafe system at the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC).

outside Laramie. These systems provide researchers the ability to measure individual animal feed intake, feeding behavior, and feed efficiency. GrowSafe feed intake systems are a series of feed bunks electronically linked to a computer and software system that continuously monitors feed present in the bunk. Each bunk is restricted to one animal at a time. Each time an animal enters a bunk, its electronic ID tag is recorded as well as the feed consumed and the time spent at the bunk.

The GrowSafe system is unique for several reasons, including: 1) the amount of labor required is dramatically reduced; 2) animals remain in a natural group setting as opposed to being penned individually; 3) feeding behavior information is collected by the system, such as how many times an animal ate, the size and time of each individual meal, and the duration of each meal; and 4) the feeding information is recorded automatically by the

equipment and monitored remotely by GrowSafe and university personnel. This reduces error and improves the quality of the information received from feeding studies.

Beef Cattle Research at SAREC

SAREC has 10 GrowSafe units, and scientists have completed two research studies with two underway. These four completed and current studies evaluate the impact of cow nutrition and management during pregnancy and what impact these management decisions may have on the subsequent performance (e.g., feed efficiency) of calves produced from those pregnancies.

The two completed studies examine energy and protein restriction during the middle period of pregnancy, which, for spring calving herds, would be late August through November. This is a period where lack of grass or reduced forage quality may affect the developing fetus and, ultimately, calf performance.

Research projects at SAREC are re-evaluating these same mid-pregnancy management decisions as well as evaluating the potential of camelina meal as a pre-calving supplement for beef cows and its impact on the calves produced. The information gathered from the latter project will aid in the Food and Drug Administration clearance of camelina meal as an accepted feedstuff for livestock.

Bull Tests in Four-State Area

In addition to research trials, researchers at SAREC evaluated 100 bulls the winter of 2008-2009 for seedstock producers in Wyoming, Nebraska, South Dakota, and Kansas. The set of bulls was evaluated on a high-forage growing ration to determine individual feed intake, daily gains, and, most importantly, individual feed efficiency during a 70-day evaluation period. To adequately interpret the data, bulls were compared to the group averages to generate relative rankings. The results showed that, despite having all spring-born bulls on the same ration, there is still an amazing amount of variation not yet understood. Producers receive a report at the conclusion of the test summarizing how their bull(s) performed and compared to other bulls in that same test.

Sheep Research at UW Stock Farm

The Laramie Research and Extension Center Livestock Farm has eight GrowSafe units. One study was recently completed, and another study is underway. The completed study looked at the effect of high dietary nitrate on feed intake and feeding behavior of wether and ewe lambs.



Single bunk within GrowSafe system at SAREC.

(Photo by Platt Price)

High-nitrate forages are common in Wyoming and surrounding states and can cause nitrate toxicity in affected ruminant livestock. The current project is a large-scale study designed to identify genetic markers for feed efficiency in rams. The GrowSafe system for sheep at the livestock farm has put UW researchers in a unique position to lead in genetic marker identification in sheep.

To accurately identify genetic markers for improved feed efficiency, individual measures of feed intake are necessary. This project will use genotype and performance data from ram lambs in the UW flock as well as information from rams submitted to the UW fall and spring ram tests by Wyoming, Nebraska, South Dakota, and Colorado producers.

Each spring and fall, UW hosts a ram test during which producers submit rams for a 70-day evaluation period. The recent installment of the GrowSafe system at the stock farm now allows producers to gain access to feed intake, daily gain, and feed efficiency on individual rams. The first full 70-day test was implemented with the fall 2009 ram test. Variation in ram performance similar to that observed with the bull test is expected. In essence, this variation is the basis for the genetic marker study previously described.

A New Way to Measure Feed Efficiency – RFI

Improving the feed efficiency of a herd or flock can mean big savings for producers. A 5-percent improvement in feed efficiency could have an economic effect four times greater than a 5-percent improvement in average daily gain (ADG). Many beef cattle breed associations have adopted a slightly different method of evaluating individual feed efficiency called residual feed intake, or RFI. Residual feed intake is defined as the difference between an animal's actual feed consumed, or eaten, and the animal's calculated feed requirements

based on its weight and ADG while on test. Essentially, RFI describes the variation in feed intake that remains after the requirements for maintenance and growth have been met. Efficient animals eat less than expected and have a negative or low RFI, while inefficient animals eat more than expected and have a positive or high RFI. The more desirable, more efficient animals have low (negative) RFI values. Canadian and Australian research with RFI suggest improvements in feed efficiency can be made through RFI selection.

Feed efficiency research will continue at both SAREC and the Laramie Research and Extension Center Livestock Farm. The research possibilities are endless; however, much of the focus will remain on determining the impact of weaning and backgrounding strategies on feed efficiency, evaluating replacement females for feed efficiency potential, identifying genetic markers for improved feed efficiency, and determining the impact of genetic selection for efficiency on other traits of economic importance, especially reproduction and carcass merit traits.



(Photo by Kristi Cammack)

Sheep GrowSafe system at Laramie Research and Extension Center Livestock Farm.

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SEED SCARIFICATION,

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Hay has been the leading cash crop in Wyoming for many decades. Alfalfa, one of the most important cash crops, is playing a key role in Wyoming hay production.

The dollar value from alfalfa hay was about \$181 million in 2008 covering 70 percent of the total hay value produced in Wyoming. There are concerns associated with alfalfa production – bloat (an animal disorder from continuous or excessive alfalfa grazing), susceptibility to diseases and pests, weed problems, and auto toxicity (a stand-declining problem associated with three or more years of alfalfa). Forage legumes with better yield and

quality, fewer pest and disease problems, and higher adaptability will be desirable for diversified forage production systems.

Growing Interest in Forage Legumes

There is increasing interest among producers in the Central West/High Plains regions to identify forage legumes as alternatives to alfalfa. Examples include sainfoin, cicer milkvetch (CMV), and medic.

Sainfoin is a perennial forage legume that has high-yield capacity, improved quality, high pest resistance, high wildlife acceptability, high-quality



(Photo by Emi Kimura)

A vigorous plant of Russell oat showing seed head.



(Photo by M. Anowarul Islam)

Partial view of one of the experimental plots at the Laramie Research and Extension Center showing plots with only legumes (foreground) and legumes plus oats.

COVER CROPS

enhance establishment of forage legumes

honey production ability, and, most importantly, no bloat problem.

Cicer milkvetch is also a perennial legume with a vigorous root system that can be grown in a broader range of soil conditions than alfalfa.

Winter annual medic (sometimes called annual alfalfa) produces high-quality, early-spring forage and has tremendous seed production potential that can produce a significant seed bank in soils for regenerating seedlings without planting the following year (ley farming); however, establishment of these legumes is difficult in the field. Some of the reasons are a hard seed coat, a slow rate of germination, low seedling vigor, weed competition, and disease problems.

To minimize or overcome the problems and to promote the establishment of these forage legumes, we initiated a research project in the Department of Plant Sciences. The goals are to reduce hard seed content or coat (the outer protective covering of a seed that prevents embryo from dehydration and physical or mechanical damage) by appropriate and cost-effective scarification method(s), test germination and vigor of the scarified seeds, and, finally, plant the scarified seeds in the field with a cover or companion crop to reduce weed infestations while enhancing legume establishment.

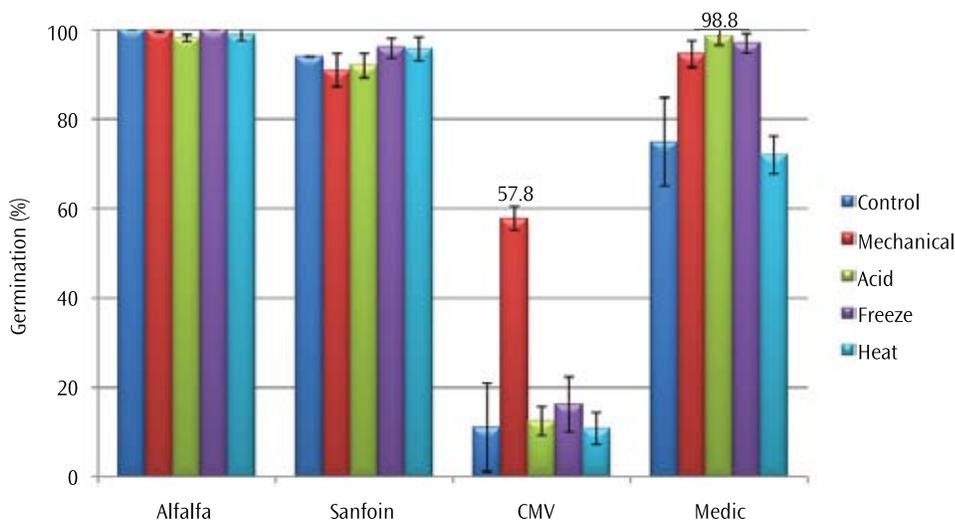


Figure 1. Germination of different forage legumes after imposing different scarification treatments. Scarification includes control (no treatment), mechanical, acid, freeze, and heat (for details, see text). CMV = cicer milkvetch.

