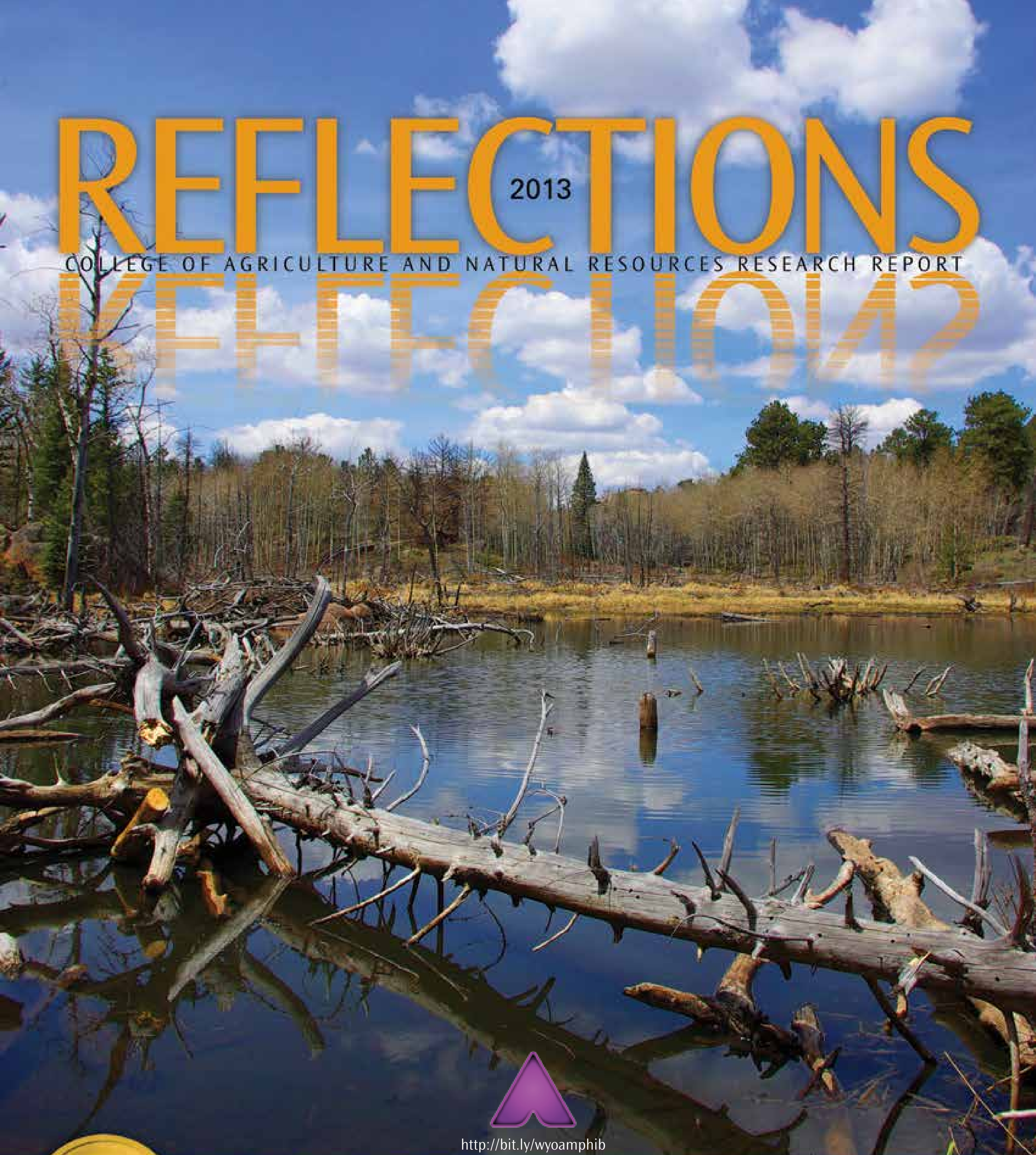
REFLECTIONS

2013

COLLEGE OF AGRICULTURE AND NATURAL RESOURCES RESEARCH REPORT



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UNIVERSITY OF WYOMING

COLLEGE OF AGRICULTURE AND NATURAL RESOURCES

Introducing the 2013 *Reflections* theme "Focus Wyoming" is a distinct pleasure on behalf of the University of Wyoming College of Agriculture and Natural Resources and Wyoming Agricultural Experiment Station. Focus Wyoming captures the essence of the college's commitment to fulfill the land-grant mission for the citizens of the Cowboy State.

This issue of *Reflections* covers topics that provide readers a glimpse of how the college's students, faculty members, and extension educators conduct activities leading to discovery, learning, and engagement. The focus on Wyoming is illustrated through a combination of articles describing field studies and participatory projects involving Wyoming students and citizens.

Results of various **field studies** in this issue provide:

- insight into the role of beavers in a forest ecosystem on Pole Mountain in southeast Wyoming,
- the most productive perennial grass in irrigated hayfields of northeast Wyoming,
- the optimal combination of legume and grass mixtures in Wyoming's forage production systems,
- suitable turfgrass cultivars for rain-fed and irrigated conditions in southeast Wyoming,
- the economical consequences of not using Roundup Ready sugar beets, and
- implications of applying Roundup on sainfoin grown near Powell.

Examples of **participatory learning** and **citizen engagement** are documented in articles describing projects conducted by the college's students, faculty members, and extension educators. The second-to-last story features how a student and a farmer realize the utility of remote sensing technology upon reviewing a Landsat image showing areas of low and medium crop growth. The second article discusses an increasing desire to involve citizens in science.

Examples of **direct producer involvement** are highlighted in articles on integrated pest management strategies to control grasshoppers and the long-term sustainable agricultural systems project at the James C. Hageman Sustainable Agriculture Research and Extension Center near Lingle. A whole host of **student** and **citizen support** is described in the article explaining efforts to extend the growing season with high tunnels. An article on evaluating the impact of facilitation lists **participant perceptions** on the value of facilitated sessions when dealing with complex and difficult subject matter confronting the people of Wyoming.

I sincerely hope you enjoy reading about our college's efforts on "Focus Wyoming."

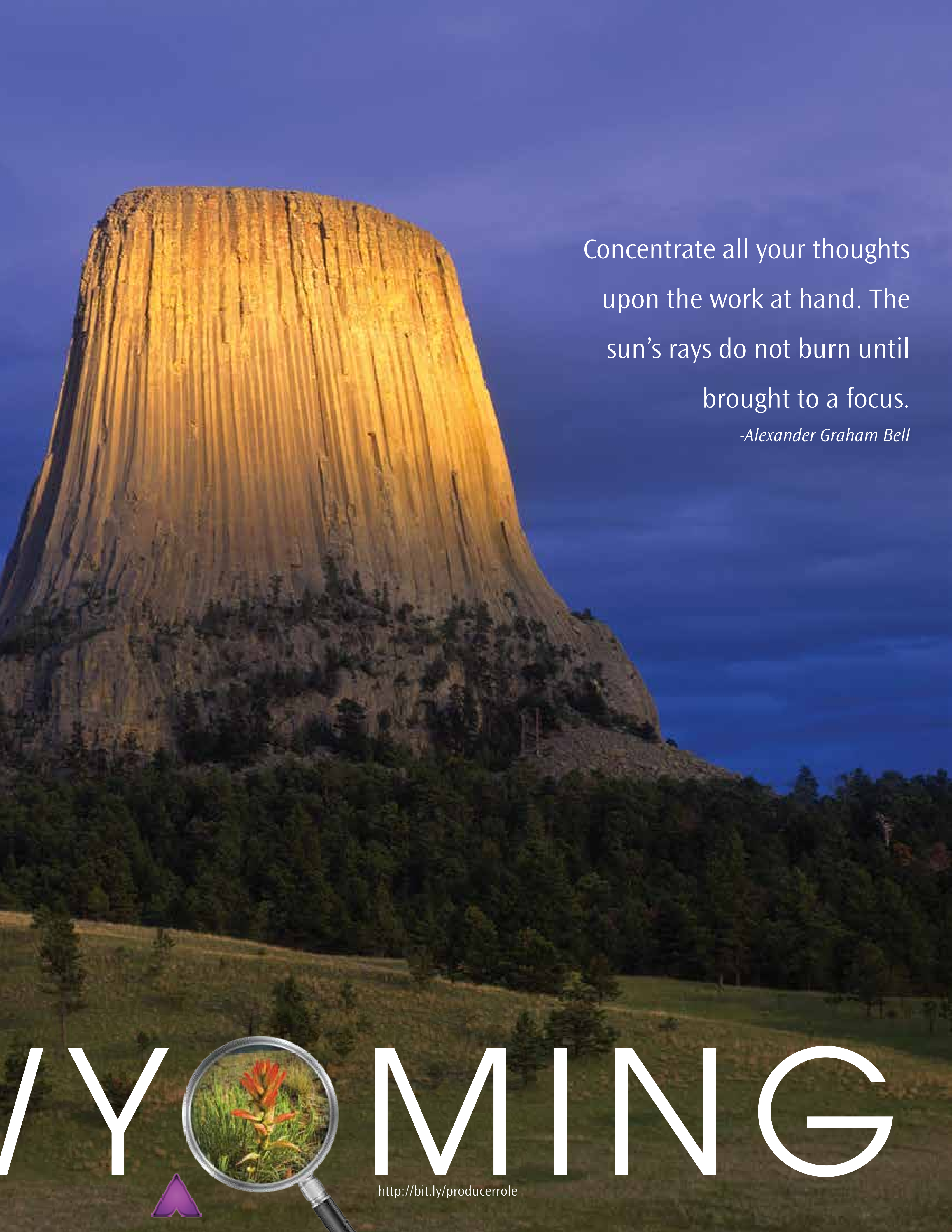
As always, we welcome your input. Please feel free to contact me with your comments, suggestions, and questions at (307) 766-3667 or aes@uwyo.edu.

Bret W. Hess
Associate Dean for Research and Director, Wyoming Agricultural Experiment Station

Associate Dean Bret Hess

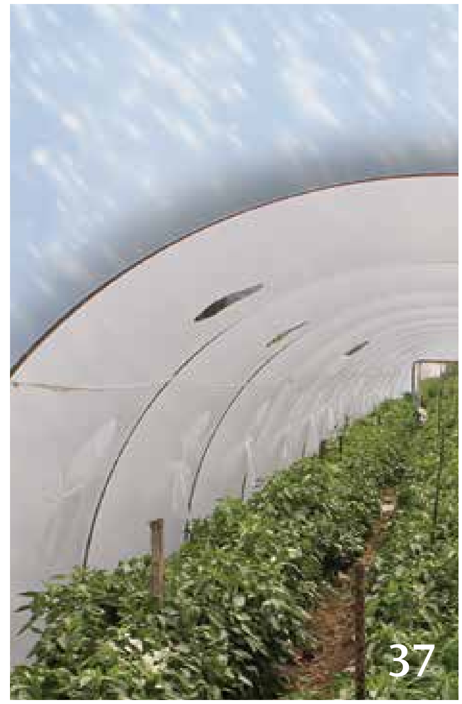
http://bit.ly/focuswyoming

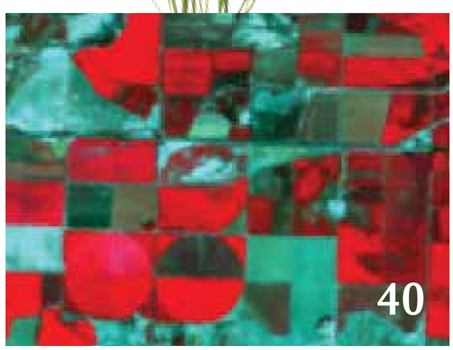
FOCUS W


Concentrate all your thoughts upon the work at hand. The sun's rays do not burn until brought to a focus.
-Alexander Graham Bell
WYOMING
http://bit.ly/producerrole

contents

REFLECTIONS





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Selected as the
Reflections 2013 top story

What would happen to PRODUCER PROFITS if Roundup Ready sugar beets WEREN'T AN OPTION?

Brian Lee
Research Scientist

John Ritten
Assistant Professor

Christopher Bastian
Associate Professor

Department of Agricultural and Applied Economics,

Andrew Kniss
Assistant Professor
Department of Plant Sciences

Producers are constantly searching for technologies and crops that improve profitability.

One important technology is the use of crops resistant to herbicides such as Roundup. These crops, often named Roundup Ready, allow producers to control weeds with less tillage and/or labor operations than conventionally produced crops. One crop offered to producers in a Roundup Ready form is sugar beets. Sugar beets are an important cash crop for irrigated farmers, and Roundup Ready sugar beets have become a popular choice among Wyoming producers (see "Sweet production" at right).

Roundup Ready technology was commercially introduced into the sugar beet market in 2007 and has since seen a 95-percent acceptance rate among producers nationally. Producers using the technology can apply glyphosate to a growing field of sugar beets for weed control without harming the crop. Some producers have attributed the increase in produced tonnage across the state to the adoption of Roundup Ready technology in sugar beets.

Genetically Modified Seed Concerns

Recently, some have expressed concern about the use of genetically modified (GM) seeds, and legal cases have been filed against use of Roundup Ready crops including alfalfa and sugar beets due to potential risks posed to producers using other technologies. As a result, the possibility exists that Roundup Ready sugar beets may be removed from the market. In addition, scientists are concerned about the potential for weeds to become glyphosate resistant, reducing the economic advantage of growing Roundup Ready sugar beets.

http://bit.ly/noroundup

Assistant Professor John Ritten

Andrew Kniss, weed specialist and assistant professor, collaborated with agricultural economist Brian Lee, research scientist at the James C. Hageman Sustainable Agriculture Research and Extension Center, John Ritten, assistant professor and production systems specialist, and Chris Bastian, agricultural economist and associate professor, to evaluate what the cost to producers might be if Roundup Ready sugar beets were no longer available.

SWEET PRODUCTION

Sugar beets are a valuable crop in Wyoming – especially in the southeast and Big Horn Basin. In 2009, the value of sugar beet production in Wyoming was $36,544,000, with 678,000 tons produced in the state – ninth in the nation for total production. The total value of production in the United States was just over $1.5 billion in the same year. Wyoming produced 917,000 tons in 2012 – up 239,000 tons from 2009.

Conventional and Roundup Ready Sugar Beet Comparison

An economic evaluation was conducted to compare profitability of conventional and Roundup Ready sugar beets using historical price data. Profitability of the systems was compared across a range of prices for fuel, fertilizer, and sugar beets. Given the variability in conventional sugar beet production practices, two extremes of production (High Cost and Low Cost) were analyzed. Both production

http://bit.ly/herbresist

Sugar beet research at the James C. Hageman Sustainable Agriculture Research and Extension Center determined producers could lose more than $220 per acre if Roundup Ready technology was not available and they had to revert to a high-cost, conventional weed control system.

THE MONTE CARLO METHOD

Monte Carlo simulation provides all the possible outcomes of decisions and was first used by scientists working on development of the atomic bomb.

systems are based on data from producers and assume a 24 ton/acre yield with cost differences based on various levels of weed control activities.

GM or Roundup Ready sugar beets were also examined at yields of 24 ton/acre and 26 ton/acre as many producers claim a yield increase due to the Roundup Ready technology. Past publications have assumed the yield increase to range from 5 to 15 percent. Sugar beet budgets were developed and a technique called Monte Carlo simulation (see above right) was used to analyze profitability of these different scenarios across a wide range of potential prices for both outputs and production inputs.

Determine Average Profitability

The goal was to evaluate the average profitability of each system (conventional and Roundup Ready) on a per-acre basis over a variety of potential economic situations since both input and output prices are highly variable. The Roundup Ready sugar beet system was charged a $75/acre technology fee above other production costs.

