COLLEGE OF AGRICULTURE AND NATURAL RESOURCES RESEARCH REPORT

REFLECTIONS 2016

WYOMING AGRICULTURAL EXPERIMENT STATION
CELEBRATING 125 YEARS OF SERVICE
1891 • 2016

LARAMIE AGRICULTURAL EXPERIMENT STATION LOOKING WEST

The Wyoming Agricultural Experiment Station did indeed look West – across Wyoming, cultivating and sustaining a connection between agricultural researchers and agricultural producers. Its rich history is detailed by University of Wyoming agricultural liaison librarian David Kruger.

Page 31

UW University of Wyoming

B.C. Buffum Papers, American Heritage Center, University of Wyoming

CELEBRATING 125 YEARS

Associate Dean Bret Hess

Presenting the 2016 *Reflections* to the magazine's readership is truly an honor! The exclamation point is intended to capture your attention. If I'm successful thus far, just wait until you read this issue.

There is an excellent line up of articles featuring some of the impressive research being conducted by departments housed in the College of Agriculture and Natural Resources. As noted in the past couple editions, we ask each department to select a representative to contribute an article to the annual magazine. You'll see the departments designated at the bottom of the pages. This approach gives readership an opportunity to learn about the broad scope of research while simultaneously drilling further into specific research topics. The top student article, as selected by a panel of judges who review and score each submission, is also included.

Readers of this year's issue are in for a special treat! This edition coincides with the Wyoming Agricultural Experiment Station (WAES) celebrating its 125th anniversary. A synopsis of the WAES history is included as a bonus article. The history article walks through the establishment and developments of WAES and its affiliated research and extension centers through the lens of some who were part of the institution from 1952 to present.

I sincerely hope readers enjoy learning about some of the College of Agriculture and Natural Resources' current research as well as some of the important changes that have occurred with WAES and its affiliated research centers over time.

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.

Best regards,

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

REFLECTIONS

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Cover Photo from: B.C. Buffum Papers, American Heritage Center, University of Wyoming

From wallpaper and green dresses and across the centuries TO YOUR WELL WATER

Drop-dead decorators of the 19th century are part of the arsenic story weaving from there to drinking water now

KJ Reddy,
Professor

David Legg,
Professor

Viswatej Attili, Carol Martinson, Travis Roth, *and* ***Kyle McDonald,***
Former graduate students

Brandon Reynolds,
Former research scientist
Department of Ecosystem Science and Management

What do some 19th century wallpapers and green fabrics have in common with some 21st century well water?

Arsenic, that's what.

Our arsenic research eventually led us to test 80 water wells in Wyoming and five other western states. The results reported later in the story are startling, but first, a tour of a 19th century home and how arsenic has plagued mankind through centuries.

Brilliantly colored wallpaper and dresses and paints were all the fashion in Europe at the time, and green was perhaps the most coveted color. That was because even the best green pigments and dyes of the day were not a brilliant shade of green, and they faded quickly.

There was a scramble to be the first to find a better pigment.

Two new kinds of green pigments were discovered, both of which contained arsenic, but one provided a more brilliant color of green; that one became known as emerald green.


Photo from NGO Forum for Public Health

Human health symptoms from arsenic poisoning from drinking groundwater (arsenicosis)

Emerald green was the shade everyone was looking for; it had lasting power in everything to which it was applied.

Unfortunately, the pigment was an unstable form of arsenic that, under damp conditions, gave off toxic gasses. This meant people who lived in homes with green wallpaper or those who wore brilliant, emerald green dresses could be sickened. Some artists mixing emerald green powder into their paints, often with unprotected hands, were also suffering.

Fast forwarding to the 21st century, arsenic has thankfully been removed from our paint and dyes and wallpaper; however, arsenic occurs in some drinking water, which can cause serious health hazards.

Arsenic Around the World

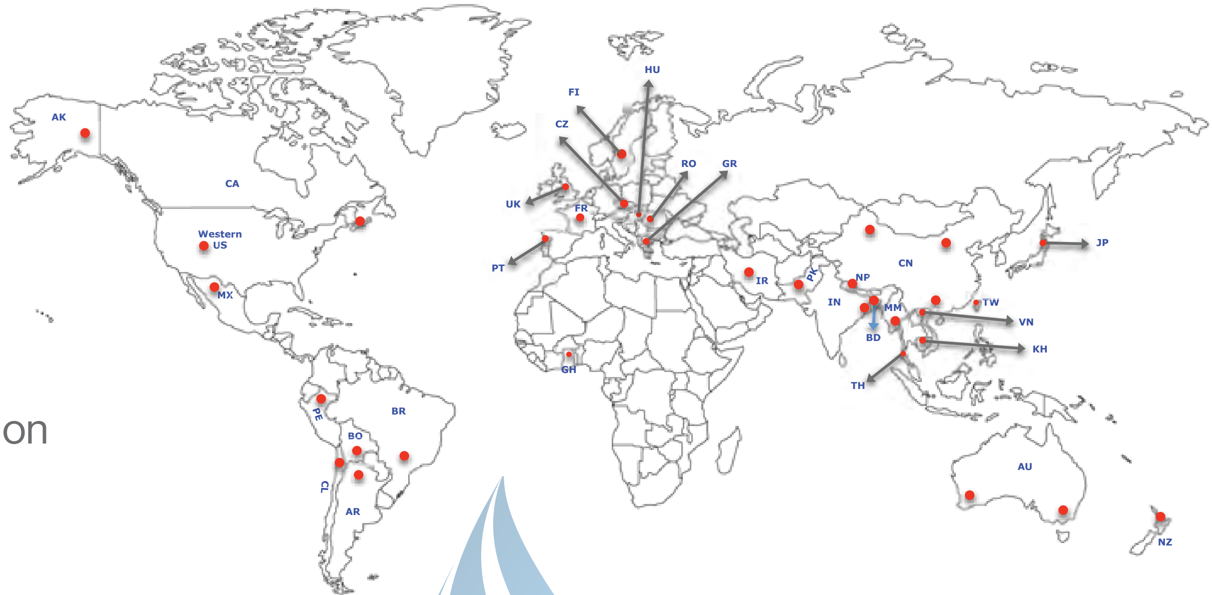
Groundwater is an important drinking water resource for many in rural communities everywhere. Arsenic is a rare earth trace element commonly found in groundwater aquifers. Arsenic in groundwater comes from **natural** and **human-made** sources.

The **natural sources** include weathering of arsenic-containing minerals and then the dissolving of those minerals into the groundwater; this is known as a geogenic process.

The **human-made** sources include disposal of solid by-products from combustion processes (for example, coal plants, solid waste incinerators, cement plants, and paper mills), the discharge of groundwater produced when extracting substances such as uranium or natural gas from the ground, and the application of arsenic-based pesticides.

Studies show exposure to elevated levels of arsenic could result in

Countries Affected by Arsenic Contamination



discoloration of skin, development of diabetes, intestinal maladies, carcinogenesis, and ultimately death.

The Environmental Protection Agency (EPA) and World Health Organization (WHO) recommend a level of 10 micrograms of arsenic per liter (µg/L) (or 10 parts per billion) as a maximum contaminant limit for human drinking water.

Arsenic maximum contaminant limits for livestock/wildlife and irrigation water are 1,000 and 100 (µg/L), respectively. Studies show arsenic is not carcinogenic in animals; however, higher arsenic levels in irrigation water can concentrate in soils and accumulate in crops. Literature suggests that

See: bit.ly/wyolabs for a listing of commercial and government laboratories in Wyoming.

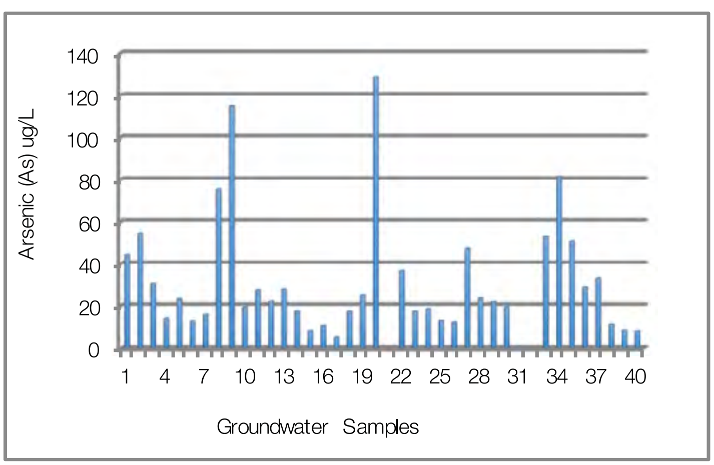
animals (e.g., cattle and sheep) eliminate arsenic too quickly from their bodies for cancer to develop.

In response to the poisoning of drinking water in India and Bangladesh in the 1990s, awareness of the health implications of arsenic contamination of groundwater has increased enormously. Since then, many countries in Asia, Australia, North America, Europe, and South America have reported high levels of arsenic concentrations (> 10 µg/L) in their groundwater supplies (above). A recent publication estimated that as of 2015, more than 196 million people in different countries are using arsenic contaminated groundwater.

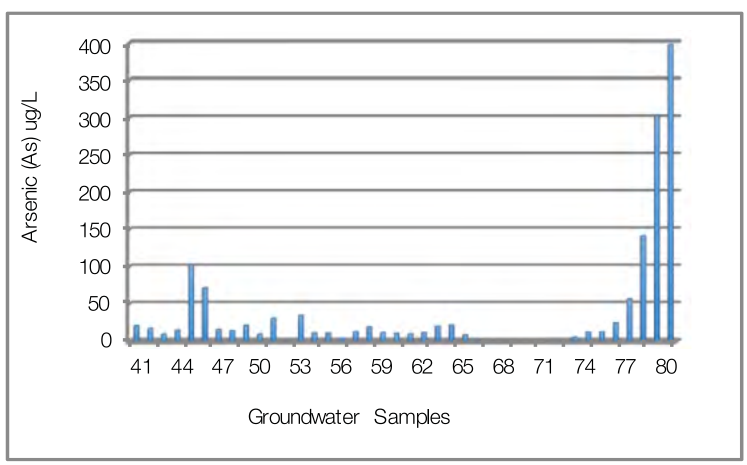
As global incidents and severity of health issues associated with arsenic contamination of groundwater became more widely known, we began to realize not much data was available concerning arsenic levels in the groundwater of rural areas of the western U.S.

We asked ourselves the uncomfortable question,"Was this largely a developing country problem?"

