COLLEGE OF AGRICULTURE AND NATURAL RESOURCES RESEARCH REPORT

REFLECTIONS

2017

FAR-RANGING RESEARCH

Whether your life is defined by Wyoming landscapes or city limit signs, our scientists seek solutions to important issues facing our state.

UW | University of Wyoming

REFLECTIONS

is published by the University of Wyoming College of Agriculture and Natural Resources.

Frank D. Galey — Dean

Bret W. Hess — Associate Dean and Director
Wyoming Agricultural Experiment Station

Joanne Newcomb — Administrative Associate
Wyoming Agricultural Experiment Station

Mark Stayton — Associate Dean and Director
Academic and Student Programs

Glen Whipple — Associate Dean and Director
UW Extension

Editor
Steven L. Miller — Senior Editor
Office of Communications and Technology

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

Departments

Agricultural and Applied Economics: (307) 766-2386

Animal Science: (307) 766-2224

Ecosystem Science and Management: (307) 766-2263

Family and Consumer Sciences: (307) 766-4145

Molecular Biology: (307) 766-3300

Plant Sciences: (307) 766-3103

Veterinary Sciences: (307) 766-9925

Please visit our website at
www.uwyo.edu/UWAG

Mountain West Farm Bureau Mutual Insurance Company

Supported in part by Mountain West Farm Bureau Endowment

Welcome to *Reflections*, the research magazine of the University of Wyoming's College of Agriculture and Natural Resources.

Associate Dean Bret Hess

The Wyoming Agricultural Experiment Station celebrated its 125th anniversary last year. This *Reflections* is a perfect way to start making the next 125 years as notable as the station's first 125 years.

Articles feature the breadth of research conducted by departments in our college. The 2017 edition includes one article from a representative chosen by each of the college's seven departments in addition to the top student article selected by a panel of judges. Readers can learn about the college's broad array of research while delving a little deeper into specific research topics.

Readers will learn about Wyoming's landscape and resource management in articles on the invasive weed species cheatgrass, adaptive management strategies for cattle ranchers, sage-grouse conservation strategies, brucellosis surveillance in the greater Yellowstone area, and non-lethal costs of livestock predators. Two of the articles are related to human health through understanding the complex mechanisms involved in determining a bacteria's anatomical features and exploring wildlife as potential reservoirs for food-borne pathogens. Another article points to the challenge of living in a geographically large state with an aging population demographic.

I hope readers are as impressed as I am with how the college's researchers are able to tackle complex problems relevant to Wyoming.

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

Best regards,

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

REFLECTIONS

YouTube *Search Wyoming Agricultural Experiment Station*

CHEATGRASS

Developing potent strategies to bridle a thief plundering green space

Cheatgrass slipped into the West and stole millions of productive acres from agricultural producers and outdoor enthusiasts – then dares us to resist

Brian Mealor
Sheridan Research and Extension Center, Department of Plant Sciences

Slade Franklin
Weed and Pest Coordinator Wyoming Department of Agriculture

The Ecology of Cheatgrass video

At the time it felt as though we could just as easily have been asked to put a genie back in a bottle.

"How can we get ahead of the cheatgrass problem at the state level?" from the Governor's Subcabinet for Energy and Natural Resources was not a question our small group of cooperators (see "Importance" page 7) had really anticipated needing to answer.

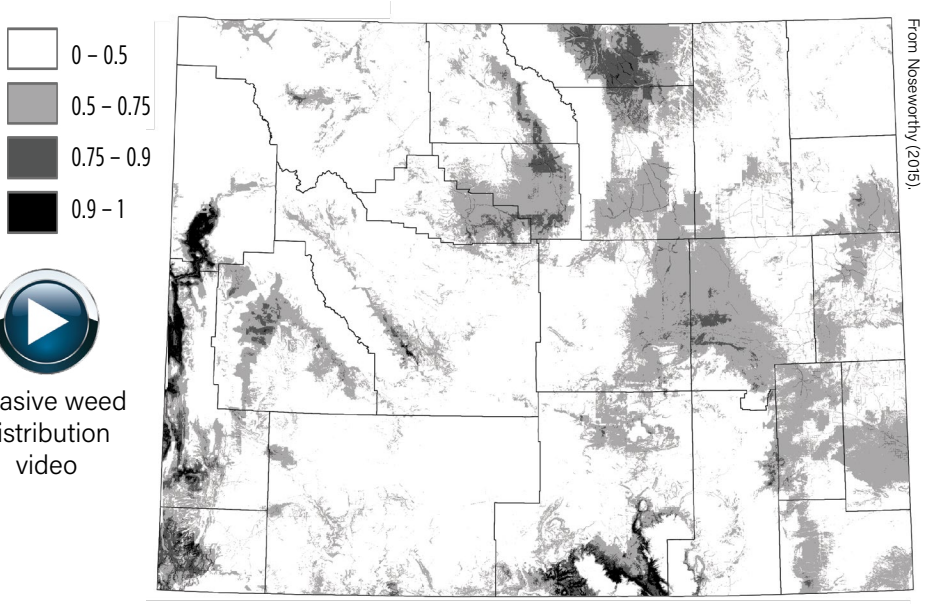
Cheatgrass (*Bromus tectorum* or downy brome) is one of the worst invasive weeds in the western U.S., largely because of its ability to change the way an ecosystem functions, leading to a host of impacts: reduced forage quality, increased fire frequency, reduced species diversity, altered nutrient cycling ... the list goes on.

When one begins to pull the thread of how serious those impacts are to our part of the country, the cloth quickly becomes a tangled mess. Livestock operators in the Great Basin to Wyoming's west make many management decisions around cheatgrass. Efforts to control cheatgrass-fueled fires, especially at the urban-wildland interface, have cost taxpayers millions of dollars. Non-native annual grasses, primarily cheatgrass, are one of the leading drivers of habitat deterioration for the greater sage-grouse, which has been a focus of vast conservation efforts in our region.

Cheatgrass has been in Wyoming since the early 1900s. The prevailing sentiment in ecological literature, until fairly recently,

CHEATGRASS IMPACT NICHE

(probability of >50% cheatgrass cover)



Invasive weed distribution video

Figure 1. Cheatgrass impact niche (probability of greater than 50 percent cover) for Wyoming.

had been our elevation and climate would limit distribution and impact.

By the early 2000s, many natural resource professionals suggested cheatgrass was so widespread in Wyoming we should simply learn to manage the invasive as part of the system.

What is the reality?

Under these uncertainties we began to think through an approach to address the question posed by the Governor's Subcabinet for Energy and Natural Resources.

We proposed a strategic approach with several over-arching steps:

1) Gain more certainty about the current and potential distribution and impacts of cheatgrass and other invasive grasses in Wyoming,

2) Couple the distribution and threat data with information on other important resource concerns (such as sage-grouse habitat) to prioritize sites for their probability of successful management and to characterize appropriate management tactics for each site, and

3) Evaluate management tactics across a range of conditions to recommend actions to take at various locations.

This "Wyoming Invasive Grass Initiative" forms the basis of a decision-making process driven by scientific information and cooperation among multiple partners.

Understanding Distribution and Threat

To better understand the current and potential distribution of cheatgrass in Wyoming, graduate student Cara Noseworthy (now with the U.S. Forest Service in Montana) worked with partners to compile

WHAT MAKES CHEATGRASS SUCH A PROBLEM?

As an annual plant, cheatgrass depends on production of live seed to sustain its population from year to year – and it is very good at producing seed. Cheatgrass can produce over 400 pounds of seeds per acre. Small plants, reduced in overall growth by mowing, grazing, or drought, usually still produce several viable seeds to perpetuate the plant on a given site.

The annual growth habit makes a single plant easy to control – simply pull it up, and the plant is dead because there are no persistent roots from which new shoots can grow. However, it is capable of growing in very high densities across large acreages (Figure 1). Hand-pulling is not viable in rangelands.

The challenge of managing cheatgrass and restoring more desirable vegetation to infested sites was considered nearly impossible as early as the 1940s. More detailed information on cheatgrass biology, ecology, and management is here: bit.ly/managecheatgrass

Cara Noseworthy photo

Figure 2. Cheatgrass infestation in south-central Wyoming.

HITCHING A RIDE

Cheatgrass arrived in the U.S. like our many immigrant forebears – by ship. See bit.ly/hitchingaride – and at least one deliberate introduction for a college experiment in Pullman, Washington, in 1898.

This species was first identified in the United States in 1861 in New York and Pennsylvania. It now grows throughout the United States, including Hawaii and Alaska. For more cheatgrass information, also see bit.ly/bromustectorum.

existing cheatgrass distribution data and survey thousands of points across Wyoming for abundance of cheatgrass and other invasive grasses.

She combined the distribution information with other spatial data (soils, precipitation, wildfires, roads, etc.) to develop a model that assesses potential for cheatgrass to become dominant (comprise more than 50 percent of plant cover) on locations around the state (Figure 1). This model is now allowing us to focus on important areas with appropriate tactics based on risk of cheatgrass impacts.

Right Thing, Right Place, Right Time

By matching appropriate management tactics to the given situation, we hope to optimize efforts for the best possible results – the impact model above helps us make those decisions. For example, areas with high susceptibility to cheatgrass impact, but currently low cheatgrass populations, provide good opportunities to prevent introduction and aggressively manage small populations before they expand.

Other invasives video

One of the ongoing challenges is to understand the effectiveness of management actions in different situations.

Cheatgrass contamination in native plant seed used for reclamation is a large concern (Figure 3) in areas where vegetation has been disturbed (by energy development, wildfires, etc.) and reseeding is needed.

Graduate student William Rose (now with the Wyoming Office of State Lands and Investments) explored using biological differences to remove cheatgrass seed from native grass seed lots. He found exposing seed lots to moisture and cold temperatures followed by a drying period kills a large portion of cheatgrass seeds while retaining viability in some native grasses – potentially leading to less cheatgrass unintentionally planted on sites being seeded with native species.

We are continuing research like this in hopes of cheatgrass-free reclamation seed for the future. Noseworthy evaluated using

photo by William Rose

Figure 3. Cheatgrass seed (with awns) and bluebunch wheatgrass seed.

high-intensity, short-duration grazing to reduce cheatgrass on a highly degraded site. Over two years of heavy spring grazing, cheatgrass seed production was reduced by roughly 50 percent while one application of the herbicide rimsulfuron nearly eliminated seed production for two years.

Graduate student Clay Wood is working to identify thresholds that will help managers realize opportunities to improve cheatgrass management. His team has collected detailed data at four sites in Wyoming across a range of cheatgrass abundances prior to and after large-scale aerial herbicide applications (Figure 4).

Preliminary analyses from two sites suggest treatment of low-density cheatgrass stands may not provide as much benefit on a given site than treatment of moderate-density stands. We anticipate that cheatgrass control alone (without seeding desirable species) of very high-density cheatgrass areas may not provide meaningful improvement of the perennial plant community. This research is ongoing and updates can be found in the Wyoming Agricultural Experiment Station annual field days bulletins.

Putting the Pieces Together

Eradication, or complete removal, of cheatgrass from rangelands is not a viable option for many reasons. By increasing our understanding of which management actions provide the greatest benefits of removing cheatgrass and increasing desirable plants across a range of settings in Wyoming, the Wyoming Invasive Grass Initiative will enable resource managers to make informed decisions to optimize effectiveness.

Hopefully, we will be able to limit the negative impacts of cheatgrass, and other invasive annual grasses, on Wyoming's natural resources into the future.

To contact: **Mealor** *can be reached at (307) 673-2856 or at* ***bamealor@uwyo.edu****, and Franklin at (307) 777-6585 or* ***slade.franklin@wyo.gov****.*

Figure 4. Graduate research assistant Clay Wood and Wyoming Game and Fish Department terrestrial habitat biologist Katie Cheesebrough collecting Vegetation near Saratoga.

Data gathering tools video

IMPORTANCE OF PARTNERSHIP

From its inception, the Wyoming Invasive Grass Initiative has been a cooperative effort that has depended upon support, both financial and hands-on, from all our partners including, but not limited to: Wyoming Department of Agriculture, Wyoming Weed and Pest Council (and all the districts), Wyoming Office of State Lands and Investments, Wyoming Game and Fish, Wyoming Governor's Office, Wyoming State Forestry, Wyoming Wildlife and Natural Resources Trust, The Nature Conservancy, Bureau of Land Management, U.S. Forest Service, Wyoming Infrastructure Authority, Wyoming State Parks, Dow Agrosciences, DuPont Corporation, Willbur-Ellis, Thunder Basin Grassland Prairie Ecosystem Association, AgTerra, Wyoming Army National Guard, U.S. Fish and Wildlife Service, and the following UW units: Department of Plant Sciences, Wyoming Agricultural Experiment Station, Wyoming Reclamation and Restoration Center, and UW Extension.

WE CORRALLED OUR COMPUTERS, BRANDED THEM "SOUTHEAST WYOMING RANCH" & WEANED SOME SURPRISING RESULTS

John Ritten
Associate Professor

Christopher Bastian
Professor
Department of Agricultural and Applied Economics,

Justin Derner
Research Leader
USDA Agricultural Research Service – Cheyenne

Retaining calves as separate stocker enterprises can improve profits 23 percent over long haul

Mother Nature's Precipitation Department seems more closed than open in Wyoming over the years.

A line showing the state's annual precipitation over the years displays the peaks and valleys of an erratic EKG. Overlay that onto a chart of the up-and-down cattle market prices and they merge to paint a picture worthy of kindergartners drawing outside the lines.

Simple enterprise budgets (listing all estimated income and expenses of a business to estimate profits) can't accurately present the losses in profitability, so we created a model southeastern Wyoming ranch to examine how profits are affected over time as herd numbers fluctuate with prices and variable precipitation influences annual forage productivity.

We drew from long-term research at the USDA Agricultural Research Service High Plains Grasslands Research Station near Cheyenne. The information yielded data on forage and livestock production in response to growing season weather conditions.

Economic Returns and Precipitation Patterns

We estimated economic returns given historical precipitation patterns across a suite of price cycles over a number of 35-year periods. That research indicates April–June precipitation is a good predictor of forage production and livestock performance.

