Resilience

A VOICE OF THE NEW AGRARIANISM

BEYOND RESILIENCE

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- *Restoring Cañon Bonita Ranch in the Light of New Normals*
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NO. 40 SEPTEMBER 2014

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From the Editor

In 2007, the Board of the Quivira Coalition added the words "build resilience" to our mission statement. Resilience means "to bounce back" or "recover quickly" from a shock or surprise. In ecology, it refers to the capacity of plant and animal populations to handle disruption caused by fire, flood, drought, or insect infestation. In ranching, it means enduring droughts, low cattle prices, and other stresses over the years.

At the time, we were concerned about new and rising challenges, including climate concerns, which made increasing economic and ecological resilience in working landscapes a constructive way for us to help. To do so we focused on four areas: 1) improving land health, 2) sharing knowledge and innovation, 3) building local capacity and 4) strengthening diverse relationships.

Today, while building resilience is more important than ever, it may not be enough. That's because the definition of "normal" is changing. Hotter and drier conditions, for example, are becoming the "new normal" in the Southwest and are projected to increase over time. If resilience means bounce back, the question becomes bounce back to what?

In this issue of our journal, we tackle the idea of going ***beyond resilience*** for ranchers, landowners, wildlife and young people. I want to thank Todd Graham for raising this topic last fall at Quivira's annual conference and I also want to thank Tamara for doing another stellar production job.

Courtney

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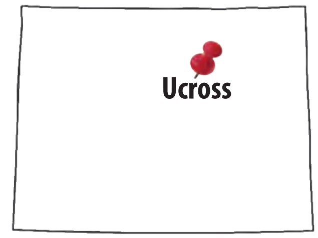
Beyond Resilience: Managing Toward a Higher Level of Ranch Performance

Ucross Ranch, Wyoming

By Todd Graham



Wyoming

Many conservationists and ranchers speak of resilience, the notion that resources, when they are well taken care of, should bounce back from a disturbance. It is said that managers should position their resources to quickly recover from events such as drought, fire and insect outbreaks. Pastures facing drought, for example, may rapidly respond once rains return. Or, a lightning-caused fire may only disrupt grazing operations for a couple of years. The point of resilience thinking seems to be that it is best for resource managers to endure disturbances while waiting for the return of better conditions.

This is a pleasing idea, but achieving resilience is largely impractical. How does a manager quantify a resource's preparedness for a disturbance when the incidence rate and duration are largely unknown? For example, a ranch may build cash reserves in preparation for a dry year, but managers will not know how long the drought will last and how much cash may be needed until grasslands "bounce back." Further, how should a resilient pasture be defined? After analyzing its ecological and financial assets, what would a ranch need to quantify to know if it was truly resilient? Answers to these questions don't arrive easily, which suggests that a better approach is needed.

One such approach is to focus on constant improvement while realizing that disturbances, such as drought, slow the rate of improvement. By contrast, good years allow for greater gains. This is analogous to a tree whose rings grow smaller in poor years and larger in good years. The tree adds less trunk mass in poor years, while piling it on in good years. Thus, the fundamental management strategy for a ranch should be constant improvement of is ecological and financial assets. In good years, great gains may accrue, but in poor years, those gains are slowed. This strategy, when followed through time, will produce an overall higher level of ranch performance.

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A CASE STUDY OF IMPROVEMENT

A case study in this approach to management is found at Ucross Ranch, near the community of Clearmont in northeast Wyoming. Despite enduring disturbances such as fire, grasshopper outbreaks and several dry years, Ucross has increased pasture productivity, tripled its stocking rate and reduced bare ground. Streams that were once ephemeral now carry water year round. The ranch's ecological assets have increased greatly, along with its ability to generate revenue. The story of this improvement is one of mixed-pace gains that are highly dependent upon growing conditions. These gains are so noteworthy that in 2014 the Society for Range Management awarded the ranch its prestigious National Excellence in Rangeland Stewardship Award.