Hard Seed – A Problem in Many Legumes

Forage legumes have the potential to lower nitrogen fertilizer costs on farms and may provide a more sustainable option for pasture-based production systems not only economically but also in terms of impact on water quality, soil health, fossil fuel consumption, and climate change. Legumes capture atmospheric nitrogen through bacteria in the roots and convert it to available forms for plant uptake. Through this process, plants and bacteria mutually benefit. The bacteria are host-specific, and fixation of nitrogen depends on plant species. For example, alfalfa alone can fix up to 220 kilograms (kg) of nitrogen (N)/hectare (ha)/year (yr)

and 250 kg N/ha/yr with grass-mixture, whereas red clover alone can fix 110 kg N/ha/yr and with grass-mixture 150 kg N/ha/yr. These are substantial amounts of nitrogen naturally supplied by legumes; however, legumes may disappear from the stand because of poor establishment, too much competition with other species, weed invasion, nutrient deficiency, and disease or pest attacks.

One of the major causes for poor establishment is associated with the hard seed of legumes.

Hard seed content varies species to species and even varieties within species. Relatively softer seeds may have been scarified at the time of harvest resulting



(Photo by Emi Kimura)

M. Anowarul Islam uses a hand harvester to glean samples of forage legumes and oats at the Laramie Research and Extension Center.

in high germination naturally; however, many legume seeds are very hard and require artificial scarification to enhance germination and eventual establishment.

Seed Scarification May Promote Germination and Establishment

Seed scarification is well-documented to reduce hard seed content and thus increase germination in many crops, including alfalfa; however, the question is whether the same procedures can be applied for legumes other than alfalfa. Another worry is whether these procedures would be feasible and economically viable for producers. A recent study in the plant sciences department showed Ranger alfalfa and Shoshone sainfoin have much softer seeds compared to Monarch CMV and Laramie medic (Figure 1, page 39). As a consequence, Ranger alfalfa and Shoshone sainfoin do not require scarification.

On the other hand, CMV and Laramie medic have higher hard seed content and thus require artificial scarification. Different scarification treatments applied to seeds include a control (no treatment), mechanical scarification for five minutes with sandpaper (by hand rubbing seeds using two sheets of sandpaper),

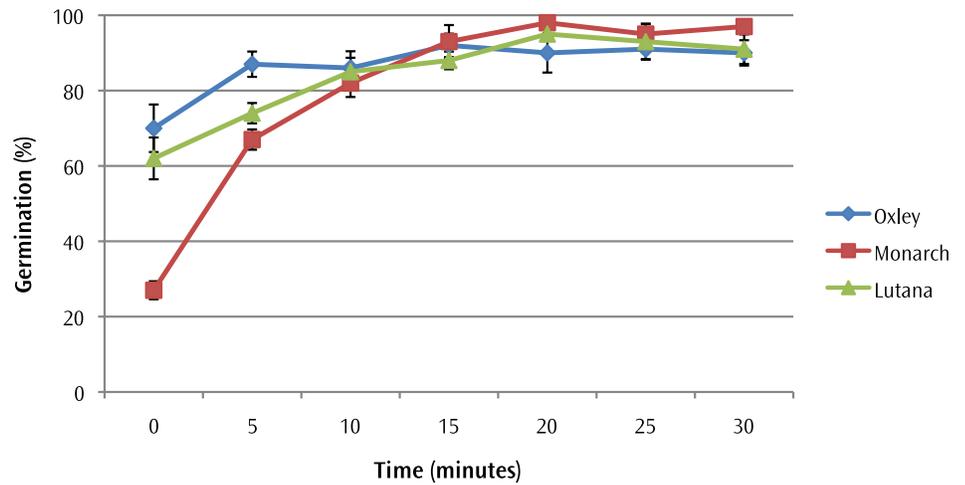


Figure 2. Germination of different varieties of cicer milkvetch after imposing mechanical scarification with varying treatment time. Varieties used include Oxley, Monarch, and Lutana (for details, see text).

sulfuric acid scarification for five minutes, low temperature (-80°C or -112°F) freeze scarification for 12 hours, and heat (60°C or 140°F) scarification for two hours.

Among the imposed treatments, mechanical scarification seems to work best for CMV (58-percent germination), while acid scarification works best for Laramie medic (99-percent germination) (Figure 1). Increased time of mechanical scarification for different varieties of CMV (e.g., Monarch, Oxley, and Lutana) further enhances germination, and the best results were obtained from 15 minutes of scarification (90- to 98-percent germination) (Figure 2, above).

Although acid scarification works best for Laramie medic, this may not be a viable option for producers because of health hazards and safety issues. Additionally, other than mechanical and freeze scarification, heat scarification would be a very good option because of the easy, cost-effective, and practical method to use (seeds could be heated in a large oven or dehydrator). Further research with different timings of heat scarification is needed to confirm this trait.

Oat as a Cover Crop May Enhance Legume Establishment

In addition to seed scarification, use of cover or companion crops and seed inoculation with the right inoculants may enhance legume establishment. Using cover or companion crops (oat, rye, and triticale) in establishing alfalfa is a common practice in the western Great Plains region, but information is lacking if the same technique can be used in other forage legume establishment.

To determine whether oats as a cover or companion crop can be used to enhance legume establishment, a field study was initiated at the James C. Hageman Sustainable Agriculture Research and Extension Center near Lingle and the Laramie Research and Extension Center in spring 2009. Legumes were planted in four replicated plots perpendicular to oats at both locations in such a way that half of the plots had Russell oats and the rest had none. Legumes in the study include Ranger alfalfa, Shoshone sainfoin, Monarch CMV, and Laramie medic.

Preliminary data suggest that oats, as a cover or companion crop, may have potential to suppress weed



Emi Kimura, left, and Larry Miller harvest and sample forage legumes and oats at the James C. Hageman Sustainable Agriculture Research and Extension Center near Lingle.

(Photo by M. Anowarul Islam)

infestation and enhance establishment of different forage legumes. Plots with oats and legumes had consistent significantly lower weed dry matter compared to plots with only legumes (Figures 3 and 4). This may have contributed to the additional fact a better healthy stand of legumes will be seen the following year with plots that had oats the previous year.

This is too early to conclude the ongoing study in the Department of Plant Sciences on enhancing forage legumes establishment through seed scarification and use of cover crops; however, preliminary information indicates proper seed scarification and use of an appropriate cover or companion crop may enhance seedling establishment the first year and eventually may provide healthier and productive legume stands for subsequent years. This information will be invaluable to not only scientists or researchers at the University of Wyoming but also to producers in the region with concerns about failing to establish forage legumes. *m*

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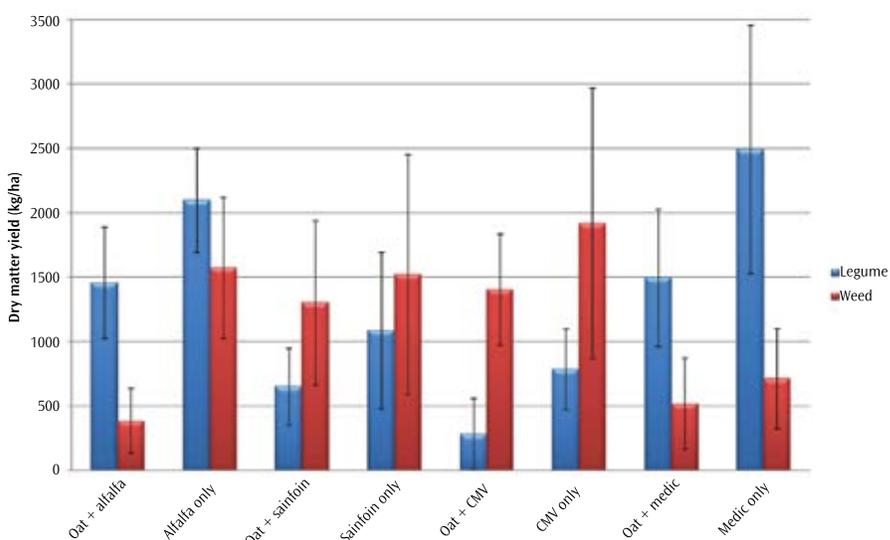


Figure 3. Dry matter yield of different forage legumes and weeds at the James C. Hageman Sustainable Agriculture Research and Extension Center near Lingle. Plots were harvested in September 2009. CMV = cicer milkvetch.