Our representative ranch has a land base for southeastern Wyoming given acreage estimates collected from USDA surveys. The ranch has 1,385 privately owned acres, with access to just over 300 Animal Unit Months (AUMs) on public land. An AUM is how much forage a 1,000-pound cow with calf would eat in one month – about 26 pounds of forage per day.

We compared outcomes from historical precipitation data to a scenario where growing season precipitation was average in all years. This shows how growing season precipitation variability affects ranch profits.

Our model results reveal profitability is overestimated by 81 percent over a 35-year horizon if a ranch planned for average weather every year instead of the actual fluctuations.

Why did this happen? Destocking during dry years (especially when prices are unfavorable), coupled with the production lag associated with rebuilding through retention, reduces profitability.

Adding a Stocker Enterprise

Dry years hurt profitably by liquidating breeding stock (or purchasing additional feed), and the ranch can lose sales in subsequent years while herd numbers are rebuilt. Ranches also can lose out in wet years due to the inability to rapidly increase stocking to take advantage of additional grass. Quickly adjusting cow numbers is unfeasible when additional forage is available if keeping heifers to retain herd genetics.

However, profitability can be increased if steer calves are retained as a separate stocker enterprise (to provide flexibility in the operation). Buying and adding calves when there is extra forage available can improve long-term profitability by over 23 percent.

Not every year is profitable, regardless of strategy. Even in the absence of droughts, cattle price cycles caused roughly 8 percent of years to be unprofitable. This number nearly doubles when including growing season weather effects on herd dynamics (Table 1).

Our results become more impressive in the face of more extreme weather. For example, what happens to ranch profitability if growing season precipitation amounts over the 35-year

Table 1. Probability of Annual Returns Less than $0

Static Weather Cow/Calf	Historical Weather Cow/Calf	Historical Weather Cow/Calf/Yearling
8.8%	15.7%	13.7%

horizon remain the same, but the variability is increased by 25 percent? Cow/calf operations could expect profits to drop by an additional 20 percent with increased growing season precipitation variability. However, ranches that add a stocker operation would increase long-term profitability under increased weather variability by 35 percent compared to cow/calf only operations.

Being better able to match forage availability with forage demand is the biggest reason for the increased profits from adding yearlings to a cow-calf operation.

For example, optimal cowherd numbers decrease by 50 percent when actual growing season precipitation is used in the model over the 35 years compared to the scenario using average precipitation across all years. This decrease in optimal cow numbers for our ranch is because replacement only occurs from within the herd, and cow numbers rarely have time to fully recover post-drought before liquidation begins again in response to the next drought/extended dry period.

Stocker Strategy

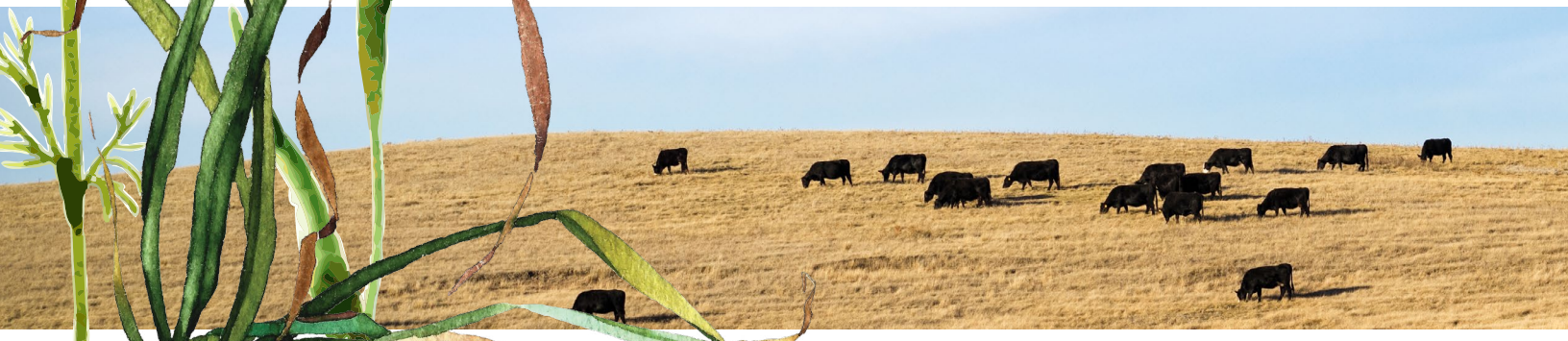
Using stockers as a flex strategy allows a more timely response to effectively match forage demand with forage availability. Adding a stocker enterprise to the cow-calf operation will result in a smaller herd of cows compared to the average cow-calf operation, but this cowherd is more stable over time, lessening impacts of liquidating herd genetics. Total animal units supported by the ranch actually increases by 23 percent on average.

Adding stockers allows the ranch to better match forage demand to

WHAT WE FOUND

Understanding the variable nature of cattle prices and forage production is important to making better long-term planning decisions. One way to reduce risk and increase long-term profitability is to diversify the cow-calf ranch enterprise by retaining steer calves.

Our results suggest adding yearlings to an operation can allow a ranch to better adapt to Mother Nature's variability and the related changes in forage supplies. This strategy can help stabilize cow numbers across years, enhancing long-term sustainability of the herd genetics.



availability. This translates into opportunities to utilize "extra" forage in good years while minimizing overuse in bad years. The second benefit is the ranch has a more stable number of cows. This benefits ranchers by not having to liquidate valuable herd genetics in drought years.

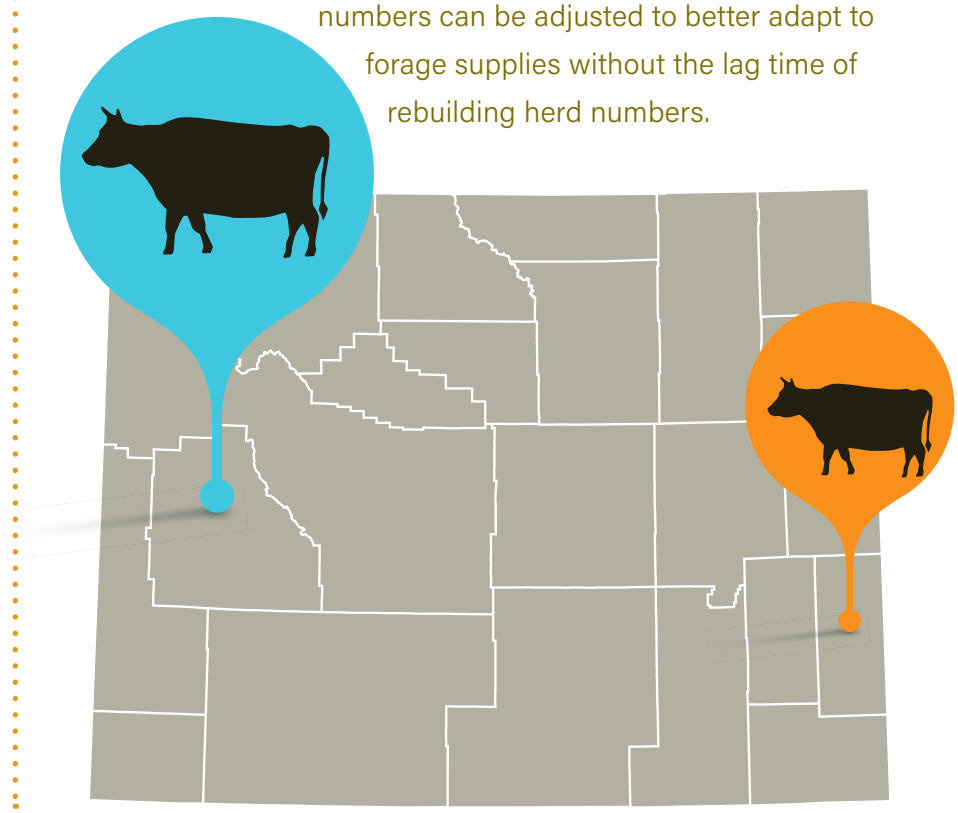
Of course, a stocker strategy does not always perform better than simply having a cow-calf operation. There will be some years a ranch with a stocker strategy is not as profitable as a ranch that solely sells calves. However, the ranch that does have stockers will be in a better profit position most years.

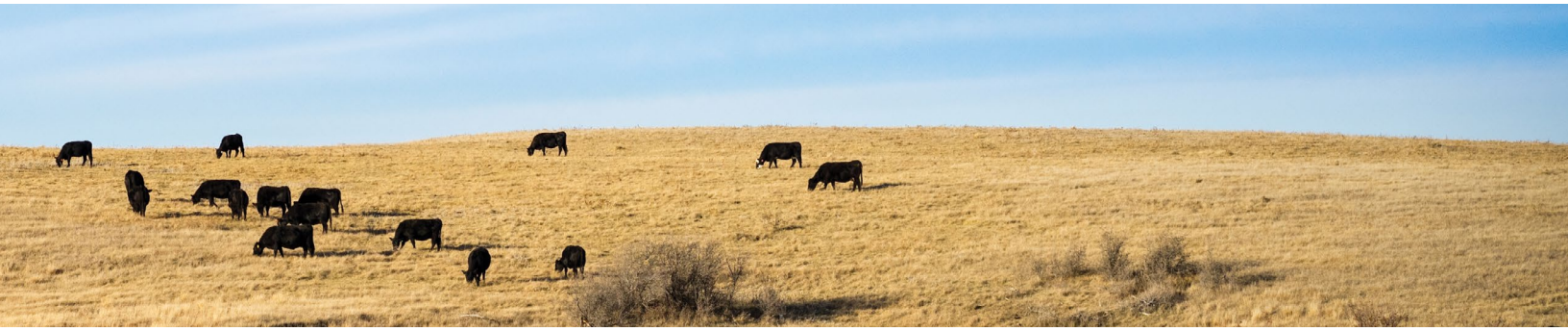
Understanding that some ranches may have increased costs associated with adding a stocker strategy is important. For example, additional labor (checking, herd health) and infrastructure (equipment, corrals/fencing) costs may be incurred with yearlings; however, the increase in returns over time should more than cover these costs.

To contact: **Ritten** *can be reached at (307) 766-3373 or* ***john.ritten@uwyo.edu****; Bastian at (307) 766-4377 or* ***bastian@uwyo.edu****; and Derner at (307) 772-2433 or* ***justin.derner@ars.usda.gov****.*

WESTERN PROFIT PUNCH

Our research modeled a representative ranch in southeast Wyoming. Results are even more impressive when looking at a representative ranch in western Wyoming. For a ranch over 1,000 acres, and with over 4,000 AUMs of leases, adding a stocker operation from retained steers increased the long-term profitability of the ranch by 50 percent. Western ranches tend to have more animals with more public land available for summer forage. Many animals can be carried in the good moisture summers with adequate forage, and numbers can be adjusted to better adapt to forage supplies without the lag time of rebuilding herd numbers.





CUTTING-EDGE TECH
traces food contamination to its sources

Bledar Bisha
Assistant Professor
Department of Animal Science

Molecular sleuthing helps determine how wildlife spread foodborne illnesses

Wildlife are becoming increasingly recognized for their ability to contaminate food with foodborne pathogens via fecal shedding or indirectly through contamination of water, feed, and soil.

About 75 percent of all infectious diseases originate in one way or another from wildlife, and 26 percent of human pathogens are capable of infecting wild and domestic animals. Both wild and domestic animals may serve as hosts for foodborne pathogens associated with wildlife, with incidence and prevalence affected by a variety of factors, including proximity to livestock operations or urban areas, weather, and geographical location.

Moreover, wildlife are recognized as carriers and/or hosts of antimicrobial resistant (AMR) bacteria and genes and can serve to spread these across agricultural operations.

Our studies couple ecosystem-level understanding of the wildlife-agricultural interface with cutting-edge laboratory analyses to determine the wildlife-associated foodborne pathogen problem (especially AMR).

Tracking AMR

We have focused on characterizing the extent of the AMR problem by determining the prevalence and distribution of AMR in specific wildlife carriers, food animals, feed, water, and the environment, to profile AMR emergence, evaluate transmission dynamics, and for identifying mitigation points for wildlife managers and producers.

Our research relies on extensive collaboration with research partners from UW and other institutions, especially those at the USDA National Wildlife Research Center in Fort Collins, Colorado.

We assessed the antimicrobial susceptibilities of AMR indicator bacteria collected from concentrated animal feeding operation-associated wildlife (from five different concentrated animal feeding operations [CAFOs]) with similar bacteria from the CAFO environment, emphasizing the detection of several types of resistances deemed important by the Centers for Disease Control and Prevention (CDC).

We used *Escherichia coli* and *Enterococcus* sp. as AMR indicators,

since they serve as reservoirs of antimicrobial resistant genes and can transfer these genes to pathogenic bacteria.

A combination of culture testing with more advanced methods such as mass spectrometry and whole genome sequencing (WGS) were used to isolate, identify, and characterize the target bacteria. Mass spectrometry in the form of matrix assisted laser desorption ionization-time of flight mass spectrometry (MALDI-TOF MS) detects primarily ribosomal proteins of bacteria and utilizes a spectral database for rapid, high throughput, and inexpensive identification of bacterial isolates (see Obtaining Isolates page 14).

WGS is based on next-generation sequencing techniques (short read, massively parallel sequencing) and reveals the total genetic makeup of a microorganism to identify specific organisms, but more importantly to determine genetic relatedness of these isolates with an unprecedented discriminatory power, allowing us to determine sources and dynamics of transmission of foodborne pathogens in the wildlife-livestock-environment interface.

Rebellious Bacteria

We found ample correlation between AMR in cattle or the environment and associated wildlife. Most isolates displayed resistance to multiple antibiotics, including some important antibiotic classes. For example, *E. coli* showed resistance to cephem antibiotics (considered by the CDC as a "Serious Threat" for the treatment of extended spectrum beta-lactamase producing *Enterobacteriaceae*).

Multiple wildlife species were included (via fecal samples) in this study, including coyotes, kangaroo rats, house mice, deer mice, raccoons, European starlings, and other species

Figure 1. Raccoons trapped on a concentrated animal feeding operation

WHAT IS THE PROBLEM?