UCROSS RANCH'S LAND BASE

Ucross lies in a mix of resource areas: to the east of the Bighorn Mountains, to the west of the Great Plains and to the north of the Cold Desert (Figure 1). The ranch hosts physical features from all three resource areas and plant species from the mountains, plains and deserts, oftentimes in the same pasture. Large hills and towering spires rise above deep-soiled rangelands in a mix of vegetation types that provide ample cover and forage for big game and sage grouse. All of the ranch's 21,000 acres are located in a 10-14 inch precipitation zone and—as with so many western ranches—consist of a mix of rangelands, state and federal grazing leases, irrigated meadows and sub-irrigated bottoms. Clear Creek, the area's major drainage, flows through the ranch and provides a perennial source of water for livestock, waterfowl and big game. Running parallel to Clear Creek on the ranch's opposite flank is a major railroad track, over which coal is hauled from Wyoming's famous Powder River Basin to far-off population centers. Coal mines, trains and gas wells are as visible here as cows and sheep.

In 2002, when Ucross considered changing management approaches, managers were faced with abundant bare soil, signs of erosion, low plant productivity, too many noxious weeds (such as cheatgrass and leafy spurge) and poorly watered pastures. This ranch was underperforming and managers realized that change was needed. The first step was to alter the grazing strategy.

MIDDLE ALKIRE PASTURE AND ECOLOGICAL PROCESSES

A good example of the ways in which grazing management was altered is found in the Middle Alkire Pasture, which is rectangular in shape and divided down the middle by a small stream. Historically, cattle were placed in this pasture from early May until late June (roughly 60 days every year), and they spent much of their time in the willows and cottonwoods along the creek, rarely venturing into surrounding rangelands. As a result, streambanks were degraded, water quality suffered and erosion was evident. The grazing management strategy that produced these negative impacts on the land was 350 cow/calf pairs, grazing 1700 acres for 60 days (350 pairs x 60 days / 1700 acres), which equaled a stocking rate of 12.3 Animal Days per Acre (ADA).

...in 2014 the Society for Range Management awarded the ranch its prestigious National Excellence in Rangeland Stewardship Award.

ADA is a handy measure of stocking rate and allows pasture performance to be tracked through time and to be compared across ranches. The ADA is a grazing manager's greatest measure of ecological and financial performance.

When altering the grazing strategy, managers elected to keep the same stocking rate (12.3 ADAs), but increased the number of livestock to 569 animal units (equivalents of sheep and cow/calf pairs), shortened the grazing period to 35 days and kept the number of acres the same. On the first try, cattle roamed well beyond the riparian areas to the rangelands, and their hoof action knocked standing dead plant material to the soil surface. Grazed plants were then allowed to recover until the next growing season, which greatly improved plant vigor (Figure 2, page 4).

Within a few short years, signs of erosion declined; desired grasses were more commonly observed in the pasture; and the once heavily grazed riparian area displayed