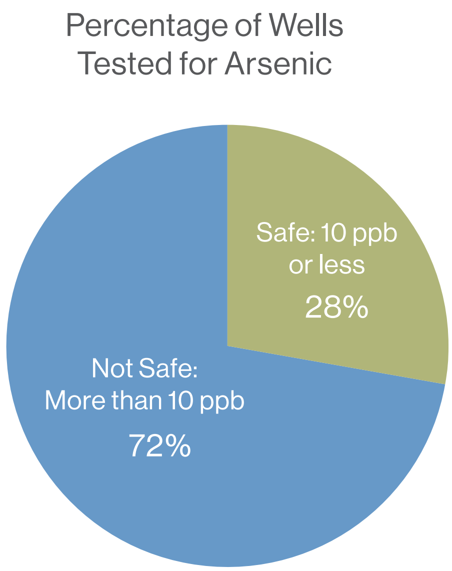
Not necessarily, as arsenic is being found in the groundwater of several western U.S. states.

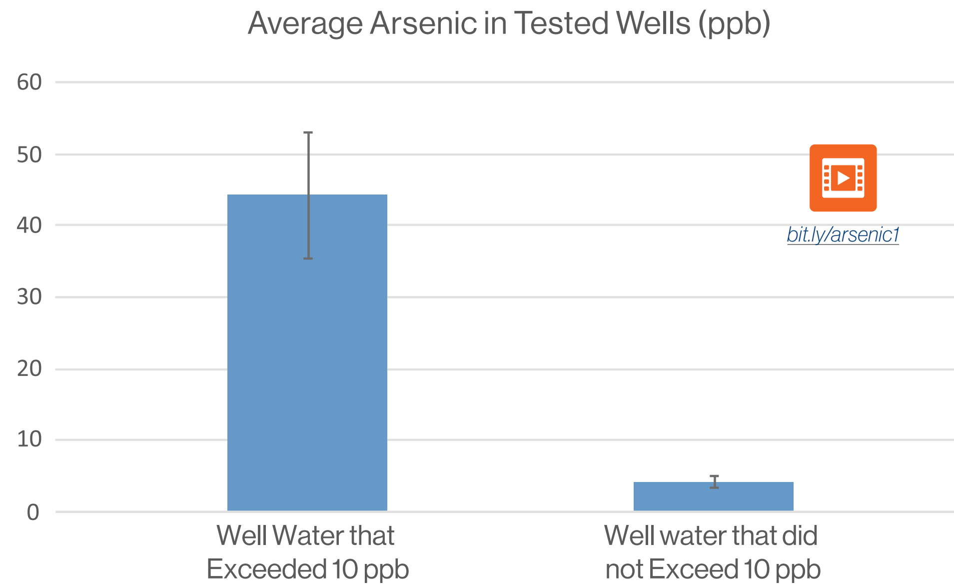


Arsenic Levels in Tested Wells



Arsenic Levels in Tested Wells





Arsenic in the West

With the help of the Cooperative State Research, Education, and Extension Service water quality coordinators, we identified approximately 80 rural domestic wells that did not have water treatment facilities for groundwater sampling. These domestic wells were in Colorado, Montana, Nevada, South Dakota, Utah, and Wyoming.

Samples from each well were tested for arsenic levels.

Results were eye-opening.

The arsenic concentrations in these groundwater samples ranged from non-detectable to as high as 398 µg/L (see bottom right figure page 6). And of those, 72 percent exceeded the EPA maximum contaminant limit of 10 µg/L. Worse, the arsenic concentrations in some samples were almost 10-40 times higher than the EPA maximum contaminant limit.

To our knowledge, arsenic concentration in most of the wells we investigated was from geogenic processes.

What Now?

There is potentially good and bad news.

First, the bad.

Given the arsenic concentrations detected in groundwater from several western U.S. wells, millions of people in rural communities may be at risk from arsenic poisoning. We advise testing well water for arsenic.

As for the good, there are different arsenic treatment options available. These resources can be found at the EPA website bit.ly/arsenictreatmentoptions.

Finally, note that not all well water tested had arsenic levels exceeding the maximum contaminant limit. But knowing the level of arsenic in the groundwater at a well is impossible without testing.

The bottom line?

Test your well water to find out how much arsenic it contains!

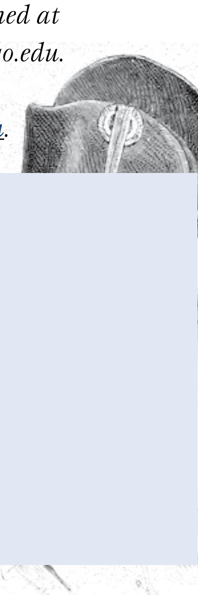
Acknowledgments

We thank landowners for providing access to groundwater samples. We also thank the Cooperative State Research, Education, and Extension Service Region 8 water quality coordinators for identifying landowners to sample groundwater wells. We appreciate and recognize the contributions of former graduate students and research scientist to arsenic research.

References

References used in preparation of this article can be found at bit.ly/arsenicinfo.

To contact: *Reddy can be reached at (307) 766-6658 or katta@uwyo.edu. Legg can be contacted at (307) 766-3369 or **dlegg@uwyo.edu**.*



NAPOLEON'S DEMISE?

After conquering most of Europe and then exiled to St. Helena, did Napoleon succumb to arsenic poisoning? See bit.ly/napoleonwallpaper

What is history but a fable agreed upon?

– Napoleon Bonaparte

GOOD FAT BAD FAT

WHY CAN'T WE JUST GET ALONG?

Because consuming one form can lead to a host of problems. We study how to increase the good fat in meat.

Dan Rule
Professor
Department of Animal Science

Let's separate the fat to get to the meat of this story.

Unsaturated = good.

Saturated = bad.

Transfat = we'll leave that out of the discussion.

Getting to the "good" in our diets from meat has been a long, and ongoing, journey, including to our studies described below. Scientists have even mixed vegetable oil droplets with protein meal and coated it with formaldehyde – more about that later. Our research at UW has included adding soybean and safflower oils to sheep and cattle diets, and combining fish oil with calcium and coating with molasses for a more palatable (to cattle) taste.

Fat in diets are critical to our health and well-being, but too much of a good thing can become a problem. Researchers firmly linked high blood cholesterol and related issues such as heart disease to over-consumption of processed foods and fast foods, which often contain substantial amounts of fat. Animal fat, especially from lamb and beef (tallow), is highly saturated.

On the other hand, vegetable oil is composed primarily of unsaturated fat.

How our bodies metabolize unsaturated fat results in less bad cholesterol in the blood (LDL cholesterol), which has been identified as the most significant cause of hardening of the arteries (atherosclerosis) and eventual heart attack and stroke.

The last quarter of the 20th century was a time of rapid discovery of different unsaturated fats that could benefit consumer health, as well as discovery of appropriate amounts and balance of the various types of fats.

Research finds Omega-3 Fat Benefits

Studies of dietary patterns of Greenland Inuit (Eskimos) revealed an unusually low incidence of cardiovascular disease that was related to consumption of fish and other marine animal products. The fat they consumed was largely made up of the omega-3 fats that are part of the common food vocabulary used today.

We refer to some fats as the omega-3 fatty acids, while other common fats are part of the omega-6 fatty acid group. Omega-3 fatty acids are common in fish, as well as in some plant materials – the most common of which is flax seed (also known as linseed).

Scientists began in the 1970s to increase the amounts of omega-3 and omega-6 fats in beef and lamb. Unfortunately, in cattle and other animals with a similar digestive tract, just feeding flax seeds is not effective to significantly increase omega-3 fats in the meat.

The problem is in the stomach of the animals.

The stomach is composed of four compartments in cattle and sheep. The first two function as a fermentation vat (the rumen and reticulum) where feeds like forages, hays, and grains are broken down and digested by microbes, most of which are bacteria. This type of stomach defines cattle and sheep, as well as other species like deer, elk, and moose, as "ruminants" because of the presence of the rumen.

When bacteria digest the fiber and starch, sugars (glucose) are released that are fermented by bacteria to generate the energy they need to exist and reproduce. Byproducts of fermentation include gasses like carbon dioxide and methane (greenhouse gasses), and other small chemical materials that get absorbed by the cow and used for energy by the tissues of the animal's body. This process is beneficial for both the bacteria and the cow.

Digestive Process takes a U-Turn

If the animal consumes fat, however, the bacteria take a different approach. Most of the basic fat structure goes from the rumen to the intestine to be absorbed along with other nutrients like proteins.

In ruminants, unsaturated fats are detrimental to rumen bacteria. Portions of the bacterial population have the capability to fix the problem by converting unsaturated fats into saturated fats. This is why fats from cattle, including products such as butter, are highly saturated.

Modifying dietary fat so it can escape this rumen process has been a priority since the 1970s. Feeding large amounts of vegetable oil (over 5 percent) decreases digestibility of fiber, which is counterproductive. The earliest attempts by scientists to protect the fat involved mixing vegetable oil droplets with protein meal and coating it with formaldehyde. It worked, but

Professor Dan Rule, left, and visiting scientist Osman Kucuk take tissue samples to determine if grass-fed beef given a supplement of calcium salt of fish oil produced less saturated fat than grain-fed beef. Kucuk received his doctorate in animal science at the University of Wyoming and is now an animal science professor in Turkey.

Pie charts represent the overall nutrient content, including fat, of grass-fed and feedlot beef. The proportions of fats are then shown in the circle charts: n-3 depicts the amount of omega-3 fat, n-6 the omega-6 fat, then saturated fat and other fats. There is slightly more saturated fat in feedlot beef than grass-fed beef.

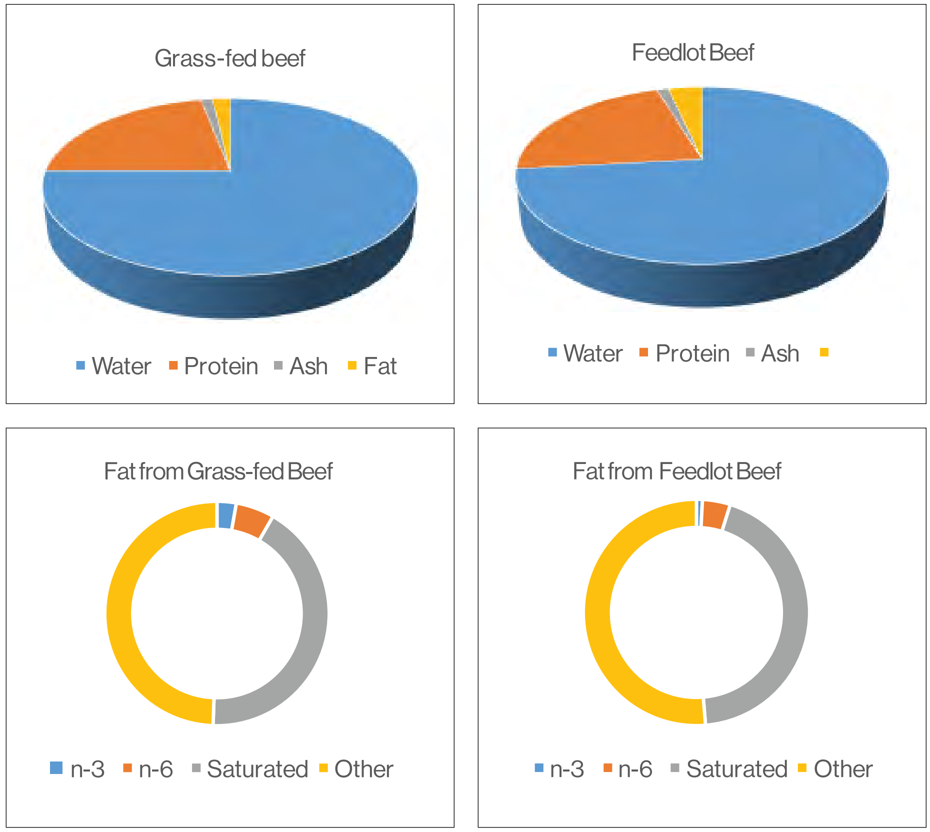


Figure A

consumers probably wouldn't want to eat beef from cattle that were fed formaldehyde!