Major foodborne pathogens cause an estimated 9.4 million illnesses, 56,000 hospitalizations, and 1,400 deaths each year in the U.S. at an estimated annual cost of $77 billion.

Unspecified disease agents are to blame for an additional 38.4 million illnesses linked to the consumption of tainted food, with 72,000 hospitalizations and slightly fewer than 1,400 deaths annually.

Viral agents seem to cause the highest number of illnesses, and bacterial foodborne illnesses are estimated to cause the largest number of deaths.

So why do we still experience foodborne illness at this magnitude in the United States and the developed world in general?

We certainly claim (and rightfully so) we have one of the world's safest food supplies. Yet we can't seem to eliminate foodborne illness.

There are many factors, including changes in demographics (such as increased numbers of immunocompromised individuals), changes in food consumption patterns, and increased complexity of the food production chain; however, the multitude of potential sources of food contamination is an important reason for the persistence of foodborne illness.

Figure 2. Raccoon in a tree next to a concentrated animal feeding operation

in conjunction with sampling of cattle and environment.

When deposited fecal samples were insufficient or could not be identified, wildlife were trapped (See Figure 1), and fecal material extracted via rectal swabs or fecal loops.

A separate story emerges by sampling different species of wildlife. Small mammals, which usually reside in the farm environment, are more likely to maintain AMR bacteria and genes within agricultural facilities, but larger mammals such as raccoons (See Figure 2) can travel longer distances and may contribute to the dissemination of AMR across agricultural landscapes.

Similarly, avian wildlife (especially migratory birds) are more likely to contribute to dissemination of AMR over long distances. Even though overall prevalence of pathogens may be low, since these birds visit farms in high numbers (often as high as 50,000 at a time for European starlings), the potential for contamination through deposited feces becomes very real (See Figures 3 and 4).

The story is not always so clear-cut.

In a study we conducted in the San Louis Valley, Colorado, we looked at wildlife's role in contaminating produce fields with the foodborne pathogens *Salmonella enterica*, *E. coli* STEC (pathogenic strains producing powerful toxins) or noroviruses with limited success. Even though we documented ample evidence of wildlife regularly entering the produce fields (See Figure 5), we did not isolate any of the target pathogens. The limited intensive animal agriculture in the region, the large distance from produce fields, composition of wildlife species, and other factors were determined to have played a role.

Why does this all matter?

Our work provides producers and regulatory agencies the tools and information to develop mitigation strategies to reduce the threat of wildlife-mediated dissemination of foodborne pathogens and AMR bacteria. Further, our targeted "One Health" approach helps maintain wildlife biodiversity and limit potential scorched earth farm practices, which use indiscriminant methods to prevent wildlife farm and field intrusions.

To contact: **Bisha** *can be reached at (307) 766-3140 or* ***bbisha@uwyo.edu***.

OBTAINING ISOLATES

The laser's intense heat supercharges molecules, which are then analyzed by the mass spectrometer.

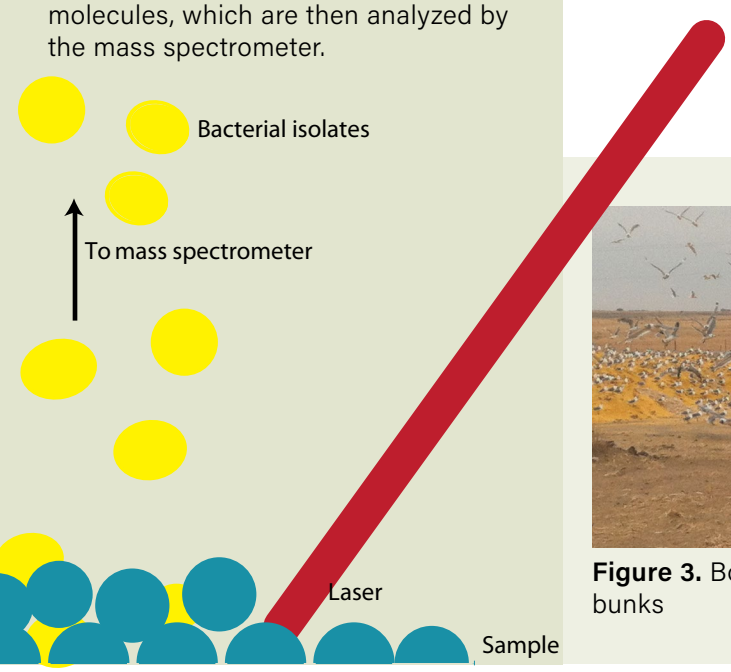


Figure 3. Bonaparte gulls in feed bunks

Figure 4. Starling feces on feed bunk on a CAFO

Figure 5. Wildlife visitation in produce fields

Fox tracks in a field

Rabbit trapped in hay bale wind break along edge of produce field

Antelope bedded down on edge of produce field

NO MAGIC BULLET

Wildlife incursions into industrialized livestock production, specifically concentrated animal feeding operations (CAFOs), could perpetuate antimicrobial resistant bacteria (AMR), because these facilities are recognized as agricultural foci of AMR.

Antibiotic use in animal production, which has been identified as the sector where the largest portion of antibiotics are utilized in the United States, has been singled out as a contributor of AMR throughout microbial ecosystems even as the practice of using antibiotics for growth promotion is scheduled to be phased out soon.

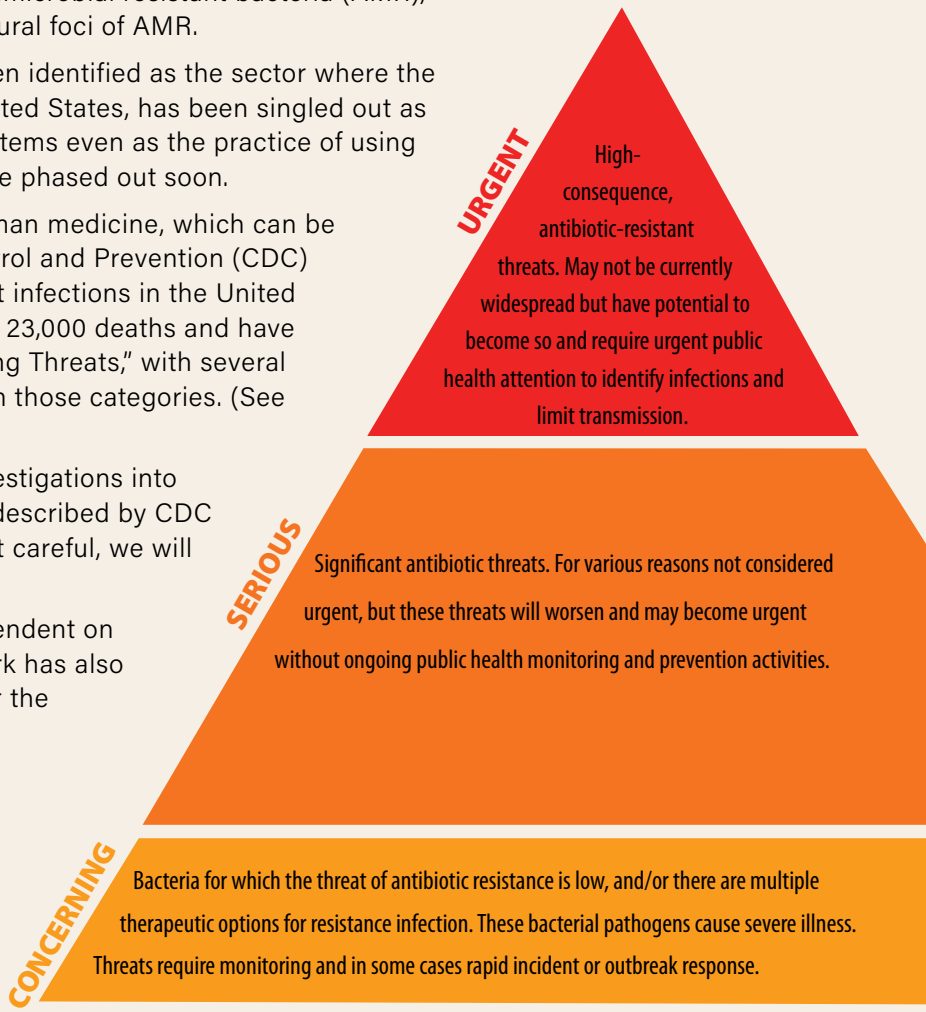
Certain antibiotics are used in agriculture and human medicine, which can be a cause for concern. The Centers for Disease Control and Prevention (CDC) estimates annual illnesses with antibiotic-resistant infections in the United States at over 2 million people resulting in at least 23,000 deaths and have classified AMR as "Urgent, Serious, and Concerning Threats," with several foodborne or potentially foodborne agents listed in those categories. (See right for details).

The potential consequences of not prioritizing investigations into AMR research and surveillance are perhaps best described by CDC director Dr. Tom Frieden, who states, "If we are not careful, we will soon be in a post-antibiotic era."

AMR in the food chain has been shown to be dependent on antibiotic use in primary production, but other work has also indicated AMR can persist in agriculture long after the selective pressure is removed.

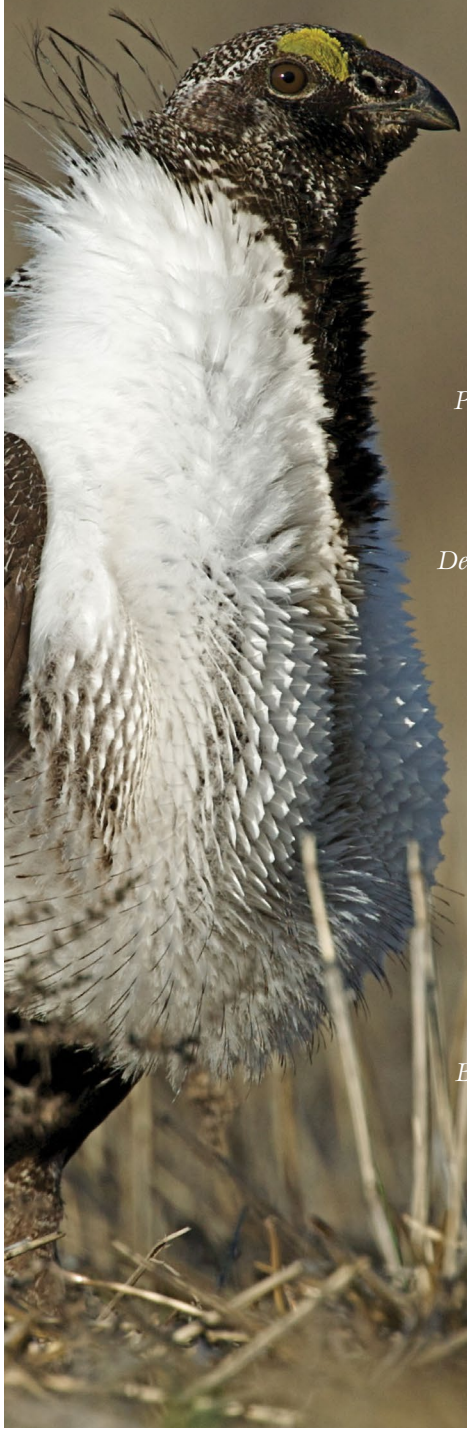
What does that tell us?

There is no magic bullet solution. Only a holistic approach that takes into account the close connections between human activity, food animal operations, wildlife, and environment and how these components affect the maintenance and dissemination of microorganisms can be successful in addressing these issues.



Is Wyoming's SAGE-GROUSE core area strategy successful?

Unknown until now, numbers show whether or not sage-grouse and other species benefitted from state's action limiting development in core areas



Jeffrey Beck
Associate Professor

Kurt Smith
Postdoctoral Research Associate

Jonathan Dinkins
Former Postdoctoral Research Associate
Department of Ecosystem Science and Management,

R. Scott Gamo
Former Ecosystem Science and Management Ph.D. student
Wyoming Game and Fish Department,

Andrew Gregory
Assistant Professor

Emma Spence
Former Master's Student
School of Earth, Environment and Society
Bowling Green State University

Some conservationists consider Wyoming's Sage-grouse Core Area Strategy the largest experiment in species conservation ever undertaken.

Our laboratory with funding from the Wyoming Legislature has evaluated the effectiveness of the core area strategy created in 2008 for sage-grouse and conservation of other wildlife. We found some aspects of the strategy effective and other aspects that need modification to be effective.

Multiple layers of regulations influenced by seasonal requirements of sage-grouse underlie a complicated landscape for study. Our work suggests:

- The program has met the goal of providing habitat to at least 67 percent of male sage-grouse attending leks;
- That it is most effective for breeding habitat; and
- That smaller core areas provide less protection to sage-grouse in winter than larger core areas.

The 31 core areas encompass approximately a quarter (about 15.5 million acres) of Wyoming's surface area. The areas were intended to protect at least 67 percent of

the breeding population of greater sage-grouse (*Centrocercus urophasianus*; see male grouse in lek photo) statewide, which includes the Powder River Basin and Wyoming Basin (see Figure 1 for management zones [MZ]).

In spring 2010, the U.S. Fish and Wildlife Service (USFWS) concluded greater sage-grouse were warranted protection under the Endangered Species Act of 1973 but precluded them from listing because threats were moderate and did not occur equally across their range.

Fast forward to fall 2015 – the USFWS determined greater sage-grouse no longer warranted listing, noting the rigorous plans in place in Wyoming and other states to conserve sage-grouse and their habitats.

So What Changed?

Energy development disturbance is one of the primary threats in Wyoming and other portions of the sage-grouse's eastern range. In 2008, then-Governor Dave Freudenthal created the Wyoming Governor's Sage-grouse Executive Order (SGEO) in response to concerns about listing the greater sage-grouse as a threatened or endangered species and its impact on Wyoming's economy.

The sage-grouse implementation team identified core areas and established regulatory protections to limit disturbance to grouse. The strategy limits development around leks, where most sage-grouse activity occurs.

Governor Matt Mead adopted the SGEO in 2011, and it has been embraced by state and federal land and wildlife agencies throughout Wyoming.

Disturbances such as well pads are limited to no more than 1 per 640 acres (on average). Surface disturbances are restricted to no more than 5 percent (of a square mile). Surface disturbing activities are precluded during breeding (March 15–June 30) and winter (December 1–March 14) seasons.