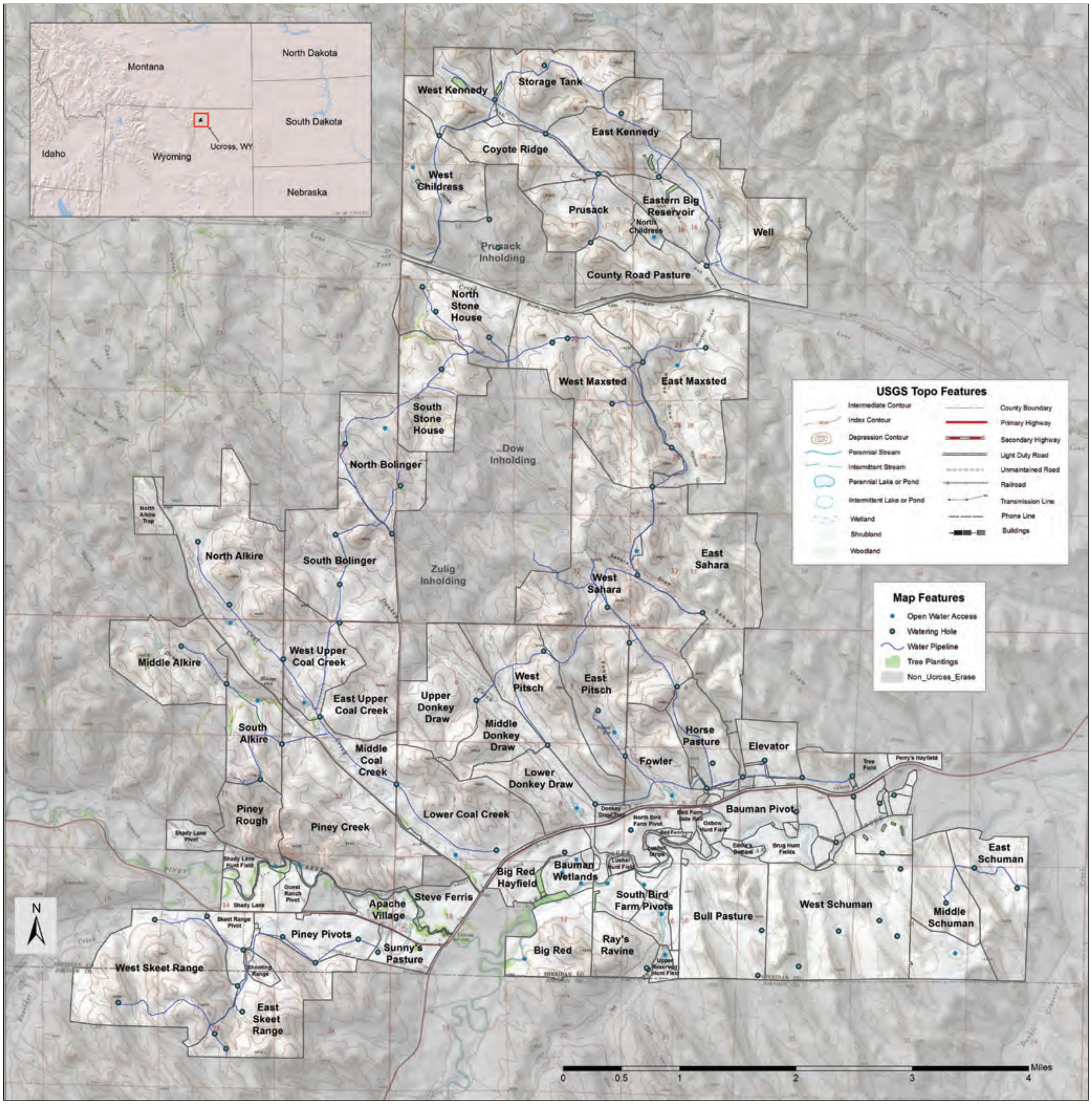

Figure 1. Ucross Ranch map, courtesy of Ucross Ranch.

abundant new growth, providing forage and cover for both wildlife and livestock. In later years, Ucross divided Middle Alkire into four separate pastures, using high-tensile electric fence to further increase stock density, and shortened the grazing duration to less than 10 days per pasture.

Armed with what they learned from pastures like Middle Alkire, grazing managers knew they had a recipe that could be repeated elsewhere on the ranch. Improvements in rangeland health could lead to improved stocking rates and increased future revenue. But, they first needed to spread and improve stock water points across many dry acres.

CORRECTING DISTRIBUTION PROBLEMS WITH WATER DEVELOPMENTS

Sixteen total pastures existed when the ranch changed management in 2002, but roughly 25 percent of the ranch lacked reliable stock water. This meant that much of the ranch simply could not support livestock and that cattle tended to congregate near existing water sources, potential revenue was reduced and the ranch performed below its 21,000-acre potential. Only water developments would improve this grazing distribution problem. Using grant funding and its own cash reserves, the ranch embarked on a series of stock water development projects that greatly increased its grazeable acres. Placement of new stock tanks was dependent upon providing the greatest number of new grazeable acres on the best soils, which maximized financial returns relative to costs.

Further, the ranch designed a series of stock water tanks called "water circles" that service multiple pastures at once. These circles (Figure 3) are designed with a tire tank in the center (nearby coal mines provide an ample supply of used tires) and a small corral around the outside. Cattle are prevented from lingering near water with this design, and the gate to the next pasture can simply be thrown open to reduce cowboying time and costs.

On the Ucross, once new stock water was developed, pastures could then be broken into smaller units to facilitate improved grazing distribution. Using high-tensile electric fence (which is less expensive than barbed wire) and temporary poly-wire fencing, the ranch was divided into 57 total rangeland pastures. This number of pastures added flexibility for livestock operations and altered the grazing strategy even further. Ultimately, infrastructure improvements cost the ranch $10.45 per acre to develop. Over a five-year window, each dollar spent on infrastructure returned 3.66 additional animal days of grazing, and the ranch was able to pay for all water and fencing within 3.5 years.

MAJOR VARIABLES OF GRAZING MANAGEMENT

Reliable water and altered pastures changed the way in which the whole ranch was grazed. The major variables of grazing management may be described as follows:

- Grazing duration is the number of days cattle or sheep are in a pasture—in most cases, fewer than 14 days per grazing.