The results of the analyses are in Table 1. Roundup Ready sugar beets, assuming a 2-ton/acre yield increase, were on average $95.65/acre more profitable than their low-cost conventional counterparts ($813.87 minus $718.22). When no yield increase was assumed for Roundup Ready sugar beets, the low-cost conventional system was on average $20.91/acre more profitable (due mainly to the fact that producers pay a $75/acre technology fee for Roundup Ready sugar beets). A .33 ton/acre yield increase in the Roundup Ready sugar beet system is needed to break even with the low-cost conventional system. If a producer utilizes high-cost conventional production practices, the Roundup Ready system is $107.17 more profitable without any yield increase, or $223.73 more profitable assuming a 2 ton/acre yield increase for the GM system.

Regulation May Hurt Profits

Because our simulation shows increased profitability due to an increase in yields with Roundup Ready sugar beets, it suggests producers in the state could potentially be hurt by regulation of GM technologies. If our assumption of a 2 ton/acre yield increase in a Roundup Ready system is correct, producers could lose as much as $223 per acre if they revert to a high-cost, conventional weed control system. However, our analyses also shows that adopting lower cost production practices could help to offset that loss.

To contact:
***Brian Lee** can be reached at (307) 837-2000 or at blee@uwyo.edu; **John Ritten** at (307) 766-3373 or at jritten@uwyo.edu; **Chris Bastian** at (307) 766-4377 or at bastian@uwyo.edu; and **Andrew Kniss** at (307) 766-3949 or akniss@uwyo.edu.*

Table 1. Predicted profit distribution of genetically modified and conventional sugar beets assuming varying production practices (shown as profit/acre)

	High Cost conventional, 24 ton/acre	Low Cost conventional, 24 ton/acre	GM, 24 ton/acre yield	GM, 26 ton/acre yield
Min	$ (348.14)	$ (215.09)	$ (236.00)	$ (153.65)
Max	$ 2,891.38	$ 3,019.49	$ 2,998.58	$ 3,315.54
Mean	$ 590.14^{D}	$ 718.22^{B}	$ 697.31^{C}	$ 813.87^{A}
95% CI +/-	$ 5.22	$ 5.22	$ 5.19	$ 5.65
SD	$ 266.61	$ 266.49	$ 264.81	$ 288.10

Note: Superscript letters denote significance at the 0.05 level

Facilitators create and apply the correct processes at a meeting to help group members participate meaningfully.
(Photo: CJ Baker, Powell Tribune)

Evaluating our facilitation efforts in Wyoming

Tara Kuipers
Educator
University of Wyoming Extension

Selected as the *Reflections* 2013 second-place story

Facilitation is more than getting along with each other. A facilitator applies a process to the content of a meeting and enables participants to best reach goals.

- *Brucellosis in wildlife and domestic livestock.*
- *Collaboration among community non-profit agencies.*
- *Deer herds in city limits.*
- *Local foods issues and opportunities.*
- *Landfills and garbage transportation.*
- *Use of public land among private and public users.*

Can you guess what these six seemingly unrelated things have in common?

Yes, they are all difficult, complex, and potentially contentious issues facing Wyoming communities.

What else? They are all topics of recently convened facilitated sessions.

Over the past 18 months, facilitation helped stakeholders share information with each other and gather input from the public on these – and many other – important Wyoming issues. Facilitation is an effective tool to help organizations, boards, and governments communicate and work together to better serve Wyoming residents.

Working Together Better

Facilitation is the implementation of processes and skills to help groups function more effectively. Facilitators guide groups by planning and leading the process of a meeting, which includes the manner in which dialogue occurs and the way a meeting flows. By asking pertinent and thought-provoking questions, creating an agenda with an organized flow from one topic to the next, engaging all group members to full participation, planning activities to create reflection and begin dialogue on important topics, and offering summarization and guidance on next steps, a facilitator allows group members to fully and meaningfully participate in the meeting.

Facilitation can be best understood by distinguishing between the *content* and *process* of a meeting. Group members who are part of a committee, task force, or team are the experts in the *content* required for the meeting; they have the expertise and knowledge that needs to be contributed for the goals of the group to be accomplished. But good dialogue and efficient progress on a group's goals may not just happen; it might take planning, guidance, and leadership to elicit the content in a meaningful way. In other words, it takes the right *process.* The facilitator is an expert in a meeting's process. After preparation and planning, a facilitator who creates the right process can make the content come to life by asking questions, planning dialogue, and helping the group reach decisions.

Groups that participate in facilitation may include a workplace team, nonprofit board of directors, a county or municipal elected board, or members of the general public attending a public forum. Topics can range widely, from the examples at the beginning of this article to the ongoing demands faced by any organization, like strategic planning, managing organizational change, or gathering public input on an issue.

Seemingly endless factors determine whether or not facilitation is deemed successful or effective. A successful facilitation may be measured by the ease with which decisions are reached, the amount of new information gathered in a brainstorming session, or the ability of groups to understand opposing views on a

> After preparation and planning, a facilitator who creates the right process can make the content come to life.

divisive issue. While measuring facilitation success can be elusive, using facilitation to help Wyoming organizations and citizens is still important.

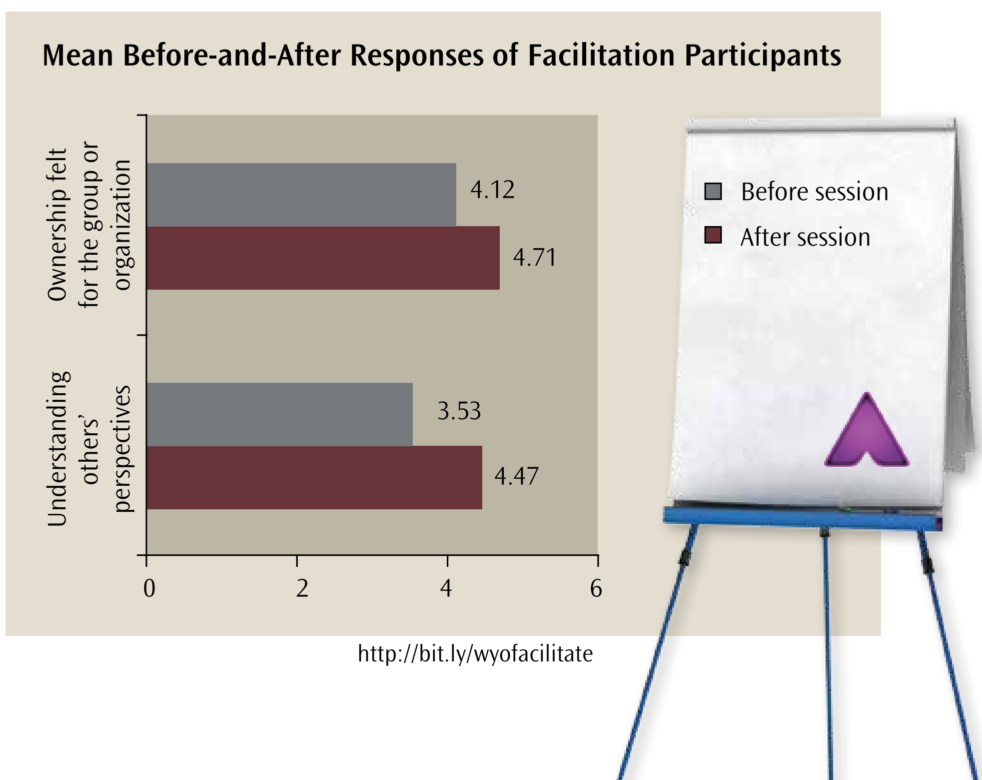
Study Examines Success Factors

University of Wyoming Extension community development educators in offices across the state are trained and skilled facilitators. Recently, a study among Wyoming residents who participated in facilitation measured a number of success factors of the facilitated session. The study involved a survey completed by nearly 30 individuals. They were members of nonprofit boards of directors, professional association leaders, and county or municipal boards. Each person surveyed participated in a facilitated session within 18 months prior to completing the survey.

Respondents were asked about their levels of understanding of other members' perspectives and the ownership they felt for the group or the issue BEFORE and AFTER the facilitated session. Results show a number of ways facilitation is making a positive impact for Wyoming groups, governments, and organizations. The figure below shows two key effects of facilitation: participant understanding of other points of view and participant ownership felt for the group and/or the issue. Respondents were asked to rate these qualities, based on a scale of *1 (Poor/Very Low)* to *5 (High/Very Strong).* Respondents reported a significant increase in understanding and ownership following their participation in facilitated sessions.

Session Qualities

Participants were also asked to identify characteristics of the facilitated session. The following session qualities, which facilitation research tells us are necessary for a session to be beneficial, were rated as 4 or higher on a scale of *1 (Does Not Describe)* to *5 (Very Clearly Describes):*



Mean Before-and-After Responses of Facilitation Participants

http://bit.ly/wyofacilitate

- *I Understood What Was to be Accomplished;*
- *Participants Were Interested and Engaged;*
- *Participants Interacted Openly and Productively;*
- *We Thoroughly Addressed Items on the Agenda; and*
- *I Feel Satisfied with the Achieved Outcomes.*

Participants suggest that increasing the ability to understand each other's perspective and feel ownership for the issue is a positive outcome. Participants who are engaged, interested, and satisfied with what their group achieves are more likely to accomplish the group's work.

Facilitation Requests Indicate Success

Wyoming's facilitation successes are supported not only by the positive responses to the survey, but also the frequency of requests from groups who utilize facilitation. Statewide, the six community development educators are requested to facilitate about 30 meetings each year ranging from half-day to multi-day sessions. Around Wyoming, during any given month, two or three organizations, local government boards, or issue-specific groups are benefitting from the facilitation and group process expertise provided by UW's community development educators.

The goal of facilitation is to improve individuals' understanding of difficult issues while enhancing a group's ability to work together. UW Extension is helping Wyoming's organizations, boards, and local governments achieve that goal by handling complex issues and improving cooperation. Through facilitation, these groups will better serve Wyoming residents now and in the future.

http://bit.ly/whyfacilitator

Community development educator Tara Kuipers says correct facilitation increases a group member's ability to understand other perspectives.

Recent examples of Wyoming communities and organizations using facilitation to address important public issues include:

City of Cody Parks, Recreation, and Public Facilities Department
Addressing Urban Deer Issues
October 2011

Park County Commissioners and local public lands advocates
Public Lands Forum
February 2012

Wyoming State Veterinarian and UW Small Acreage Task Force
Brucellosis in Northwest Wyoming
March 2012

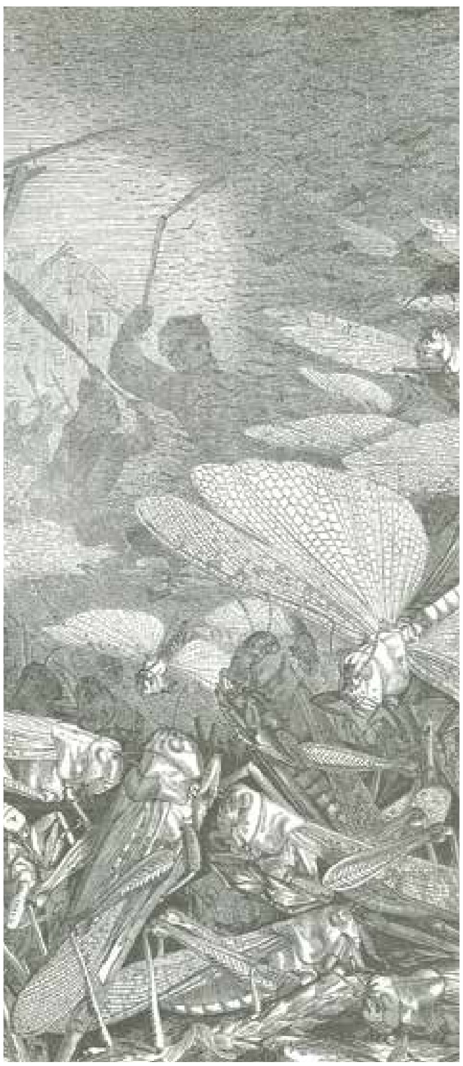
Cities of Powell and Cody, Town of Meeteetse, and Park County
Landfill and Garbage Transportation
Park County
November 2012

To contact:
Tara Kuipers *is the community development educator based in Park County and also serves Big Horn, Fremont, Hot Springs, and Washakie counties and the Wind River Reservation. She can be reached at (307) 527-8560 or by email at tkuipers@uwyo.edu.*

UW researchers advance INTEGRATED PEST MANAGEMENT to most effectively, economically control

Scott Schell
Assistant Entomologist
University of Wyoming Extension

Mobile workshop/lab, crew members, pilot, and spray plane follow the grasshopper hatch north through Wyoming testing strategies with help from UW researchers.



Grasshoppers have long been a hazard to Wyoming agriculture. In the days of open range, livestock and wildlife probably migrated away from areas being ravaged by population explosions of grasshoppers to find forage elsewhere. Even though a range cow or buffalo can weigh a million times more than an individual grasshopper, they can't compete with the insects for forage. A cow will starve on a pasture where grasshoppers are abundant and thriving; densities of just 25 adult grasshoppers per square yard can exceed 50 pounds of the insects per acre. The grasshoppers can eat their weight daily in forage as new leaves barely emerge from the root crowns, which is too short for cows to graze.

The amount of grass the insects consume is only part of the forage loss as they also clip grass blades and make it unavailable to other animals.

As the open range period ended in Wyoming and fenced boundaries were established, controlling grasshopper population explosions became necessary. Grasshopper infestations can cover millions of acres, and entire ranches can be devastated by severe forage loss.

A Biological Wildfire

Rangeland grasshoppers are unlike typical, localized agricultural pests. For example, a farmer with a lygus bug-infested alfalfa field can effectively manage the pests and not expect an immediate re-infestation. Grasshopper infestations are managed more like a biological wildfire because of the large scale of the outbreaks and potential for long-range movement en masse.

Because vast areas were affected by grasshopper infestations crossing private and administrative land boundaries, the government was asked to help. The first government agency charged by Congress to help with grasshopper management was the U.S. Department of the Interior. The U.S. Entomological Commission was formed in 1876 to study the Rocky Mountain locust, a species of grasshopper that caused severe losses to the pioneers, and suggest management techniques.

grasshoppers grazing the range

http://bit.ly/wyohoppers

Nowadays, the United States Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine service (USDA-APHIS-PPQ) helps lessen agricultural losses caused by rangeland grasshoppers and their cousins the Mormon crickets in the western U.S.

Control Method Evolution

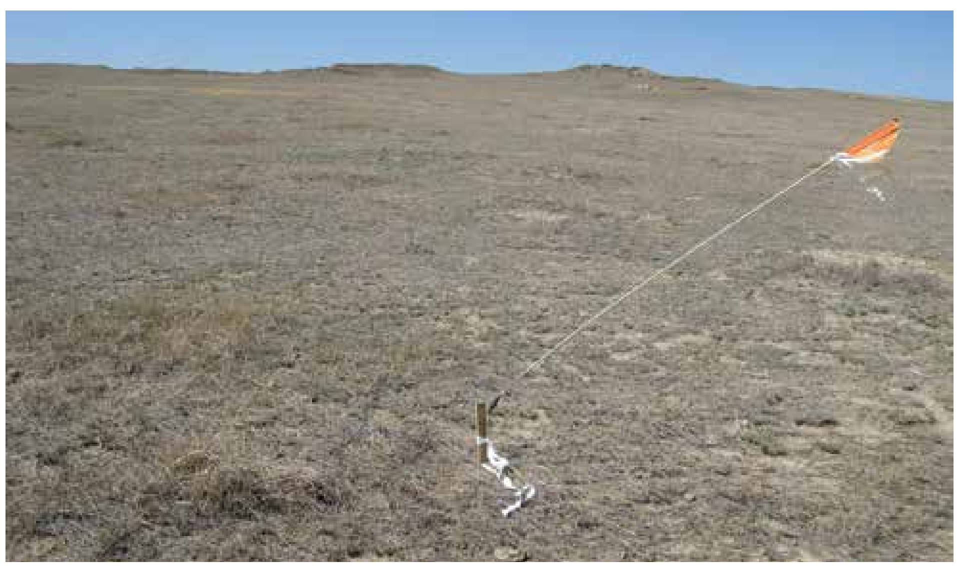
The first management recommendations in the 1880s included ditches filled with water and topped with kerosene or crude oil to act as barriers to protect crops from grasshopper nymphs and Mormon crickets. In the early 1900s, to protect rangeland and crops, poisonous baits and dusts that used sodium or calcium salts of arsenic insecticides were advised. These insecticides were very hazardous to the applicators, livestock, and even vegetation.