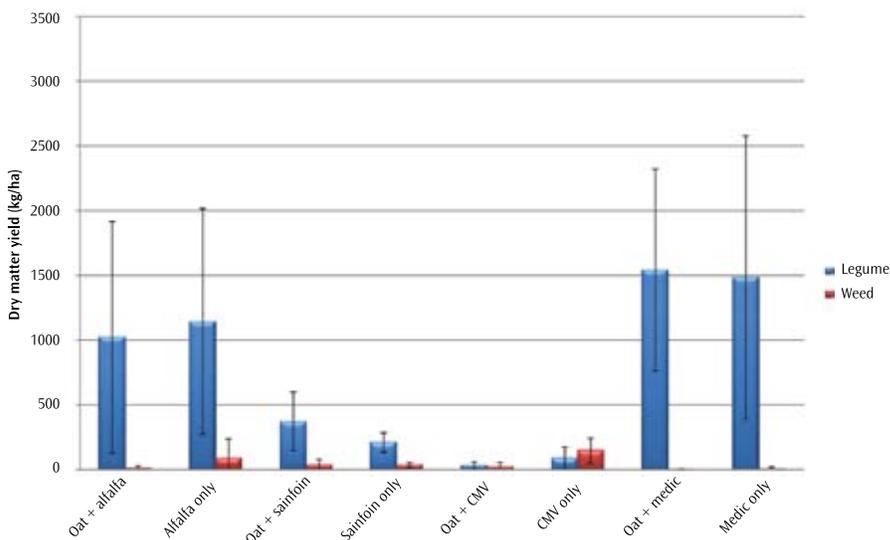


Figure 4. Dry matter yield of different forage legumes and weeds at the Laramie Research and Extension Center. Plots were harvested using a hand-harvester in September 2009. CMV = cicer milkvetch.



IT'S NOT



Amber and Lacey Degraw of Worland learn to make Bread-in-a-bag Cinnamon Rolls during a Cent\$ible Nutrition Program class.

JUST ABOUT FOOD

CNP changes Wyoming lives through nutrition education

Mary Kay Wardlaw, Ph.D.
Director
Cent\$ible Nutrition Program
Department of Family and
Consumer Sciences
College of Agriculture and Natural
Resources

“After that class, the teacher was so nice and she gave us all the information that we needed. She’d made a good change in our life... she made it really easy for us. It was something that I really needed... I think the best thing I got was that I felt like I was worth something.”

CNP Class Participant

Food is life sustaining. We all eat to live.

Those who enjoy a very high standard of living regularly enjoy fine dining restaurants or employ chefs so they know the food will taste good, and their concern is, “Will it be presented well?”

The typical middle class adult asks, “Will it taste good?”

For families in poverty, the food question routinely is, “Will there be enough?”

Families in every county across Wyoming struggle to have enough food to last until the next paycheck.

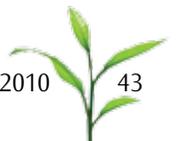
The Cent\$ible Nutrition Program (CNP) is a federally funded, low-income program to help families eat better for less. Funding comes through the Expanded Food and Nutrition Education Program and the Supplemental Nutrition Assistance Program Education — formerly called Food Stamp Nutrition Education.

CNP is implemented as part of the University of Wyoming Cooperative Extension Service and the Department of Family and Consumer Sciences in the College of Agriculture and Natural Resources.

Through a series of hands-on classes taught by county-based trained educators, participants gain skills in food resource management, food safety, and dietary quality.

Assesses Long-term Impact of CNP

A research project using quantitative and qualitative techniques assessed the long-term impact of CNP in Wyoming. Adults who participated in the program at least one and up to four years previous to the research were contacted to complete an 18-item behavior checklist. Each participant had filled out the behavior checklist when he or she enrolled in CNP classes and upon graduation. The pre-, post-, and follow-up behavior checklists were matched for each respondent to observe changes in behavior over time. Semi-structured interviews were conducted to learn more about changes related to food and nutrition behaviors as well as other life changes attributable to their involvement in the program.



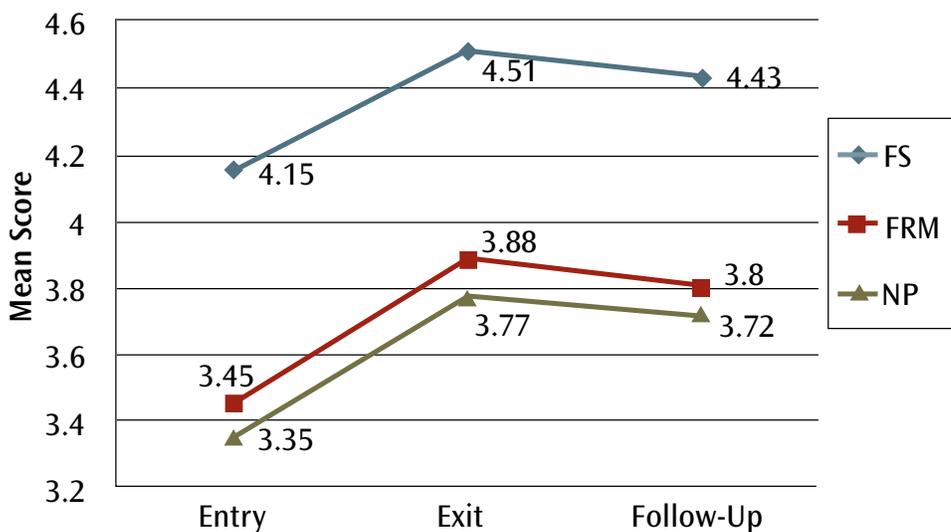


Figure 1. The mean scores for the three subscales FS (food safety), FRM (food resource management), and NP (nutrition practices) are depicted at three data collection points.

The study sample for this research was the 2,668 adult graduates completing the CNP program between October 1, 2004, and September 30, 2007. Of those, 1,221 names were removed due to lack of, or undeliverable, addresses, missing surveys, and/or residence in correctional facilities. The 493 respondents comprised 34 percent of the convenience sample and 18.5 percent of the study sample and represented a 46.4-percent response rate of deliverable surveys.

From the 493 survey respondents under the age of 51, potential interviewees were randomly selected. Respondents over age 50 were not included in the sampling to increase the possibility interviewees would have children in their homes. A total of 19 interviews were part of the qualitative analysis. An additional source for qualitative data was the 234 written comments from the 493 follow-up assessments.

Food and Nutrition Behaviors

The behavior checklist uses a Likert-like scale allowing respondents to indicate the frequency they perform selected behaviors. Response choices ranged from 1 to 5, with 1 as never, 2 as seldom, 3 as sometimes, 4 as most times, and 5 as always. The instrument



A local chef in Big Horn County demonstrates how to chop butternut squash for a Moroccan Ragout dish he created using commodity foods such as canned tomatoes and canned beans.

has three nutrition education components or subscales: food resource management (FRM), food safety and handling (FS), and nutrition practices (NP). These match the three focus areas of the CNP curriculum.

Statistical analyses for each subscale were completed to examine changes. The means over time are depicted as a graphic representation in Figure 1 and show a pattern for the subscales with an increase in desired behavior from entry to exit and a smaller decline from exit to follow-up. It also shows the maintenance of the behaviors, or the follow-up scores, were higher than the entry scores for all areas.

Time was the only attributable effect for the behavior changes. There were no changes based on age, the number of years since participation, where they lived, or their program eligibility.

Positive Changes Over Time

The behavior changes from entry to exit and entry to follow-up were significant and indicate graduates were doing many things differently to eat better for less. The change from exit to follow-up was small and was not significant in terms of describing a behavior change. The finding of positive changes over time for food and nutrition behaviors was supported through the interviews. Within the food resource management area, 19 respondents provided 16 different thematic behaviors they had learned and/or maintained. Past graduates said that, as a result of their involvement in CNP, they still use a grocery list for shopping, compared prices before purchasing, planned menus, bought items on sale, and cooked at home. They noted



Goshen County Cent\$ible Nutrition Program assistant Jacqueline Hauptman helps Robert Bradley of Torrington prepare chicken breasts for cooking during a Meat: The Protein Connection class.

the use of CNP master mixes – make-ahead staples including a baking mix, a white sauce mix, and a meat sauce mix.

Jean shared the following regarding what she does to save money on food:

I do like the master mixes. I really like those. I have to make a monthly list, I buy monthly. . . . But I do know that when I make the menu, the menu is a big one, that helps me most for money saving. I know what I need, when I need it, and I don't buy other stuff. (personal communication, November 12, 2008)

The food safety subscale had the highest starting mean, suggesting respondents reported more of the desirable food safety behaviors when they enrolled in the program compared to behaviors in food resource management and nutrition practices. The majority of the food safety behaviors learned and maintained were from the topic areas of chilling food and cleaning food preparation areas and hands. Interviewees reported they still use a sanitizing solution to clean, they clean better and more often, they cool food properly, and they wash their hands better and more often as a result of the classes.