Figure 2. Basal cover chart in the Middle Alkire Pasture. In 2005, bare ground was 44% and in 2011, 5%. Over the same period of time, desirable live plant cover increased from 4% to 10%, and the number of plant species found at the site nearly doubled.

BASAL COVER

	2005	*2007*	*2011*
Bare	44%	25%	5%
Litter	52%	69%	85%
Live	4%	6%	10%

PLANT SPECIES COUNT

2005	*2007*	*2011*
21	29	38

During this change in management strategy, Ucross also established a rangeland monitoring program designed to track changes in land health through time and to provide guidance for future management decisions. Data from Middle Alkire showed that undesired bare ground decreased, desired live plant cover increased and the number of plant species nearly doubled.

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Figure 3. "Water circles" provide stock water to more than one pasture (three in this case). When the time comes to move cattle onto fresh pasture, a gate is thrown open and many cattle move themselves.

- Frequency of grazings is the number of times a pasture is grazed per year. For example, twice, once or not at all, depending on the condition and production of the pasture.
- A recovery period between grazings allows grass to regrow. When growing conditions are favorable, 90 days is the standard recovery period; when they are unfavorable, pastures are allowed at least a year to recover.
- Timing of grazing may be altered seasonally, based on historic use and growing conditions. Ucross has displayed historic sensitivity to spring grazing, so spring grazing events are altered each year.

With such short grazing durations, strong flexibility exists to adjust pasture movements in response to plant growth and disturbances such as fire, and also to provide a forage reserve. At Ucross:

- Stock density (the number of livestock per unit area) has more than doubled, reaching roughly one head per acre by 2013.
- Stocking rate (the number of livestock grazing a given pasture for a unit of time) has tripled since 2002.

HOW THE LAND RESPONDED TO MANAGEMENT

The land responded quickly to the new grazing strategy. The first changes observed were strong reductions in bare ground. Following the establishment of various rangeland health transects, bare ground was found to have dropped dramatically. The North Childress Pasture's bare ground decreased from 29 percent in 2004 to 6 percent in 2011, while live plant cover more than doubled (Figure 4).

Figure 5 data suggest that the water cycle was improving. Signs of erosion began to disappear. As water flowed into the soil rather than running off, an unexpected, massive increase occurred in undesired species, such as cheatgrass and Japanese brome. These two species seemed to flourish for several years and often composed nearly half of total plant production in the community. But Ucross didn't panic. These were pioneer species in the beginning phase of the successional process. In later years, as the successional process advanced, most cheatgrass was replaced by more desired plant species.

Next, plant productivity increased. In the Stonehouse Pasture, plant productivity has more than tripled since 2003 (Figure 5). Photos show the changes in plant productivity well. For example, the Upper Coal Creek Pasture's production climbed substantially (Figure 6, page 6).

Lastly, shifts in plant species composition brought more highly desired bunchgrasses, including green needlegrass and Idaho fescue. These are high-producing species, and in this area, they are favored by cattle. Increases in desired species in three pastures are displayed in Figure 7, page 6.

BASAL COVER - North Childress Pasture

	2004	**2008**	**2011**
Bare	29%	5%	6%
Litter	63%	88%	77%
Live	8%	7%	17%

Figure 4. Basal cover from the North Childress Pasture. The amount of bare ground decreased by 23 percentage points and live plant cover more than doubled.

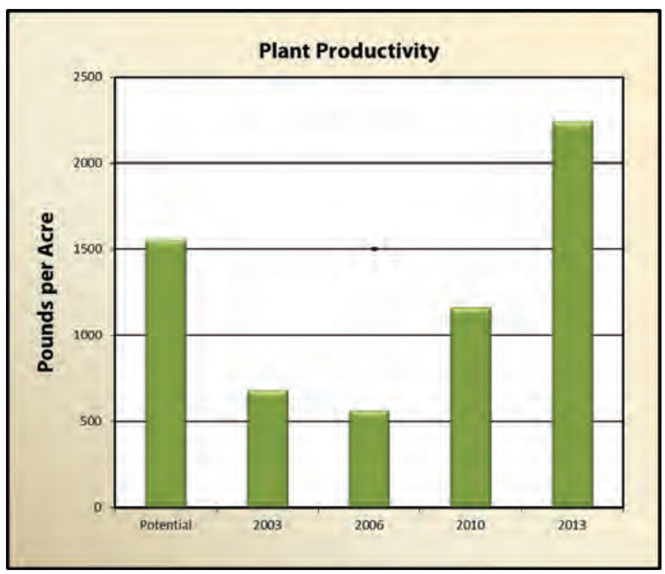

Figure 5. Total above-ground plant productivity in the Stonehouse Pasture. The years 2003 and 2006 were both dry, and 2010 and 2013 approached average precipitation. Each year shown in this figure corresponds to the year in which the pasture transect was read.