Our work in the Department of Animal Science has included adding soybean and safflower oils to sheep and cattle diets to determine how high-forage and high-grain diets influence the amount of unsaturated fat reaching the small intestine.

About 90 percent of the unsaturated fat is converted to saturated fat, but this level might be a bit higher or lower depending on the nature of the diet. Roasting and extruding soybeans, as well as feeding whole (unprocessed) oil seeds (soybeans and canola seeds), increased the amount of unsaturated fat escaping the rumen intact, but the levels were not remarkable.

Grass-fed beef has shown promise as a production method to increase omega-3 fatty acids in the meat compared with amounts found in grain-finished beef; however, the increases are small compared with amounts of the other nutrients (Figure A).

A fairly recent form of protected fat is made by combining fish oil with calcium under the right conditions to produce a fish oil powder that can be dry mixed with other dietary ingredients. We nearly doubled the omega-3 fat in meat of grass-fed beef by supplementing steers with the calcium salt of fish oil (and without fishy-tasting beef), but we also found some of the cattle considered the supplement very unpalatable. We subsequently fed the fish oil calcium salts as an ingredient in a dried molasses lick tub with a consistency similar to peanut brittle. Cattle found this more appealing, and the omega-3 fat level in the meat was greater and more consistent using this method.

Professor Dan Rule and his grass-fed beef research at the James C. Hageman Sustainable Agriculture Research and Extension Center near Lingle.

A calf eats supplement out of a lick tub.

One interesting by-product from this latest study was the observation that our heifers increased breeding success by about 20 percent over the main group of heifers fed the same forages without any fish oil (no omega-3 fat). (See accompanying story for details of our efforts)

While it was known greater fertility in dairy cows occurred with omega-3 supplementation, this idea has not been applied to grazing beef heifers. We plan to test this strategy using our dried molasses lick tub delivery system at UW and with beef producers in Wyoming. Positive results could mean beef cattle producers will have a dietary means of ensuring a greater calf crop from their replacement heifers.

To contact: *Rule can be reached at (307) 766-3404 or* ***dcrule@uwyo.edu***.

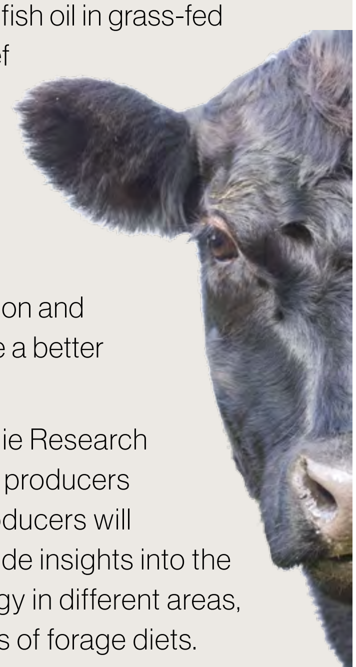
INCREASED HEIFER FERTILITY

The unknown fertility of replacement heifers is a serious concern of beef cattle producers.

Our research has led us from supplementing fish oil in grass-fed steers to increase omega-3 fatty acids in beef to observing possible increases in heifer fertility.

Future studies will focus on strategic supplementation of omega-6 and omega-3 fatty acids before and after breeding of beef heifers to increase the probability of conception and retention of the embryo so the heifer will have a better opportunity to produce a calf.

Controlled studies are planned at the Laramie Research and Extension Center and with cooperating producers in Wyoming and Colorado. Working with producers will increase the number of heifers and will provide insights into the effectiveness of the supplementation strategy in different areas, with multiple breeds, and with different types of forage diets.

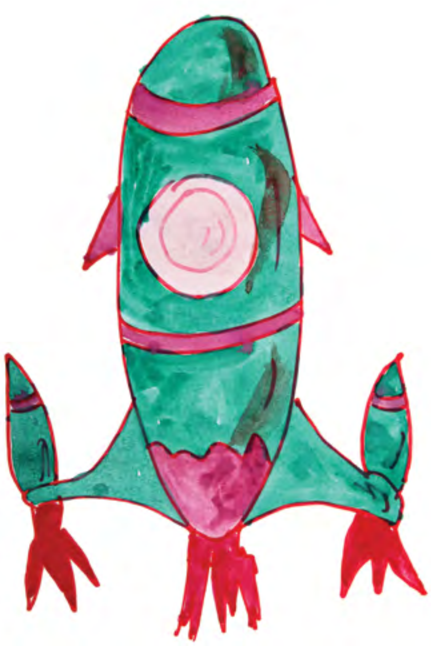


STUDY EXAMINES LONG-ACCEPTED PRECEPTS OF AFTER-SCHOOL PROGRAM EFFECTS ON BEHAVIOR

Some research links positive behaviors, some no effects, and even some to later antisocial behaviors

what makes a diff

Christine Wade
Associate Professor
Department of Family and Consumer Sciences



Children spending after-school hours playing with their neighborhood friends used to be common.

However, changing attitudes toward child supervision and an increasing number of parents working outside the home have led to over 8 million school-aged children in the U.S participating in after-school programs. Federal funding to support such programs surpasses $1 billion annually.

This enormous use of funding for after-school programs has led to demands for evaluative evidence after-school programs do in fact support positive child development.

Researchers and practitioners have suggested after-school programs can provide safe environments in which children can develop supportive relationships and social skills.

Research findings, though, have been unexpectedly mixed. Some studies have found after-school program participation is linked with positive behavioral and social development, some studies have found no relationship, and others have even found program participation linked with antisocial behaviors.

How do parents navigate these mixed results? Should parents feel guilty if their child attends an after-school program while they work? Are some types of programs better than others? Do children's experiences in their after-school programs make a difference in their development?

Using data from the longitudinal National Institute of Child Health and Human Development (NICHD) Study of Early Child Care and Youth Development (SECCYD), which has followed 1,363 children across the United States from birth into their adolescent years, I examined these questions, and we may be getting closer to the answers.

bit.ly/afterschool_1

erence?

Do after-school program relationships affect children's behaviors?

Overall, children's relationships with their after-school program were related to their future levels of behavior problems (e.g., aggression, rule-breaking), supporting previous findings suggesting positive relationships with caregivers is related to decreases in problem behaviors.

However, when children in an after-school program were compared to children not in an after-school program, a slightly different picture emerges. Children who had positive relationships with their caregivers did not actually differ in their behavior problem levels when compared to children who were not in an after-school program.

Children who had negative relationships with their after-school program caregivers were the ones who showed subsequently higher levels of behavior problems than children not in an after-school program. In other words, a negative relationship with an after-school caregiver seems to actually put children at greater risk for behavior problems than would be expected if they did not attend an after-school program at all.

Do after-school experiences affect children's social skills?

Children who had positive relationships with their caregivers did benefit through improved social abilities. More specifically, as the relationship between a child and caregiver became more positive, the child's self-control in social interactions increased.

This finding fits well with the idea supportive contexts like an after-school program may provide a child with positive role models and helpful feedback regarding social interactions that then allow the child to build on and improve social skills.

However, there was one caveat to this finding: it only mattered for boys. This finding is consistent with the idea boys may be at higher risk for problematic behavior, including lower levels of social skill development, and thus a positive environment that fosters those skills may be even more important.

Do program features matter?

Often of highest concern to funders is what features that can be regulated make a high-quality, after-school program. For example, does it matter what education or experience a caregiver has, or their wages?

> '… a negative relationship with an after-school caregiver seems to actually put children at greater risk for behavior problems than would be expected if they did not attend an afterschool program.'

Overall, higher levels of staff experience and higher staff wages predicted more positive relationships between children and their caregivers and, in turn, higher levels of child self-control. Even more interesting than these main effects, when children experienced a decrease in child-to-caregiver ratios in their after-school programs, they benefited from the additional one-on-one attention through better relationships with their caregivers and improved social skills.

To contact: *Wade can be reached at (307) 766-4011 or* ***cwade@uwyo.edu****.*

WHAT DOES THIS MEAN FOR PARENTS?

bit.ly/afterschool_2

I often wonder, as I work on my research, what I would tell other parents to consider as they try to make after-school arrangements.

What should a parent look for in a program?

Although there is still more work to be done, there are a few important things to consider.

1. Look for a program with low child-to-caregiver ratios and experienced, reasonably paid staff. The latter two aspects will often go hand-in-hand, as experienced staff are more likely to seek out and obtain higher paying positions. Unfortunately, as is the case in many care industries, after-school providers are woefully underpaid, often leading to high turnover. But parents can seek out programs that support staff members in every way possible and advocate for appropriate wages for childcare providers.

2. Look for a program that fits your child. Parents should pay attention to their child's feelings about and experiences in the after-school program. Particularly for boys, watch for any signs of negative experiences between the caregivers and your child and take seriously any concerns your child has about the program. If the program seems to foster negative experiences for your child, share your concerns with program staff members. Consider finding a different program that is a better match for your child if his/her experiences continue to be negative.

Overall, evidence is mounting that high-quality programs fostering positive child-caregiver relationships can support healthy development. If parents take the time to find the right program for their child, and ensure the program supports its staff members and values individualized attention, then parents can feel good about their choices.

SCIENTIFIC DOGMA:

MELDING BASIC AND APPLIED RESEARCH TO IMPROVE INDUSTRIAL FERMENTATION

'Aha' moment comes when young scientists take fresh look

dogma |ˈdôgmə|

noun

a principle or set of principles laid down by an authority as incontrovertibly true

Peter Thorsness
Professor and Chairman
Department of Molecular Biology

bit.ly/yeast_1

In science, there's "*DOGMA,*" "Dogma," and "dogma."