In analyzing the qualitative responses to the nutrition practices area, respondents identified 12 thematic areas learned and 10 maintained. When asked about what behaviors they maintained, respondents said they eat more fruits and vegetables; they select and cook foods with lower fat, sugar, and sodium; they read labels in the grocery store; and they use MyPyramid to help balance food choices.

Tracy told what she learned about nutrition and how she uses that information in her life:



A mother and her two children make tortilla self-portraits using healthy proteins, fruits, and vegetables at North Casper Elementary School. The trio attended a Cent\$ible Nutrition Program nutrition information program that included separate components for children and parents.

I use it every day actually. Every day with what you put into your body. Kind of like a gas tank, what you fill your body with depends on how well your engine will run. We try and eat healthier each day and get those lessons to my kids.

The Bottom Line

Through the interviews, past graduates talked about positive changes in their lives they indicated were a result of their participation in CNP. These

Participants in this research made changes they integrated into their lives positively, affecting them, their families, and communities.

effects included improvements in health, decision-making skills, tracking and goal setting, confidence, parenting, quest for learning, peace, and worthiness. TM conveyed how the program changed her life, first through nutrition and then through other areas. TM said the following:

I guess you could say that I just got a little bit calmer and seemed to become more peaceful when I did it. And it kind of continued and bled into the rest. It didn't stop when the class stopped. It bled into the rest of the day, the week, the month. It's still kind of been that way. I mean, every now and then I think, 'I can't do this,' and I go and get the quick meal. But, I always come back and say, 'No, we can do this. We can do this from scratch.'... It just gave me a sense of peace, you know. And I can't explain what type of peace it is. But it's there and it's nice and it feels good. ... In fact, I

started trying to find that type of feeling in other areas of my life as well.

Stacie found value and worthiness in herself that had not previously existed. She shared her personal experience through the following quote:

I have more self-confidence. I guess I always thought that, well, everybody treated me like I was stupid or had the plague or something. After that class, the teacher was so nice and she gave us all the information that we needed. She'd made a good change in our life. ... she made it really easy for us. It was something that I really needed. ... I think the best thing I got was that I felt like I was worth something.

Through quantitative and qualitative data analysis, it appears CNP graduates maintain many positive food- and nutrition-related behaviors at least one and up to four years following participation in the program, and they perform these behaviors more often than before they started the program. Data indicated increased positive behaviors in the areas of nutrition practices, food safety, and food resource management.

Further, graduates believe their involvement in CNP changed their lives related to food and nutrition and other aspects. The interviewees shared insights and personal reflections pointing to how they made changes and improved their lives in numerous ways because they believe they are confident, connected to others, and worthy.

Participants in this research made changes they integrated into their lives positively, affecting them, their families, and communities.

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Is a sister better than a brother for ewe?

Researchers investigate whether twin to a male or female better for producers

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The economic impact of twinning is so large it is commonly selected for even though it is lowly heritable; hence, one selection criteria often used for replacement ewes is that they be born as a twin.

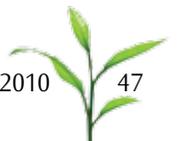
Although “freemartinism” (anatomical changes to the reproductive tract of female calves born twin to a male) rarely occurs in sheep, ewes co-twinning with a male are exposed to higher levels of testosterone in the uterus than ewes with a female co-twin.

This *in-utero* exposure to elevated concentrations of testosterone has the potential to affect growth, reproduction, and behavioral traits. At the USDA-Agricultural Research

Sheep Experiment Station (www.ars.usda.gov/main/site_main.htm?modecode=53-64-00-00) at Dubois, Idaho, rams co-twinning with another male mated with more females during sexual behavior testing than rams born co-twin to a female. This increase in serving capacity is likely a result of the increased exposure to testosterone resulting from the male-twinning pregnancy.

Hypothesize Co-Twin to Male Alters Ewe’s Reproductive Potential

Freemartins also do not occur in human twins, but the presence of a male fetus increases the female co-twin’s birth weight and increases



the amount of male-typical play she engages in. In litter-bearing species, such as rodents and swine, females born to litters with a large proportion of males reach puberty later and have a shortened reproductive life; therefore, we hypothesize co-twinning with a male in sheep would also alter a ewe's reproductive potential. To evaluate this hypothesis, historical (1995-2003) lambing records from 547 ewes from the University of Wyoming purebred sheep flocks were analyzed to determine effect of breed and sex of co-twin on lifetime flock productivity.

Breed of the ewe affected both number of lambs born (Table 1) and years ewes remained in the flock (Table 2). Suffolk ewes were the most productive with the most number of lambs born and longest flock longevity. Flock longevity of Suffolk ewes did not differ from Rambouillet ewes (Table 2). Columbia ewes had the fewest number of lambs and shortest flock longevity, which did not differ from Hampshire ewes (Table 2).

Lambs of British breeding, such as Suffolk and Hampshire, tend to reach puberty earlier and more commonly conceive in their first year of life than lambs with Spanish ancestry, such as Rambouillet and Columbia, which commonly have their first lamb as 2 year olds; although white-face ewes are noted for their hardiness, differences in flock longevity of Rambouillet ewes did not differ from the black-face breeds in this farm-flock management system.

Based on these data, producers would benefit from selecting ewes co-twinning with a female rather than those co-twinning with a male.

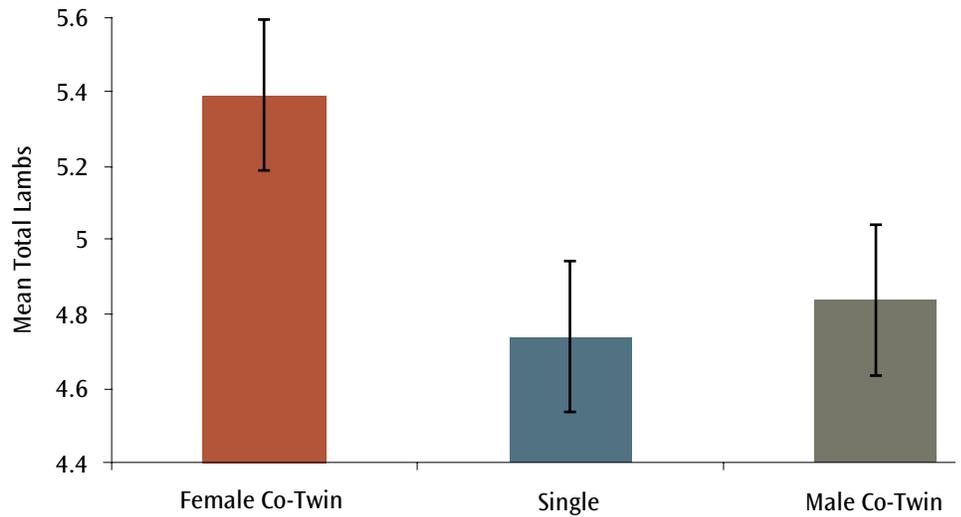


Figure 1. Total number of lambs delivered by ewes born single, co-twin to a female, or co-twin to a male fetus. Number of lambs tended ($P = 0.08$) to be effected by twinning.

Table 1. Breed effect on total lambs produced by each ewe

	Mean	Std. Error
Columbia	4.25 ^a	±.28
Hampshire	5.01 ^b	±.25
Rambouillet	4.78 ^{a,b}	±.25
Suffolk	5.92 ^c	±.28

Columns with differing superscripts differ ($p < 0.05$)

Table 2. Breed effect on ewe longevity in the flock

	Mean (yr)	Std. Error
Columbia	3.69 ^a	±0.16
Hampshire	3.69 ^b	±0.14
Rambouillet	4.08 ^{a,b}	±0.14
Suffolk	4.15 ^c	±0.16

Columns with differing superscripts differ ($p < 0.05$)

Females Born Co-twin to Male Produce Fewer Lambs

Under the UW management system, sex of the co-twin did not affect number of years a ewe remained in the flock; however, females born co-twin with a male produced approximately 10 percent fewer lambs during their lifetime than ewes born co-twin with a female. Numbers of lambs born to ewes with a male co-twin did not differ from ewes born as singles (Figure 1). Based on these data, producers would benefit from selecting ewes co-twinning with a female rather than those co-twinning with a male.

Clearly, management systems differ among flocks and could mask effects of sex of a co-twin on ewe productivity.

For example, time of lambing, age when ewes are first exposed to rams for breeding, and culling criteria influence ewe productivity.