No longer accepted are previous recommendations to use environmentally persistent insecticides, such as the organochlorine-based Aldrin, applied in ways to maximize grasshopper control with no regard for environmental impacts. Now the goal is to use just enough low toxicity – but still effective – insecticides to reduce grasshopper populations to non-damaging densities and leave food for the natural predators of grasshoppers, which include many species of birds and insects such as robber flies, spiders, and predatory wasps and beetles. The combination of chemical control applied in ways that minimize the impact on the creatures that normally help keep grasshoppers in check is how we "integrate" the management of these pests. The ultimate goal of all Integrated Pest Management (IPM) is to reduce the pest species below the economic threshold with the lowest possible cost – both environmentally and economically.

Trial Strategies for Wyoming

The APHIS Center for Plant Health Science and Technology (CPHST) lab in Phoenix, Arizona, is the scientific support division for PPQ. The lab develops methods used by PPQ. The work takes personnel to 17 western states to test those methods APHIS-PPQ may use to conduct control programs for diverse crop and rangeland pest insects – including rangeland grasshopper management programs.

Federal researchers enjoy coming to Wyoming to conduct experimental trials because they can count on assistance from cooperative landowners, efficient county weed and pest control districts, local USDA-APHIS-PPQ personnel, and University of Wyoming Extension. The dedicated members of the CPHST team travel with a mobile workshop/lab, spray plane, and pilot.



(S. Schell Photo)

Figure 1. Mid-June on Plot 19 of 36 on the AU-7 Ranch shows little green growth despite the early season and rainfall the week before. The flexible flag bending with the wind marks the center of the plot and the start of the circular array of 40 metal rings that help accurately estimate grasshopper population density.

http://bit.ly/hoppersample

(S. Schell Photo)

Figure 2. A closeup of one of the 40 metal rings used to estimate grasshopper population density in each plot. The area of the ring equals 1/10 of a square meter. The number of live grasshoppers that hop out of the 40 rings are counted, totaled, and divided by four to get an accurate estimate of the density per square meter for each plot. This was done before treatment and 7, 14, and 21 days after treatment for every plot. Due to recounts caused by weather delays, at a minimum, 5,760 rings were counted during the AU-7 Ranch experiment.

Figure 3. Long-billed curlews hunt for insects on one of the Prevathon RAATs-treated plots on the AU-7 Ranch. The combination of reduced toxicity of current insecticides to vertebrates and reduced exposure due to the low application rates applied to only half of the infested area allows the birds to safely aid in reducing the remaining grasshopper population.

During the spring and summer field season, CPHST crew members work much like typical Wyoming ranchers – long hours seven days a week. Often, they are up before dawn to spray test plots in the cool temperatures and calm winds of early morning and then work well into the evening sampling the plots and calibrating the plane for the next day's treatments.

UW Extension Monitors Plots

UW Extension entomologists collaborated with CPHST to sample and monitor their experimental plots in Wyoming before and after treatments. This allowed the CPHST crew to follow the grasshopper hatch north, conduct other trials, and get more data on other treatments than they could do alone. Large grasshopper infestations were not easy to find in Wyoming in 2012. After large-scale grasshopper outbreaks in 2010, cooperative control programs protected six million acres from grasshoppers in Wyoming. The following year, grasshopper populations subsided back to non-economically damaging levels over most of eastern Wyoming's prairie. However, grasshoppers are resilient, and some species have been documented to increase from sub-economic levels to severe infestation in one year.

Testing on AU-7 Ranch

In the early spring of 2012, a large grasshopper infestation was found by Wyoming APHIS-PPQ personnel scouting on the historic AU-7 ranch owned by Bob Stoddard southwest of Newcastle. With his permission, 36 forty-acre plots in the infestation were surveyed in early June. Preliminary grasshopper densities on the plots ranged from 12 to 35 per square meter. Uncooperative weather and equipment problems spread the application of the experimental treatments over three weeks. Drought conditions combined with heavy grasshopper feeding made most of the normally productive pastures on the AU-7 look like parking lots.

The goal of the test was to establish the lowest effective rate of the low-toxicity insecticide Prevathon, which was recently registered by

Table 1. A summary of the efficacy data resulting from the AU-7 Ranch Prevathon application rate and RAATs trial. Plots treated with the old standard insecticide, carbaryl, were used to compare results with the recently labeled insecticide Prevathon. In addition, untreated plots were also monitored to ensure that the insecticides were not credited with any naturally occurring mortality.

Grasshopper Mortality			
	Days after treatment		
Treatment*	**7 days**	**14 days**	**21 days**
Carbaryl standard @ 12 fl oz /ac 50% RAATs**	37%	65%	67%
Prevathon @ 8 fl oz/ac full coverage	95%	99%	99%
Prevathon @ 8 fl oz/ac 50% RAATs	80%	94%	99%
Prevathon @ 6 fl oz/ac full coverage	93%	89%	100%
Prevathon @ 6 fl oz/ac 50% RAATs	88%	87%	92%
Prevathon @ 4 fl oz/ac full coverage**	95%	99%	99%
Prevathon @ 4 fl oz/ac 50% RAATs**	61%	79%	87%

*Average of four plots per treatment

**Grasshopper populations had developed into adults when these treatments were applied, and they are harder to kill than nymphs

(USDA-APHIS-CPHST Photo)

http://bit.ly/trialday

Figure 4. The USDA-APHIS-CPHST spray plane applying a Prevathon treatment to a 40-acre plot as part of an experimental trial to determine the best rate to reduce grasshopper population densities to non-economically damaging levels using the Reduced Area and Agent Treatment system.

DuPont for rangeland grasshopper control. We also sampled the non-target insects in the plots to see what impact the insecticide has on their populations. We are still sorting and analyzing the hundreds of sweep net samples collected in the plots. We also needed to make sure that Prevathon is compatible with the Reduced Area and Agent Treatments (RAATs) method of grasshopper control that reduces the amount of insecticide applied to an infestation by half as compared to conventional blanket treatments.

RAATs was developed and promoted by researchers at the University of Wyoming in collaboration with USDA-APHIS colleagues. RAATs takes advantage of grasshopper movement as the insecticide is applied in a pattern that leaves up to half of the infested rangeland untreated. Before RAATs, great care was taken to ensure insecticide was applied to every acre of an infestation, without skips, attempting to kill as many grasshoppers as possible. That level of treatment was found to be both unnecessary and uneconomical for successful IPM, and RAATs is now the preferred method of management for grasshoppers when necessary.

Having a reduced-risk insecticide with low toxicity that will work as part of grasshopper IPM is notable progress. The good news is that the lowest rate of Prevathon tested, applied via RAATs, reduced grasshopper densities to economically acceptable levels (see Table 1, page 14). Hopefully, progress on even more sustainable and environmentally benign IPM techniques for grasshopper control will continue through the collaboration of the USDA and the agencies and people of Wyoming.

To contact:
***Scott Schell** can be reached at (307) 766-2508 or at sschell@uwyo.edu.*

Figure 5. Determining the impact Prevathon insecticide treatments have on non-target arthropods requires hours of sorting insects and spiders from samples collected with sweep nets in the plots before and 7, 14, and 21 days after treatment. Because high grasshopper populations have a big impact on other insects (through competition and reduction of habitat), samples are collected from untreated plots for comparison at every sampling period.

Is sainfoin really resistant

You may have heard so. Our studies indicate sainfoin can survive Roundup application, but the cost of yield losses outweighs any benefits.

Ryan Rapp
Research Associate,

Andrew Kniss,
Assistant Professor,

Jared Unverzagt,
Graduate Research Assistant

Department of Plant Sciences

Sainfoin has increased in popularity for Wyoming forage producers because of its many desirable attributes:

- high nutritional content,
- seems well adapted to Wyoming (particularly northern Wyoming), and
- does not cause bloat so it can be grazed.

This deep-rooted perennial legume, which is widely adapted for the Rocky Mountain region, has great potential for Wyoming. Two varieties of sainfoin have been developed at the University of Wyoming by researchers in the Department of Plant Sciences. Those varieties are 'Shoshone' and 'Delaney' and are very well-suited for the area.

Many studies have looked at grazing management and livestock response to sainfoin. Basic agronomic information is also available such as how much seed to use and what time of year to plant. However, at least one major management issue facing sainfoin producers remains: How do we manage weeds in sainfoin?

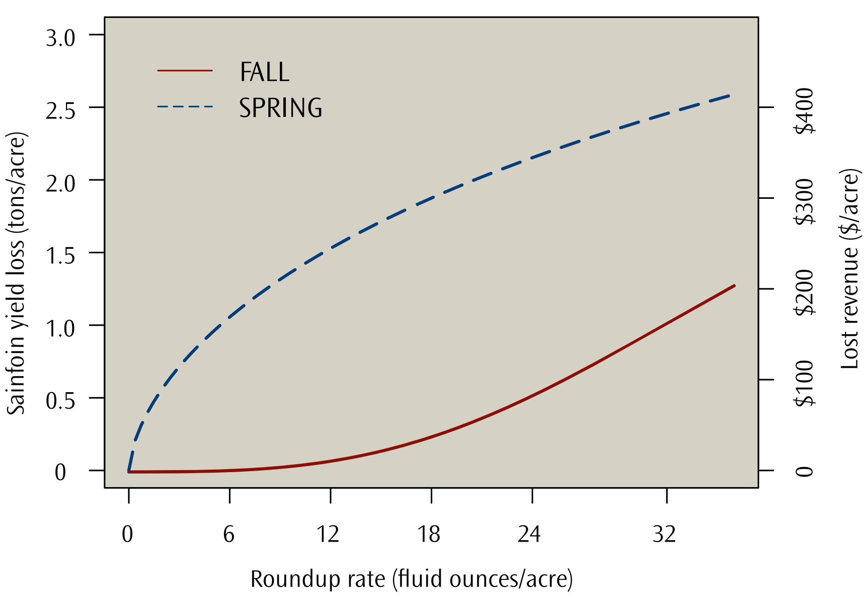


Figure 1: Sainfoin yield loss and associated lost revenue (assuming value of $160/ton) caused by Roundup PowerMAX at a range of rates applied in the fall or spring.

How to Manage Broadleaf Weeds?

Herbicide options for use in actively growing sainfoin are few. Select (clethodim) or Poast (sethoxydim) herbicides can be applied postemergence to sainfoin, but these products only have activity on grass weeds. A few promising herbicides have been identified as safe for use in sainfoin, but only the two listed above have been registered for post-emergence use.

According to Wyoming Agricultural Statistics, 620,000 acres of alfalfa were planted for hay in 2011. Sainfoin acreage is quite small by comparison. While herbicide producers will devote money and resources to develop products for large-acreage crops like alfalfa, there is less interest in developing herbicides for minor crops like sainfoin – there simply isn't enough return on investment.

to Roundup?

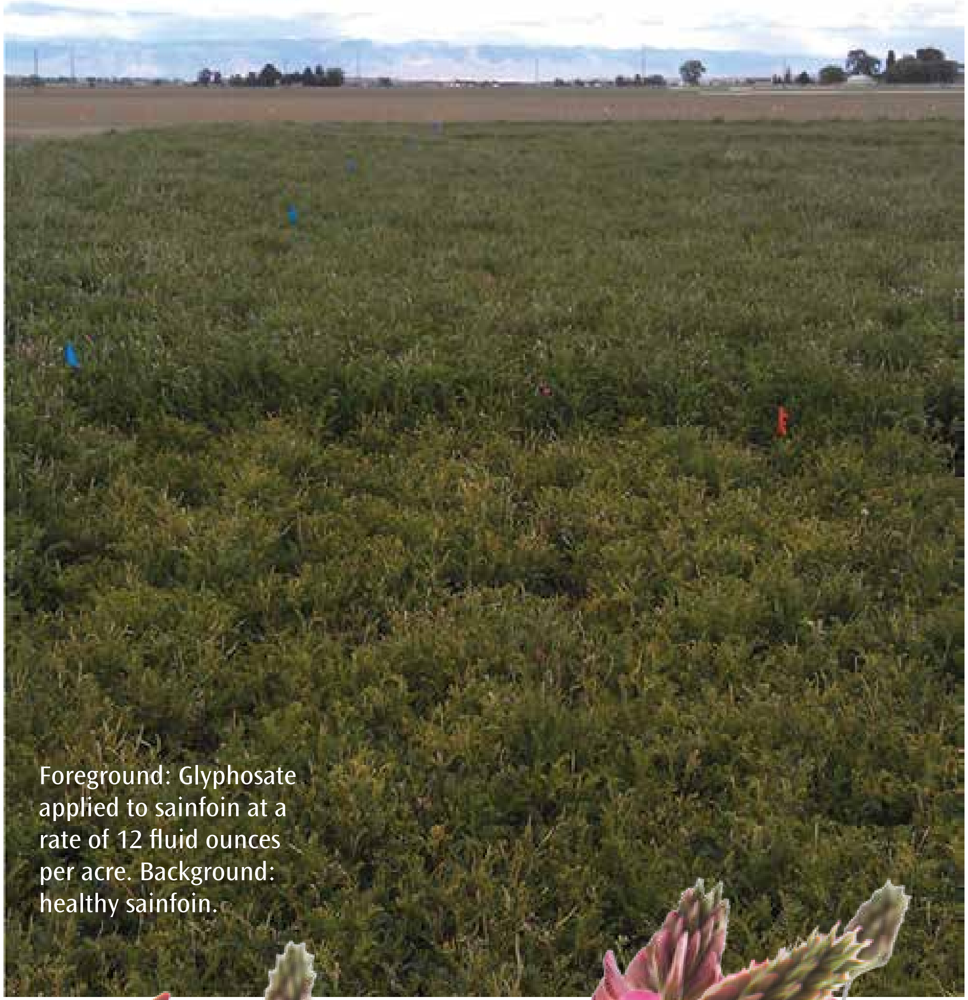
Scientists Conduct Weed Control Studies

There have been suggestions sainfoin has a natural tolerance to glyphosate (the active ingredient in the herbicide Roundup), even in actively growing plants. Some previous studies have shown that sainfoin does possess some natural tolerance to glyphosate, but these studies did not quantify the effect of glyphosate on sainfoin forage yield. To test the effects of postemergence herbicides on sainfoin forage yield, researchers in the Department of Plant Sciences are conducting studies at the Powell Research and Extension Center by applying varying rates of glyphosate to sainfoin.

Yield Reduction Significant

A range of glyphosate (Roundup PowerMAX) rates were applied to an established stand of sainfoin in the fall of 2011 and again in the spring of 2012 (see Table 1, page 18). Sainfoin yield was then collected for three cuttings during the 2012 growing season. Sainfoin did exhibit tolerance to glyphosate (it survived), but yield reduction was significant even when applied at relatively low rates.