For biologists, *DOGMA* is a fact like DNA is the genetic material, or evolution is the basis for genetic diversity – all biologists regularly conduct experiments or make observations that take advantage of these facts, and at the same time add to the overwhelming evidence that support them.

Bucking scientific *DOGMA* is rarely a good use of time or resources, although more than a few have tried.

Then there's "Dogma" with a big "D," which is comprised of the prevailing theories that arise from *DOGMA*, such as the idea that evolution of organisms is driven by selective advantages bestowed infrequently by preexisting mutations.

Very few scientists successfully challenge and rewrite "Dogma," and those who are successful become household names (at least in a household of scientists).

And finally, there's "dogma," the "not sure where this idea came from, but everyone in this particular field believes this is true" type of ideas. It's in questioning this particular version of dogma where most scientific advancements are made.

Those of us charged with training young scientists spend a lot of time teaching them how to distinguish between the different types of scientific scripture, a valuable skill for those interested in making scientific progress and impact.

Fermentation Questions Simmer

The dogma I've been dealing with for several years concerns the biological production of ethanol by fermentation. The observation is that when yeast are given sugar and cultured at a comfortable temperature in the

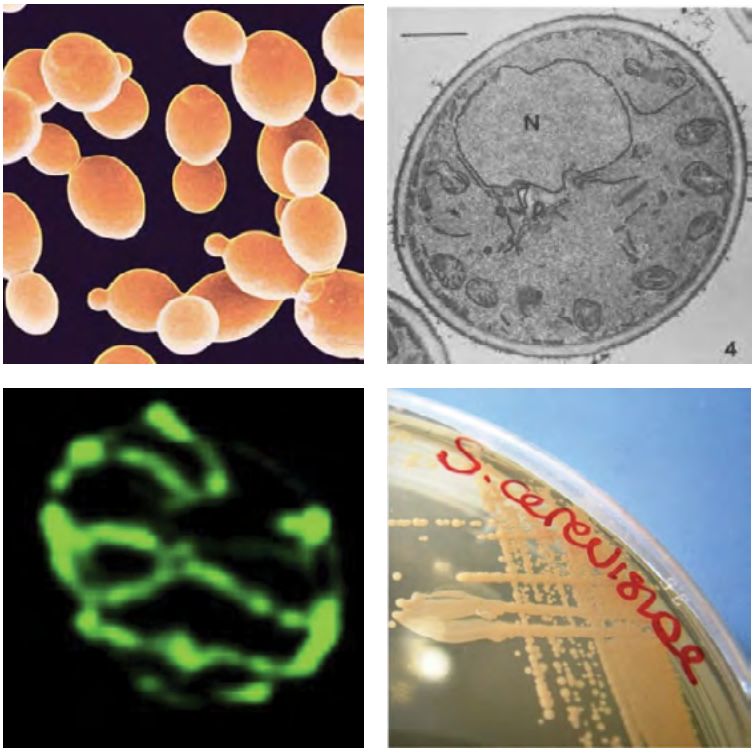


Figure 1: A yeast cell is about 0.00015 inches in diameter. Upper left: yeast cells imaged with a scanning electron microscope. Upper right: an electron micrograph of a single yeast cell, showing the internal cellular structure in two dimensions. The nucleus is labeled "N" and the mitochondria are the oval compartments at the periphery of the cell. Lower left: mitochondria in a single yeast cell are visualized by a fluorescent protein localized inside the mitochondrial compartment. Lower right: yeast grown on agar media contained in a Petri dish. Each single white dot is a yeast colony that contains approximately 1 million cells.

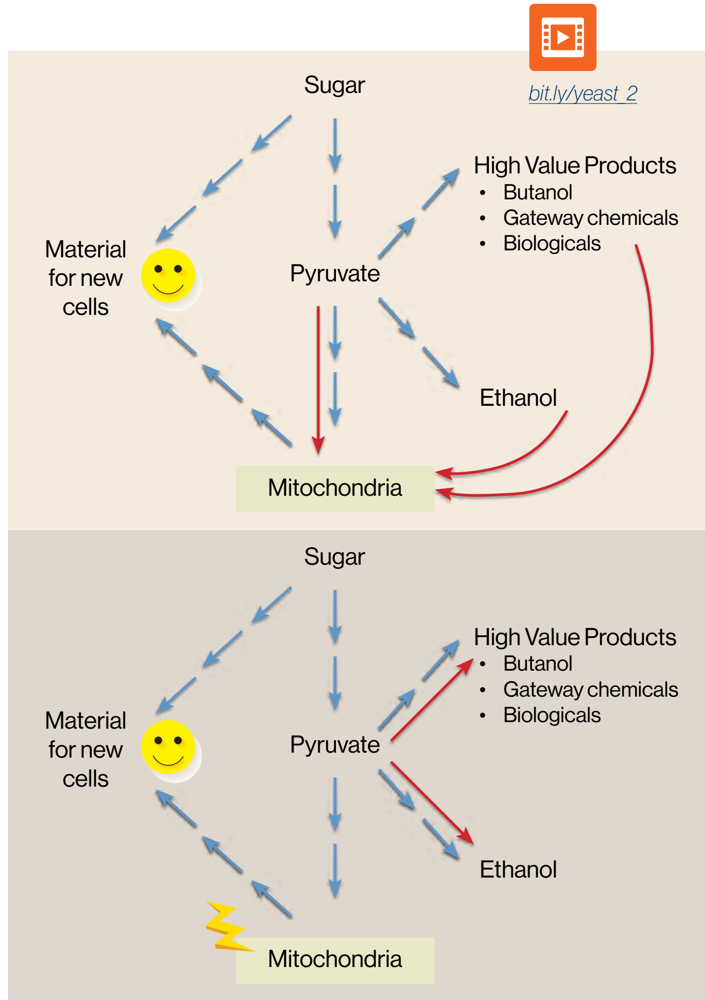


Figure 2: Altered mitochondrial function enhances fermentation outputs. Upper panel: Normal mitochondrial function drains product and precursors, limiting product accumulation. Lower panel: Altered mitochondrial activities prevent both precursor and product loss and enhance formation of product.

absence of oxygen, they produce ethanol as they grow.

Knowledge of that fact was sufficient for thousands of years, but eventually folks became interested in understanding how it worked, and over the past 50 years we've figured it out in pretty minute detail. In short, the "dogma" in this field was that yeast invoked a relatively simple pathway for turning sugar into new cells and ethanol and avoided some of the more complex metabolism required to consume alternative nutrients.

My research centers around how yeast regulate and position mitochondria, the intracellular structures that extract energy from nutrients other than sugar. Prevailing dogma said mitochondria are unimportant for fermentation, but several of our research projects kept bumping into it, and so we started thinking about fermentation critically.

Thinking Outside the Field

One reason research scientists like to hang out at universities is because young, developing scientists (undergraduate and graduate students) are prone to ask naïve yet insightful questions, at least in part because they're not so ingrained with the dogma of the field.

During the discussions and debates we had in the lab, it became clear I couldn't adequately explain to my students why mitochondria were seen as unimportant for yeast during fermentation. We even generated data that showed the importance of mitochondria during fermentation.

Some mutations that curtailed mitochondrial metabolism interfered with fermentation, while other mutations that enhanced mitochondrial activities improved it. A graduate student in my lab found some of our mutant yeast strains increased ethanol production by 20 percent when compared to the normal yeast strain. I made her repeat the experiment a half-dozen times before I would accept this dogma-contradicting result.

Beyond the excitement of making progress in the lab, we quickly saw potential practical applications. Industrial fermentation at its simplest produces ethanol, and the market for ethanol ranges from beverages to fuel.

While our modified “super fermenting yeast” may not be appropriate for use in the beverage industry, it could profoundly enhance the bottom line for those using corn stock and yeast in industrial fermentations to produce ethanol for automotive fuel – and over $30 billion of ethanol is produced annually! Additionally, high-value chemical products such as succinate (a water-soluble, colorless crystal with an acid taste used as a chemical intermediate in medicine, the manufacture of lacquers, and perfume esters) and farnesene (forms the basis for a wide range of products varying from specialty products such as cosmetics, perfumes, detergents and industrial lubricants, to transportation fuels) are produced by alternative fermentation strategies using engineered yeast and corn stock to the tune of $20 billion annually. Our modified yeast might also enhance the efficiency of those processes.

Our First-born—Showed Promise

Our first generation yeast strain did what we’d hoped – it produced more ethanol from a given unit of sugar than the standard, unmodified yeast strain. But it didn’t do some things needed to be a commercially viable alternative to the currently used yeast strains: our Version 1.0 didn’t grow well at elevated temperatures, survive dehydration, or grow rapidly in the presence of oxygen. So we went back to the drawing board and sketched our way to Version 2.0, a yeast strain that had enhanced fermentation outcomes but which also had the necessary features of an industrial strain.

Our goal was to have Version 2.0 be capable of following standard industrial procedures during the preproduction phase and then become supercharged with respect to ethanol output in the production phase.

The trick was to engineer yeast to alter mitochondrial metabolism during the production phase in response to metabolic signals that only exist in that condition. Consequently, supercharged fermentation yeast Version 2.0 is a genetically modified organism (GMO).

HAVE FUN WATCHING YEAST GROW!

bit.ly/yeastgrow

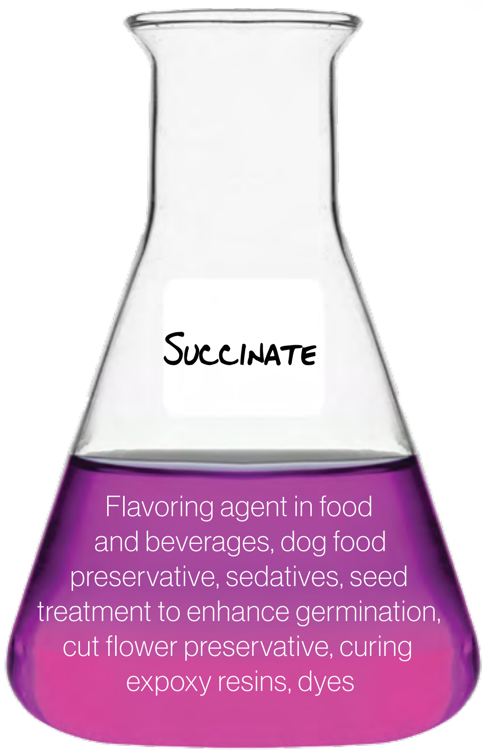
These movies show mitcochondria, the cell’s powerhouse

bit.ly/spinningmitochondria

bit.ly/mitochondriamotion

Yeast growing | Spinning mitochondria | Mitochondria motion

THINGS YOU DIDN’T KNOW YEAST COULD PRODUCE



See *bit.ly/turboyeast* for more about Thorsness' turbocharged yeast. He's even on the cover!