To more firmly determine the impacts of sex of a co-twin on ewe productivity, data sets from flocks at Montana State University and New Mexico State University are being evaluated and will be presented at the American Society of Animal Science annual meeting in Denver, Colorado, this summer.

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Educators promote farmers market establishment on WIND RIVER INDIAN RESERVATION

*Justina Russell
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Wind River Reservation
University of Wyoming
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Service*

The closest farmers markets are 15 to 60 miles away in the neighboring Fremont County towns of Lander, Riverton, and Dubois.

Seeds planted for the establishment of a local farmers market on the Wind River Indian Reservation may come to fruition.

Farmers markets are, in the most traditional sense, markets held outdoors during summer at which vendors sell produce and other goods, such as prepared foods and crafts, directly to the public.

Finding fresh, reasonably priced produce is often hard in Wyoming's remote rural communities. The 2.2 million acres of the reservation present an obstacle of mass proportions for the approximately 11,000 Eastern Shoshone and Northern Arapaho peoples within the boundaries of the reservation because of long travel distances required to reach larger city centers. The closest farmers markets are 15 to 60 miles away in the neighboring Fremont County towns of Lander, Riverton, and Dubois.

A centrally located market or several markets located throughout the reservation would provide a valuable service for residents because nutritious fresh fruits and vegetables would be more readily accessible. A local market would also enable area farmers, ranchers, and other vendors to sell their goods at home, thereby supporting the local economy and providing a way for people to supplement existing incomes.

Survey Four Main Communities

The population's four main communities were surveyed last summer to assess the usefulness of a reservation market. Survey collection boxes were placed at several locations in Fort Washakie, Ethete, Kinnear, and Arapahoe. Responses were regularly collected

throughout the summer. By mid-August, University of Wyoming Cooperative Extension Service (UW CES) office members had collected and tabulated results from nearly 400 respondents. Almost 90 percent of survey participants indicated they would buy fresh produce at a local market while 81 percent said they would consider selling various products if a market was established on the reservation since it would provide a convenient, as well as consistent, place to sell their goods within reservation boundaries.

Most farmers markets in Wyoming focus on the sale of fruits and vegetables; however, tribal members expressed interest in providing less typical farmers market items to be sold alongside locally harvested produce. Approximately 50 percent of the

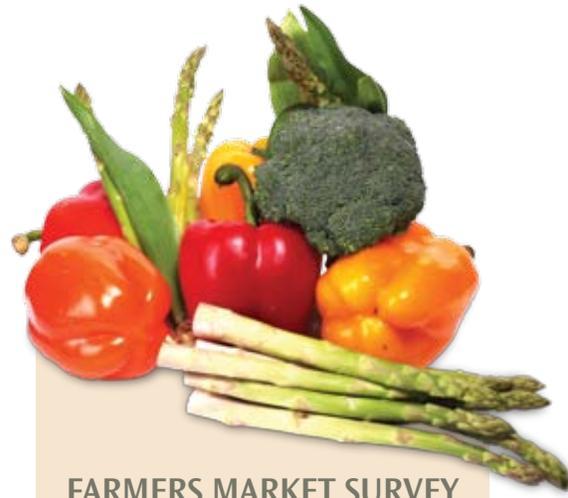
survey participants shared they not only would be interested in buying and selling products such as cucumbers, corn, and tomatoes, but also traditional Native American favorites such as fry bread and Native American arts and crafts. A future reservation farmers market will most likely include space for crafts and prepared food vendors to meet the unique wishes of reservation community members.

Harvest-oriented Hands-On Workshop

As there seemed to be genuine interest in a farmers market on the reservation, the UW CES office teamed with extension's Cent\$ible Nutrition Program (CNP) educators to develop a hands-on workshop "From Planting to Plate." This harvest-oriented workshop was seen as an opportunity to encourage community members to start thinking about farmers markets on a more personal basis. If people could learn how to efficiently grow, preserve, and sell produce locally, they would have more incentive to participate in a reservation farmers market.

Skills learned included growing an indoor/outdoor container garden, how to prepare healthy salads and breads, and home canning of peaches using the water bath method, which involves placing fresh produce in jars to be heat sterilized in boiling water to preserve produce for later consumption.

The presentation on container gardening was designed for people who may not have the time, ability, or land to grow a large garden to produce fresh foods for home consumption or farmers market sales. The use of containers was also promoted because the primary growing season on the reservation is only about 140 days; therefore, container gardens will allow for indoor gardening during winter months.



FARMERS MARKET SURVEY 400 responses

90% - Would buy fresh produce at local market

81% - Consider selling various products at local market

Surveys collected in Fort Washakie, Ethete, Kinnear, and Arapahoe

Participants were taught container selection, soil preparation, and overall plant care through inspection of vibrant containers of various herbs and vegetables planted earlier in the summer by the reservation extension educator. The advantages of buying and selling goods, particularly fruits and vegetables at local markets to save money, eat better tasting produce, and reduce environmental consequences due to lengthy food transportation distances, were also emphasized.

Reservation CNP educators Jennifer Schaff, Renee Goetz, and Nan Craft led the group in salad and bread preparation, which was enjoyed for lunch by all participants. During lunch preparation, educators reminded attendees of proper food preparation and safety procedures. Patti Griffith and Phyllis Lewis, area UW CES nutrition and food safety educators, taught participants the proper steps to can fresh peaches.



Roberta Behan eats lunch with her baby, Whittlee Whiteman, after helping prepare lunch during the healthy salad and bread-making session.

Participants have Diverse Backgrounds

The 12 “From Planting to Plate” participants were comprised of people from all walks of life making up a very diverse group of learners. They included several high school students, one young couple with a baby, a handful of middle-aged individuals, and several elderly women. Attendees expressed appreciation of the hands-on demonstrations, which enabled them to gain a greater understanding of local food production and preparation.

Educating community members on the specifics of growing, preparing, and preserving certain food products will hopefully encourage even more community members to consider buying and/or selling produce and other goods at a local market once established. Reservation UW CES staff members would like to follow up with a workshop this year focusing on spring garden preparation, freezing/drying of various foods, and pressure canning of fruits and vegetables.

With input from the reservation community, the Wind River Reservation UW CES office members are persevering in efforts to see the development of a reservation-specific farmers market come to fruition. A small amount of funds have already been acquired to advance a farmers market on the reservation over the next several years.

In the future, residents and visitors to the Wind River Indian Reservation may enjoy a taste of delectable produce from a vibrant farmers market while at the same time experiencing the cultural uniqueness of the area through the exchange of traditional Native American products. *m*

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Mitchell Whiteman learns from UW CES Nutrition and Food Safety educator Phyllis Lewis how to properly place the lid on a jar of freshly canned peaches before placing it in the water bath.



Workshop participants listen to UW CES Nutrition and Food Safety educators Phyllis Lewis and Patti Griffith during the peach canning session.



Confetti salad prepared by workshop participants during the salad and bread-making session.



Examples used during the container gardening presentation, which were given away to workshop participants as door prizes.

(Photo by Rhonda Bowers)

(Photo by Justina Russell)

Researchers determining best methods to reclaim areas disturbed by energy development

*Amber Mason
Ph.D. Student*

*Jay Norton
Assistant Professor
Department of
Renewable Resources*

A better understanding of how stripping and stockpiling topsoil affects the physical, biological, and chemical properties of soils could result in better topsoil management practices and reclamation of disturbed lands during energy development.

Livestock owners using the land for many generations are usually not involved in the reclamation process but may have an important role in restoring disturbed lands. Understanding effects of natural gas well development and reclamation activities on topsoil disturbance could lead to

greater reclamation success. Successful reclamation will contribute to the sustainability of the sagebrush steppe ecosystem for livestock grazing and wildlife habitat.

Energy Development in Wyoming

Much of the land in Wyoming is managed by the federal government and leased to private companies for energy development. Our research is conducted in western Wyoming on the Pinedale Anticline, Jonah, and Wamsutter gas fields where the federal government manages or owns from 50 to nearly 100 percent of the surface and/or mineral estates. Much of the land managed by the government for energy production is leased by local ranchers for cattle grazing; however, with the increased need for energy development, there is an increase in landscape disturbance.

Much of the natural gas produced in this state is in sagebrush-steppe grasslands that support wildlife like sage-grouse and ungulates as well as rangeland grazing for cattle. These ecologically and economically important areas are continuously being fragmented by networks of pipelines, roads, and well pads for energy development.

Natural gas drilling on the Pinedale Anticline located south of Pinedale.



(Photo by Amber Mason)

Amber Mason collects soil samples from a topsoil stockpile on the Pinedale Anticline.