The rate of Roundup used in most Roundup Ready crops to manage annual weeds is 22 to 32 fluid ounces per acre. Only eight fluid ounces per acre of Roundup applied in the spring reduced sainfoin yield by more than one ton of dry matter per acre – an estimated $198 per acre of lost revenue.



Foreground: Glyphosate applied to sainfoin at a rate of 12 fluid ounces per acre. Background: healthy sainfoin.

Howard F. Schwartz, Colorado State University, Bugwood.org

Table 1: Sainfoin yield reduction and lost revenue in response to fall- and spring-applied Roundup PowerMAX.

Application timing	Roundup rate	Estimated yield loss in one growing season	Lost revenue[1]
	fl. oz./acre	tons/acre	$/acre
FALL	8	0.01	$2
	12	0.06	$10
	16	0.16	$26
	20	0.30	$50
	24	0.50	$82
SPRING	8	1.20	$198
	12	1.50	$245
	16	1.80	$283
	20	2.00	$316
	24	2.20	$344

[1]Lost revenue assumes hay price of $160 per ton.

MORE SAINFOIN

UW scientists have conducted other sainfoin studies. Find sainfoin under "crops" in the index of the 2012 Field Days Bulletin from the Wyoming Agricultural Experiment Station online at bit.ly/2012fielddays. And see bit.ly/sainfoinherbicide

Eventually, the sainfoin outgrew the injury symptoms from the lower rates of glyphosate, and yield loss was higher in the first cutting but less pronounced in the second and third cuttings. Even fall applications, which resulted in far less sainfoin injury, resulted in significant yield reductions and associated lost revenue.

What it Means

Sainfoin yield loss due to glyphosate application has significant economic implications, especially in a year when hay prices are high due to drought conditions. Recently, the price for prime quality hay exceeded $200 per ton. If we conservatively estimate that sainfoin hay could be sold for $160 per ton, the potential revenue lost due to glyphosate application far exceeds the likely benefit we would have received by spraying Roundup for weed control (Figure 1, page 16). Roundup may be an inexpensive herbicide to apply, but the costs associated with sainfoin yield reduction make this an extremely expensive weed management decision.

Herbicides other than glyphosate are being evaluated, and some promising options have been identified. This research will continue with the hope that at least one of these promising herbicides will be registered. Until then, growers are encouraged to use one of several registered preemergence herbicides during stand establishment to aid weed control. If a vigorous stand of sainfoin can be established, the need for postemergence herbicides will be greatly reduced.

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Scientists study TURFGRASS PERFORMANCE under supplemental irrigation and rain-fed conditions

Anowar Islam
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Most traditional turfgrass species require large amounts of water to produce good-quality turf. In the semi-arid Central Great Plains (CGP) of Wyoming where average annual precipitation is less than 14 inches, water availability for turfgrass irrigation is limited.

Identifying drought-tolerant, low-maintenance turfgrass is of prime interest to landowners and turf managers. Kentucky bluegrass and tall fescue are the most widely planted cool-season turfgrass species for high- and low-maintenance turf systems. Recent studies report that several cultivars of Kentucky bluegrass and tall fescue provided high visual quality under reduced inputs (e.g., irrigation and fertilization). However, information on the performance of recently released cool-season turfgrasses under drought conditions is limited in the semi-arid CGP.

New Cultivars Show Promise

Selecting grasses that have the ability to maintain green cover for long periods without supplemental irrigation could have a significant impact on seasonal water use. Blue grama and buffalograss are native grass species found in the North American Great Plains. These warm-season grasses are tolerant to drought, adapted to semi-arid regions, and are being used as low-maintenance turfgrass species across the Great Plains. Efforts have been made to breed native grass species, particularly buffalograss, for their suitability as turfgrass in the CGP. 'Bowie' and

Turfgrass performance at SAREC under rain-fed conditions.

Selecting grasses that have the ability to maintain green cover for long periods without supplemental irrigation could have a significant impact on seasonal water use.

'Cody' are turf-type buffalograss cultivars released recently by the University of Nebraska with superior turf quality and drought tolerance. In Manitoba, Canada, blue grama cultivar 'Bad River' has been reported to produce good-quality turf with excellent drought tolerance with great potential as a low-maintenance turf.

These newly released cultivars are reported to have wider geographic adaptability, but their performances in the CGP have not been widely evaluated. Identifying turfgrasses adapted to the semi-arid conditions of Wyoming and comparing the performance and quality of different turfgrass species/cultivars under irrigated and rain-fed conditions provide beneficial information to both turf managers and homeowners.

What Has Been Done in Wyoming Relating to Turfgrass?

Scientists in the Department of Plant Sciences conducted evaluation of several turfgrass cultivars at the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC) near Lingle (4,171 feet elevation).

Three cultivars of Kentucky bluegrass ('Bandera', 'Common 85/80', and 'Midnight'), tall fescue ('Blackwatch', 'Tar Heel II', and 'Watchdog'), buffalograss ('Bison', 'Bowie', and 'Cody'), and blue grama ('Alma', 'Bad River', and 'Hachita') were evaluated. Cultivar selection for each species was based on reported drought tolerance. Irrigation management included irrigated vs. rain-fed. The individual plot size of the study was 5 feet by 20 feet. The study was planted in May 2009. Seeds were broadcast onto a clean, firm, and smooth seedbed then softly raked in and rolled into the soil. Sowing rates (pure live seed) were 175, 436, 87, and 131 pounds per acre for Kentucky bluegrass, tall fescue, buffalograss, and blue grama, respectively.

During the 2009 establishment year, rain-fed plots received irrigation water as needed to ensure good emergence. Good precipitation conditions following sowing in 2009 aided rapid plant establishment. Plot establishment in the autumn of 2009 was identical among all treatments. Drought tolerance was assessed in 2010 and 2011 by comparing grasses in the irrigated half of the study to the rain-fed half. The supplemental amounts of water added to the irrigated turfgrass plots through center pivot sprinkler irrigation were 9, 9.5, and 10.5 inches in 2009, 2010, and 2011, respectively. On average, the irrigated treatment received 67 percent more water than the rain-fed treatment.

Starting in July 2009, all plots were mowed bi-weekly to control weeds and stimulate growth. Plots were fertilized (based on soil test results) with 50 pounds per acre of N (nitrogen, as urea) and P (as mono-ammonium phosphate), and 20 pounds per acre of sulfur (as elemental sulfur) in mid-September in the second and third year of the study.

Turfgrass performance at SAREC under irrigated conditions.

Turfgrass Performance over Three Years

Turfgrass establishment was successful, and plant performance was similar among irrigated and rain-fed treatments in the establishment year (Table 1). However, differences occurred over time. Coverage of turfgrasses used in the study was similar in both irrigated and rain-fed conditions for the entire evaluation period. In general, better performance and turf quality in terms of vigor and color were obtained in irrigated plots (Table 2, page 22). Overall, plant vigor and color rankings were in the order of tall fescue > Kentucky bluegrass > buffalograss > blue grama under irrigated conditions. However, under limited water supply, plant vigor and color were superior for the warm-season turfgrass species (buffalograss and blue grama). Tall fescue cultivars ‘Tar Heel II’ and ‘Watchdog’ performed well under rain-fed conditions showing superior drought tolerance and low water requirements comparable to ‘Cody’ (buffalograss), and ‘Bad river’ (blue grama). There

Table 1. Turfgrass performance under irrigated and rain-fed conditions at SAREC in the establishment year. Emergence recorded July 1, 2009; other parameters recorded July 29, 2009.

Species	Cultivar	Emergence (%)	Coverage (%)	Vigor†	Color†	Dormancy (%)	Density†
Irrigated							
Blue grama	Alma	72.5	81.3	6.0	5.3	13.8	7.5
	Bad River	78.8	88.8	6.5	6.5	13.8	8.3
	Hachita	55.0	40.0	5.5	5.8	3.8	2.3
Buffalograss	Bison	55.0	45.0	5.5	5.3	4.0	1.8
	Bowie	46.5	60.0	5.5	5.5	4.0	5.0
	Cody	58.8	68.8	6.8	6.3	1.8	4.0
Kentucky bluegrass	Bandera	68.8	72.5	6.8	7.3	15.0	7.0
	Common 85/80	73.8	77.5	7.3	6.8	9.0	7.3
	Midnight	72.5	77.5	7.5	9.0	29.0	6.0
Tall fescue	Blackwatch	93.8	97.3	8.8	9.0	6.3	8.5
	Tar Heel II	95.0	93.8	8.5	8.3	42.5	8.8
	Watchdog	92.5	95.0	8.3	8.5	38.8	8.5
Mean		71.9	74.8	6.9	7.0	15.2	6.3
LSD(0.05)		5.3	8.3	0.6	0.5	14.0	1.0
Rain-fed							
Blue grama	Alma	71.3	90.0	6.8	5.8	13.8	8.5
	Bad River	72.5	90.0	6.3	5.8	14.0	8.3
	Hachita	61.3	51.3	5.3	5.0	10.5	4.3
Buffalograss	Bison	58.8	45.0	5.5	5.3	4.0	1.8
	Bowie	58.8	60.0	5.5	5.5	4.0	5.0
	Cody	56.3	68.8	6.8	6.3	1.8	4.0
Kentucky bluegrass	Bandera	80.0	85.0	7.5	7.5	10.0	8.0
	Common 85/80	83.8	96.3	7.8	7.0	4.0	8.8
	Midnight	78.8	95.0	7.5	8.5	4.0	8.8
Tall fescue	Blackwatch	95.0	93.8	8.3	8.3	10.0	8.8
	Tar Heel II	92.5	96.3	8.0	8.0	29.0	8.8
	Watchdog	92.5	93.8	8.0	8.5	25.0	8.3
Mean		75.1	80.4	6.9	6.8	10.8	7.0
LSD(0.05)		5.3	8.3	0.6	0.5	14.0	1.0

†Visual ratings are based on 1 to 9 rating scale where 1=poorest or lowest and 9=best or highest.

Anowar Islam talking about turfgrass performance during a SAREC field day.

was little-to-no weed invasion in tall fescue turfgrass plots over the three-year study period indicating its superior competitiveness to weed infestation compared to other turfgrass species tested.

Based on three-years of results from the evaluation, tall fescue cultivars 'Tar Heel II' and 'Watchdog', blue grama cultivar 'Bad River', and buffalograss cultivar 'Cody' are the most promising drought-tolerant cultivars and have potential for use in the CGP of Wyoming, and perhaps beyond, under limited irrigation.

Specific or detailed cultivar information can be obtained from the authors.

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Table 2. Turfgrass performance under irrigated and rain-fed conditions at SAREC in the third year. Recorded July 26, 2011.

Species	Cultivar	Coverage (%)	Vigor†	Color†	Dormancy (%)	Steminess†	Density†	Weeds (%)
Irrigated								
Blue grama	Alma	69.5	6.3	6.0	23.0	6.0	5.8	23.3
	Bad River	82.0	6.3	6.0	17.0	6.0	7.0	11.7
	Hachita	56.2	6.3	5.8	17.5	6.0	4.0	43.3
Buffalograss	Bison	62.3	6.3	5.8	11.3	6.3	4.5	18.3
	Bowie	87.5	6.5	6.3	10.3	6.0	6.5	15.0
	Cody	83.7	6.0	5.3	17.0	6.5	6.8	13.3
Kentucky bluegrass	Bandera	61.5	6.8	6.5	19.5	7.0	5.0	3.3
	Common 85/80	74.3	6.5	6.3	10.5	7.5	5.8	0.0
	Midnight	55.0	7.0	7.0	34.5	8.0	5.3	5.0
Tall fescue	Blackwatch	82.5	7.3	7.8	16.5	8.0	6.8	0.0
	Tar Heel II	73.8	7.3	7.3	20.0	7.5	6.3	0.0
	Watchdog	74.0	6.8	7.0	22.0	6.3	8.0	0.0
Mean		71.8	6.6	6.4	18.3	6.8	6.0	11.1
LSD (0.05)		18.0	0.7	0.7	13.8	0.7	1.9	11.5
Rain-fed								
Bluegrama	Alma	66.5	5.0	5.0	30.0	4.8	3.3	33.3
	Bad River	66.3	3.3	3.5	49.3	3.5	5.8	23.3
	Hachita	56.5	3.8	4.0	47.5	5.3	4.3	43.3
Buffalograss	Bison	62.5	3.5	5.0	42.5	6.3	3.8	23.3
	Bowie	76.5	3.3	3.5	73.4	6.0	5.0	26.7
	Cody	78.8	4.0	4.2	46.3	5.5	6.3	13.3
Kentucky bluegrass	Bandera	80.5	2.5	2.8	86.3	1.5	3.8	6.7
	Common 85/80	42.3	1.5	1.5	94.5	1.0	2.8	16.7
	Midnight	60.0	1.8	1.8	96.5	1.5	3.5	30.0
Tall fescue	Blackwatch	46.0	2.8	2.5	88.3	2.0	2.5	10.0
	Tar Heel II	65.0	3.8	4.0	61.3	4.8	5.0	0.0
	Watchdog	38.8	4.0	4.5	55.0	4.5	4.0	0.0
Mean		61.6	3.3	3.5	64.3	4.0	4.1	18.9
LSD (0.05)		39.3	2.6	2.9	43.0	2.4	3.2	21.9

†Visual ratings are based on 1 to 9 rating scale where 1=poorest or lowest and 9=best or highest; for steminess, 9=no stem or seed head and 1=highest stem or seed head.

Leave It To Beaver

Victoria Zero
Master's Student
Melanie Murphy
Assistant Professor
Department of Ecosystem Science and Management

Beaver dams and mounded lodges may be what you first see. What you don't see are the many species dependent upon these ecosystem engineers.

Beaver constructions are conspicuous features in Wyoming landscapes – what is less noticeable are the amphibians that are dependent upon them for survival.

If you're like many of my friends – even scientific colleagues – you may be wondering, "Do we really have frogs out here?" You may have heard of the Wyoming toad, because it is the only amphibian species endemic to Wyoming, and it is functionally extinct in the wild. However, residents may not realize there are 11 other species of amphibians within our borders, and some of them are in need of help, too.

Wetlands act as oases for numerous wildlife and livestock species in Wyoming's dry, open landscapes. Although they comprise less than 2 percent of the land in Wyoming, wetlands support more kinds of wildlife than any other habitat. Approximately 90 percent of the wildlife species in Wyoming use wetlands and riparian habitats daily or seasonally during their life cycles, and about 70 percent of our bird species live in wetland or riparian ecosystems.

The star players in our study area are the northern leopard frog, boreal chorus frog, and tiger salamander. Leopard frogs use beaver ponds for breeding, while adults may spend time foraging upland. Advertising males sound a bit like two large balloons being rubbed together. The small but vocal chorus frog tends to be found along the marshy edges of beaver ponds or flooded meadows. The breeding call of this species sounds like someone running their nail along the teeth of a comb. The nocturnal tiger salamander prefers small ponds without fish and has the interesting characteristic of being able to retain their gills and retain their larval form while still reaching sexual maturity – a state termed neoteny.

While these wetland denizens may be perfectly suited to historic climate and habitat conditions (see Adapted amphibians page 26), more frequent and more intense droughts may threaten their future (see The amphibian-beaver connection page 25). Gathering more information on the requirements of these species may help prevent future extinctions. To this end, we are studying 60 wetland sites across Pole Mountain (see diagram page 25) to determine where these amphibians are breeding. Sites were selected randomly and include 35 beaver ponds and 25 other wetlands. Each site is visited multiple times over the summer to look for all three of the amphibian species. Water quality is measured along with the amount of water in each wetland, temperature, pH, and pollutant levels. Taking into account site features and the influence of beaver, these data can be used in developing a model to help us understand the characteristics that may influence where amphibians decide to lay their eggs.