Little has been done to evaluate the strategy's effectiveness.

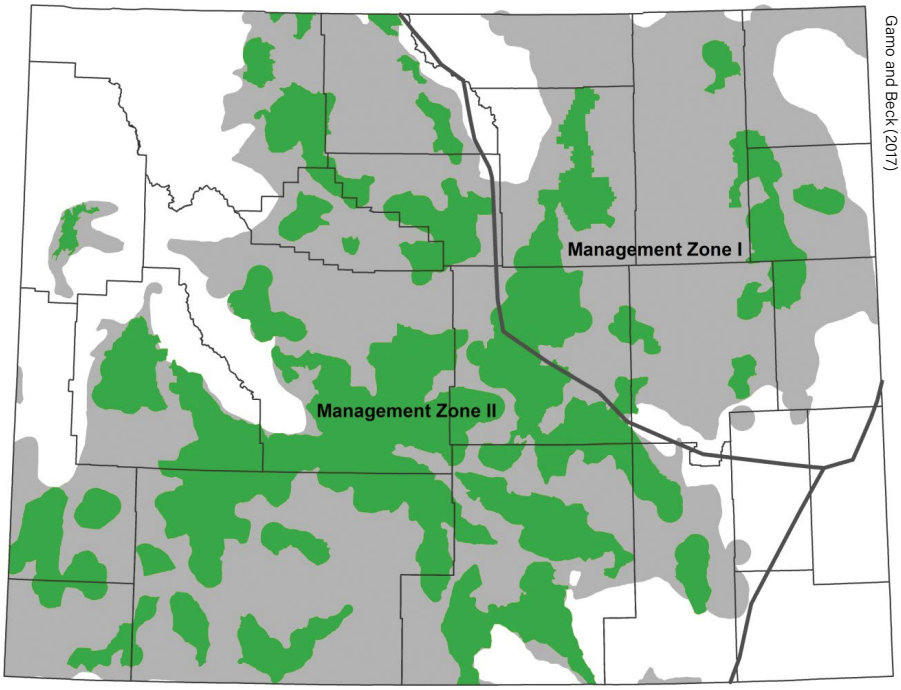


Figure 1. Core population areas (green-shaded areas; gray-shaded areas represent sage-grouse range where non-core sage-grouse populations occur) within Western Association of Fish and Wildlife Agencies Management Zones I and II in Wyoming.

Core Area Constraints

Core areas were established where energy development was historically limited. These areas arguably served as *de facto* core areas before SGEO establishment in 2008; however, one way to evaluate the effectiveness of the core area policy is whether the rate of energy development has remained lower within core areas compared to non-core areas since policy implementation.

Using active well pads as a surrogate for energy infrastructure, we found well pads in non-core areas, as opposed to core areas within the statewide sage-grouse range, increased at a ratio of 29 non-core pads to 1 core pad per year – 48 to 1 in MZ I, and 15 to 1 in MZ II from 1986–2014.

The rate of increase in well pads statewide and in MZ II did not differ from before compared to after SGEO implementation. In MZ I, the rate of increase in well pads before was less than after core area designation.

Conserving Sage-grouse Breeding Habitat

Breeding habitat includes areas for leks, nesting, and brood-rearing. Wyoming core areas included about 66 percent of active leks and about 83 percent of male sage-grouse attending leks from 1999-2013. As expected, the probability of lek collapse was higher

Photo courtesy of C. P. Kirol

A male sage-grouse displaying at a lek, or strutting ground, in Carbon County, Wyoming.

WYOMING'S SAGE-GROUSE BY THE NUMBERS

77% Wyoming has about 62 million acres. Of this, about 48 million (77 percent) was historic range for sage-grouse

24 percent of the state has been designated as "core" habitat for sage-grouse

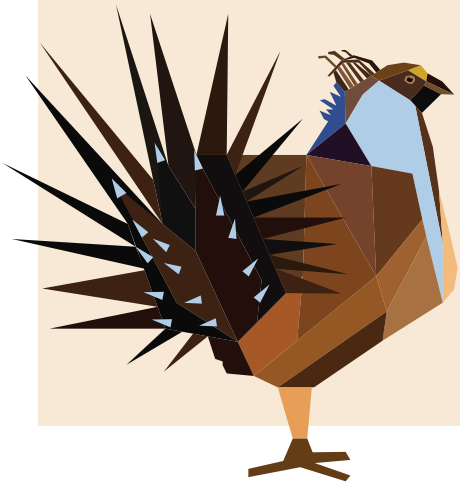
24%

90 percent (43 million acres) of historic habitat in Wyoming is still occupied as compared to 56 percent of range-wide habitat

90%

82 percent of Wyoming's breeding population of sage-grouse displayed on leks in core areas at implementation in 2008

82%



Wyoming habitats are generally more intact/continuous than in other states with sage-grouse populations

outside of core areas from 2001-2013. Probability of lek collapse was 10.9 percent in core areas and 20.4 percent outside core areas.

During the same period, well density as far as 3 miles outside core area boundaries was related to the probability of collapse among leks greater than 3 miles from inside core area boundaries (Figure 2).

Results indicate lek attendance in core areas was more stable and resilient to changing environmental conditions from 1997-2014 (Figure 4). We found quality of microhabitat within about 33 feet of 924 sage-grouse nests did not differ inside or outside core areas (see nest photo above).

We found the risk of mortality for sage-grouse broods in the Atlantic Rim of south-central Wyoming increased dramatically after 5 percent surface disturbance, providing support for the SGEO regulation of no more than 5 percent surface disturbance in core areas (Figure 3).

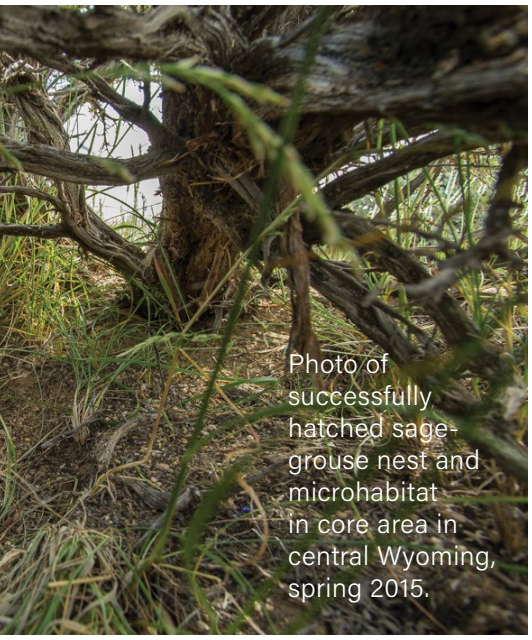
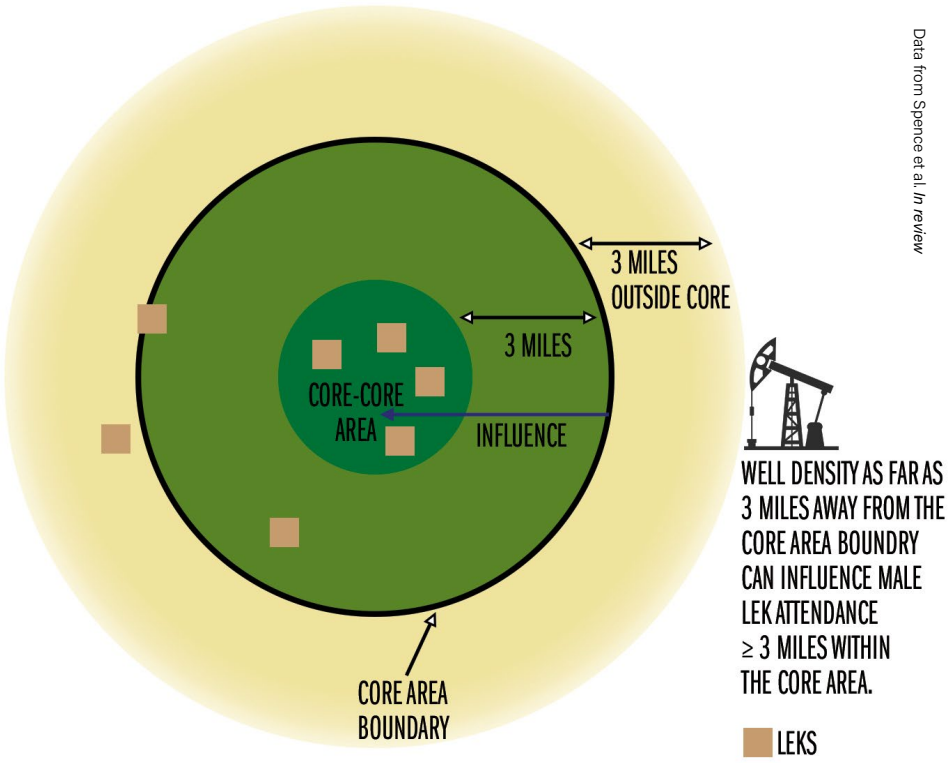


Photo courtesy of © Noppadol Paothong.

Photo of successfully hatched sage-grouse nest and microhabitat in core area in central Wyoming, spring 2015.



Data from Spence et al. *In review*

Figure 2. Density of well pads as much as 3 miles outside core areas influenced lek attendance of male sage-grouse as much as 3 miles inside core areas from 2001–2013.

Conserving Sage-grouse Winter Habitat

Data from central Wyoming and the Bighorn Basin indicate large core areas protect more summer and winter habitat than smaller core areas. This result was unknown due to shape and size of core areas and differences between summer and winter habitat. We found sage-grouse on winter ranges sooner and longer than the winter and spring periods set by the SGEO. Sage-grouse in our study areas were on winter ranges in early to late October and stayed until March 21, so the December 1 to March 14 range is not broad enough to reduce disturbance to wintering sage-grouse and should begin earlier. However, the breeding and brood rearing policy provision begins March 15, which does extend wintering sage-grouse protection.

Female sage-grouse wintering in core areas had lower mortality risk compared to females that wintered outside core areas or for females in summer/fall inside or outside core areas (Figure 4).

Mary Ellen (Mel) Harte, Bugwood.org

Conclusions

Energy development has remained limited in core areas since Wyoming's conservation strategy was implemented in 2008. Core areas met the

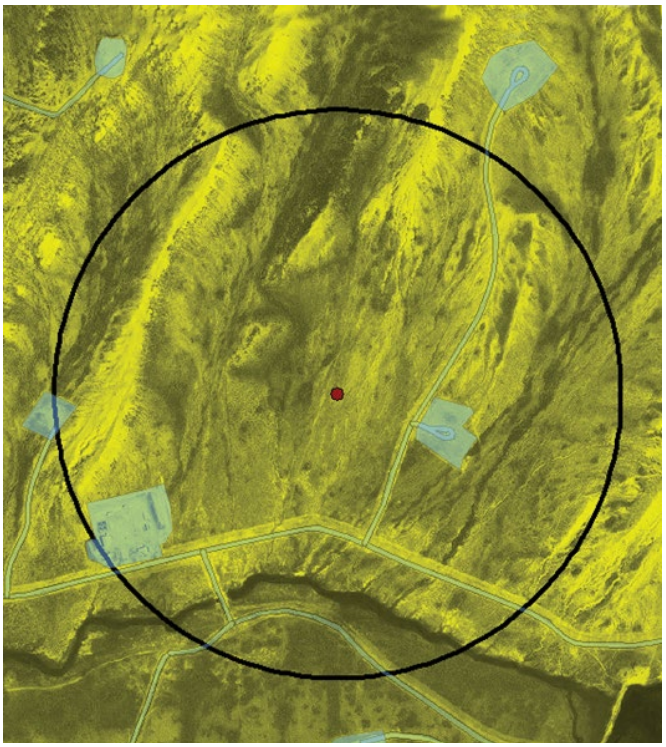
SAGE-GROUSE STUDIES

Our research evaluated whether the Wyoming core area strategy was specifically effective in:

- Constraining energy development in core areas,
- Conserving sage-grouse breeding habitat,
- Conserving sage-grouse winter habitat, and
- Enhancing conservation for other species.

UNIQUE TO THE WEST

See bit.ly/greatersagefacts for facts, figures, charts, and maps about this bird that is the largest grouse species in North America. Wyoming has the most birds of the 11 states and two Canadian provinces that have sage-grouse populations. The U.S. Fish and Wildlife Service estimates 200,000-500,000 birds across the distribution area.



Data from Kirol et al. (2015)

Figure 3. Aerial image depicting 5 percent surface disturbance around a brood-rearing location (red point at center of image) within a 1.0-km^2 area (black circle).

FOR MORE INFORMATION

Go to bit.ly/beckpublications and click on "Peer-Refereed Journal Articles" to see more articles about this research and other topics.

goal of providing habitat to at least two-thirds of male sage-grouse attending leks in Wyoming after implementation of the Wyoming SGEO in 2008.

- **Lek collapse** was about half as likely in core areas versus non-core areas. Boundary effects as far as 3 miles outside core area borders influenced male lek attendance at least 3 miles inside core areas from 2001-2013.
- **Quality of nesting microhabitat** was not different inside and outside core areas, suggesting landscape factors at larger spatial scales influenced sage-grouse populations inside core areas.
- **Smaller core areas** provided less protection to sage-grouse in winter than larger core areas. Female sage-grouse wintering inside core areas were predicted to have the lowest risk of mortality.

Collectively, these data suggest the core area strategy is most effective for breeding habitat; however, additional evaluation of development densities adjacent to core areas may be worth considering to further protect breeding populations.