Meeting Reclamation Criteria

Energy companies are required to reclaim land in accordance with Bureau of Land Management policies, and there are many interests in how the land is reclaimed. Energy companies have a written contract or bond to guarantee the lands disturbed from energy development activities will be reclaimed. Different energy companies apply different reclamation techniques to speed the process of bond release, but BLM reclamation policies must be met prior to the release of a bond. BLM reclamation criterion differs depending on the area, which varies with vegetation.

In general, there may be interim or rollover reclamation criteria and final reclamation criteria. The interim or rollover reclamation criteria require establishment of viable, stabilizing plant growth and a plant community that parallels surrounding or ecologically comparable vegetative composition to the maximum extent possible. Final reclamation requires a range of species composition, diversity, cover, and production equal to pre-disturbed levels. The reclaimed sites must meet vegetative criteria that include a minimum percent cover representative of adjacent undisturbed areas of native forbs, shrubs, and grasses.

Well Development and Importance of Topsoil

Topsoil is stripped from the surface during well development and placed in stockpiles until well establishment is complete. The topsoil is re-spread and seeded with native forbs, shrubs, and grasses for reclamation.



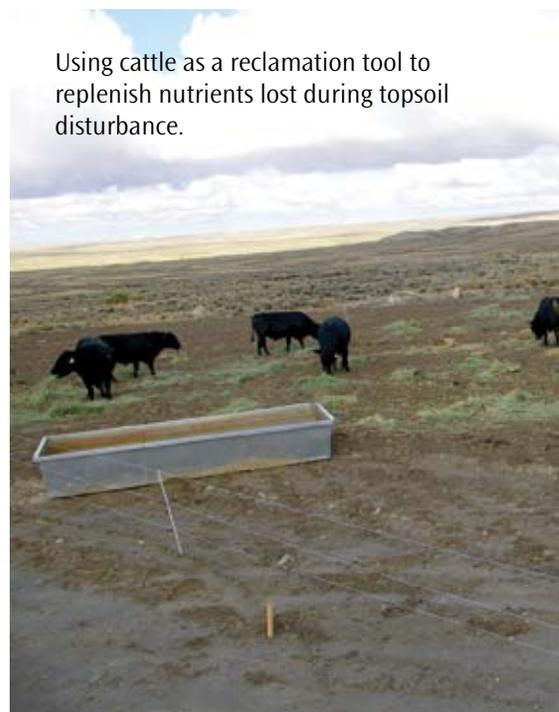
(Photo by Gailly Dreesen)

Topsoil is generally stripped and stockpiled during well development.



(Photo by Amber Mason)

Using cattle as a reclamation tool to replenish nutrients lost during topsoil disturbance.



The topsoil or surface soil supports the bulk of biological activity, including cycling of nutrients that support plant growth. The topsoil can be thought of as highly structured networks of plant roots, fungal hyphae, soil organisms, and decomposing organic materials.

Subsoils are typically zones of accumulation where clays, calcium carbonate, salts, and other materials

that can be transported by water are deposited. Subsoils, which are generally greater than 15-20 centimeters (cm) thick, are important reservoirs for soil water but are much lower in nutrients and higher in clays and salts than topsoil. In dry environments, the topsoil layer is typically thin (less than 20 cm) with relatively little soil organic matter (SOM).

Thin, nutrient-poor topsoil combined with subsoil potentially high in salts reduces the resilience of arid and semiarid soil systems following drastic disturbances. Stripping and stockpiling topsoil drastically reduces SOM by breaking apart soil structure that protects SOM. Organic matter is usually further diluted during mixing with the upper part of the subsoil because scraping only the topsoil layer in thin, dryland soils can be very difficult. Mixing of clays, salts, and sodium into topsoil further reduces its ability to recover.

Evaluating Disturbances

The purpose of our study is to evaluate human disturbance effects on soil properties and work with energy companies and cattle producers to enhance reclamation of disturbed areas.

Our study involves determining the effects drastic, but temporary, disturbances such as topsoil removal has on soil chemical and physical properties. In 2008 we worked with three natural gas companies to locate and collect soil samples from sagebrush-dominated sites slated for natural gas well pad development. We collected samples from topsoil stockpiled in spring of 2009 and again from the respread topsoil in fall of 2009. Results of laboratory analyses of different forms of soil nitrogen and carbon are allowing us to track changes in the quantity and quality of soil organic matter through the development and reclamation process. We plan to continue monitoring of soil processes as well as vegetation recovery on those sites for at least the next two years. This year we



(Photo taken by Amber Mason on 19 Oct 2009)

Cally Driessen, soil science M.S. student working on this project, collects soil to determine bulk density of the site.



(Photo by Amber Mason)



(Photo by Amber Mason)

Topsoil is re-spread and seeded for reclamation, Wamsutter Gas Field, Wamsutter.

will start sampling nearby well pads that were reclaimed five years ago. By running the same analyses on those for the next two years we can extend the time frame of our study to seven years post reclamation.

Using Cows for Reclamation

Many ranchers claim that controlled livestock impact — feeding hay to cattle or sheep on freshly planted reclaimed sites — can hasten the reclamation process by breaking soil crusts, improving seed-soil contact, and contributing nutrients and organic matter. We set up an experiment in fall of 2009 to evaluate using cattle as a reclamation tool and plan to track the effects of the short-duration, high-intensity impacts through the next two years. We placed 25 cows on a quarter-acre confined plot for 24 hours to approximate a stocking rate of 100 animals per acre per day.

Soil Health Measured

To evaluate soil health, we are analyzing how the soil organic matter

reacts to development and reclamation activities. Our analysis includes quantifying several components of soil organic matter under undisturbed sites, stockpiles, and after reclamation with and without the cattle treatments.

The components include stable organic matter compounds, such as humus, and those that react rapidly to disturbance, such as soil microbes and plant-available nitrogen. The analysis will help better understand how disturbance affects the physical, chemical, and biological components such as soil structure and nutrient transformations and/or availability. The results of the cattle treatment will help determine whether or not cattle can be used as an effective reclamation tool based upon soil nutrient concentrations and vegetation growth. We will continue to monitor and collect soil and vegetation samples over the next three years and will also collect samples from past reclaimed sites to evaluate the recovery over time.

The results from this research will be used to better understand how disturbance affects soil processes and to develop strategies for successful reclamation. Results will be reported in peer-reviewed journals and presented at scientific meetings. Reclamation bulletins will be developed, and results will also be presented at regional restoration and reclamation meetings.

This study is a collaborative effort between three energy companies — Questar, Encana, and British Petroleum local landowners, and the University of Wyoming School of Energy Resources and Department of Renewable Resources in the College of Agriculture and Natural Resources.

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Carla Grefroh of Douglas compares vegetation on her family's ranch during drought and wet years.

Enhanced learning through student-selected agricultural **REMOTE SENSING PROJECTS**

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Department of Botany and
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Science Center*

Students utilize high-tech opportunities to examine Wyoming crop, ranch, and forest areas

Images from earth observation satellites provide valuable information for students and researchers interested in monitoring natural resources. These remotely sensed images provide a birds-eye view of the earth's surface and enable monitoring of rangelands, shrublands, and forests.

Many remote sensing satellites collect images at regular intervals, giving researchers an opportunity to monitor changes on the earth's surface. They can also be used to characterize

variability in vegetation conditions within an agricultural field, ranch, or forest. Vegetation growth stage (emergent vs. full canopy) and condition (healthy vs. stressed) can be determined by examining reflected infrared light, which is measured by many remote sensing satellites.

In general, remotely sensed images contain a wealth of information about the Earth's surface and are valuable for a wide range of users.

Remotely sensed satellites divide the surface into a uniform grid of pixels and record the amount of reflected visible and infrared light coming to the satellite sensor from each pixel. Analysts examine the pattern of reflected light across a range of wavelengths to extract information about places in an image. For example, a farmer can monitor changes in crop growth during the growing season using a series of Landsat images (see story at right). A rancher can map forage conditions on a ranch and also identify areas of poor or no vegetation growth.

Increasing Student Employment Potential

Changes introduced by natural disturbances, such as wildfires and droughts, and anthropogenic (caused by human) activities, such as land conversion, are creating new applications of remotely sensed imagery. Because the imagery is so valuable, several countries have launched remotely sensed satellites to collect earth observation data. In the U.S., federal government agencies, as well as private companies, are launching and operating remote sensing satellites. Students who learn image processing and interpretation skills as part of their academic training often increase their employment potential.