While we make GMOs all the time in the lab, if this yeast is to be beneficial to industry, we had to make sure it could be released into the wild. The yeast could carry only minimal extra DNA sequences, none of which could be potentially harmful to people, animals, or the environment.

Our Second-born – Much Better

We were able to co-opt DNA from previously approved GMOs, combining them with naturally occurring yeast DNA in a way that met our criteria – changing mitochondrial metabolism to enhance yeast's ability to ferment and produce more ethanol.

We're now in the beta-testing phase, checking to see if those desirable features lost in Version 1.0 are maintained in Version 2.0.

What Do We Want?

Certainly a piece of the action in supplying yeast to the fuel ethanol and specialty chemical industry would be nice – that would be a nice piece of change for us and UW. But that's an unlikely scenario. Many a promising lab finding – indeed, **most** promising lab findings – die with the harsh reality of scaling-up: there is ample opportunity for failure when moving from a 1-liter lab flask to a 40,000-liter industrial fermenter.

We've also found not every strain responds to our tinkering by improving fermentation efficiency. Marketing may even prove to be a challenge as convincing an industry to change from something they thought couldn't be improved on – remember "dogma" – to a different process that may require some tweaks to the production cycle would be tough.

But even if our engineered yeast strain doesn't end up fueling cars or making specialty chemicals, it is an excellent tool for investigating why these specific changes in mitochondria alter fermentation properties.

After almost three decades pursuing and cataloging arcane details about yeast metabolism, I'm excited to be at a place where I can meld applied and basic research, using ideas forged in one arena – often at the expense of dogma – to fuel progress in the other.

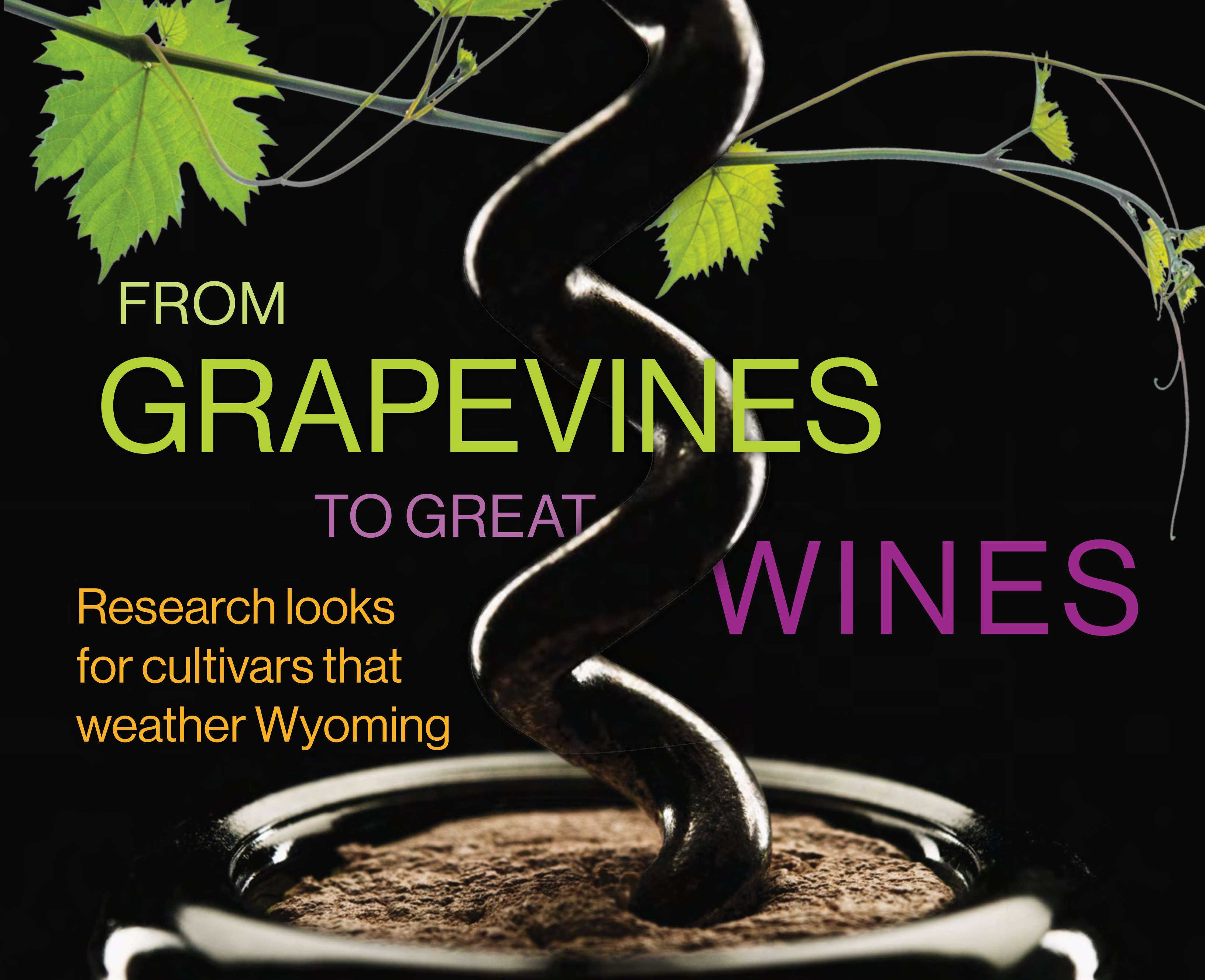
To contact: *Thorsness can be reached at (307) 766-2038 or* ***thorsnes@uwyo.edu***.

OUR LAB YEAST UPGRADE BOOSTS OUR QUEST FOR ANSWERS

We can induce mitochondrial changes in our Version 2.0 yeast that alter fermentation outcomes in a controlled manner, which will allow us to address some basic science questions:

- What compounds made prior to the changes in mitochondrial activity aren't made after the change?
- Which of the many mitochondrial activities that we change to enhance fermentation are most important for that outcome?
- When during the fermentation/ethanol production phase is the change in mitochondrial activity most effective for enhancing fermentation?

Answering these questions has the potential to not only satisfy my scientific curiosity, but also improve the fermentation industry.



FROM GRAPEVINES TO GREAT WINES

Research looks for cultivars that weather Wyoming

Our state's conditions at first glance seem intimidating but successes have piqued appetite for growing grapevines

Sadanand A. Dhekney
Assistant Professor

Daniel Bergey
Sheridan Research and Extension Center

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Master's Student
Department of Plant Sciences

Our grape research program at the Sheridan Research and Extension Center is designed to identify suitable grapevine cultivars and best vineyard management practices for expanding Wyoming production.

Successful cultivars have to weather Wyoming's diverse conditions, including surviving winter extremes, short growing seasons, varying soils, and periods of drought. Successful cultivars need optimum growing practices by producers.

Grape is the most valuable crop in the United States and accounts for 30 percent of the value of all fruit crops (excluding citrus). Grapes are grown in every state of the continental United States with special interest emerging in the Midwest and mountain states.

Figure 1. The research vineyard at the Sheridan Research and Extension Center.

Figure 2. Close up photo of grapevine growth in the vineyard.

Which fermented beverage appeared first in human history?

Which came first, wine or beer? Or maybe it was mead (fermented honey)?

Debates continue.

Did it first appear in the Near East? The Mediterranean?

Scientific testing indicated the earliest chemically confirmed alcoholic beverage was from 7,000-6,000 B.C., the early Neolithic period, in the Yellow River Valley in China. Tests of pottery from that era showed a fermented beverage of rice, honey, and fruit. For more information, see bit.ly/earlyalcohol.

Wyoming's grape industry started with two growers and has now expanded to include approximately 20 producers growing grapes on 25-30 acres with an annual production of 40-45 tons of fruit. Grapevine growers are scattered across the state from Parkman (north) to Huntley/Torrington (southeast) and Powell (northwest) to Worland/Riverton (south central-southwest).

Grapevine production and quality is governed by the complex interaction of cultivars with prevailing soil and climatic conditions. The choice of cultivar(s) is critical during vineyard establishment. Grapevine cultivars exhibit a wide variation in growth and developmental response to varying soils and climate. Vine establishment following planting, growth and development, flowering, berry development, and ripening varies regionally.

Grapevine Cultivar, Vineyard Management Trials

Cultivar trials started at Sheridan and the Powell Research and Extension Center in 2013 to identify cold-hardy table and wine grape cultivars that will mature and ripen in Wyoming's short growing season. One-year-old bare-rooted grapevines purchased from commercial nurseries were planted in about 12-inch deep holes at 5 feet spacing. The vines were trained on a high wire trellis with a drip irrigation system.

Vine survival and cold hardiness were recorded for 2014 and 2015. As grapevines mature, data on berry veraison (onset of ripening), ripening, yield, and quality is being collected to identify cultivars performing well.

Dormant cane samples are collected from grower vineyards at eight locations statewide to estimate the amount of winter damage occurring in Wyoming vineyards. Compound buds from cane samples are then excised to record the number of live and dead buds based on tissue color. Live buds are characterized by green-colored tissues, while buds suffering from cold damage appear brown.

Preliminary data collected over the past two years indicates differences in the severity of cold damage among various cultivars at different locations. Estimating cold injury over several years helps provide recommendations on when and how to prune dormant

Figure 3. Grapevine plants obtained through precision breeding express a anthocyanin-related pigment gene (green plants are controls).

grapevines for maximum growth and productivity.

Determining Water Requirements

We are also studying grapevine water requirements and exploring avenues for conserving soil moisture while improving growth, yield, and berry quality. A field trial to estimate water consumption of Frontenac and La Crescent grapevines, and evaluate the influence of fabric use on berry yield and quality, was initiated at a grower's vineyard in Wheatland.

Heavy-duty landscape fabric has been installed in rows between vines following bud break in spring. Early fruit chemistry data indicates a small but significant difference in sugars and acid content of berries obtained from grapevines covered with landscape fabric compared to the control vines. Improvement in fruit chemistry would ultimately influence wine quality, potentially resulting in higher returns to growers.

Precision Breeding for Raising Great Grapes

Improving grapevine genetics for stress tolerance is of paramount importance to the viticulture industry.

Traditional breeding techniques have limited applications for developing stress-tolerant cultivars because of extreme heterozygosity of the *Vitis* genome. Also, consumer preference for wines with specific enological (wine and winemaking) characteristics is strong so they do not readily accept hybrids developed using such cultivars. For example, 'Pinot Noir', 'Merlot,' and 'Cabernet Franc' – elite cultivars that originated in antiquity – are still popular today among consumers for their specific enological characteristics.