Better at Summer Protection

Earlier research across several study areas in Wyoming support our findings that core areas are best at protecting summer compared to winter grouse habitat. While the December 1-March 14 winter timing restriction combined with the March 15-June 30 restriction for sage-grouse provides protections for wintering grouse, additional winter protections should be considered where

Data from Dinkins et al. In review

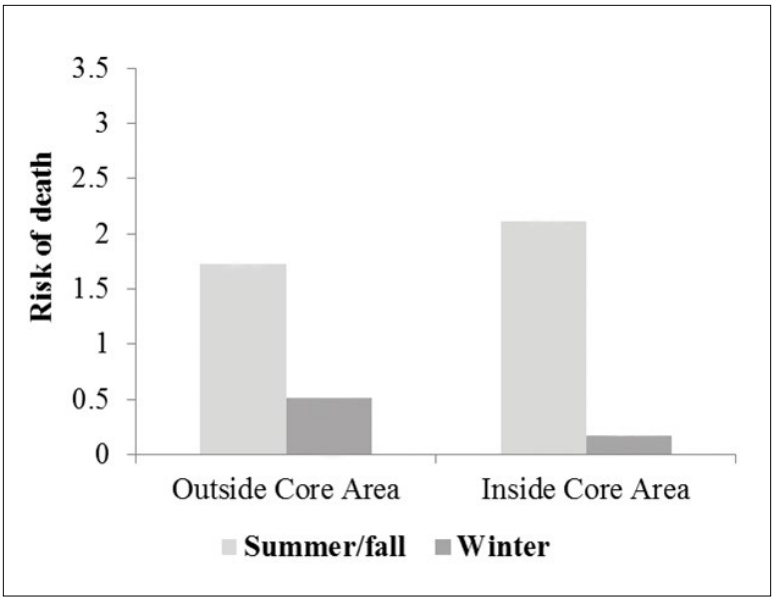


Figure 4. Predicted risk of death for 374 sage-grouse females from 2008-2015. Females inside core areas in winter had the lowest risk of mortality of any season inside or outside core areas.

sage-grouse winter outside core areas to protect these grouse from disturbance.

Finally, our example case study for mule deer fawn:female ratios in Wyoming (right) suggests core areas extend benefits to other species within the umbrella of conservation measures for sage-grouse.

To contact: Beck *may be contacted at (307) 766-6683 or jlbeck@uwyo.edu*

From Gamo et al. (2013) – *The Wildlife Professional*

SAGE-GROUSE CORE AREAS PROVIDE UMBRELLA EFFECT FOR OTHER SPECIES

Sagebrush provides habitat to approximately 350 vertebrate wildlife species in Wyoming during at least a portion of each year.

Thirty-percent of the 180 Species of Greatest Conservation Need (species whose conservation status warrants increased management attention and funding, as well as consideration in conservation, land use, and development planning. See list at bit.ly/wyoswap) in Wyoming are associated with sagebrush habitats.

Sage-grouse have been proposed as an umbrella species, or a species for which conservation measures fulfill a surrogate role in protecting other species that share the same landscape.

One of these species is the mule deer, (*Odocoileus hemionus*), where 33 percent of crucial winter range is encompassed within sage-grouse core areas. An important question is whether species such as mule deer perform better in core areas. Wyoming Game and Fish Department considers 0.66 or more fawns per 1 adult female indicative of a growing mule deer population. We found mule deer fawn-to-female ratios increased above 0.66 when hunt areas included at least 70 percent core areas from 1995–2013.

Matching elder needs to accessible services may keep GOLDEN YEARS from losing luster

Bernard Steinman, Ph.D.
Assistant Professor,
Family and Consumer Science,

Christine McKibbin, Ph.D.
Director
Wyoming Center on Aging,

Shannon Albeke, Ph.D.
Research Scientist
Wyoming Geographic Information Science Center

An older person may likely say they prefer to stay in their homes as long as possible if asked about their desired living situation as they age.

Aging at home – where memories reside and being near family, friends, and a familiar community environment is important – can influence quality of life.

Changes during aging can reduce the "fit" between an individual's abilities and home environment. Declining physical and cognitive function can make maintaining a cherished homestead difficult or impossible, unless environments are adapted and resources are available to address the changing needs of the individual.

Aging in place – the current buzz-term for a person living in a residence of their choice for as long as they are able – encompasses the spirit of a statewide and national movement that recognizes the social and fiscal benefits of staying in the home.

Older adults can live more fulfilling lives and reduce the strain on state finances if resource providers and agencies design and modify environments to meet specific needs of Wyoming's older adults and

Older adults who want to age in place should note if their locations intersect with needed services and resources.

supplementing environmental changes with programs and services that support independence.

Demographic Changes are Afoot

Communities are seeing a growing population that is older and living longer.

In Wyoming, about 18 percent of the population was aged 60 or older by 2010, and by all accounts, the trend toward an aging population is expected to continue for several decades as Baby Boomers join the ranks of older adults.

Sizeable numbers of Wyoming households have one or more persons aged 60 years and older. Many older individuals live alone, placing them at greater risk for more negative outcomes.

Wyoming shares these demographic trends with many other regions, but the state is unique due to the wide variety of landscapes and the population distribution. Wyoming's residents live in an expansive environment with widely dispersed cities and towns across the state's 97,093 square miles, and the population is small compared to other states.

These realities often create unique challenges for older adults, policy makers, and service providers who strive to deliver programs and services within this setting.

One challenge is ensuring older adults have optimal access to resources that target their age groups. Program planners attempt to make the most efficient use of resources by placing programs and services where there is the greatest need and avoiding duplicate services in the same region.

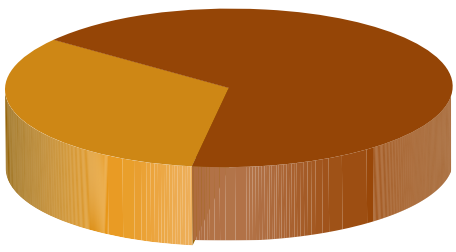
To be effective, program planners must have an accurate sense of where older adults reside and where programs and services exist.

An Atlas of Resources Targeting Wyoming's Older Adults

To better understand and characterize Wyoming's older adult population and the services available, a UW Department of Family and Consumer Sciences faculty member collaborated with the Wyoming Center on Aging and the Wyoming Geographic Information Science Center to systematically create an atlas of resources targeting Wyoming's older adults (bit.ly/wyoageatlas).

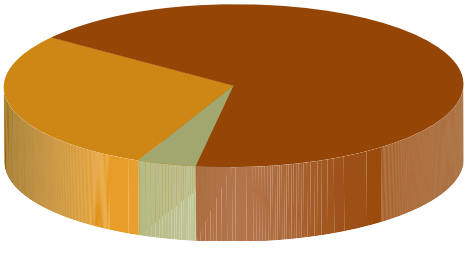
This report, funded by the Wyoming Department of Health Aging Division, includes a demographic profile of the state's older adults and a series of maps showing the distribution of specific resources available in Wyoming for older adults within the context of municipal- and county-level demographic structures.

U.S. Census Bureau population estimates for Wyoming's 23 counties and 204 cities, towns, and unincorporated areas were used to show the distribution of older residents across the state. A database of known



At least one family member 60+ 33%

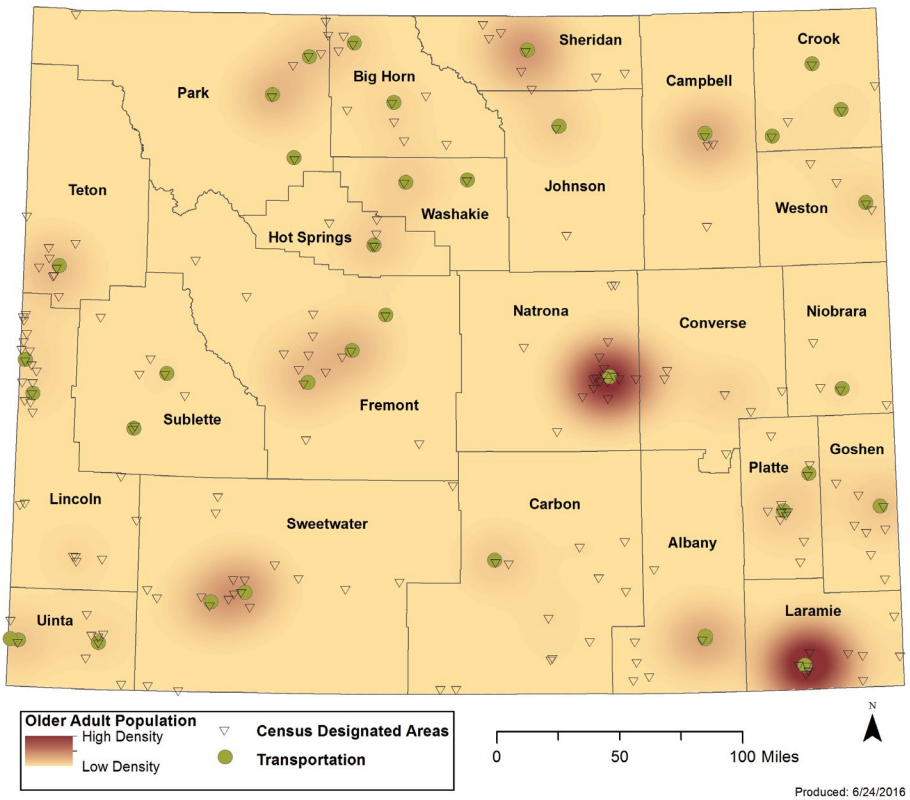
All members under 60 67%



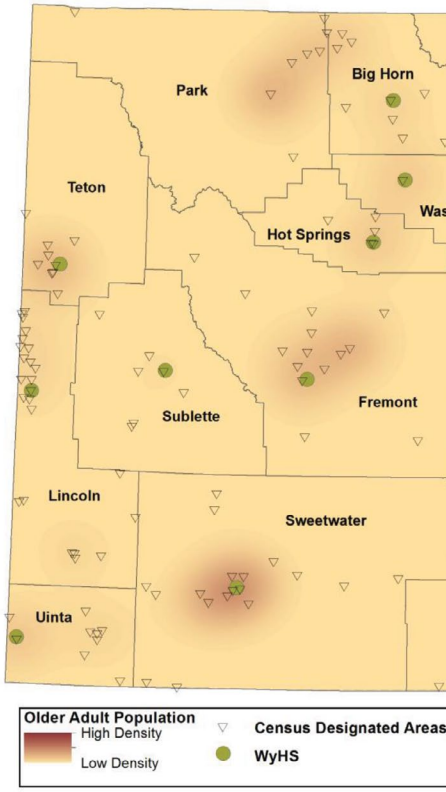
Lives alone 29%

Group quarters 4%

Lives with others 67%



Most people in Wyoming live within 20 miles of the state's 51 transportation service providers for older adults.



Distribution of 23 Wyoming Home Services providers in relation to the population density of older adults living in the state

resources, including transportation, housing, and social services targeting Wyoming's older adults, was developed and mapped on top of population distributions.

Facilitating Aging in Place Transportation

Regardless of age, most Americans require reliable transportation to support high quality of life and independence. Transportation options promote aging in place by providing individuals with access to work or volunteer activities, goods and amenities, and healthful social engagement with others in their communities.

Many Americans drive themselves in personal automobiles, but for many older adults, continued driving may become unsafe. When adequate transportation options are not available in communities, isolation and poorer social and health outcomes may result, reducing quality of life.

There are 51 transportation service providers for older residents throughout the state – at least one in each county. Most (74 percent) populated areas are within 20 miles of the nearest transportation services. Nevertheless, restricted service areas, as well as limited routes and schedules, are likely to limit access for many older residents in extreme rural parts of the state.

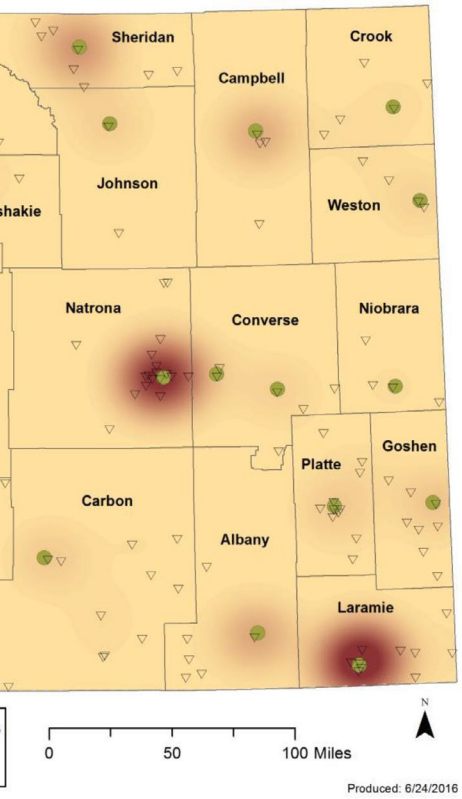
Housing Options

Access to a continuum of housing options designed to address changing circumstances is important to be able to age in place. Housing options that combine shelter and services, such as boarding homes, independent living, and assisted living facilities, can improve prospects of many older residents who can no longer maintain their homes and help them remain independent and engaged in their communities.

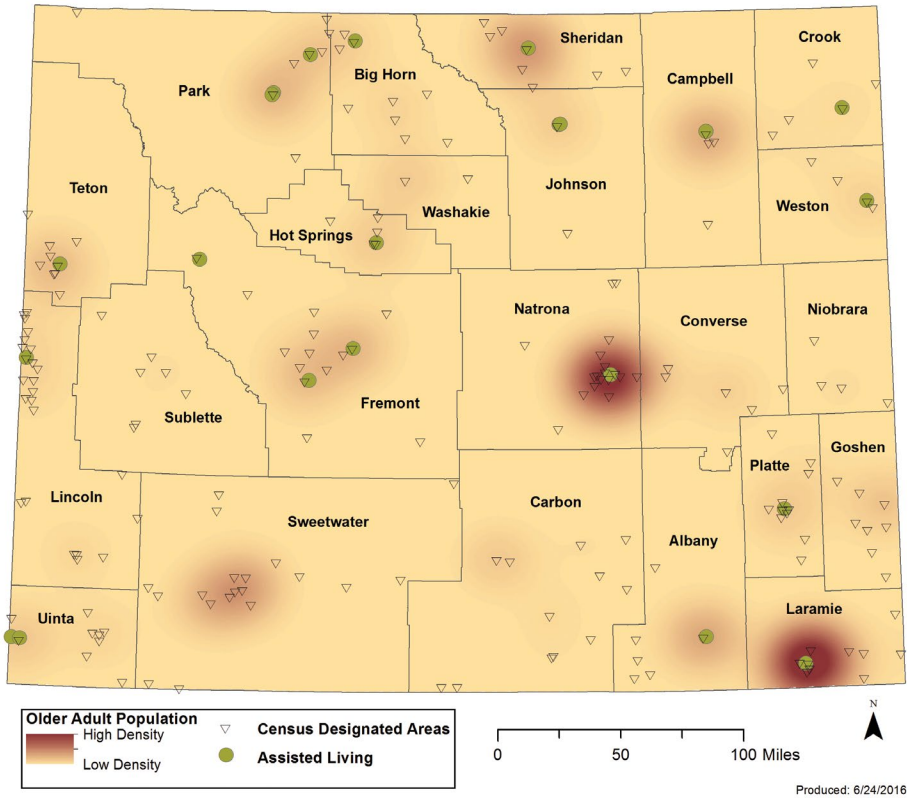
Good-quality nursing homes in the local community can assist older residents, who may be too sick or frail to live independently, to remain close to families and friends while receiving care.