Are these species in trouble? Based on first-season data, there looks to be a healthy population of northern leopard frogs on Pole Mountain. Northern leopard frogs were once widespread across North America, but western populations have winked out in various locations, including the Targhee National Forest of western Wyoming and parts of the Laramie Basin. Chorus frogs and tiger salamanders are considered to be common and widespread, but without further studies we will know very little about amphibians in Wyoming.

IMPORTANCE IN ECOSYSTEMS

Beaver are considered a keystone species – their presence and activities are so important to ecosystems that removal leads to a loss of habitat for other species. See http://bit.ly/wyobeaver

Playing tag with amphibians

We are developing a technique to detect individual species in water samples.

How?

When animals shed skin cells into water, for example, we can extract these minute quantities of DNA and design a test for the presence of any species we choose. This test takes a small region of DNA, and makes many, many copies of that region with a florescent tag – enough to be detected and quantified by a laser. We are working on developing such tests for all three amphibians mentioned in these stories, but this could be done just as easily for other critters of interest, like trout.


Author Victoria Zero and a tiger salamander.

http://bit.ly/amphibsurveys

The amphibian-beaver connection – benefits to wildlife, humans

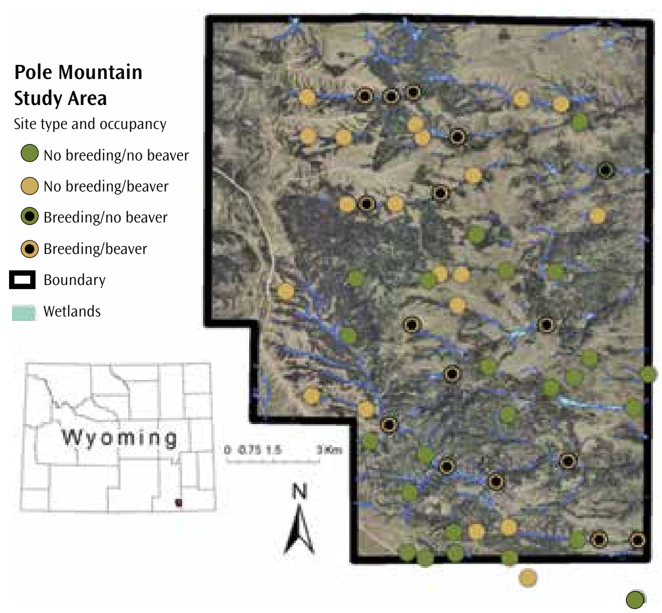
Our research suggests beaver may be central to the conservation of native amphibians – and provide additional benefits to wildlife and humans. These benefits are evident in the short-term but may be critically important in the long-term.

Beaver impoundments may have larger populations and more types of pond-breeding amphibians compared to unmodified streams. Beaver may also slow the effects of changing drought regimes. They are the unsung heroes of wetland conservation.

Frogs and salamanders, the main focus of our research, may rely heavily on beaver-created habitats as breeding grounds. These amphibians are sensitive to pollutants and can serve as indicators of both wetland water quality and biodiversity. They are also highly connected at different levels of the food chain, both as predator and prey, and may tell us about the health of our wildlife communities.

Beaver are critical for providing breeding habitat for amphibians in dry years. With the exception of one wetland, we

NORTHERN LEOPARD FROG BREEDING SITES



found leopard frog eggs and tadpoles exclusively in beaver ponds.

By converting free-flowing streams to impounded ponds through dam construction, beaver profoundly alter where water is stored, how much is stored, and how long it remains. These changes include even more benefits, such as water purification, elevated water tables, buffering against hydrological change (think flood control or increased late-summer flows), habitat creation, and biodiversity maintenance.

Another important factor in the distribution of breeding habitat is "hydroperiod" – the amount of time a wetland is frost-free and holds water. This factor is important on its own but acts synergistically with beaver. Active beaver ponds hold the most water for the longest time. If there were to be a few consecutive dry years, leopard frogs might disappear without the presence of beaver. With the increasing frequency and severity of drought in this area, beaver are likely to become increasingly important for the persistence of not just these amphibians, but also all of the other wildlife and plant species that depend upon these habitats.

BEAVERS REALLY ARE, WELL, PRETTY BUSY

Beaver, often termed ecosystem engineers, rival humans with the construction of their elaborate dam complexes. Found throughout North America, beaver nearly went extinct in Wyoming in the 1800s due to the fur trade. Reintroductions in the 1900s have promoted beaver recovery.

Humans also engineer wetland systems – for agriculture, drinking water, livestock production, and recreation. Where beaver and humans cross paths, beaver may be considered a pest because of their natural proclivities to damage property by burrowing in banks and removing trees, or causing flooding through dam construction.

http://bit.ly/beaverdams

ADAPTED AMPHIBIANS

The frogs, toads, and salamanders calling the Cowboy State home are tough. To keep from freezing while overwintering, northern leopard frogs hibernate at the bottom of water bodies that have only frozen-over the top, such as a beaver pond. Just like human residents, they have figured out how to endure limited amounts of rainfall and long, harsh winters.

Bringing science out of the lab:
ARE YOU A CITIZEN SCIENTIST?

Children from a day-care in Cheyenne display pollinator insects they caught at UW's Simpson Plaza.

Ann Hild
Professor

Kristen Gunther
Ph.D. Student
Department of Ecosystem Science and Management

The stereotype of the ivory tower is still prevalent when it comes to university research.

Most Americans live and work outside of academic settings and often think of science as inaccessible, even when scientific outcomes are directly relevant to understanding daily life. However, a recent push to involve the public in data collection, conversations, and local planning could provide a path to stronger relationships between scientists, resource managers, the public, and the ecosystems they call home.

Citizen Science Efforts

For more than a century, scientists and science-focused organizations have tapped into public volunteers as a resource to strengthen scientific data-collection efforts and to facilitate non-academic appreciation for science. Called "citizen science," this kind of engagement takes many forms. Volunteers gather to survey organisms in a concentrated area (sometimes called a "bioblitz"), report individual observations of biodiversity, or lend their time and skills toward helping scientists analyze data.

Crowd-sourcing (relying on many members of the general public for data collection) allows scientists to quickly gather information without excessive labor and at reduced costs. Additionally, crowd-sourcing provides an enjoyable way for non-professionals to engage directly in important scientific research – imagine if you were

Ralee Salinas, 6, of Cheyenne examines a damselfly she caught outside of the UW Berry Biodiversity Conservation Center during a discussion about pollinators and predators.

the one to first identify a rare bird in a nature preserve!

Perhaps most importantly, citizen science efforts help reinforce among society at large the importance of scientific research and protection of biodiversity.

Digital Data Depository

Technology expands opportunities for public engagement with scientific research as scientists turn to websites and mobile devices to generate interest in their work. A wildlife management professor in New York has even developed apps that allow anyone with a smartphone to photograph wildlife or road kill and send the photo, tied with GPS location, to a central database. These sorts of commonly available technologies can potentially create datasets that help identify large-scale distributional trends.

UW Citizen Science Opportunities

Here at the University of Wyoming, our Biodiversity Institute supports a number of citizen science initiatives that seek to make the development of ecological knowledge a two-way street. The institute makes ecological data collection forms publicly available on its website so interested members of the public can report biological observations. Institute-sponsored programs, such as Pollinator Parties, gather citizen scientists to teach pollinator identification skills. For younger audiences, the classroom-based Mission Impossible program encourages children to identify native species near their schools and report them to UW's database.

According to Brenna Wanous-Marsicek, who coordinates these projects, the institute seeks "to move beyond asking people to only submit their data to a database, to encouraging them to also interact with it, form hypotheses based on what they and others have found, think about ways they can test their hypotheses, and then do so."

Getting Engaged

The importance of initiatives to get non-professionals involved in science is receiving increasing attention from the academic community. This is especially true in fields that focus on application of new information, such as watershed management and restoration ecology. In these fields, where landscapes are at stake, scientists are recognizing the importance of communicating with and involving the public in projects that connect to their own communities.

Kristen Gunther, a Program in Ecology graduate student advised by Professor Ann Hild in the Department of Ecosystem Science and Management, is engaged in research to examine ways scientists communicate

Citizen science efforts help reinforce among society at large the importance of scientific research and protection of biodiversity.

new information to land managers. They target managers as an audience that might apply new scientific findings. Their goal is to make this communication pathway more effective by understanding communication techniques that best engage land managers.

Over the next two years, Gunther will work with faculty members in natural resources to design written pieces that convey research to managers, hoping to enhance application of new science to the landscape. The articles will emphasize management decision making for weed control and watershed monitoring. Surveys were conducted this past spring as part of this project. The surveys intend to capture citizen opinions about which kinds of communication strategies are most popular and useful. The first surveys were to be distributed during the 2013 Wyoming Agricultural Experiment Station (AES) field days.

Strengthening interactions between scientists and managers can benefit land management by increasing the accessibility of best-available science in decision making to enhance ecosystem stewardship. Additionally, Hild and Gunther believe allowing managers to direct communication efforts will help them to articulate their research needs – providing a dialogue to voice their priorities to scientists.

If you are a range manager and would like to participate in this project and/or receive a survey, please contact Gunther or Hild.

If you would like to get involved in the Biodiversity Institute's citizen science program, visit http://bit.ly/citizenscience or contact the institute at biodiversity@uwyo.edu.

To contact:
Professor **Ann Hild** *can be reached by email at annhild@uwyo.edu.* **Kristen Gunther** *is a Ph.D. student in the Program in Ecology and can be reached at kgunthe1@uwyo.edu. To contact either Hild or Gunther by phone, please call the Department of Ecosystem Science and Management at (307) 766-3114.*


Children from Cheyenne take a closer look at pollinator insects they caught in a net.

HOW DO YOU DETERMINE EFFECTIVENESS OF NATURAL RESOURCES COMMUNICATION?

Ann Hild and Kristen Gunther's research on communicating science to range managers seeks to identify the best ways to present technical information. Their research has several phases and many ways for you to be involved.

They plan to distribute a survey at this summer's AES field days with copies of *Reflections* articles asking readers to share opinions about their favorite articles and what kind of stories they like to read.

Feedback offered by readers of *Reflections* will be used to develop articles on watershed management and weed control to be published in *Rangelands*, an international journal produced by the Society for Range Management (available online at http://www.srmjournals.org/loi/rala).

Readers of *Rangelands* will also be surveyed about their readership preferences and how they receive new information for integration into their management practices.

Hild and Gunther are planning open, public workshops to discuss effective, written communications among scientists, managers, and local stakeholders in 2014. Look for more information about them in subsequent *Reflections*.

Anowar Islam, left, and Larry Miller harvest and sample forage at the James C. Hageman Sustainable Agriculture Research and Extension Center near Lingle.

Legume grass mixtures reduce nitrogen

Dhruba Dhakal
Ph.D. Student

Anowar Islam
Assistant Professor
Department of Plant Sciences

Based on first-year data from a study by the Department of Plant Sciences, it appears that a 50-50 ratio of grass-legume mixture could increase yield, improve quality, and reduce production costs (no use of nitrogen) in forage production systems.

A study initiated in 2011 at the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC) near Lingle sought to increase yield and quality of forage, reduce production costs, and improve long-term profitability and sustainability of the forage production system by selecting an appropriate ratio of grass-legume mixture.

Two cool-season perennial grasses (meadow brome and orchard grass) and a legume (alfalfa) with different mixture ratios with two levels of nitrogen (zero and recommended dose at 134 pounds nitrogen per acre as urea) were used. Sixteen treatments including monoculture grass (with or without nitrogen), monoculture legume, two grass mixtures, one grass and one legume mixture, and two grasses and one legume mixture were used.

Grass-Legume Mixtures Increase Forage Yield

First-harvest dry matter yield of forage ranged from 733 to 1,631 pounds per acre (Figure 1, page 31). Among the 16 treatments, yield was highest from treatment number 9 (50-50 mixture of alfalfa and meadow brome). The 50-50 (alfalfa and meadow brome) mixture produced greater forage yield than the nitrogen-added treatments.

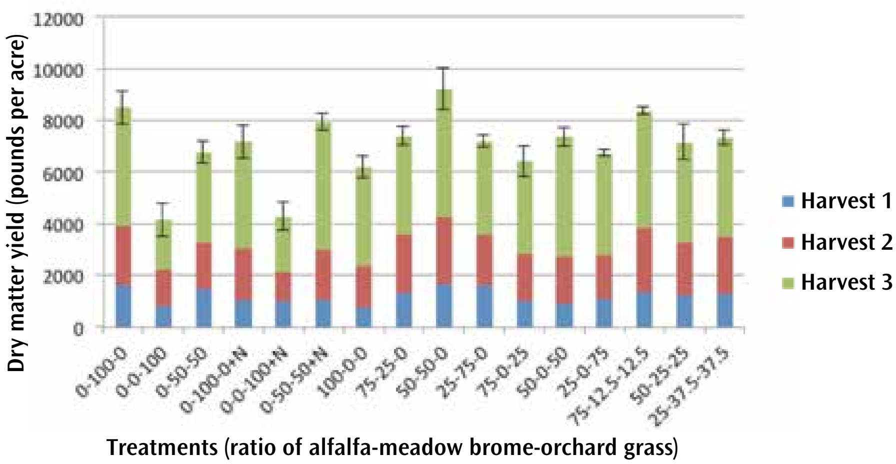


Figure 1. Dry matter yield of forage from different ratios of grass-legume mixtures at SAREC, 2012. +N = recommended dose of nitrogen as urea.

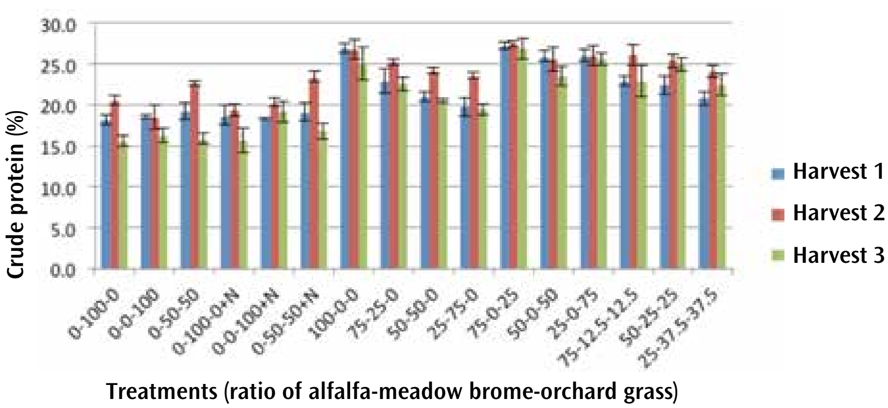


Figure 2. Crude protein of forage from different ratios of grass-legume mixtures at SAREC, 2012. +N = recommended dose of nitrogen as urea.

requirements and production costs

The yield from all treatments increased in the second harvest and ranged from 1,143 to 2,625 pounds per acre (Figure 1). The yield was highest from treatment number 9 (50-50 mixture of alfalfa and meadow brome) and lowest from treatment number 2 (100 percent orchard grass).

The dry matter yield again increased for all treatments in the third harvest and ranged from 1,892 to 4,812 pounds per acre (Figure 1). Similar to previous harvests, the highest dry matter yield was obtained from treatment number 9 (50-50 mixture of alfalfa and meadow brome).

Grass-Legume Mixtures Improve Forage Quality

The crude protein content of forage ranged from 18 to 27 percent in the first harvest (Figure 2); was highest from treatment number 11 (75-25 mixture of alfalfa and orchard grass); and lowest from treatment number 1 (100 percent meadow brome).