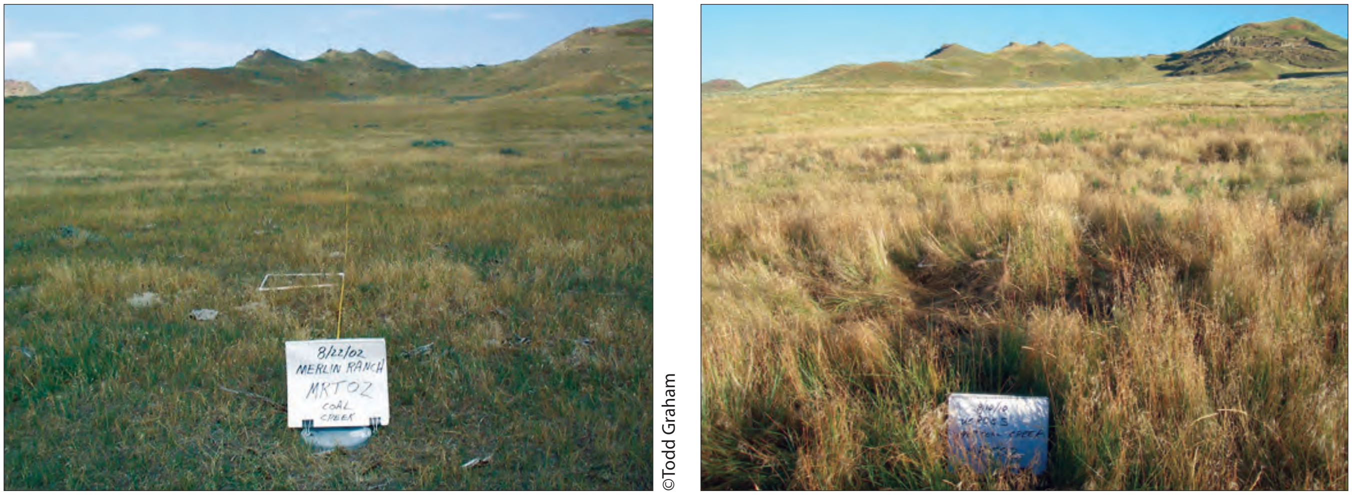

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Figure 6. The photo on the left shows the Upper Coal Creek Pasture in 2002, the first year of the new management approach. On the right, plant productivity had more than tripled by 2011. Both photos show the pasture before grazing.

Green needlegrass in Ray's Ravine Pasture	**2002**	**2005**	**2011**
	0%	18%	35%
Idaho fescue in Stonehouse Pasture	**2006**	**2010**	**2013**
	3%	6%	21%
Idaho fescue in North Childress Pasture	**2004**	**2008**	**2011**
	19%	46%	58%

Figure 7. Changes in relative basal composition of desired grass species in three different pastures.

When examined together, these data paint a picture of mixed-pace gains. In the drier years of 2002 through 2004, management changes produced slow improvement in ecological processes, including small reductions in bare ground. Wetter years like 2005 brought more rapid change and large reductions in bare ground. This allowed the ranch to achieve an overall higher state of performance than it had ever known. By the late 2000s, data showed increased basal cover of the more desired plant species (Idaho fescue, green needlegrass, winterfat). Warm-season grasses like sand dropseed and little bluestem also appeared more prominently. These changes elevated the ranch's overall ecological performance.

PROGRESS DURING DISTURBANCE

The improvements described above also occurred in the face of disturbance. In 2008 and 2009, for example, severe grasshopper outbreaks resulted in the loss of much standing forage across the region. Some Ucross pastures were severely affected by these outbreaks, to the point where grazing durations were greatly shortened. Grasshoppers consumed so much forage in the Bollinger Pasture that it could barely be grazed. Fortunately, forage reserves had been planned, and cattle were moved away from the grasshopper-afflicted pastures to better forage elsewhere. Improvements in rangeland health were slowed for these two years, but the amount of bare ground measured in the Bollinger still declined.