Unfortunately, many counties in Wyoming still lack adequate housing options to meet the diverse needs of the older population. There are only 27 independent living facilities and 30 assisted living facilities throughout the state, and the majority of the state's older residents live greater than 20 miles from these facilities.

As a result, many older Wyoming residents may need to relocate against their wishes to new communities where their health and service needs can be met.



and the state's Census Designated Area. A CDA is a concentration of population defined by the Census Bureau for statistical purposes



Distribution of the state's 30 assisted living facilities in relation to the population densities of older adults in the state.

Human Services

Communities must also ensure older adults have access to a variety of home and community-based human services, as well as public and commercial amenities. Many older adults, particularly those who have mobility difficulties or who can no longer drive, may benefit from medical and social services that can be delivered directly to their homes.

Programs and agencies that connect older residents with affordable assistance for doing housework, and which provide learning opportunities, exercise programs, and social activities, can be instrumental in helping community members remain active, engaged, and independent.

As early as 2016, there were 23 Wyoming Home Services providers that helped older adults at risk of entering nursing homes. Sixty-six senior centers exist throughout the state to provide a mixed array of health and social services to local older adults. Most Wyoming residents live within 20 miles of these service providers.

Mapping team members, from left, Bernard Steinman, family and consumer sciences; Shannon Albeke, Samantha Lee Ewers, Teal Wyckoff, Wyoming Geographic Information Science Center; and Kadi Lee Cooley and Tad Johnson, Wyoming Center on Aging.

The Future of Aging in Wyoming

Like most places in the United States, Wyoming is expected to see unprecedented growth in the number and proportions of older adults, likely straining resources. Living situations and access to resources varies greatly across the state, adding to challenges associated with serving older residents, and planning for needs in the future. These circumstances mandate a continuing search for innovative ways to address the many needs of a dispersed and aging population. Seeking a better understanding of how older Wyoming residents live best starts this process.

To contact: **Steinman** *can be reached at (307) 766-5688 or* ***bsteinm1@uwyo.edu****.*

Bacteria, rubber duckies, & PopZ

1. Get some rubber ducks (a LOT of rubber ducks)
2. Toss them in a pool
3. Let them bob around
4. Toss in an organizer named PopZ and you'll see how order emerges from chaos, and how living things are organized at the microscopic scale.

Grant Bowman
Assistant Professor, Department of Molecular Biology

Bacteria are the simplest life forms on planet Earth. They have 1/600th as much DNA as humans, they produce a much smaller variety of proteins and other biomolecules, and their body size is smaller by about a million fold.

Being simple provides a great advantage: duplication is fast and easy. One bacterial cell and its progeny can repeatedly divide to produce ten billion cells in less than a day, whereas the human population has required tens of thousands of years to approach that number of individuals.

And yet even bacteria can't be TOO simple. Their survival and proliferation depends upon some complex features they share with their human counterparts (Figure 1). One is anatomical organization. Just as humans have dedicated anatomical features for actions like movement and reproduction, bacterial cells have comparable structures that perform the same types of functions.

Multicellularity is another feature shared with more complex organisms. For many bacteria, cell division produces two very different daughter cells that play distinct roles in that species' strategy for survival and proliferation.

Even the simplest cells on the planet produce specialized parts placed in discrete locations. My laboratory research asks how such anatomical features are created.

Much Bobbing and Bumping

To understand the challenges a bacterial cell faces in constructing discrete structures:

Imagine it as a swimming pool that contains about 1.5 million rubber duckies, all floating so closely together they continually bump into each other (as in Figure 2). Each of the ducks represents an individual protein, and their number and density approximates the typical conditions in a bacterial cell.

Now imagine there are about 2,500 different kinds of duckies. This represents the number of different types of proteins in a cell. The pool is somewhat wavy, and the duckies are making frequent contact and exchanging positions. This represents the random movement and collisions of particles inside the cell. Without some kind of system for rubber ducky organization, the pool would be a chaotic mixture.

Now imagine programming the duckies with rules that determine whether one type of ducky will stick to another. For example, duckies with eye patches will stick to duckies with red hats, and they will remain together for a few seconds before parting and going their separate ways. Other duckies might prefer to stick to the sides of the pool. These rules approximate interactions that occur between proteins in real cells. Anatomical features like those discussed in Figure 1 would include hundreds or thousands of proteins of many different types. The

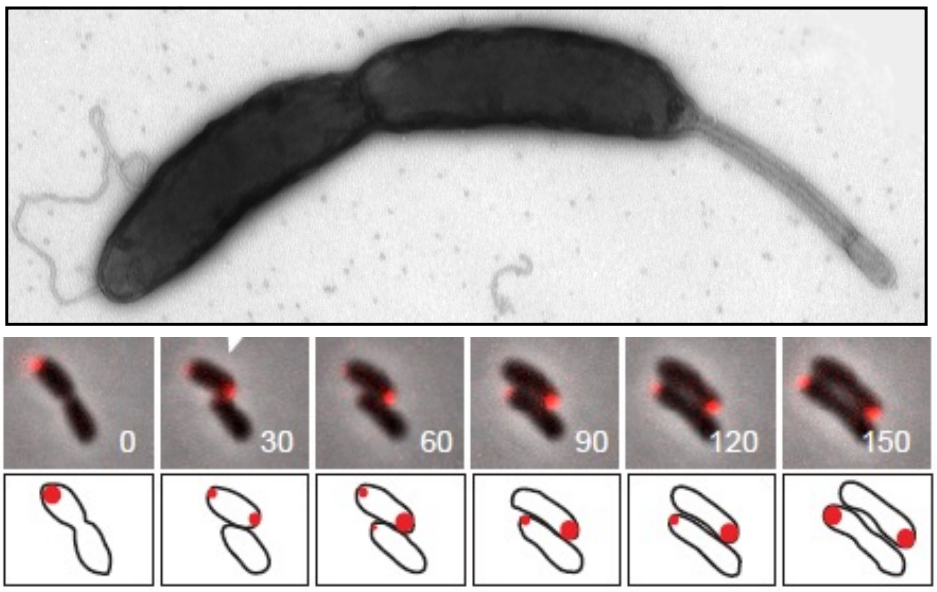


Figure 1. (Top Panel) The ends of rod-shaped *Caulobacter crescentus* cells exhibit distinct anatomical features. One end has a flagellum that rotates like a propeller to move the cell through water. The other end has a stalk, which includes an adhesive material that will anchor the cell to a fixed surface. This cell will soon divide through the middle to produce two daughter cells. The behavior of the daughter cells is determined by their external anatomies as well as internal regulatory factors (not shown), which activate distinct patterns of gene expression. (Bottom Panel) Two different cell types are produced in this time-lapse sequence of cell division in *Agrobacterium tumefaciens*. Here, an anatomical feature is labeled by a red fluorescent indicator, which marks the location of an organizing protein called PopZ.

Figure 2.

challenge is to devise a system of rules that will produce these multicomponent structures.

PopZ, the Great Organizer

Our research is revealing that anatomical features in *Caulobacter crescentus*, *Agrobacterium tumefaciens*, and other bacteria are produced with the aid of an organizing protein called PopZ. This protein has a fascinating combination of properties that give it organizing capabilities: it interacts with itself to form a loosely connected network, and it also interacts with certain other "guest" proteins to bring them into the network.

Through biochemical experiments and microscopic observation, we are learning the organizing effect of PopZ depends upon the interactions among PopZ molecules being weak. Returning to the ducky analogy, weak interactions among PopZ duckies make temporary gaps that allow other types of duckies to enter the crowd. Those that have no particular affinity for PopZ duckies pass through the crowd relatively quickly, while those that can stick to PopZ duckies pass much more slowly (Figure 3).

Even if individual interactions between the "guest" duckies and PopZ duckies are short-lived, the large number of PopZ duckies in the crowd provides a large number of temporary interactions. This has the effect of concentrating sticky "guest" duckies within the PopZ crowd.

For contrast, imagine a pool in which interactions between PopZ duckies are strong and long lasting. This would create a tightly packed PopZ crowd and prevent the incorporation of other types of duckies. Alternatively, if interactions between PopZ and other types of duckies were very strong, this would reduce the amount of time for interactions between PopZ duckies and disrupt the formation of the PopZ crowd.

Strong Organization, Weak Interaction

Thus, our model has a surprising implication: that organization occurs most easily when interactions between duckies are weak, not strong. The success of weakness over strength seems counterintuitive until one considers the model, especially considering the chaotic movements of the duckies in the pool.

As this is my laboratory's working model of cell organization, a number of major questions must still be addressed. A meaningful way to advance beyond the rubber ducky model is to understand more about the molecular structure of PopZ, both when interacting with itself and when interacting with other proteins.

Our data suggests PopZ interacts with itself and other proteins through the same interface, and that structural disorder provides the flexibility needed for interactions with multiple partners. An important remaining question is whether increasing structural flexibility has corresponding effects on reducing binding strength and longevity.

Cancer Connections

We know structurally disordered binding proteins exist in humans, and it is interesting to note these types of proteins are mutated in most human cancers, and that cancer cells are quite disorganized. While it is unlikely that rubber duckies kissing has ever been used to discuss such serious subject matter, there is a chance this could happen.

To contact: Bowman *can be reached at (307) 766-2147 or at* ***grant.bowman@uwyo.edu***.