Inserting desired traits in elite cultivars without disrupting existing characteristics can overcome limitations in conventional breeding for grapevine improvement. Precision breeding is a new approach to plant genetic improvement that transfers only specific desirable traits among sexually compatible species without disrupting existing desired characteristics.

Efforts have been initiated to identify grapevine DNA sequences that

V

IN VINO VERITAS

IN WINE THERE IS TRUTH

In late August 2015, 'Frontenac' grapes harvested from the Wheatland site were used to produce two experimental wine batches.

Our primary focus was to identify enological (wine related) limitations and potential processing techniques during wine production to overcome undesirable chemical characteristics that may be present in the variety.

In early December 2015, the two wines from the Wheatland site along with two commercially produced 'Frontenac' wines were subjected to a blind tasting evaluation by a 24-member panel. The wines were individually scored using an evaluation chart established by the American Wine Society that included variables like appearance, aroma, taste, and texture.

Averaged scores were higher for both experimental wines in comparison to the commercially produced wines. We anticipate continuing the investigation into the vinicultural characteristics of grape varieties produced in Wyoming in the coming years, and hope to identify grape and wine production practices that support industry expansion through the improvement of fruit quality characteristics.

could improve genetics through precision breeding. Precision breeding is consumer and ecofriendly; it disrupts the grape genome much less than conventional breeding and should cause fewer genetically modified organism-related concerns.

A key breakthrough has been the identification and successful demonstration of a grapevine-derived marker gene normally involved in anthocyanin pigmentation and red color development in berries. This gene has been inserted in several grapevine cultivars, and its expression results in a change in color of mature plant parts including the leaves, roots, shoots, and tendrils.

Additional efforts include testing of genes involved in abiotic stress tolerance pathways that could improve drought and salinity tolerance using precision breeding technology.

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ANSWERING VEXING VINE QUESTIONS

- Wyoming's diverse growing conditions make providing general recommendations for grapevine production difficult and necessitates multi-location trials of promising grapevine germplasm to identify suitable cultivars for specific regions.
- Drought-related stress and winter damage to dormant grapevines are other factors affecting early establishment and productivity. Dry weather during the growing season can provide optimum conditions for vigorous, disease-free growth of grapevines and production of high-quality fruit if suitable cultivars for specific regions of the state are identified.
- Developing optimum practices for Wyoming vineyards can decrease establishment times and improve productivity and economic returns.

GROWING GRAPES FERMENTS INTEREST

Interest in Wyoming grapevine production for the table and for wine has steadily risen since Table Mountain Vineyards near Huntley, the first vineyard and winery, was established in 2001.

Harsh winter temperatures, spring frosts, and short growing seasons prevent using traditional grape cultivars; however, intensive breeding efforts resulted in the development of cold-hardy, excellent quality, interspecific grapevine hybrids, which can be successfully grown in colder regions, including Wyoming.

For more information on cold-hardy hybrids visit:

- University of Minnesota Grape Breeding Program: http://mnhardy.umn.edu/varieties/fruit/grapes
- Northern Grapes Project: http://northerngrapesproject.org/

MOUNTAIN LION RESEARCH

shows what's possible when Wildlife Genomics and Disease Ecology Laboratory brings to bear its ample expertise on Wyoming wildlife

Holly Ernest
Professor
Wyoming Excellence Chair
Department of Veterinary Sciences

P1 slinks silently through a dark mountainous forest, sniffing the duff and leaves for scent trails.

He does this to locate family members and to detect interlopers in his patrolled home range.

At over 150 pounds of raw might, his regal bearing and magnificent tawny coat inspire a vision of wild beauty. Yet this mountain lion (*Puma concolor* is the scientific name, cat of one color) is a predator, a carnivore, and will stalk deer or unwelcome interlopers with unwavering ferocity. Over a decade of his reign, mating with P2 and other resident females, P1 amazingly founded a lineage, reconstructed through our DNA work, of over 40 mountain lions living in California's Santa Monica Mountains.

Moving south across the Los Angeles Basin from P1's home range, F92 carefully navigates and weaves through her coastal sage-scrub brushy habitat of the Santa Ana Mountains, just north of San Diego. She has two spotted kittens to protect, feed, and train for the year and a half they are dependent on her (go to bit.ly/reflectionsmag2016 to see an online video of F92 and her kittens). These are the urban carnivores and coastal cats, members of small remnant populations that were once abundant and ranged unimpeded throughout the west coast of North America. Now the coastal California mountain lions depend on what's left of a fractured and damaged habitat within the greater metropolitan spheres of two megacities of over 18 million people.

- How did we come to know P1 and F92 were even there (mountain lions are rarely seen and generally work hard to keep themselves hidden)?
- How can we trace their family tree over five generations?
- Why are highways leading to dangerous levels of inbreeding and a vortex of

LISTEN TO THE LIONS (MOUNTAIN, THAT IS)

Wyoming Public Radio offers five tracks of the sounds of mountain lions, plus a radio story and several videos about Wyoming mountain lions.

bit.ly/soundsoflions

extinction in coastal California mountain lions?

- How can we determine what constituted a population unit of mountain lions, not just in coastal California, but throughout their western North America habitat?

Collaborators at the National Park Service, The Nature Conservancy, local governmental agencies, University of California (UC), Davis, and UCLA combined field work, animal capture, Global Positioning System (GPS) collar telemetry, camera traps, and DNA analysis to provide important new insights into the ecology, behavior, and health of mountain lion populations.

Previous to these studies, many in wildlife agencies assumed mountain lions were broadly interbreeding, that there would not be much structure to their populations, and that western mountain lions would have healthy levels of genetic diversity. DNA evidence has proven this is not the case in California.

Coastal California mountain lions have a distinct population genetic structure, meaning nearby lions tend to mate with each other and tend not to mate and share genetic material with other groups. Populations of lions to the north of Los Angeles in the Santa Monica Mountains where P1 once roamed, and to the south of Los Angeles in the Santa Ana Mountains where F92 still roams, have very low genetic diversity and signs of a genetic bottleneck.

The low level of genetic variation is approaching that of the highly inbred Florida panther (that is, prior to bringing Texas mountain lions to Florida to diversify the gene pool. See related story at bit.ly/bigcatrestore.) Two of the mountain lions examined in southern California had kinked tails – a potential sign of inbreeding. While

Left, postdoctoral research associate Erick Gagne, whose project is mountain lion population genomics. Right, laboratory manager and postdoctoral researcher Sierra Love Stowell's project is bighorn sheep genomics. See more information at bit.ly/gagnestowell.

DISCOVERIES TRANSFORM RESEARCH

Key discoveries in DNA technology in the early 1990s revolutionized wildlife genetics, forensic genetics, pathogen diagnostics, basic biology, and more.

PCR (polymerase chain reaction) was one such innovation, followed by capillary electrophoresis and microsatellite DNA markers, and now next generation whole genome sequencing (NGS).

Microsatellites were named because of an early observation that DNA in a test tube separated into a larger layer of DNA and smaller "satellite" layers of repetitive DNA. Microsatellites have DNA sequences that typically repeat five to 50 or more times in the genome. They mutate faster than most DNA, making them useful to detect differences between individuals and populations.

Microsatellites have been a very important tool in wildlife genetics for conservation and management for the past 20 years. Now the newer generation of DNA tools including NGS is adding to the usefulness of microsatellites and increasingly surpassing the tool for many applications in animal, plant, microbial, and human research and diagnostic tests. Since much work is still needed to compare NGS with previous microsatellite DNA data, microsatellites are not yet left in the dust – the Ernest lab is conducting work with both tools to make sure previous wildlife genetics data sets using microsatellites can be compared to future NGS data.

Over a decade of his reign, mating with P2 and other resident females, P1 amazingly founded a lineage, reconstructed through our DNA work, of over 40 mountain lions living in California's Santa Monica Mountains.

kinked tails can be caused by injuries and reasons other than inbreeding, these individuals also had among the lowest genetic diversity in their southern California population.

Clearly these populations are in trouble. When you add to this genetic bottleneck the mountain lion deaths due to vehicle strikes, rodenticide poisoning, parasites, viruses and bacteria, you increase the risk of a downward spiral in population numbers called an "extinction vortex."

However, not all the news is bleak. P22, a son of P1, became widely known through frequent tweets on "his" Twitter account @MountainLionP22 (above). Efforts like this to help publicize the plight of coastal California mountain lions have led to some positive changes: banning dangerous rodent poisons and considerations for changes in road construction, including wildlife over- and underpasses, are a few of the initiatives that could make a difference for the lions' future.

To contact:** Ernest can be reached at (307) 766-6605 or hernest@uwyo.edu. Check out updates of Ernest's Wildlife Genomics and Disease Ecology Lab at* ***www.wildlifegenetichealth.org

National Geographic photo used with permission

Hollywood Lion, P22

Photo credit: Winston Vickers

Mountain lion F92 and her kittens.

LABORATORY FOCUSES RESEARCH ON POPULATION HEALTH OF ROCKY MOUNTAIN WEST AND CALIFORNIA WILDLIFE

The Wildlife Genomics and Disease Ecology Laboratory (www.wildlifegenetichealth.org/) in the College of Agriculture and Natural Resources is using techniques developed during work in California to study wildlife close to home.

Forensic DNA tools the Ernest lab developed determined that certain isolated populations of mountain lions in southern California have very low genetic diversity caused by loss of migration corridors and road kill deaths on 10-lane highways. Their work on mountain lion genetics continues, now with funding from the National Science Foundation. They employ the latest genomics techniques to evaluate wildlife adaptations to their environment and viral pathogen genomics to study transmission and spread of disease-causing agents in wildlife.

Insights and techniques gathered through more than two decades of wildlife genetics and population health work have benefited a wide variety of species. For example, Ernest's research on desert bighorn sheep discovered migratory pathways across the Mexico-California border provided vital gene flow between bighorn populations in the two countries – a crucial key to the health of the species (see bit.ly/bighornbyways). The main migration corridor has proposals for large energy and other developments. Now with this information, mitigation measures can be put in place to protect this migration pathway and help conserve this endangered bighorn sheep population.

Pre-veterinary student Erin Bentley labels a cryotube of sample to preserve DNA in the ultracold freezer in Professor Holly Ernest's Wildlife Genomics and Disease Ecology Laboratory in the College of Agriculture and Natural Resources. Bentley is from Green River.

Black bear studies conducted by Ernest's team at University of California, Davis, used minimally invasive DNA sampling techniques to estimate bear numbers along the central coast of California. Prior to the 1930s, black bears were excluded from coastal California by their larger cousins, the grizzly bear. Since the extinction of the grizzly bear in California, black bears are now increasingly populating coastal California. Ernest's team conducted genetics studies that detected where the bears were immigrating from and provided a means for estimating these elusive and hard-to-count animals.