Ag Remote Sensing Projects

UW students are learning to implement many of the applications described above in the applied remote sensing for agricultural management course (BOT/RNEW 4130/5130 and AECL4130). One requirement of this course is that students complete a class project using imagery to answer questions about a real-world agricultural issue. For example, some students use images of their parents' farms or ranches to better

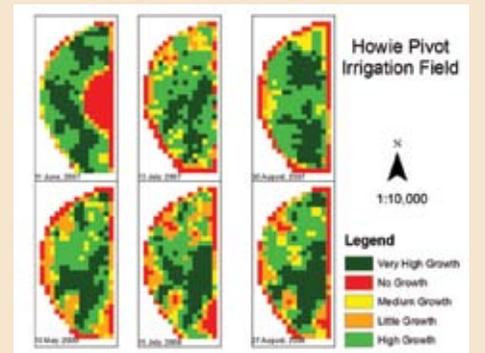
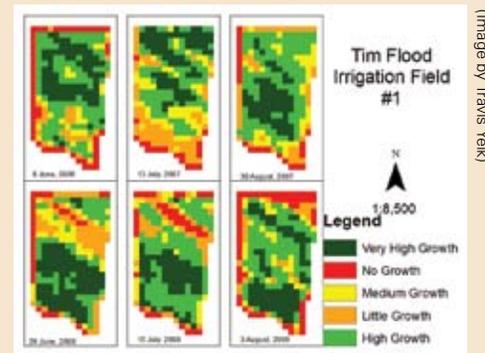
understand crop growth patterns by comparing the images to conditions observed on the ground.

Students associate areas of poor growth (often characterized by low infrared reflectance) identified in the image to problems such as soil alkalinity or poor water drainage. Similarly, several students obtained images acquired in normal and drought years for rangelands and mapped changes in vegetation condition. Students enhanced their learning experience by selecting images for areas of interest to them rather than working on pre-defined laboratory exercises.

Mapping Crop Growth in Big Horn River Basin

Garret Klein, Pavillion, and Laramie Wiginton, Kinnear, (rangeland ecology majors); Chris Heil, Elkhart, Texas, (agroecology and rangeland ecology major); and Travis Yeik, Veteran (geography major and soil science minor), used Landsat images for monitoring crop growth in agricultural fields in Fremont and Washakie counties. Klein and Wiginton mapped crop growth by computing a vegetation index derived from the amount of reflected red and infrared light. Based on their research, they concluded Landsat images could be used to accurately identify areas of poor and medium growth for different crops; however, they noticed some weed-infested areas also had high infrared reflectance due to dense canopy, thereby reducing the utility of Landsat data under these circumstances.

Yeik analyzed growth patterns in sugar beets and alfalfa crops near Worland using Landsat images acquired from 2006, 2007, and 2008 (see upper right). This multi-year analysis of crop growth patterns was



(Image by Travis Yeik)

LANDSAT IMAGES

Landsat images have been collected by a series of remote sensing satellites operated by the U.S. government since the early 1970s (<http://landsat.usgs.gov>) and represent an extensive civilian archive in terms of duration (more than 36 years) and geographic coverage. Landsat collects a new image every 16 days (except Landsat 7, which collects an image every 14 days) for every place on Earth. Each image covers a relatively large geographic area (approximately 90 miles by 90 miles). Landsat records information from the visible and infrared regions of the spectrum, which is useful for monitoring vegetation condition and a wide variety of other applications. Countless studies have demonstrated the value of Landsat data for monitoring changes in croplands, rangelands, and forests. Landsat images are useful when monitoring rangelands and croplands through conventional field surveys not feasible due to cost or access issues.



Cody Tully of Sinclair helped fight the 2006 Isabelle Fire that burned near Lake Owen in southeast Wyoming. He is examining satellite images of the burn.

necessary for identifying areas of poor and high growth and for devising appropriate management plans to help improve crop yields.

Assessing Wildfire Damage to Forest Vegetation

Using Landsat images, Cody Tully of Sinclair estimated wildfire burn severity of a fire in the Medicine Bow National Forest; Brice Stanton of Newcastle, and Adam Stephens of Rapid City, South Dakota, for a fire in the Black Hills National Forest; and Anne Morabito, Chicago Park, California, for a fire in Southern California. Stanton and Tully worked on firefighting teams and had firsthand knowledge of the effects of fire on forest vegetation. This knowledge was valuable for interpreting the information from Landsat images about burn severity patterns.

Tully helped fight the 2006 Isabelle Fire that burned 1 mile south of Lake Owen in southeast Wyoming. Burn ratio indices derived from the Landsat images acquired before and after the wildfire enabled him to distinctly

classify the burned areas and also group them by severity classes.

Using the same method, Morabito generated burn severity maps depicting various levels of damage caused by the Station Fire near Los Angeles in Southern California during August 2009. Methodology used by these students is identical to the methods used by federal and state land management agencies tasked with fighting wildfires and monitoring vegetation establishment in burned areas.

Monitoring Wyoming Rangelands

Many students used Landsat images for monitoring rangelands throughout Wyoming. Students compared vegetation condition during drought years to normal years and estimated the differences in spectral reflectance in different regions of the electromagnetic spectrum. For example, Carla Gefroh of Douglas (rangeland ecology major) compared the vegetation condition for her family ranch using images acquired in June 2002 and 2009, representing drought and

wet years, respectively. Landsat images highlighted changes in vegetation condition during drought and wet years.

Monitoring vegetation response to drought was one topic in the class. Other projects included monitoring vegetation condition in a growing season for estimating forage availability and areas of overgrazing. The synoptic view provided by Landsat images was invaluable for gaining insights about vegetation condition in rangelands, and repeat coverage helped students map those changes.

USGS Offers Free Landsat Satellite Images

In December 2008, the entire Landsat satellite image archive was made available for free through the U.S. Geological Survey. Previously, images had to be purchased (terrain corrected images could cost as much as \$800) unless they were archived by programs like AmericaView (www.americaview.org) or on dedicated public Web sites like that of the Global Land Cover Facility (<http://glcf.umiacs.umd.edu>).

The recent availability of free Landsat images has created opportunities and enhanced learning experiences for students. When fewer no-cost Landsat images were available, students had to modify the scope of their projects to match data availability. Now, students can download any number of images for anywhere on Earth.

UW students enrolled in the applied remote sensing for agricultural management course are taking advantage of this valuable opportunity and are using these images for monitoring and mapping Wyoming croplands, rangelands, and forests.

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Transforming agricultural education and the undergraduate experience

Our college's role in the National Academies Research Council Project

*James Wangberg
Associate Dean and Director
Office of Academic and Student Programs*

The Office of Academic and Student Programs in the College of Agriculture and Natural Resources has led institutional teams to two conferences sponsored by the Research Council of the National Academies – the first in April 1991 and the second in October 2006 at the National Academy of Sciences, Washington, D.C.

The first was to “chart the comprehensive changes needed to meet the challenges of undergraduate professional education in agriculture” and resulted in published proceedings. A number of recommendations and ideas emerged to inspire further advances in undergraduate education, but, as

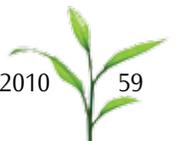
the 1992 proceedings states, a lot has changed since 1991. “Universities are different, careers are different and constantly evolving, and even the meaning of the term agriculture has changed. Moreover, what students expect, what is expected of them, and the need for a scientifically educated population, have expanded.”

Consequently, the purpose of the second conference was to explore ways to “improve the learning experience for students at the intersection of agriculture, environmental and life sciences, and related disciplines.”

Universities and colleges with agriculture programs were invited to submit proposals for participation in which most institutions would be represented by a four-member team

to include a senior administrator with responsibilities beyond a college of agriculture, a person with responsibility for undergraduate education in agriculture, such as an associate dean for academic programs, and additional team members to include faculty members, students, or other administrators.

The University of Wyoming four-member team was organized by me and included UW Trustee Taylor Haynes, Dean Frank Galey, and Assistant Professor Mariah Ehmke in the Department of Agricultural and Applied Economics. The UW team joined 96 others from colleges, universities, government agencies, institutes, and other entities throughout the nation interested in preparing agriculture graduates for the 21st century.





Associate Dean James Wangberg, right, visits with student Stephanie Budd.

Conference participants addressed themes and topics related to change, improving the learning experience, breaking down departmental boundaries, developing greater external partnerships, and considered recommendations that should come from the conference.

Keynote speakers, seminars, workshops, and formal and informal discussions throughout the three-day conference provided a lively forum for this exchange of ideas.

Emerging from the conference are nine broad sets of recommendations paraphrased here for brevity.

Recommendation 1. Engage in strategic planning for student recruitment and retention and involve a broad array of stakeholders and implement within two years.

Recommendation 2. Broaden the treatment of agriculture in the overall undergraduate curriculum by having agriculture faculty members teach introductory courses that serve multiple populations.

Recommendation 3. Broaden the undergraduate experience via undergraduate research, outreach and extension, internships, and international experiences.

Recommendation 4. Promote and support ongoing faculty development with particular attention to preparing the next generation of faculty members and providing additional resources for courses, curriculum, and course material development.