Some grass-legume mixtures (50-50 mixture of alfalfa and orchard grass, 25-75 mixture of alfalfa and orchard grass) had similar crude protein content to 100-percent alfalfa. The crude protein of forage varied from 18 to 28 percent in the second harvest (Figure 2) and was highest from treatment number 11 (75-25 mixture of alfalfa and orchard grass).

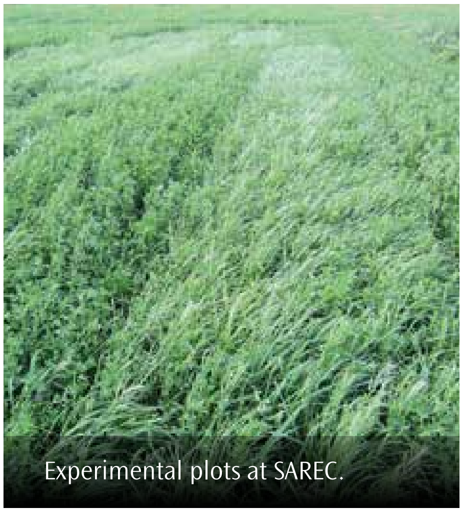
A similar trend was also found in the third harvest in terms of crude protein content and ranged from 15.5 to 26.9 percent (Figure 2). This clearly indicates that legume in the grass mixtures improves forage quality.

Fiber content (both acid detergent fiber [Figure 3 page 32] and neutral detergent fiber [Figure 4]) was low in earlier harvests (first and second) compared to late harvest (third) and also in alfalfa monoculture and grass-legume mixtures .

Highest Forage, Crude Protein Yield

The study shows that 50-50 alfalfa and meadow brome has the highest forage and crude protein yield among the treatments. In contrast, the highest forage quality was obtained from 75-25 alfalfa and orchard grass, indicating the superior quality of alfalfa and orchard grass compared to meadow brome.

The study is ongoing and will continue for at least two more years. Researchers anticipate that results



Experimental plots at SAREC.

A plot with 50-percent alfalfa and 50-percent meadow brome mixture at SAREC.

from this study will be useful to researchers and forage growers in the region in the long-term to improve profitability and sustainability of forage production systems.

To contact:
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Based on first-year data from a study by the Department of Plant Sciences, it appears that a 50-50 ratio of grass-legume mixture could increase yield, improve quality, and reduce production costs (no use of nitrogen) in forage production systems.

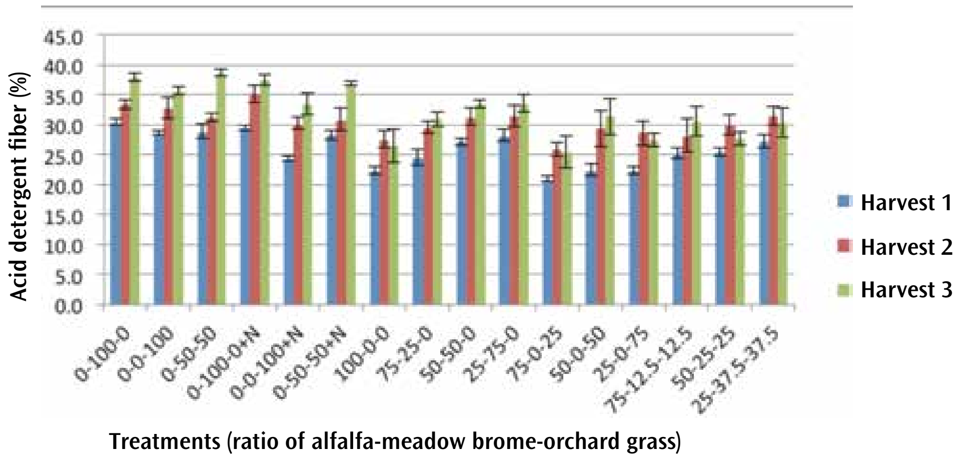


Figure 3. Acid detergent fiber of forage from different ratios of grass-legume mixtures at SAREC, 2012. +N = recommended dose of nitrogen as urea.

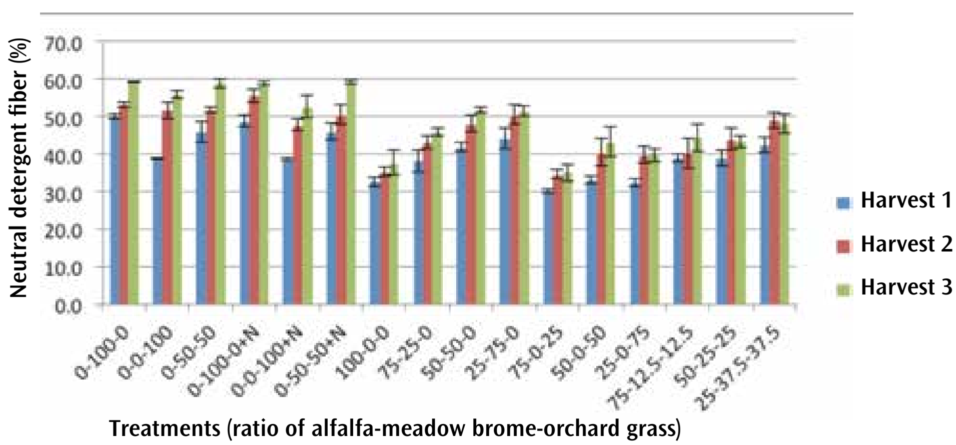


Figure 4. Neutral detergent fiber of forage from different ratios of grass-legume mixtures at SAREC, 2012. +N = recommended dose of nitrogen as urea.

View of experimental plots before harvesting at SAREC.

Important to Wyoming agriculture

According to Wyoming Agricultural Statistics, the cattle industry accounted for $603 million (46 percent of cash receipts of Wyoming agriculture), and forage crops contributed $306 million (23 percent) in 2011.

Although forage contributes significantly to the state's economy, the productivity of forage crops in Wyoming, less than 5 tons per hectare, is less than the national average (6 tons). Many factors, such as fluctuating weather conditions, shorter growing seasons, use of unimproved cultivars, monoculture production systems, and poor management practices contribute to this low productivity.

Chemical Fertilizers and Effects

Fertilizer application is the easiest way to increase forage productivity. However, this option may not be economically viable when fertilizer costs add 10 to 30 percent to the total production costs. Additionally, fertilizers can cause environmental problems such as greenhouse gas emissions, groundwater pollution, eutrophication (depletion of oxygen in water), human health hazards (blue baby disease), cattle health hazards (nitrate toxicity), and soil degradation, including soil structure deterioration, and reduction of soil microbial population and activity.

Grass-legume mixtures may be a better option to not only minimize the above-mentioned problems but also to increase forage yield, forage quality, and reduce nitrogen requirements. It has been reported that fertilizer nitrogen replacement value of forage legumes ranged from 223 to 268 pounds nitrogen per acre depending upon the legume species used.

Although many studies have been conducted on grass-legume mixtures in different areas of the United States and other countries, information is scarce about which mixtures will be most productive and persistent in Wyoming.

HAY STUDY FINDS ANSWER TO what is most productive

Blaine Horn
Educator, University of Wyoming Extension

Hay is the mainstay livestock winter feed for many Wyoming ranchers.

As a result, hay is the leading crop in Wyoming in terms of value of production. More than half of the irrigated land in the state is in a hay crop – primarily alfalfa – but there are many acres in perennial cool-season grass such as smooth bromegrass.

If managed properly, perennial cool-season grasses can annually produce two to three tons or more hay per acre. Proper management includes nitrogen fertilization, but it has become expensive.

If there are grasses that use nutrients more efficiently, especially with respect to nitrogen, and produce more forage on less fertilizer, hay producers could possibly lower fertilizer costs without sacrificing hay yields or stand longevity.

Hay Yields by Nitrogen Rate

A research project funded by a USDA Western Sustainable Agricultural Research and Education grant was conducted at the Gerry Miller ranch near Buffalo in 2010 and 2011 to compare hay yields of eight cool-season perennial grasses (see Cool-season grasses in this study, right) under flood irrigation fertilized with nitrogen.

The grasses were seeded in April 2008 and were in their second and third years of production. Nitrogen rates ranged from 0 to 250 pounds per acre of actual nitrogen applied in late April. The grasses were harvested on June 22, 2010, and on July 2, 2011.

Actual hay yields of each grass by nitrogen rate for the two years were analyzed to develop nitrogen response curves. Statistical analyses response curves show what the potential hay yields of each grass would be at any level of nitrogen between 0 and 250 pounds per acre. The R^2 values for each equation ranged from a low of 0.32 for 'Bozoisky' Russian wildrye to a high of 0.87 for 'Luna' pubescent wheatgrass (Table 1). An R^2 of 1 indicates

COOL-SEASON GRASSES IN THIS STUDY:

1. 'Paiute' orchardgrass,
2. 'Paddock' meadow bromegrass,
3. 'Manchar' smooth bromegrass,
4. 'Luna' pubescent wheatgrass,
5. 'Oahe' intermediate wheatgrass,
6. 'NewHy' hybrid wheatgrass,
7. 'Hycrest' crested wheatgrass,
8. 'Bozoisky' Russian wildrye.

Wyoming cool-season perennial grass

more confidence that the estimated data will actually represent the real data. An R^2 of 0 indicates no fit at all. Except for 'Bozoisky', the R^2 values for each grass are considered good to exceptionally good.

Hay Yields With and Without Nitrogen

Estimated hay yields with no applied nitrogen were lowest for 'Paiute' orchardgrass followed by 'Manchar' smooth bromegrass and highest for 'NewHy' hybrid wheatgrass and 'Oahe' intermediate wheatgrass (Table 1).

Table 1: Estimated hay yields in tons per acre of eight cool-season perennial forage grasses at 50 pounds nitrogen per acre increments and the R2 value for the nitrogen response curves.

Grass 'Variety' and species	R2	Nitrogen (pounds per acre)					
		0	50	100	150	200	250
'Paiute' orchardgrass	0.70	0.52	1.16	1.68	2.06	2.32	2.45
'Paddock' meadow bromegrass	0.51	1.21	2.00	2.59	2.99	3.19	3.20
'Manchar' smooth bromegrass	0.72	0.90	1.81	2.55	3.14	3.58	3.85
'Luna' pubescent wheatgrass	0.87	1.14	2.02	2.76	3.34	3.77	4.05
'Oahe' intermediate wheatgrass	0.85	1.48	2.41	3.18	3.79	4.25	4.55
'NewHy' hybrid wheatgrass	0.59	1.44	1.97	2.38	2.69	2.90	3.00
'Hycrest' crested wheatgrass	0.52	1.24	2.17	2.83	3.21	3.31	3.14
'Bozoisky' Russian wildrye	0.32	1.04	1.52	1.91	2.20	2.39	2.50

Although 'NewHy' and 'Oahe' had similar estimated hay yields with no applied nitrogen, 'Oahe' yielded an average of nearly twice as much additional hay per pound of applied nitrogen as 'NewHy' (Figure 1, page 36).

As the amount of applied nitrogen increased, nitrogen use efficiencies declined in all the grasses (Figure 1). With up to 100 pounds of applied nitrogen, 'Hycrest' crested wheatgrass, 'Oahe' intermediate wheatgrass, 'Manchar' smooth bromegrass, and 'Luna' pubescent wheatgrass appeared to be the most efficient in converting applied nitrogen to plant growth but thereafter the efficiency of 'Hycrest' substantially dropped off to the point that applying more than 150 pounds per acre of nitrogen would not increase potential yield.

'NewHy' hybrid wheatgrass and 'Bozoisky' Russian wildrye appeared to be least efficient in use of applied nitrogen for growth followed by 'Paiute' orchardgrass and then 'Paddock' meadow bromegrass (Figure 1).

Based on these low nitrogen use efficiencies, especially for 'NewHy' and 'Bozoisky', selecting these grasses for irrigated hay field production, at least in northeast Wyoming, may be ill-advised.

'Oahe' Appears Top Producer

Estimated hay yields of 'Oahe' intermediate wheatgrass were highest regardless of the amount of applied nitrogen (Table 1). This was apparently a result of the amount of growth produced without applied

nitrogen in conjunction with its efficiency in converting applied nitrogen to plant biomass. Both 'Manchar' smooth bromegrass and 'Luna' pubescent wheatgrass had similar nitrogen use efficiencies as 'Oahe' (Figure 1), but because their estimated hay yields with no applied nitrogen averaged a half-ton per acre less than 'Oahe,' this difference persisted with applied nitrogen.

The results of this two-year study indicate that 'Oahe' intermediate wheatgrass may be the grass to select for hay production in northeast Wyoming irrigated fields. Smooth bromegrass is the most common grass found in irrigated hay fields throughout Wyoming – most likely the variety 'Manchar' – and, based on its nitrogen use efficiency as determined from this research project, it has not necessarily been a bad selection. However, based on our study, 'Manchar' underperforms relative to 'Oahe' intermediate wheatgrass at all nitrogen levels. Other hay trial studies in Johnson and Sheridan counties have shown that smooth and meadow bromes generally yielded slightly more hay compared to intermediate and pubescent wheatgrasses regardless of whether fertilized with nitrogen or not. These contradictory findings show the need for additional research to provide a more definitive answer to the question of which perennial cool-season forage grasses are the most productive with the least amount of nitrogen fertilizer or in mixed stands with legumes such as alfalfa.

To contact:
Blaine Horn *is the University of Wyoming Extension educator in Johnson County specializing in range management and also serves Campbell, Crook, Sheridan, and Weston counties. He can be reached at (307) 684-7522 or at bhorn@uwyo.edu.*

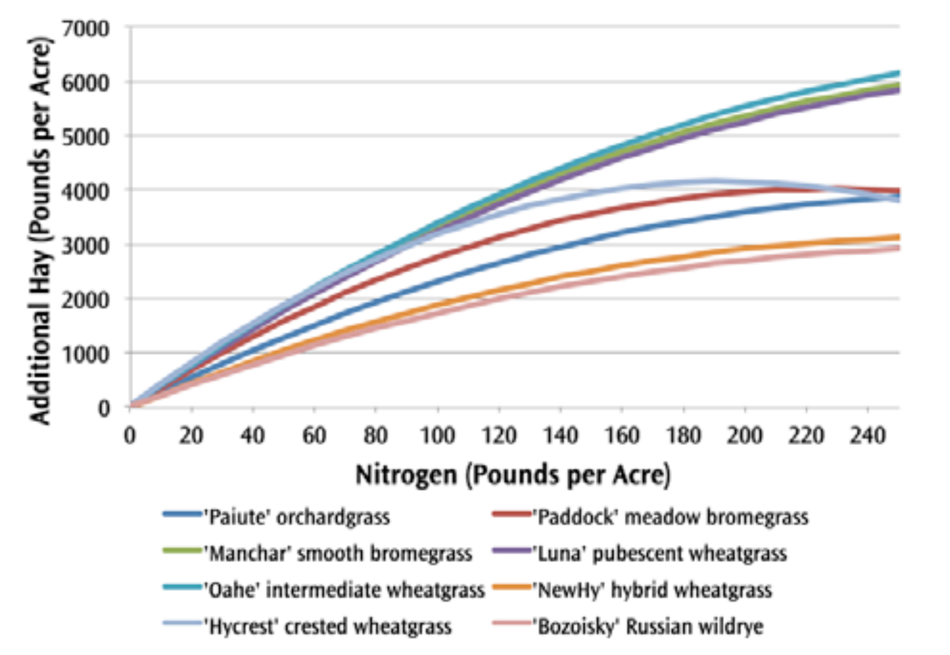


Figure 1: Estimated amount of additional hay produced by eight cool-season perennial forage grasses due to nitrogen fertilizer at Gerry Miller ranch northwest of Buffalo.