Now that Ernest has moved her lab to the University of Wyoming, all of these research developments are being built upon to advance management and conservation of wildlife in the Rocky Mountain West. With a special focus on Wyoming, her lab is applying these and other research techniques to bighorn sheep, pronghorn "antelope," deer, hummingbirds, and owls.

Photo credit: Javier Mercado

SELECTED AS THE *REFLECTIONS* 2016 STUDENT ARTICLE

TINY WASPS TAKE BIG BITE OUT OF BARK BEETLE POPULATIONS

Lawrence Haimowitz
Masters Student
Entomology

Scott R. Shaw
Professor
Department of Ecosystem Science and Management

Bark beetles may be chewing through our forests, but who is eating the beetles?

Tiny wasps, known as parasitoids, are among the beetle's most important natural enemies. If you've seen the movie "Alien," then you're well acquainted with the parasitoid lifestyle. The wasp stings a host insect and then deposits an egg into the paralyzed host. The host may then recover from the sting, but (creepy!) the wasp egg hatches into a wasp larva that eats the host from the inside out.

Luckily for us, these wasps don't sting people. Their names are as alien as their lifestyle – *Coeloides, Roptrocerus, Rhopalicus, and Heydenia* are common in Wyoming.

Parasitoid wasps are one of nature's most significant population controls for other insects, including bark beetles. Bark beetle parasitoids are no bigger than a few millimeters.

A Coeloides wasp drills through the bark to lay an egg on a mountain pine beetle larva.

Photo credit: Beat Fecker, WSL

While most bark beetle parasitoids attack larval beetles, there are a few that attack the adults. Tomicobia wasps develop inside the abdomen of adult beetles. When mature, the adult wasp chews its way out of the dead victim, leaving a round exit hole.

To see one, you have to be at the right place at the right time and look very carefully. You may never see one, but they are always there, guarding forests.

Natural enemies help regulate the severity, extent, and timing of epidemics. Seeing all the dead trees in the nearby mountains may make one a little skeptical of that claim – but the beetle epidemics could have been a lot worse without them.

How do we know that?

Just as animals evolve resistance to diseases, forests develop resistance to insects that attack trees. One way to study resistance to a disease is to expose organisms that have not been exposed to that disease. Recently, Mother Nature performed her version of this experiment in Canadian forests: mountain pine beetle epidemics have spread through millions of acres of pine trees that have not seen epidemics in historic times. Epidemics outside the beetle's historic range were considerably worse than those inside the historic range. Nature showed how much worse the beetle epidemics might have been in the U.S.

Our research begins where nature left off, looking for answers to some of the many questions she left for us.

The Enemy of My Enemy is my Friend

How effective are natural enemies at defending forests from mountain pine beetle?

This question has not been adequately answered despite rich literature on the subject, in part because of the need for easier, more direct methods of measuring the effect of natural enemies on mountain pine beetles.

Most of what bark beetles and their parasitoids do in nature takes place under the bark of standing trees, and what happens in a standing tree is not easy to duplicate in the laboratory. The effect of a successful bark beetle invasion is spectacularly visible, but what happens under the bark is not.

Predator exclusion, a simple, direct method to measure the effect of predation, to our knowledge has not yet been tried in mountain pine beetle research. A portion of a prey animal's environment is protected from predators, and then survival of that protected prey is compared with survival of prey naturally exposed to predators.

The difference is a direct measure of the effect of predation.

Sounds simple, but in practice

there are many pitfalls. Fortunately, this method has been used in studies of three other bark beetles, so we had the benefit of previous researchers' mistakes and experience to draw upon as we set up our first experiment last summer in the Shoshone National Forest near South Pass. There is plenty of room for mistakes; these are different trees in different regions with different beetles. Results will not be in until after beetles emerge in late July to early August and will be taken into account in the next round of experiments.

We expect to see a large effect based on studies of other bark beetles.

On Time for Dinner?

Parasitoids have to be present and ready to lay eggs when their prey/hosts are present. If environmental changes like a warming climate affect parasitoid and host lifecycles differently, the parasitoid may no longer be on time to take full advantage of its prey and may lose some of its effectiveness. Evidence shows this occurs in at least some parasitoid/host systems.

To determine timing of parasitoid emergence, one method under development is to place a trap on standing trees. A simpler method could be used to infer emergence times, such as peeling bark from infested trees and rearing insects from those bark samples, but an emergence trap is still needed to validate the inferences.

Emergence traps have been used for decades to study bark beetle emergence, but bark beetle traps are not effective for sampling natural enemies for two reasons: (1) natural enemy populations under the bark are much lower than beetle populations, so beetle traps don't cover enough area of the bark to get representative samples

Photo credit: Javier Mercado

An adult mountain pine beetle is the size of a grain of rice.

Inner surface of bark with mountain pine beetle galleries and Coeloides cocoons. Researchers in the past counted things like these cocoons, number of egg galleries, larval tunnels, and emergence holes to calculate beetle mortality. Simpler, more direct methods are needed to give future researchers an easier way to measure the effect of natural enemies.

of the wasps; and (2) the parasitoids that attack bark beetles are much smaller than the beetles, so they can easily escape through the screen mesh that is used to construct bark beetle traps. Because traps for bark beetle emergence are not suitable for parasitoids, I have designed three prototype emergence traps to capture the tiny wasps.

The newly designed traps consist of a sleeve-like, no-see-um mesh enclosure that covers 3 feet of the tree trunk. On a 15-inch diameter tree, the enclosure covers 12 square feet of bark. Bark beetle emergence traps cover 1 to 2 square feet. The traps were deployed in the Pole Mountain Unit of the Medicine Bow National Forest in the summer of 2014.

I redesigned the trap in 2015 because the enclosures had to be custom field-fitted to each tree, making installation time-consuming and difficult and making it impossible to reuse the traps. The new design can be fabricated in a lab or shop to fit a wide range of trees and can be reused.

If beetle conditions remain favorable to my study – meaning finding enough beetle-infested trees to conduct experiments – we plan to compare results from this technique to classical methods. In the classical method, an infested tree is cut down, and insects are reared from a series of bark or wood samples taken along the length of the trunk. To get comparable measurements using emergence traps on standing trees requires placing a series of traps at different heights on the same tree. It is easier to cut a tree down than to work at heights to install such a series of emergence traps on a standing tree.

Development of both of these techniques will continue for the next several years, even though mountain pine beetle epidemics have died down in our area. We do not expect to have the opportunity to apply our new methods to epidemic phase beetles (bark beetles have killed most of the trees suitable for the high reproductive rates needed to sustain an epidemic), but these methods will be available to other researchers in other areas and times where the beetles are epidemic.

The Forest Abides

Humans exert too large an effect on forests to be uninformed about how we affect them. Well-intentioned fire suppression, for example, has been known to create much higher densities of mature trees, which lead to much higher bark beetle reproduction, thus contributing to the severity of epidemics.

In the past, humans did everything possible to keep fires from forests, but we now realize some fires are necessary for forest health. Forestry professionals are beginning to see bark beetles in the same light. With future policies informed by new research, our forests can return to a condition in which bark beetle epidemics are more self-limited and contribute to forest health.

Foresters using bark beetles as a tool for forest management is even likely, just as fire is used today. This may take decades, or even centuries and calls for public understanding and patience.

Acknowledgements: *This material is based upon work that is supported by Wyoming Agricultural Experiment Station funding provided through the National Institute of Food and Agriculture, U.S. Department of Agriculture, McIntire-Stennis under #1005811 (WYO-553-15).*

Explore more:

- For an animation showing spread of recent bark beetle epidemics in Rocky Mountain Region

  bit.ly/epidemicmaps
- For more on the spread of mountain pine beetle beyond its historic range in Canada

  bit.ly/beetlespread
- For more on the ecological role of bark beetles in forests

  bit.ly/beetlerole

  bit.ly/cufirestudy

The author's wife, Robin Hill, sews a seam on an emergence trap on the trunk of a bark beetle-infested tree.

Research assistant Rachel Lentsch with predator exclusion cage for mountain pine beetle.

Wyoming Agricultural Experiment Station: 125 YEARS OF SERVICE

David Kruger
Agricultural Liason Librarian
UW Libraries

With roots planted only one year after historic Fort Laramie was decommissioned, Wyoming citizens reap the rewards of research pivoting the state's focus toward the future

A 93-year-old man this past February made his way inside the Powell Research and Extension Center, ostensibly to sit down and talk about the Wyoming Agricultural Experiment Station (WAES) and its history as he knew it.

That man, known by many in WAES as Jay Partridge, was a significant part of WAES's 125-year legacy and particularly the Powell Research and Extension Center (PREC), serving from 1952 until his retirement in 1988.

"I started out testing soils," the former PREC superintendent recalled. "Farmers would bring in soil samples and I would make a recommendation as to how much fertilizer they should put on for how much they were growing. I ran a lot of research projects to help a lot of farmers out around here: corn, beans, alfalfa. Most of my research projects were in the Heart Mountain area. Some in the Worland area, and some between Cody and Greybull. Some even in the Star Valley area."

The celebration of the WAES and its 125th anniversary is really a celebration of service between agricultural researchers and agricultural producers, ultimately in an ongoing effort to improve Wyoming agriculture. The experiment station is, in actuality, nearly as old as Wyoming itself, signed into law in 1891 just a few months after Wyoming attained statehood.

Differentiating between WAES and UW Extension

Recognizing the distinctive nature of WAES is often difficult for many Wyoming residents in the 21st century. Hearing longtime experiment station farms simply referred to as "extension farms" is not uncommon,

LARAMIE RESEARCH AND EXTENSION CENTER

Established March 2011 in its current form, although some of the original structures west of Laramie were built in 1890. The UW Stock Farm at the territorial prison operated from 1908-1990. The current center consists of beef, swine, and sheep units, the research greenhouse, the McGuire Ranch, and the Cliff and Martha Hansen Teaching Arena.

not to mention many other conflations between the two organizations, despite WAES actually predating UW Extension by more than 20 years.

"The distinctions are really quite simple even today," explained former WAES director Colin Kaltenbach, "not just for Wyoming but pretty much any land-grant university. The Wyoming Agricultural Experiment Station is the research component of the UW College of Agriculture and Natural Resources. UW Extension, of course, is the outreach portion of the college, and the academic component of agricultural study resides within the college. That tripartite function of experiment station, extension, and college of agriculture is still present in every land-grant university, and still functions in pretty much the same way it always has."