Recommendation 5. Enhance institutional rewards and recognition for teaching through hiring, tenure and promotion, awarding of competitive grants, and raise the overall profile for teaching across all professional societies and disciplines.

Recommendation 6. Enhance connections and collaborations among the four-year colleges, universities, and the 1890 and 1994 land-grant institutions.

Recommendation 7. Reach out to elementary school and secondary school students and teachers about agriculture and careers as well as exploring partnerships with youth-focused programs such as 4-H, FFA, and scouting.

Recommendation 8. Develop a variety of partnerships between academe and its stakeholders to facilitate greater communication and coordination with respect to food and agriculture education.

Recommendation 9. Decisions about reaccreditation, grant proposals, and institutional reviews should incorporate and be guided by the elements from this report.

Clearly, these recommendations are national in scope, and individual institutions will have their own priorities in addressing them. The UW team endorses all of these recommendations and can point to many as already being addressed or largely fulfilled. For example, the college has had a comprehensive student recruitment and retention program for many years, and steady enrollment increases

leading to record enrollments in 2009-10 are testimonials to our success. Consequently, we are well-positioned to contribute to the national dialogue about Recommendation 1 and meeting the two-year goal for implementing a national strategic plan.

Our college has also made excellent strides in fulfilling the spirit and intent behind Recommendation 2. Our faculty members are teaching introductory courses that serve multiple student populations and in so doing bring higher visibility and appreciation for the breadth of an agriculture curriculum. These classes include introductory life science, microbiology, genetics, human nutrition, agroecology, and others. Noteworthy, too, is the fact the College of Agriculture and Natural Resources now supports more Freshman Interest Groups (FIGs) than any other college providing an outstanding orientation to entering freshman and a glimpse of agriculture they might otherwise have missed. There are FIGs in animal science, veterinary science, molecular and microbiology, environment and life sciences, and a general college FIG.

Recommendation 3 is yet another theme where we claim particular strength, especially with regard to student internships and undergraduate research opportunities. Every program in the college offers such experiential learning opportunities, and it is these experiences that often separate a school of our size from larger institutions where undergraduates are not always afforded as much exposure to research or given meaningful internships. For many years, the number of internships in the college have exceeded the number of students seeking them and making it a “student-buyer’s market.”

The college continues to support efforts and activities relating to Recommendations 4 and 5, too.

The Office of Academic and Student Programs provides funding every year for faculty members to attend the Association of Public and Land-Grant Universities Western Regional Teaching Symposium and numerous teaching workshops. Professional development programs are made available by the UW Ellbogen Center for Teaching and Learning, arguably one of the best university faculty development centers in the nation. Commensurate with enhanced faculty development has been increased attention to teaching in the tenure and promotion process and a proliferation of faculty teaching and advising awards and celebratory college functions. While admirable, there can probably never be too many faculty development opportunities and awards or recognition for teaching and advising.

Examples of how we are responding to the remaining recommendations can be cited, too, but, as with most, there is always room for improvement or expansion; therefore, the college will strive to advance the teaching agenda by paying attention to these national priorities. The next step in doing so will be the 2010 APLU Summer Workshop, Pennsylvania State University, where associate deans of academic programs and others who have made commitments to the National Academies recommendations will convene to begin the strategic planning necessary for broader implementation and coordination at the national level.

The University of Wyoming was among the first universities at the table in 1991 and will be there again this July. *W*

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James Wangberg, Laurie Bonini, Kelly Wiseman, and Teresa Castano

Office of Academic and Student Programs

The Office of Academic and Student Programs is helping shape the future of students. The office is directed by James Wangberg, associate dean and director, who is joined by Kelly Wiseman, staff assistant, Laurie Bonini, recruitment and retention coordinator, and Teresa Castano, counseling and student services. The office helps lead students into exciting career possibilities in agricultural and applied economics, agricultural communications, rangeland ecology and watershed management, agroecology and the plant sciences, child and family studies, nutrition and dietetics, textiles and merchandizing, entomology, soil sciences, microbiology, molecular biology and biotechnology, animal and veterinary science, and a variety of applied sciences.

“Our priority is student’s academic success, and our office supports faculty and staff in the academic programs throughout the college in achieving that goal. All of our initiatives are built upon the principle of “Students: The Reason We’re Here,” notes Wangberg. “Our relationship with College of Agriculture and Natural Resources students starts during the recruitment process, which is why we are happy to represent the college on the Wyoming High School Principals Advisory Council. We have both drop-in and prearranged visits with prospective students and their parents, and we conduct freshman and transfer orientation sessions for five weeks each summer.”

To learn more, visit www.uwyo.edu/agPROGRAMS/



Endowments, gifts play major role

*Stephanie Anesi
Major Gift Officer,
University of Wyoming Foundation*

Readers may not know a portion of the University of Wyoming's funding comes from the generosity of university alumni, friends, corporations, and foundations.

This funding supports the student who attends UW and receives a scholarship, the rodeo team when it has to travel to competitions out of state, the professor who needs funding to study chronic wasting disease, and the program that brings renowned speakers to campus, such as Nobel laureate Dr. J. Michael Bishop in 2009. Bishop discovered that normal genes cause cancer under certain circumstances.

The organization that secures, manages, and stewards these funds is the University of Wyoming Foundation – an independent nonprofit corporation established in 1962. As a dynamic partner with UW, the UW Foundation brings the university together with alumni and friends to help make UW the best educational institution possible. On average, the UW Foundation raises \$30 million per year in private support – private funding that goes to students, faculty and staff members, and programs that benefit those students. This year, there are more than 250 endowments and expendable accounts that help fund the priorities of the College of Agriculture and Natural Resources.

UW, the UW Foundation, and the college work together to identify areas and programs deemed most important



Master's student Laura Meadows releases a calf elk from a trap at a western Wyoming feed ground.

or most in need of support. A few of those priorities are below.

Wyoming Reclamation and Restoration Center

The college has a rich history of applied research and outreach activities in rangeland ecology and wildlife habitat management. Since the late 1950s, UW faculty members have worked with communities, state government, and individual landowners to ensure Wyoming's resources are available for future generations. Our faculty members are nationally and internationally known for their work with disturbed land and water resources. As an established center of excellence in reclamation and restoration, the college and its research consistently guides federal regulators.

The Wyoming Reclamation and Restoration Center (WRRC) is an

interdisciplinary program housed within the college. Its mission is to develop, collect, and disseminate impartial, scientifically based information related to the reclamation, rehabilitation, and restoration of disturbed lands in high-altitude arid regions of Wyoming and the western United States. The center trains students in reclamation ecology, researches best practices in reclamation of disturbed lands, and provides extension and outreach for practitioners of reclamation ecology in the energy industry, state agencies, and other interested agencies and businesses.

The state of Wyoming has been generous with its support of the WRRC through Abandoned Mine Land funds. That support has allowed the WRRC a jump start on outreach efforts; however, partnering with industry is critical to the WRRC's success.

in college priorities

Wildlife-Livestock Health Center

Two of Wyoming's major industries – tourism and livestock production – depend upon maintaining healthy animal populations. The Wyoming State Veterinary Laboratory in the college is a premier center for the study of the wellness of livestock and wildlife. One of the goals of the college is to provide high-quality diagnostic services, animal disease research, economic research on the effects diseases have on the state, and education to veterinarians, livestock producers, wildlife managers, students, and others interested in animal health.

To help protect two of Wyoming's most precious resources, the center focuses on domestic animals and wildlife and the diseases common to both. The college brings together a multidisciplinary team with expertise in all categories of animal disease to help solve disease-related problems. These efforts have garnered UW a national and international reputation in this field. Examples of common disease research projects include brucellosis, chronic wasting disease, Johne's disease, malignant catarrhal fever, plague, and selenium poisoning.

Wyoming Is Our Laboratory

The college several years ago created a competitive research grant program to address topics of public importance. These seed projects help answer questions relevant to Wyoming and the region and make UW applications for larger federal or state research

grants more competitive. Each \$1 expended on projects funded through the Wyoming Agricultural Experiment Station (AES) competitive grant program has attracted an additional \$7 in outside research grant funding for projects addressing Wyoming issues. Each year, the AES in the college receives approximately 25 proposals from faculty members – all worthy of support. Dean Frank Galey routinely receives requests from communities, local and state governments, and producer groups seeking help with particular problems. However, current federal funding levels only allow the college to support four or five projects per year.

Federal funding for research projects like these has remained flat for a number of years and is unlikely to increase. The goal of the college is to expand our current applied research efforts through a program called Wyoming Is Our Laboratory. New endowments for the Wyoming Is Our Laboratory initiative will provide permanent funds for the competitive research grant program.

For more information on these projects or other areas of interest in the College of Agriculture and Natural Resources, please contact me or visit the UW Foundation Web site at www.uwyo.edu/foundation. 

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