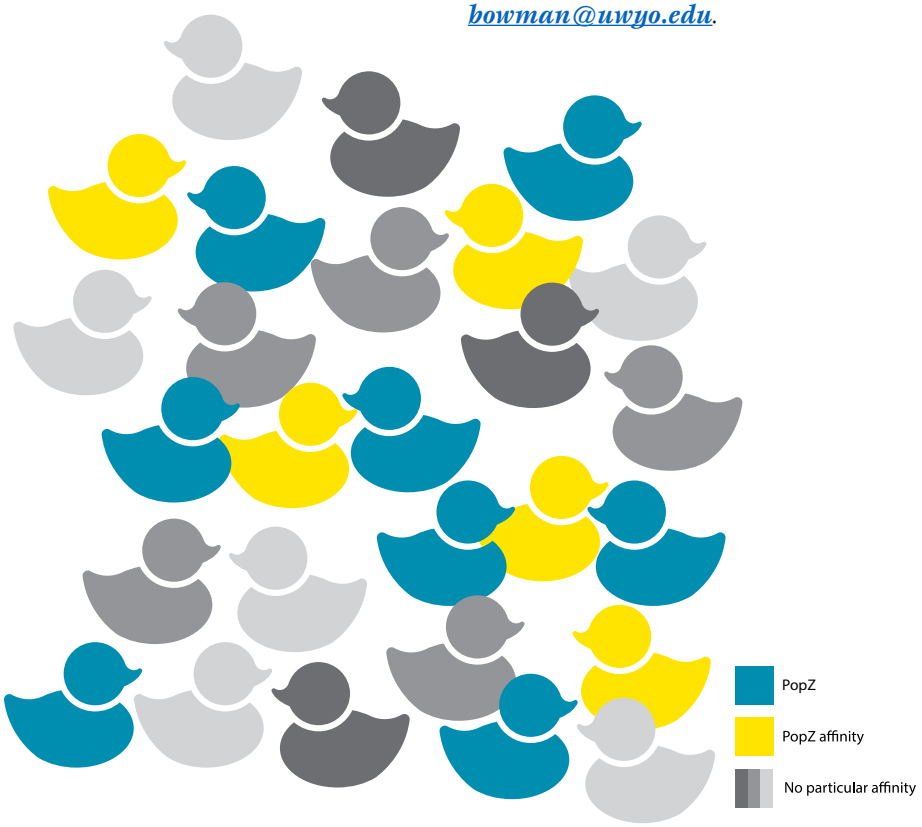
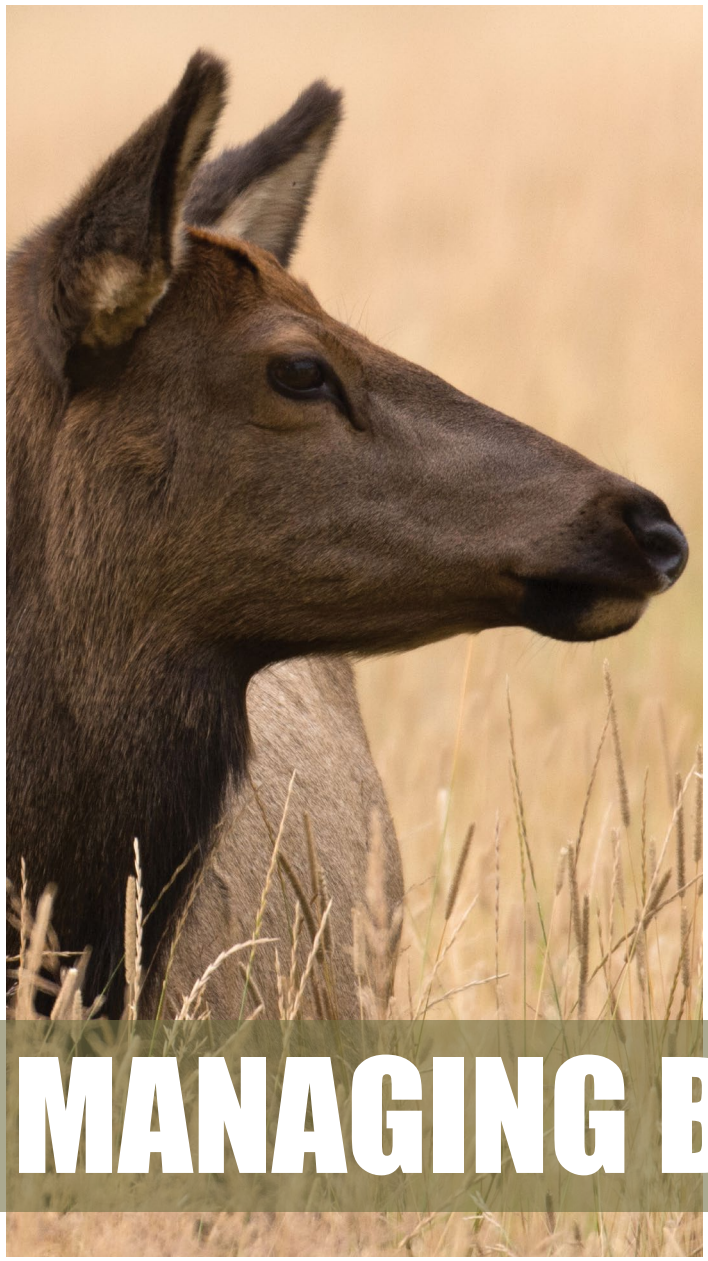
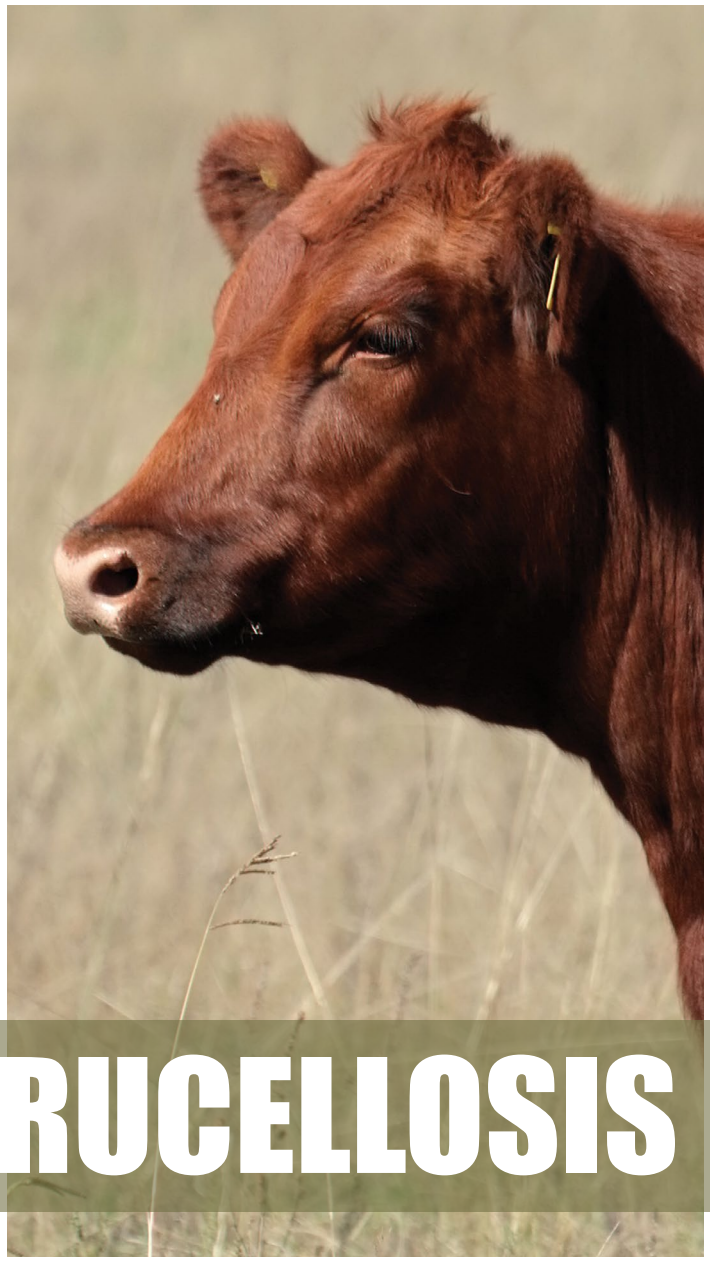


Figure 3. Weak interactions between PopZ duckies allow temporary gaps that let other types of duckies enter the crowd; duckies with little affinity for PopZ pass through quickly while those that can stick to PopZ pass more slowly.





MANAGING BRUCELLOSIS

in wildlife costs more than expected benefits

Brant Schumaker
Associate Professor
Wyoming State Veterinary Laboratory
Department of Veterinary Sciences,
Dannele Peck
Former Associate Professor
Department of Agricultural and Applied Economics,
Mandy Kauffman
Western Ecosystems Technology, Inc.,
Noah Hull
Graduate Students
Department of Veterinary Sciences,
Kari Boroff
Graduate Student
Department of Agricultural and Applied Economics

Researchers at the University of Wyoming in 2016 published two articles in the journal *Preventive Veterinary Medicine* about the efficiency of efforts to manage brucellosis in free-ranging elk, which are primarily responsible for transmission of brucellosis to domestic livestock.

This unique project harnessed the local knowledge of livestock producers in the Greater Yellowstone Area (GYA) to understand where cattle spend their time and whether elk were observed in proximity to their cattle during the late winter and early spring when brucellosis transmission is most likely.

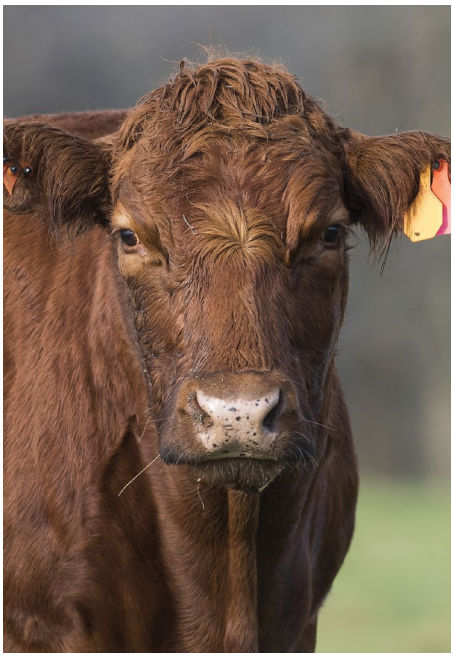
This information was used to model the risk of brucellosis being transmitted from elk to cattle at a coarse geographic scale. While modeling efforts did not employ high-tech GPS collars to locate wild animals on the landscape, they were able to evaluate which landscape features were most descriptive in explaining where cattle-elk overlap is likely to occur.

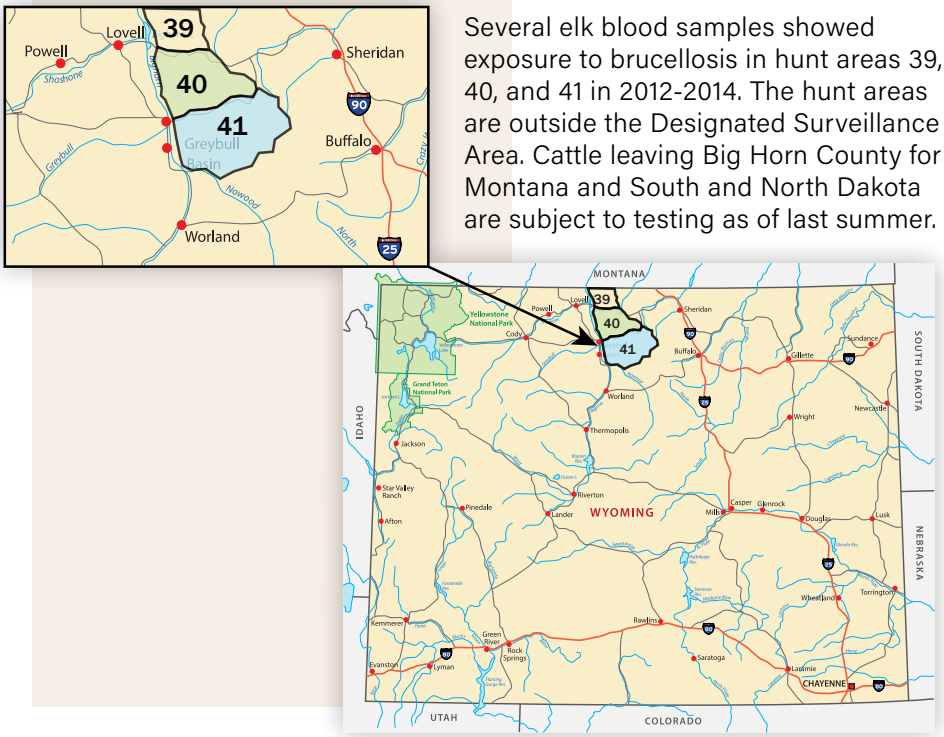
High Probability Conditions

Characteristics of areas where conditions are suitable for elk-cattle overlap:

- Far from roads
- Far from forest edges with wolves present
- Higher slopes
- Lower hunter density
- Where feedgrounds are either nearby and/or easily accessible or where they are distant or difficult to access due to topography

The landscape model helps us figure out how many elk may be in contact with cattle, but then we need to estimate how many infectious events could be occurring. To do this we used the model to estimate the risk of brucellosis in specific elk herd units under current management. The results indicate ongoing brucellosis management practices are at least somewhat effective in preventing transmission in these areas. The model was also used to simulate the benefits and costs of different management activities used to lower brucellosis levels in elk.





Several elk blood samples showed exposure to brucellosis in hunt areas 39, 40, and 41 in 2012-2014. The hunt areas are outside the Designated Surveillance Area. Cattle leaving Big Horn County for Montana and South and North Dakota are subject to testing as of last summer.

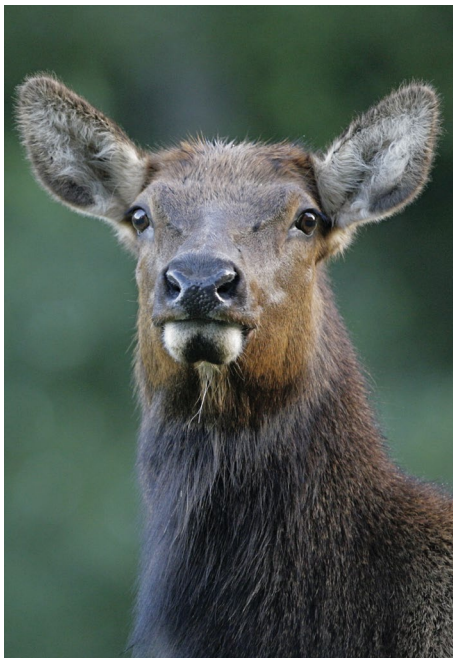
The Wyoming Game and Fish Department (WGFD) has implemented various strategies to reduce brucellosis in elk. The pilot test-and-slaughter program (2006–2010) involved trapping elk on selected feedgrounds, testing them for antibodies for brucellosis, and culling female elk that tested positive.

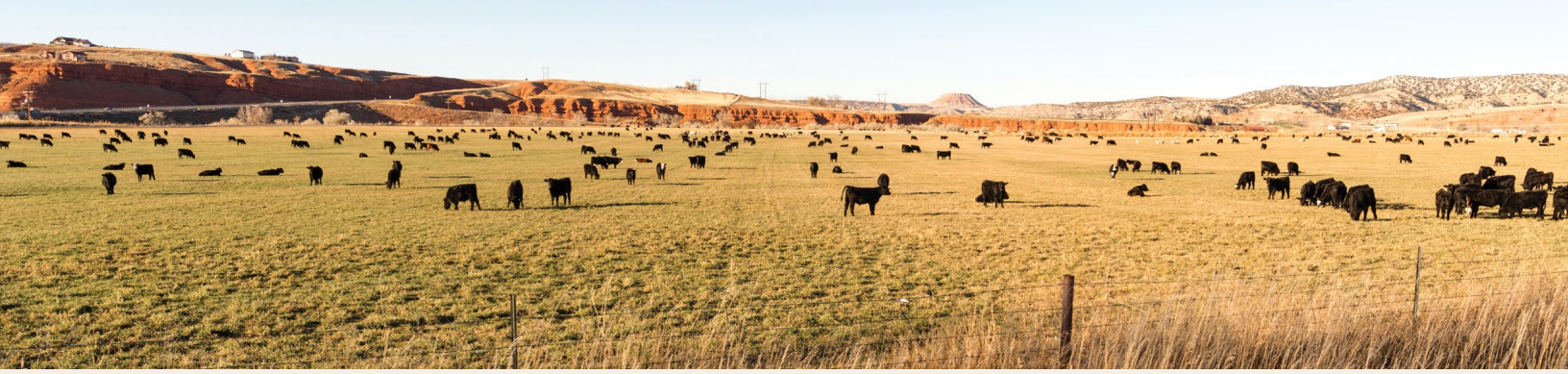
The pilot program helped reduce bovine brucellosis seroprevalence in elk from 37 percent to as low as 5 percent on select feedgrounds. However, its high social and economic costs have raised questions about its practicality at a larger scale. Additionally, the program required elk to be removed every year to sustain the lowered disease level and may be difficult to implement in areas without feedgrounds.

WGFD had also previously vaccinated elk calves on most feedgrounds, using biobullets containing the S19 vaccine. From 1985–2015, nearly 100,000 elk were vaccinated; however, efficacy of S19 in preventing abortions in elk is low, and no reductions in brucellosis due to vaccination have been documented. The S19 vaccination program was discontinued after the 2015 season when the biobullet manufacturer ceased production.

WGFD now works to limit the number of days elk are fed on the

(Continued page 32)





Producers face continual economic scourge from brucellosis

For the first time since 2010, a handful of Wyoming livestock operators were faced with bovine brucellosis in their cattle herds in October 2015.

Commonly termed Bang's disease, bovine brucellosis (brucellosis) is a contagious bacterial disease of cattle, elk, and bison that occurs in the U.S., primarily in the greater Yellowstone area (GYA) of Wyoming, Montana, and Idaho.