UW Extension high tunnel efforts fool MOTHER NATURE

Erin Anders
Agroecology
Undergraduate Student
ACRES Student President
2011-12

Four hundred eighty-four participants have built 50 high tunnels across Wyoming since the start of hoop house sessions

Wyoming green-thumbers coax her to (reluctantly) extend her vegetable production

The gardening community of Wyoming has two garden gurus: Jeff Edwards, UW Extension educator, and Milton Geiger, UW Extension energy coordinator.

Since 2010, Edwards and Geiger have been developing the Wyoming Hoop House Information Network. This network has constructed 50 high tunnels with 484 volunteers and has facilitated various workshops for nearly 1,000 people throughout the state. Workshops provide hands-on demonstrations in constructing low-cost, energy-efficient high tunnels.

The high tunnel design is based on a modified, traditional hoop style high tunnel developed by Del Jimenez of New Mexico State University Sustainable Agriculture Science Center. Wyoming's volatile weather, the rising costs of food, and the success of local food movements have increased the demand for high tunnel education. The initial high tunnel project sought to enroll 80 participants and conduct four workshops; results were nine workshops with 308 participants.

Volunteers built five hoop houses for ACRES at the Laramie Research and Extension Center greenhouse complex.

Albany County Newest Demonstration Site

With help from Ted Craig, Wyoming Department of Agriculture specialty crops grant coordinator, Edwards and Geiger extended efforts into Albany County – among the most altitude-challenged counties in the state. At 7,200 feet, the county is home to the project's newest demonstration site – UW's Agricultural Community Resources for Everyday Sustainability (ACRES) Student Farm.

ACRES is a UW Recognized Student Organization run by volunteers and is at the Laramie Research and Extension Center's greenhouse complex just east of the university's campus. ACRES has become an integral part of the local food movement in Laramie. Volunteers participate in two local farmers markets and offer a 15-member, 12-week Community Supported Agriculture (CSA) program. CSA is a program in which members buy a "share" (or a half-share) of produce at the beginning of the season and then receive a basket of produce every week of the season.

Real Experience, Fresh Ideas

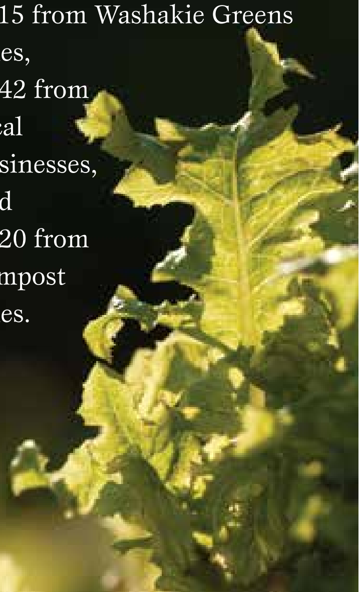
Produce is also provided to local businesses and the university's cafeteria. Students of all disciplines (see Not Just for Agriculture Majors page 39) can obtain real farm experience and are encouraged to explore fresh ideas on the farm. Many of these ideas develop into research projects or internships. The high tunnel project has provided four paid internships to undergraduate students offering valuable skills related to research and season extension.

The hands-on workshop in May 2012 was open to all interested community members and demonstrated building durable, low-cost ($3-$5/square foot) high tunnels easily constructed out of readily available materials. The tunnels measure 12 feet by 32 feet and have four different heat-retention treatments.

HARVESTING ANOTHER TYPE OF GREEN

Receipts received by ACRES during the 2012 season:

- $3,426 from Community Supported Agriculture projects,
- $791 from the Laramie Downtown Farmers Market,
- $670 from the Laramie LoCo Farmers Market,
- $115 from Washakie Greens sales,
- $142 from local businesses, and
- $420 from compost sales.



Engaging the Community

Five high tunnels were built over five days with seven to 15 volunteers per day through a combination of efforts by ACRES volunteers, various community members, and students from Wyoming Technical Institute, a technical school in Laramie.

"Any opportunity for WyoTech students to collaborate with students from the University of Wyoming is awesome," notes Jessica Nape, volunteer coordinator at WyoTech. "Many of our students come from an agricultural background and really enjoy construction projects; the work with ACRES was a perfect fit."

Most of ACRES' labor force is absent during the traditional growing season in Laramie (May – September) because volunteers are mainly students. According to Sarah Legg, ACRES vice-president and student volunteer since 2009, "The new hoop houses allow for overlap between the growing season and the school season, thus providing a larger number of students with the opportunity to get hands-on experience with agriculture."

Longer Season, More Vegetables

These tunnels have protected vegetables from the elements and provided volunteers a place to do what they love even in the cold of winter. Every night in Laramie was below freezing since October 1, but there were still peas, spinach, and cabbage growing at ACRES in the middle of January.

Perry Baptista, ACRES president-elect and volunteer since 2010, states the high tunnels, "…have definitely increased ACRES production capacity. With as harsh as the Laramie climate is, they allow us to consistently produce more during a longer season. We still had cabbages growing at the end of November. I see these hoop houses as enabling ACRES to continue future growth – not just in plant production but in the size of our organization and student/community involvement."

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NOT JUST FOR AGRICULTURE MAJORS

Students involved in ACRES include: Master's, Ph.D., and undergraduate students in agroecology, engineering, agricultural business, agricultural economics, fine arts, economics, business, chemistry, sociology, psychology, microbiology, agricultural education, undeclareds, and many non-traditional students. The oldest ACRES student is in his 70s.

TO LEARN MORE

Additional information and statewide details about the Wyoming Hoop House Information Network is available at http://bit.ly/wyohoops. ACRES Information is available at http://bit.ly/wyoacres.

http://bit.ly/3minutehightunnel

Jeff Edwards, UW Extension educator, ensures a wooden band holding the greenhouse covering will stay in place.

Researchers generate crop growth patterns

Ramesh Sivanpillai

Senior Research Scientist
Adjunct Faculty Member
Department of Ecosystem Science and Management,
Department of Botany,
and Wyoming Geographic Information Science Center

Images collected by Landsat satellites are acquired once every 16 days – farmers can use them to monitor growth patterns during one or more growing seasons.

Under precision-agriculture or site-specific management practices, farmers split fields into discrete zones based upon underlying soil properties and past crop growth patterns. By dividing the field into zones, a farmer can devote more resources to zones with medium to low growth to increase output.

Remotely sensed data (images) of crop growth acquired during the growing season in multiple years are essential to understand and map differences in crop growth through time. Data collected in the infrared region (invisible to human eyes) are particularly useful to distinguish differences in crop growth in a field.

Advances in technology are enabling us to acquire remotely sensed images using sensors mounted in balloons, unmanned aerial systems, or farm vehicles (tractors and trucks, for example).

Images collected by Landsat satellites date back to the early 1970s and comprise the longest and one of the most complete collections of remotely sensed images. Since these images are acquired once every 16 days, farmers can use them to monitor growth patterns during one or more growing seasons.

In 2008, the U.S. Geological Survey (USGS) opened the entire Landsat image archive free to users. Now any user can download images directly from the USGS websites http://glovis.usgs.gov or http://earthexplorer.usgs.gov.

University of Wyoming students enrolled in the remote sensing for agricultural management course are taking advantage of this to monitor fields in Wyoming or their home states.

Monitoring Crop Growth in One Growing Season

Carson Hessenthaler, agricultural business major from Lovell, compared sugar beet growth in a field near Lovell that had uneven soil fertility. Using three Landsat images acquired at different times of the year, he tracked growth in areas that showed poor, medium, and high growth at the start of the growing season (Figure 1, page 41).

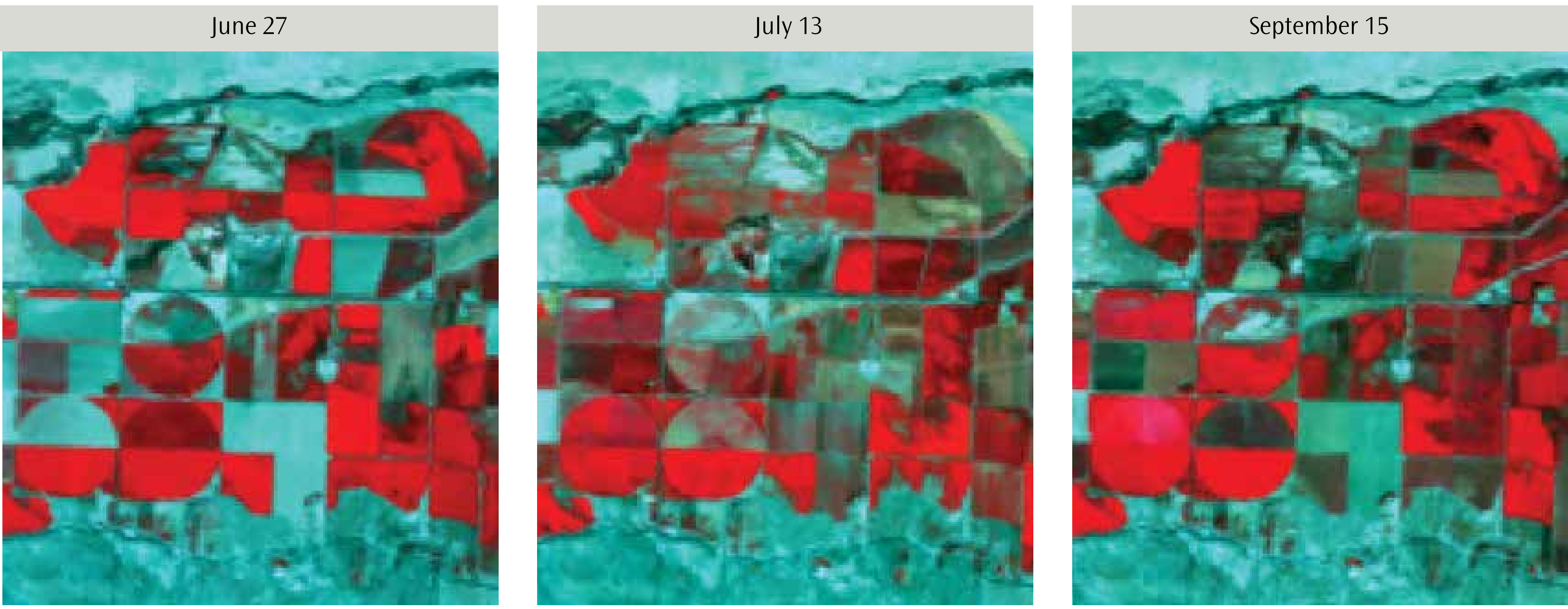
His analysis revealed that areas with high-, medium-, and poor-growth patterns at the start of the season stayed more or less same until the end of the season. However, areas with poor growth at the start had relatively more growth, albeit small, throughout the season and ultimately narrowed the gap with the other two categories.

Mapping Crop Growth Between Growing Seasons

Matthew Thoman, rangeland ecology and watershed management major from Riverton, mapped winter wheat growth patterns in non-irrigated fields east of Cheyenne. Using Landsat images acquired in April, May, and June of 2007 and 2009, he mapped winter wheat growth for the two growing seasons (Figure 2, page 41).

Combining data from three Landsat images acquired during each growing season, he was able to see that between 2007 and 2009, the area under high growth increased from 1.3 to 5.5 acres shown in dark green (Field 1). This increase occurred mostly in areas that had medium growth in 2007. Some of the medium growth areas of 2007 had lower growth in 2009 (yellow); however, this decline was noticed along the edges.

for Wyoming farmlands from satellite images



Infrared images acquired by a Landsat satellite show changes in crop growth during the 2007 growing season. Crops with high growth (or vigor) appear bright red due to more reflection in the infrared region. Darker shades of red indicate medium- to low-growth areas. Harvested areas and bare ground appear in shades of green and blue.

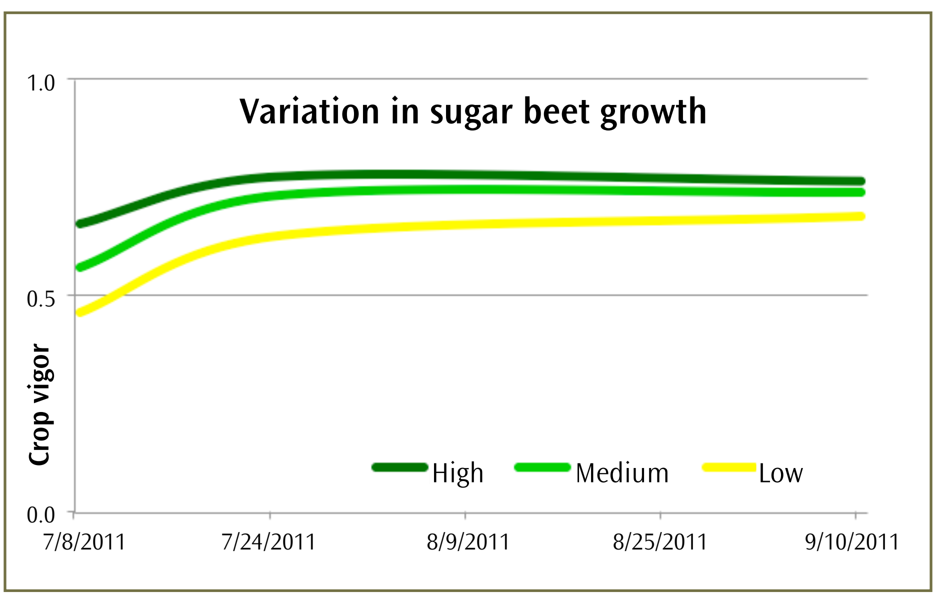


Figure 1: Landsat images revealed differences in sugar beet growth for the 2011 growing season at a farm near Lovell.

Figure 2: Variations in winter wheat growth in non-irrigated fields near Cheyenne in 2007 and 2009. Each square represents 0.22 acres (900 square meters) on the ground. Dark green to light green correspond to high to medium growth. Yellow and brown colors correspond to low and no growth.

The second field (right) showed increases in high and medium categories and decreases in low and bare ground categories. While no part of this field was classified as high growth in 2007, four acres witnessed high growth in 2009. On the other hand, areas of low growth decreased from approximately 11 acres in 2007 to 5 acres in 2009.

These examples demonstrate how information derived from Landsat images can be used to identify areas where crop growth varies between years. Farmers and crop consultants can use this information to devise suitable management plans for increasing crop growth.

Tracking changes through multiple years

Availability of free Landsat images provides numerous other possibilities for monitoring growth in Wyoming croplands. For example, farmers can adapt Hessenthaler's technique and obtain images from several years to analyze crop growth prior to its maturity.