Origins of WAES in 1891

Just as the Smith-Lever Act became the life force for creating UW Extension, the Hatch Act of 1887 set in motion events leading to creating WAES in 1891. Under the provisions of the Hatch Act, Wyoming would receive $15,000 in federal funds each year to establish and operate agricultural research farms. The establishment of WAES and its farms was in hindsight very timely for the state. Prior to the turn of the 20th century, Wyoming was not just a new state, but a blank slate for agricultural potential beyond simply large ranching operations of the 19th century.

As Wyoming historian T.A. Larson noted, early cattle and sheep operations in Wyoming could be seen as the vanguard for other agricultural activities soon to follow in the late 19th and 20th centuries.

"Many people in the East thought it inevitable that farms would supercede the stockmen in Wyoming," Larson wrote. "Quite a few people in Wyoming thought so, too."

Of course, pursuing such untested agricultural activities throughout Wyoming without agricultural research and support, much less the existence of UW Extension, was a largely untenable proposition for most agrarian newcomers. And in the greater scheme of Wyoming's future, such a hindrance could greatly impede the state's agricultural and economic potential during the following century.

Establishment of Early WAES Farms

In 1891, the challenge of setting up the initial Agricultural Experiment Station farms across Wyoming was certainly a geographic one, as the state itself had a variety of agricultural areas with markedly different elevations, soils, and rainfall; however, the challenge was also indicative of former Senator Alan Simpson's later quip, "Everything in Wyoming is political (except politics - that's personal)."

Territorial governors had politically denied Lander an opportunity to become home to the University of Wyoming, and subsequently denied Sheridan and Buffalo a chance to host Wyoming's first agricultural college. As a result, the first WAES farms outside of Laramie were naturally located in Lander and Sheridan, along with Saratoga, Sundance, and Wheatland.

As opposed to Sheridan's Wyarno station established by the United States Department of Agriculture (USDA) in 1915, the early Sheridan experiment farm was west of the city limits. Within the main station at

POWELL RESEARCH AND EXTENSION CENTER

Founded in 1947 one mile north of Powell on Highway 25. About 175 of the 220 acres are irrigated cropland. Research focus includes agronomic weed control, irrigation, cropping systems, high tunnel production, variety performance testing, transgenic variety response to herbicide treatments, and alternative crops.

Laramie were three research facilities, the "WU Experiment Farm" on campus, the "WU Experiment Grounds" 2 miles west of town, and a U.S. Grass Station that was discontinued after 1892.

Under the overall direction of John "Dice" McLaren, each farm had its own superintendent, and each farm was utilized for a variety of agricultural experiments, including Bert Buffum's research of timeless Wyoming issues such as weed control and crop variety testing.

Although the Sheridan Research and Extension Center is currently experimenting with Wyoming grape production under plant scientist Sadanand Dhekney, a variety of fruit production experiments were also conducted at every WAES farm throughout the late 19th century. Meticulous records were kept for each farm regarding fruit production and conventional crop yields under various varieties and conditions, ultimately to aid Wyoming producers in making the most productive selections for their respective areas.

In an era that pre-dated UW Extension, public field days at the farms and ongoing research bulletins since 1891 were vital for communicating the fruits of WAES research to producers throughout the state, a communicative function that remains vital to WAES researchers and Wyoming agricultural producers even today.

Keeping these initial experiment farms open proved financially untenable in the early years of WAES. The Saratoga farm was discontinued after five years. By June of 1897, the Sundance and Wheatland farms had been discontinued as well, leaving only the farms in Lander, Sheridan, and Laramie. Nevertheless, research from each of these discontinued farms continued to be published in Agricultural Experiment Station bulletins long after their active roles had ended.

By 1900, the Lander and Sheridan farms had also been discontinued, and WAES facilities were consolidated exclusively to the main station in Laramie; however, with the acquisition of the Territorial Prison property in 1907, significant improvements followed at the existing Laramie experiment farms. In 1908, a new UW Stock Farm was unveiled while the existing experiment farm 2 miles west of town was improved and renamed the UW Agronomy Farm. On campus, a new Agricultural Hall was constructed and built for WAES offices five years later along 9th Street, in what is now part of the UW Health Sciences Complex.

JAMES C. HAGEMAN SUSTAINABLE AGRICULTURE RESEARCH AND EXTENSION CENTER

Formed in 2006 combining Archer and Torrington centers. There are 1,522 acres of dry land cropland, 349 acres irrigated cropland, 1,880 rangeland, 19 aces irrigated organic cropland, 40 acres of dry land organic cropland, a feedlot, and livestock research laboratory. In 2007, the center was officially named the James C. Hageman Sustainable Agriculture Research and Extension Center in honor of the former longtime state representative of Goshen County and UW alumnus.

Re-Establishment, Expansion of WAES Farms beyond Laramie

For all of the improvements in Laramie, those in the WAES believed its agricultural research was of limited use to the rest of the state if experiments were only conducted in Albany County. In 1918, WAES was able to resume agricultural research in Sheridan by utilizing the Wyarno farm, a facility opened by USDA in 1915. WAES director A.D. Faville also had good news for Lander residents that same year, announcing that the Lander farm would soon resume operations again as a WAES research facility. By 1921, Faville had further expanded WAES operations to new farms in Eden, Grover, Lyman, and Torrington, with cooperative arrangements at another USDA farm in Archer, just east of Cheyenne. Faville articulated his rationale behind the expansion:

"The State Farms, substations as they are called in many states, fill an important place in a state like Wyoming. No one section even approximately represents a large area of the state, unless it be the Laramie Plains. A careful study of the whole problem indicates that only thru several well located and well supported farms can the state hope to be in a position to study her varied agriculture. Station authorities should lend every assistance in making the State Farms real factors in the work they are attempting to do. We must not lose sight of the fact that the Experiment Station has been and will continue to be the keystone in the arch supporting

John Hill

agricultural education both in the schools and in the extension field and any crippling of research work is a most serious handicap to the general advancement of agriculture."

Faville resigned his directorship of WAES in 1922 to take a position in the Wyoming Department of Agriculture. Faville's loss proved a fortuitous gain for WAES, however, as successor John Hill would go on to provide outstanding leadership of the organization for almost 30 consecutive years.

Hill was an Ohio transplant but an avid wool scientist passionate about improving the quality of Wyoming wool. Armed with only a bachelor's degree from the university, he had largely been responsible for the Wool Department since 1907 and concurrently began leading the College of Agriculture as its dean 15 years later. Under Hill's direction, WAES naturally made significant strides in improving wool scouring and coring techniques as well as sheep culling.

Wyoming Stockman Fred Warren specifically singled out Hill's work for improving the economic viability of his own sheep operations across the state. Hill even went so far as to develop a new breed of sheep for Warren Livestock conducive to optimal wool production in Wyoming, naming it "Warhill" as the synthesis of their surnames.

Hill also continued expanding WAES farms to enhance other agricultural research throughout the state. By 1927, five years into his directorship, he had opened additional research farms in Gillette and Worland, while continuing cooperative research on USDA facilities in Archer and Sheridan, and exploring dairy science experiments for the state at an emerging farm in the Star Valley, the westernmost substation ever established by WAES.

Limited funds and resources during World War II forced WAES to contract operations once again, operating just four active farms beyond Laramie in Afton, Archer, Gillette, and Torrington. By 1947, Hill was finally able to announce good news for ongoing agricultural research in the Big Horn Basin. "Powell is the newcomer among our experimental branch stations," he excitedly wrote in his annual report. "Crops under investigation there include beans, small grains, potatoes, and alfalfa."

In his final years as WAES director and dean of the College of Agriculture, Hill also resumed agricultural experiments at the Wyarno farm near Sheridan and was proud to break ground for the current facilities for the College of Agriculture on the University of Wyoming campus, just off the circle of Prexy's Pasture.

After a nearly 30-year career as WAES director, Hill retired in 1950, turning his duties over to Hilton Briggs, who would subsequently negotiate the acquisition of the Archer and Wyarno farms from USDA in 1954, a move that would keep the nucleus of WAES farms Hill had established intact for nearly 20 years beyond Briggs's departure in 1959.

From 1959-1979, Neal "Dutch" Hilston would lead WAES, a career second only to Hill in longevity. Harold Tuma replaced the retiring Hilston as WAES director in 1979, followed by Colin Kaltenbach in 1984.

Taking WAES and Wyoming Agriculture into 21st Century

Although agricultural research remains an ongoing activity, WAES facilities have greatly evolved over the last three decades. Director Kaltenbach had set in motion construction of a new UW Livestock Farm west of town before he departed for the University of Arizona in 1989. The facility replaced previous operations at what is now the Wyoming Prison State Historical Site.

SHERIDAN RESEARCH AND EXTENSION CENTER

There are two active sites but most services have been relocated from the 300-acre Wyarno facility, founded in 1915, east of Sheridan to the Watt Agriculture Building at Sheridan College. Resources include 450 acres of the Adams Ranch south of the college and 240 acres of irrigated cropland. Research opportunities include dry land and irrigated land, forage management, horticulture, and viticulture (the science, study, and production of grapes).

> The celebration of WAES and its 125th anniversary is really a celebration of service between agricultural researchers and agricultural producers, ultimately in an ongoing effort to improve Wyoming agriculture.

Kaltenbach's successor, Alvin Gale, unveiled these new facilities in 1990. When agricultural and applied economics Professor Jim Jacobs replaced the retiring Gale as WAES director in 1994, Jacobs would continue the process of upgrading WAES facilities by closing and selling experiment farms in Afton, Archer, and Torrington, productively using their funds to establish a newer integrated research farm near Lingle, as well as upgrading the Powell Research and Extension Center.

"The Powell Center is much stronger than a decade ago," said Powell director Alan Gray after Jacobs left WAES in 2005. "Without Jim, this wouldn't have happened the way it has."

Plant sciences Professor Stephen Miller then succeeded Jacobs as director in 2005, unveiling what is now known as the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC) outside of Lingle the following year.

Since Miller's retirement in 2010, Bret Hess, who had served as assistant director, has led WAES, operating research and extension centers throughout the state, in Powell, Lingle, Sheridan, and Laramie.

Keeping stride with his 21st century predecessors, Hess has overseen relocation of the Wyarno R&E Center to the Watt Agriculture Building on the Sheridan College campus as well as expansion of research activities with the renovation of the Watt Building, construction of a research greenhouse adjacent to the Watt Building, and long-term sublease of the Adams Ranch immediately south of Sheridan College.

"I envision the next century of WAES teams will continue to be challenged with sustaining mission-oriented research operations in the face of advances in science, technology, and society," says Hess.

The ongoing service of WAES remains the same as it has for each of the 125 years of its long and prosperous existence, an active ongoing connection between agricultural researchers and agricultural producers throughout the state.

REFLECTIONS

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Two men holding a label that reads “White Hulless Barley, Spring Plowing” in a field of barley at the Wyoming Experiment Station farm in Laramie, Wyoming. 1911