While now rare in the U.S., in the early 1900s brucellosis was considered one of the most economically important diseases of the U.S. cattle industry. In 1934, due to the Great Depression and drought conditions, the U.S. began an effort to decrease the national cattle herd. A cooperative eradication program was initiated, aiming to limit the impacts of brucellosis through a test-and-slaughter program.

The U.S. cattle population was declared free of brucellosis 74 years later in 2008; however, that same year, two cases of the disease were detected in Montana cattle, causing the state to lose its free-status. This story illustrates how challenging the complete eradication of brucellosis is and will continue to be for years to come.

Brucellosis commonly causes newly infected pregnant animals to abort calves. Once an abortion has occurred, other animals may be exposed to the disease through contact with infected reproductive tissues and fluids. In most cases, brucellosis cases in cattle and domestic wildlife are thought to originate from wild elk. Wild bison generally pose less of a risk due to strict exclusion from livestock premises.

Brucellosis can result in significant production losses to cattle operations. Brucellosis can also be passed to humans who come into contact with reproductive tissues or fluids from an infected animal, or ingest contaminated milk products (for example, unpasteurized milk or soft cheeses imported from outside the U.S.).

Costs of Quarantine

Prior to 2010, cattle herds affected by brucellosis were typically slaughtered using federal funding through the U.S. Department of Agriculture – Veterinary Services (USDA-VS). Due to decreased funding, the current approach is that all cases found in the GYA are handled through quarantine, testing, and removal of infected animals. The cost of quarantine can be substantial, depending on the timing and length of the quarantine, whether there is available alternative pasture, and whether additional cases are found.

For a 400-head herd of cattle, a 12-month quarantine could cost more than $146,000 (in 2010 dollars). This large sum is due primarily to the cost of feeding hay to quarantined cattle that might not be allowed to turn-out for the grazing season. Quarantine costs are borne largely by the producer, although the state government typically pays for testing, with some support from USDA-VS.

Decreases in federal funding for brucellosis eradication from the GYA highlight the importance of efficiently using disease management dollars. With only a limited pool of funds, we need to squeeze the largest "bang per buck" from each of those dollars in terms of reducing the negative impacts of brucellosis.

Recurring cases of brucellosis in the GYA have prompted a special surveillance zone called the Designated Surveillance Area (DSA) in each of the GYA states (Wyoming, Montana, and Idaho). Cattle that graze or live inside the DSA are subject to extra testing and movement requirements. These requirements have allowed Wyoming to detect cases of the disease before it could spread to herds beyond the GYA.

Safeguards Fail to Prevent Exposure

Alarmingly, despite these management safeguards, several elk blood samples collected by hunters demonstrated exposure to brucellosis in hunt areas 39, 40, and 41 from 2012–2014 (See maps page 30). These hunt areas, on the western slope of the Bighorn Mountain range, are outside of Wyoming's DSA. In response to these seropositive elk, cattle leaving Big Horn County for a destination in Montana, South Dakota, and North Dakota are subject to import-testing requirements as of summer 2016. The Wyoming Game and Fish Department is collaring elk in this region to determine their home ranges and associated risk to cattle using the area.

state's 22 elk feedgrounds. Where possible, they also use low-density feeding – dispersing feed in discrete piles rather than in continuous lines – to lower the number of animals that might come in contact with an aborted elk fetus.

Managing Brucellosis in Wildlife Costs

Each of these three strategies (test-and-slaughter, S19 vaccination, and low-density feeding) to reduce elk brucellosis was evaluated using the producer-informed model described above. Results indicate each of the three elk management activities cost more than their expected benefit. That is, they each cost more than what they save in lowering the risk of brucellosis in cattle (2010 dollars).

- $2,805 per year for low-density feeding
- $6,807 per year for elk vaccination
- $595,471 per year for test-and-slaughter

This modeling effort highlights the ability of producers to inform scientific efforts using their local knowledge of animal locations and movements. By engaging these local "experts," data can be collected rapidly and affordably over large areas. Rare events that would be difficult for a sole researcher or team to observe are readily reported. This participatory or citizen-science method encourages up-front engagement between researchers and the public, who are major stakeholders in wildlife-livestock disease management decisions.

To contact: **Schumaker** *can be reached at (307) 766-9970 or at* ***bschumak@uwyo.edu****.*

FASTER, MORE-ACCURATE BRUCELLOSIS TEST DEVELOPMENT ENTERS FINAL STAGES

The ability to diagnose truly infected individuals is one of the tenets for the management of an infectious disease.

Current brucellosis diagnostics for animals is not optimal to achieve our management goals. There is an unmet need for novel diagnostics to tackle brucellosis. Diagnostics start with a live animal screening test. Those that test positive are followed up with a post-mortem (euthanized animals) confirmatory "gold-standard" test.

Screening tests, such as serology (looking for protein antibodies that indicate exposure), are run antemortem to provide insight if an individual animal is likely to be a confirmed, positive case for the disease.

Bacteria culture (growing bacterium on a petri dish) is the post-mortem confirmatory test. This is very time-consuming (14 days), expensive ($600) in supplies only for a single animal, and requires the animal be euthanized. Unfortunately, it is not very sensitive in correctly identifying an animal as disease-positive. Only 30–50 percent of animals that test positive using serology are also culture-positive. This begs the question, what is the true status of the other 50–70 percent of the serologically positive, culture-negative animals?

This is where our current research project starts.

We are in the final validation stages of a novel molecular assay (polymerase chain reaction [PCR]) that would replace culture testing. Preliminary results show we are able to identify over 2.3 times the number of serologically positive animals as infected versus culture tests. Additionally, we are able to obtain a result in two to three hours after receiving the sample and at one-fourth the cost of culturing.

With this new diagnostic test, we will be able to make meaningful strides toward management of brucellosis by identifying more true-positive animals than the current "gold-standard" culture test.

DEAD LAMBS AND CALVES AREN'T THE ONLY LOSS

Counting the non-lethal cost of predators in Wyoming

Jessica Windh
Undergraduate Student

Derek Scasta
Assistant Professor
Department of Ecosystem Science and Management,

Barton Stam
Extension Educator
University of Wyoming Extension

"Predation is a huge problem that is not currently being addressed enough to help us. Our loss is emotionally devastating."

–Anonymous survey respondent

The interaction between livestock and predators has been a substantial concern for ranchers in the western United States for more than a century.

This concern continues to escalate in part due to the limitation of states to manage large carnivores such as grizzly bears and wolves relative to federal provisions. This limited state jurisdiction has contributed to the increase of many predator species in Wyoming over the last several decades.

Livestock losses to predators, and associated compensation programs, are based on federal mortality surveys, yet these surveys do not document the many non-lethal losses faced by ranchers.

Examples of such non-lethal losses may include lower birth rates, lower weight gains, and changes in distribution of grazing. Most concerning is the estimated economic impacts can equal or exceed those caused by mortalities.

We Ask Ranchers

We administered a survey to Wyoming ranchers regarding livestock interactions with predators in a collaborative effort between University of Wyoming Extension, Wyoming Wool Growers Association, Wyoming Stock Growers Association, the Wyoming Department of Agriculture's Animal Damage Management Board, and a local rancher. A total of 274 ranch surveys were returned with responses from all 23 Wyoming counties. One question asked about behavioral

"Predation is the single biggest cost associated with our sheep operation. When you include time spent, equipment, fuel, and the eventual death loss it is a higher dollar value than feed or labor!"

–Anonymous survey respondent

Predator protection video

changes noticed in livestock when predators were known to be present:

- 241 (88 percent), reported increased nervousness in herds,
- 86 ranches (31 percent) reported animals were more difficult to work,
- 77 ranches (28 percent) reported animals were more difficult to gather.
- 184 ranches (67 percent), reported changes in distribution or grazing patterns, and
- 91 ranches (33 percent) reported animals spent less time grazing.

Non-lethal losses also reported by participant ranches:

- A production loss (43 percent)
- Lower than normal weight gains (34 percent)
- Lower conception rates (25 percent)
- Lower birth rates (16 percent)
- Delay in birthing season (15 percent)

Figure 1 lists a summary of all of the reported behavioral changes and non-lethal losses. Only two survey respondents reported production losses not accompanied by a behavior change.

Snowball Effects

These livestock behavioral changes are known to cause reductions in weight gains, and coupled with reduced reproductive success, financial damages can increase. We think of this cascading set of losses as a snowball effect: higher stress can lead to reduced weight gains, which can then lead to lower conception rates, lower birth rates, and changes in the birthing season.

For the 65 beef producers from all 23 counties in our survey that reported reduced weight gains, if we assume an average herd size of 213 cows (2012 USDA inventory), the total affected cows would be 13,845 head.

In a state with over 6,000 beef producers, our survey participation accounts for only 4 percent of total beef producers – an indication potential losses could be much larger.

The 65 beef producers who reported reduced weight gains also reported 661 death losses caused by predators or an average of 10 head per producer who also experienced these non-lethal losses. These cattle loss estimates do not account for yearling cattle with some ranches reporting summer gains more than 100 pounds per head lighter on allotments with high bear densities than allotments without bears.

For the 29 sheep producers from 14 Wyoming counties that reported reduced weight gains, if we assume an average flock size of 460 sheep (2012 USDA inventory), total sheep affected would be 13,340. If weight gains are reduced by 2 pounds per lamb, total losses would exceed 26,000 pounds just for our survey participants and could likely be much higher given twins and triplets. Wyoming had 771 sheep producers in 2012. Our survey accounts for only 4 percent of those producers. The 29 sheep producers who reported reduced weight gains also reported 3,636 death losses caused by predators (not necessarily

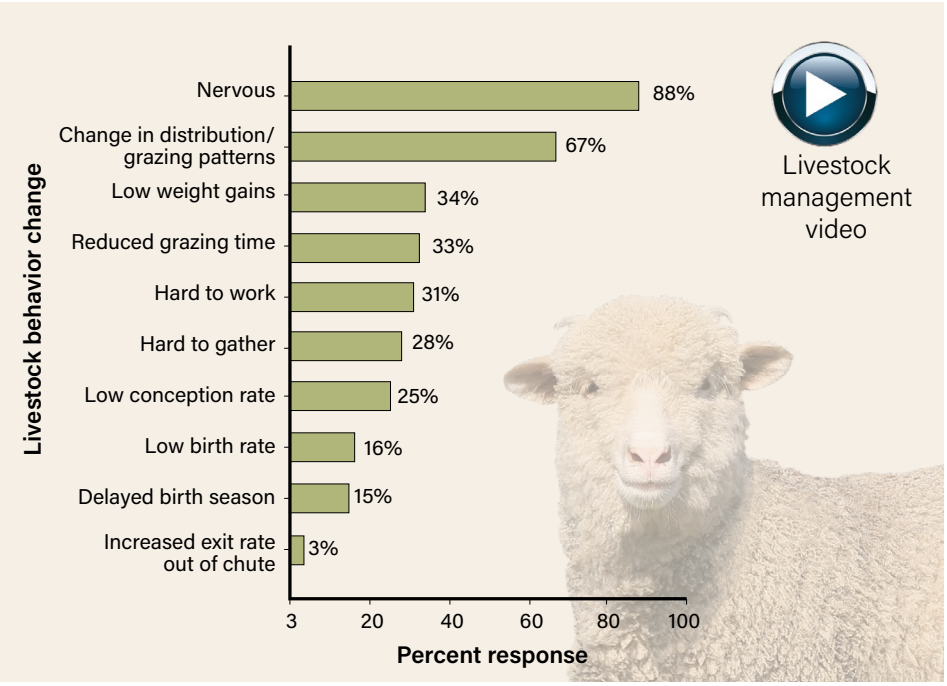


Figure 1. Summary of livestock behavior changes reported to be associated with the presence of predators in Wyoming. Results from 212 ranches participating in the survey.

Photo source: Barton Stam.

Lion in a live trap after predating sheep in Hot Springs County, Wyoming.

confirmed). This is an average of 125 sheep per producer who also experienced these non-lethal losses.

Non-Lethal Affected Animals Could Exceed Number Killed

Although it can be difficult to extrapolate our survey data to the state scale due to a potential higher participation rate by producers experiencing predation and a lower participation rate by producers not experiencing predation, we can simply compare the data reported by our participants to statewide mortality reports. For example, for the 65 affected beef producers, we estimate that approximately 13,845 cows and 12,460 calves would be affected by non-lethal losses. In other words, the number of calves that are assumed to be affected by non-lethal losses on our participant ranches exceeds by more than three times the number of calves killed in 2011, reported as 3,500.

> "Lack of effective predator control has forced many smaller ranches out of business and reduced incomes of larger ones greatly hurting other businesses, schools, etc."
>
> *–Anonymous survey respondent*

Further predator research video

Similarly, if we consider the total number of ewes and lambs affected by non-lethal losses reported in our survey (13,340 lambs and potentially more than 20,000 lambs due to twinning), then more lambs are affected by non-lethal losses than the 17,300 head of sheep and lambs killed by predators in 2013. Such indirect losses due to predation could potentially be the factor that moves a producer from making a positive marginal profit to making no profit, or even losing money. Moreover, dealing with predators can also increase labor costs – a sentiment echoed by some of the respondents.

Conclusions

Livestock losses to predators are more than just dead lambs or calves. The non-lethal losses reported in our study suggest greater numbers of animals in Wyoming may experience negative consequences other than death. Current compensation ratios for documented livestock kills range from 1:1 to 7:1 depending on predator species and livestock age; however, compensation ratios of 18:1 up to 24:1 for each confirmed depredation have been suggested to more accurately account for the total loss – and our results indicate this would be prudent. However, no compensation program can account for the emotional loss of livestock which propelled some ranchers to participate in our survey to make their voices heard.

Many understand the importance of predator conservation, but backing these efforts when their livelihoods are at risk is often difficult. Once a consensus has been reached based on robust scientific evidence on the comprehensive effects of predators on livestock, there might finally be hope for producers and predators to coexist with less social conflict.

To contact: **Scasta** *can be reached at (307) 766-2337 or* ***jscasta@uwyo.edu***.

University of Wyoming
College of Agriculture and Natural Resources
Dept. 3354, 1000 E. University Ave.
Laramie, WY 82071