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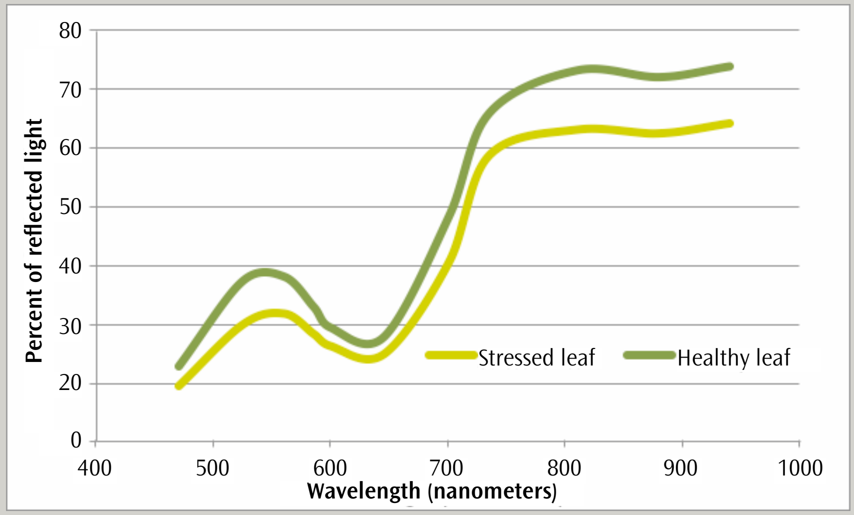
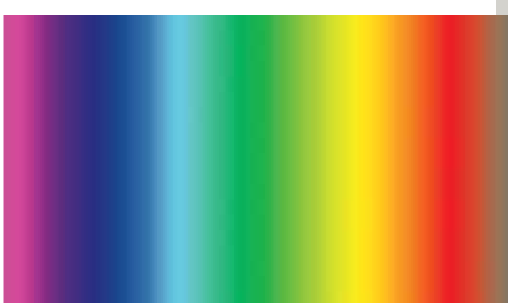


HOW TO DISTINGUISH HEALTHY AND STRESSED CROPS IN A LANDSAT IMAGE

Leaves appear green because they absorb blue and red light for photosynthesis and reflect green light within a narrow portion of the electromagnetic spectrum referred to as the visible region (400-700 nm). However, leaves also absorb and reflect beyond this visible region. Sensors aboard Landsat satellites record how different earth surface features, including leaves, interact with light in six regions of the spectrum. Healthy leaves reflect more near infrared light (more than 700 nm). Stressed leaves reflect less light in this spectrum.

Remote sensing scientists use the amount of reflected light in the red and near infrared regions to compute indices that can be related to plant vigor. Normalized difference vegetation index (NDVI) is widely used for monitoring vegetation vigor. Higher NDVI values correspond to healthy leaves or vegetation. For Landsat images, NDVI values use spectral bands 4 (near infrared) and 3 (red). Visit http://landsat.usgs.gov/ to learn more about how Landsat data are used to monitor features on the earth's surface.



Visible light spectrum
(in nanometers)

Blue – 400-500
Green – 500-600
Red – 600-700

Beyond visible light spectrum

Near infrared – 700-1400
– A nanometer is one-billionth of a meter

Bob Baumgartner, farm manager at the James C. Hageman Sustainable Agriculture Research and Extension Center, uses the combine to harvest a transect of corn.

The longer the DATA HARVEST, the more valuable THE CROP

Jenna Meeks
Project Manager (Former)

Jay Norton
Associate Professor
Department of Ecosystem Science and Management

James C. Hageman Sustainable Agriculture Research and Extension Center project joins select others in the U.S. dedicated to long-term research. The longer the study, the more valuable the outcomes to producers.

Research is a complex and intense process – particularly in agriculture.

At the mercy of nature, agricultural researchers face unique challenges to validate data and draw conclusions. In addition, agriculture has far-reaching implications making interdisciplinary coordination essential. Long-term studies ensure research provides an accurate baseline of information. Although long-term agricultural studies exist, limited information is available specific to the Western High Plains and Intermountain regions where integrated crop-range-livestock systems are prevalent.

Why is Long-term Research Important?

As described by Robertson et al. (2008) in "Long-term Agricultural Research: A Research, Education, and Extension Imperative," nature presents agricultural producers with constant variability and challenges to productivity, profitability, and social acceptability. Precipitation at the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC) near Lingle illustrates the drastic variability for rain-fed crops (Figure 1 page 45). While variables, such as soil, water, and energy, can be

Jenna Meeks collects air samples to measure gases emitted from soils beneath a dryland wheat field.

Jay Norton (foreground) conducted a teacher workshop in September 2012 as part of the project's outreach/education component. Teachers here are looking at a soil pit to determine pH and texture.

controlled through research design, their effects can best be accounted for through long-term studies across multiple spatial and temporal scales.

Robertson, et al., describe the necessity of creating a Long-Term Agricultural Research (LTAR) network. Goals for LTAR would include:

- Evaluation of management systems in a long-term setting;
- Inter-disciplinary focus with biophysical and social sciences;
- Field- and farm-scale trial sizes;
- Cross-regional comparison with improved experimental control;
- Research frameworks for smaller-scale innovations within larger, long-term treatments;
- Excellent settings for co-innovation and co-design of experiments among producers, researchers, educators, and others;
- Improved dissemination of information.

Long-term Research Sites

Modeled closely after the National Science Foundation's (NSF) Long-Term Ecological Research Network, the LTAR group would consist of numerous sites in the country to address geographic, commodity, and socioeconomic diversity where each location would focus on site-specific issues with a national support base.

The advantages of long-term research are being demonstrated. The four oldest, continuous field crop experiments in the U.S. are highlighted in "Overview of Long-Term Agronomic Research" by C. C. Mitchell et al. (1991). While there are a handful of long-term research projects in the country, most were not initially designed for long-term studies. However, the Morrow Plots at the University of Illinois, the Sanborn Field at University of Missouri-Columbia, the Magruder Plots at Oklahoma State University, and the Old Rotation at Auburn University in Alabama have been providing data on crop and soil variables for more than 50 years.

Results have shaped agronomic research. For example, the Morrow plots showed that the loss of plant nutrients rather than irreversible changes were the cause of low yields in continuous cropping systems on non-eroded soils. Also, the Sanborn Field demonstrated that crop rotations alone will not prevent deterioration of soil productivity.

The success and necessity of long-term agricultural research are further exhibited by the Sustainable Agriculture Farming Systems (SAFS) Project at University of California, Davis, and the Center for Environmental Farming Systems (CEFS) at North Carolina State University, which concentrates on sustainable agriculture and systems-based research.

SAFS consisted of 28 acres when established in 1988 and was the only one of its kind in the nation to study

Accumulating and evaluating several years of data before drawing conclusions is essential. As such, the longer experiments are conducted, the more valuable the outcomes will be to future researchers and producers.

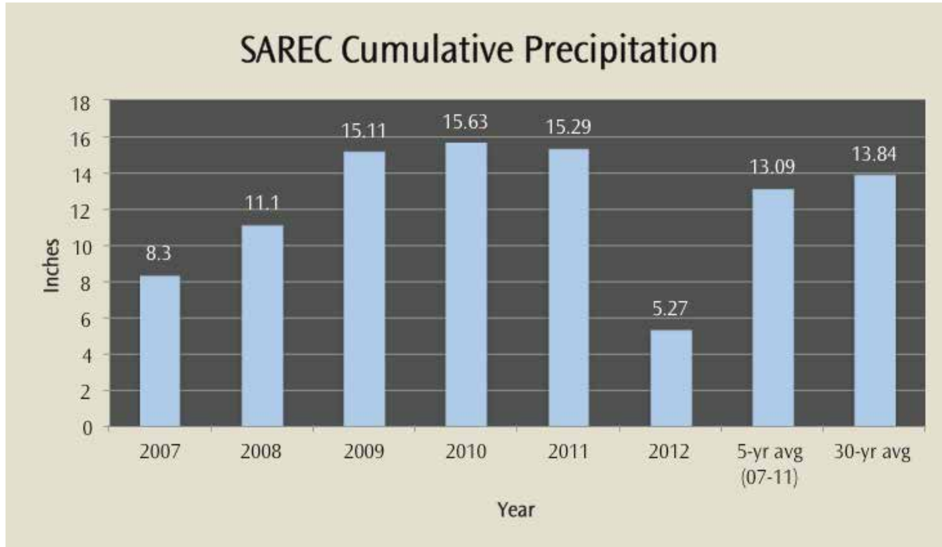


Figure 1. Precipitation history at SAREC.

the "transition from conventional to low-input or organic farm management" in the Sacramento Valley. Now, it is part of a joint research site with UC Davis' Long-Term Research in Agricultural Sustainability (LTRAS). LTRAS consists of 72 one-acre plots in which sustainability is "indicated by long-term trends in yield, profitability, resource-use efficiency, and environmental impacts."

CEFS has seven research units, which include farming systems, organic research, and pasture-based beef. The Farming Systems Research Unit (FSRU) involves five different production systems on about 200 acres. Typical of farming systems in southern states, the Best Management Practices System utilizes annual crops and short rotations with subplots comparing conventional and conservation tillage. A second system within FSRU, Integrated Crop-Animal System, involves a 6-18 year rotation of pasture, cash crops, and hay in which dairy steers utilize feed produced from each plot.

Wyoming's Own Long-term Ag Research Site

SAFS and CEFS have provided their respective area producers valuable educational and demonstration tools. To address the importance of integrated, systems-based, long-term research in Wyoming, the Sustainable Agricultural Systems Project (SASP), conducted at SAREC, was established in 2009. This framework evaluates three agricultural production approaches side by side in a statistical design that attempts to hold other factors constant. The rotations and management practices implemented under each approach are developed by an advisory team, which includes local producers who use these approaches (Table 1 below).

The first objective of the SASP is to quantify parameters that underlie long-term viability, competitiveness, and efficiency of these three production

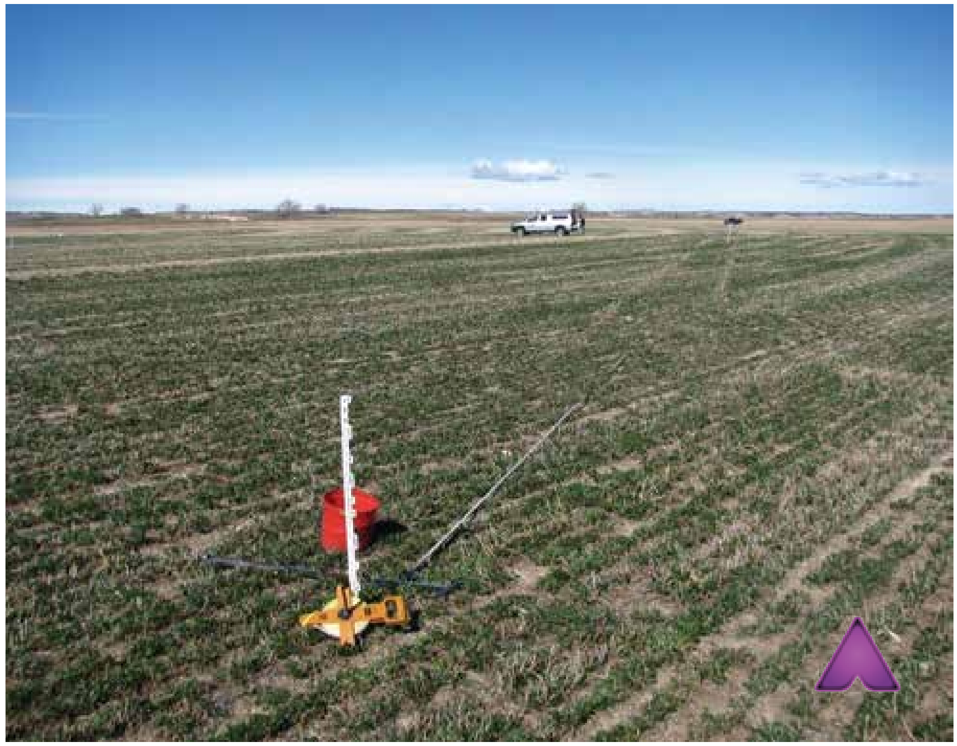
Table 1. Summary of differences between the three approaches at SAREC near Lingle.

	Irrigated cash-crop rotation	Irrigated management	Non-irrigated management (wheat-fallow)	Cattle management
Conventional	Dry beans, corn, sugar beets, corn	Synthetic fertilizer, herbicide, pesticide at recommended rates; conventional tillage	Wheat: Synthetic fertilizer and herbicide Fallow: Tillage for weed control	Feedlot from weaning to market (8 months)
Reduced-input	Dry beans with triticale cover crop, corn, sugar beets, corn	Synthetic fertilizer, herbicide, pesticide at precision rates; minimum tillage, maintain crop residue	Wheat: Synthetic herbicide, no fertilizer or tillage Fallow: No tillage, weeds controlled with herbicide	Crop residue and grass (10 months), feedlot (4 months)
Organic	Alfalfa/oats, alfalfa, corn, dry beans	Manure/compost fertilizer; tillage as needed for weeds, seed-bed preparation	Wheat: No fertilizer or herbicide Fallow: Tillage for weed control	Crop residue and grass (10 months), feedlot (3 months)

GROUNDWORK DATA

Data from the first year's study at SAREC indicate less soil disturbance, manure applications, and crop rotations with legumes enhance soil quality changes. Preliminary results from the **non-irrigated** experiment indicate reduced-input is most efficient to enhance soil organic matter building capacity and reduce carbon and nitrogen losses via greenhouse gases. Accumulating and evaluating several years of data before drawing conclusions is essential. The longer this experiment is conducted, the more valuable the outcomes will be to future researchers and producers.

For more information about this long-term research project, see page 23 in the 2012 *Reflections* magazine at bit.ly/reflections2012.



http://bit.ly/soilquality

Soil samples are taken in these 160-foot transects to determine soil ecology properties in each cropping system.

approaches, including the costs and techniques for efficiently transitioning to the alternative practices.

Measured parameters include:

1) soil biological, physical, and chemical properties;
2) soil hydraulic properties, moisture, and temperature;
3) weed, pathogen, arthropod, and nematode populations;
4) crop growth, yield, and quality;
5) livestock performance;
6) economic viability, and
7) marketing potential.

Second, results will be extended to producers, agricultural educators, consultants, and others. With these results serving as a reference point, researchers can work with producers to develop innovative new practices within each approach.

Finally, research components and strategies are incorporated into secondary, undergraduate, and graduate education.

Accumulating and evaluating several years of data before drawing conclusions is essential. As such, the longer this experiment is conducted, the more valuable the outcomes will be to future researchers and producers as seen at SAFS and CEFS.

Ideally, the SASP will become a permanent framework at SAREC, providing baseline information regarding conventional, reduced-input, and organic production approaches, and allowing producers to quantitatively assess the benefits and challenges of each system.

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College of Agriculture and Natural Resources

FEATURED OFFICE

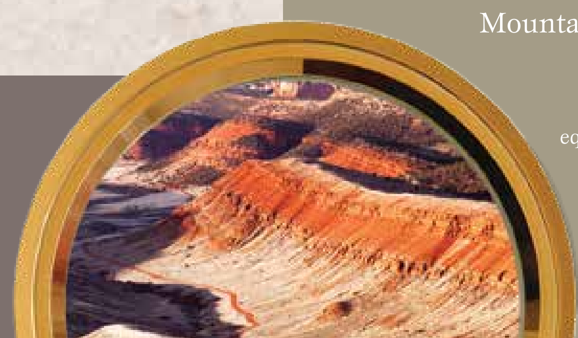
Members of the Laramie Research and Extension Center are, from left, Dave Lutterman, Dave Moore, Troy Burke, Casey Seals, Dale Hill, LREC director Doug Zalesky, Ryan Pendleton, Rod Rogers, Kristin Herman, Travis Smith, and Kalli Koepke.

Laramie Research and Extension Center

The Laramie Research and Extension Center (LREC), as part of the Wyoming Agricultural Experiment Station, comprises various units providing a wide range of facilities and animals for use by numerous disciplines. These units include the LREC greenhouse complex, the animal laboratory facilities at the Wyoming State Veterinary Laboratory, and the LREC Livestock Farm two miles west of Laramie. Included in the livestock farm complex are the swine, sheep, and beef units. Also at the livestock farm is the Cliff and Martha Hansen Livestock Teaching Arena. The mission of LREC is to provide opportunities in research, extension, and teaching for University of Wyoming faculty and staff members, students, and the people of Wyoming and others. Facilities and animals at LREC are utilized by numerous individuals to meet the mission of the College of Agriculture and Natural Resources and the University of Wyoming.

GO TO

http://multimedia.uwyo.edu/UWAG_STREAM/reflections2013/index.html for additional photographs not used in this edition and to interact with the online e-magazine.



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