In 2008, a fire started by a hunter's idling vehicle disturbed thousands of acres reserved for autumn grazing. Managers then scrambled to reallocate forage in an effort to minimize hay feeding. Again, because forage reserves had been planned, the financial impact was minimized. This disturbance also produced interesting shifts in plant species composition. Prior to the fire, the desired grass, needle-and-thread, was abundant, and after the fire another desired species, green needlegrass, grew aggressively. In this instance, one desired grass replaced another (Figure 8). Due to the pasture's high state of rangeland health and the quick response by green needlegrass, no rest period was considered and the pasture was grazed in the year following the fire (many ranchers and most federal and state agencies pursue a two-year post-fire recovery period).

Lastly, the year 2012 brought one of the hottest, driest years on record. As the summer progressed and news spread of the crippling drought, Ucross pastures did not display poor growing conditions. Rather, pastures continued to produce vigorously and even showed green growth late into the hot month of August (Figure 9). While the stocking rate was reduced to help maintain rangeland health, calves were shipped only six days early that year. This was in contrast to many other ranches in the region, which shipped their calves several weeks early due to lack of forage.

THE TAKE-HOME LESSON

It was during that hot, dry year of 2012 that the notion of achieving a higher state of ranch performance became clear. Plant production did not plummet—it was only reduced. Stocking rates did not oscillate wildly from prior years—they changed gradually. Managers did not scramble to buy high-priced hay to survive the year—they allocated grazeable forage as in prior years. The lesson learned was that high-performing ecosystem processes reduced the negative impact of this dry year. The same can be said for the grasshopper outbreak and fire. Each presented its own kind of disturbance, and a high level of rangeland health, plus a good management approach, minimized the negative effects.

Looking back on Ucross since 2002, abundant disturbances are revealed: the years 2002-2004 were dry, 2006 was hot and dry, 2008 and 2009 brought hellish grasshoppers, 2010 was dry, and 2012 was one of the hottest, driest years on record. The land did not display resilience from this series of disturbances, it displayed constant improvement. What changed was the *rate of improvement*, which slowed during the poor years. In good years like 2005, 2007, 2011 and 2013, rangeland health data revealed more rapid reductions in bare ground, strong plant productivity, and more rapid and desired shifts in plant species composition. These are the changes that produce a higher state of rangeland health and ranch performance.

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Figure 8. A fire occurred in this pasture in 2008. The yellow stripe in the photo's center is cheatgrass caused by a dozer creating a fire line. The fire burned on the left of the fire line, and the desired species, green needlegrass, responded well to the fire. On the unburned side on the right is the desired grass needle-and-thread. In this instance, one desired grass replaced another. No rest period was scheduled for this pasture following the fire because plants and rangeland health displayed rapid recovery.

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Figure 9. A gravelly, east-facing slope in the Skeet Range Pasture shows strong plant vigor and green growth in late August 2012—one of the hottest, driest years on record in northeast Wyoming.

When planning for the future and its inevitable droughts and fires, Ucross can quantify its preparedness for those disturbances. Managers can allocate forage based on a least-cost strategy while still improving the resource, even when they don't know how long the disturbance will last. This allows for a livable income stream from livestock operations in good or bad years, while still providing forage and cover for the wildlife that the ranch so highly values.

FINANCIAL AND ECOLOGICAL DIVIDENDS

A dividend is a reward for efforts that are paying off, and in the case of Ucross Ranch, the dividends have been accruing both financially and ecologically. Financially, the ranch has tripled its stocking rate (Figure 10). Since 2002, with the number of acres remaining the same, the ranch has tripled the number of animal days harvested. Herd size was reduced in 2012 due to the dry year and again in 2013 to allow the land to recover, but the ranch's grazing output was still triple that of 2002. Since adopting a new management approach and with no change in cost structure, the ranch's financial margins have increased substantially. Even if the ranch faces a series of dry years and herd size must be greatly reduced, it will still be better off financially.

The ranch's ecological dividends are accruing in newly formed perennial streams. Once flowing only during spring runoff, several channels now carry water year-round, an occurrence that no living person had observed before. Such drainages provide many new watering points for livestock and wildlife, as well as associated high-production forage. Even in the dry year of

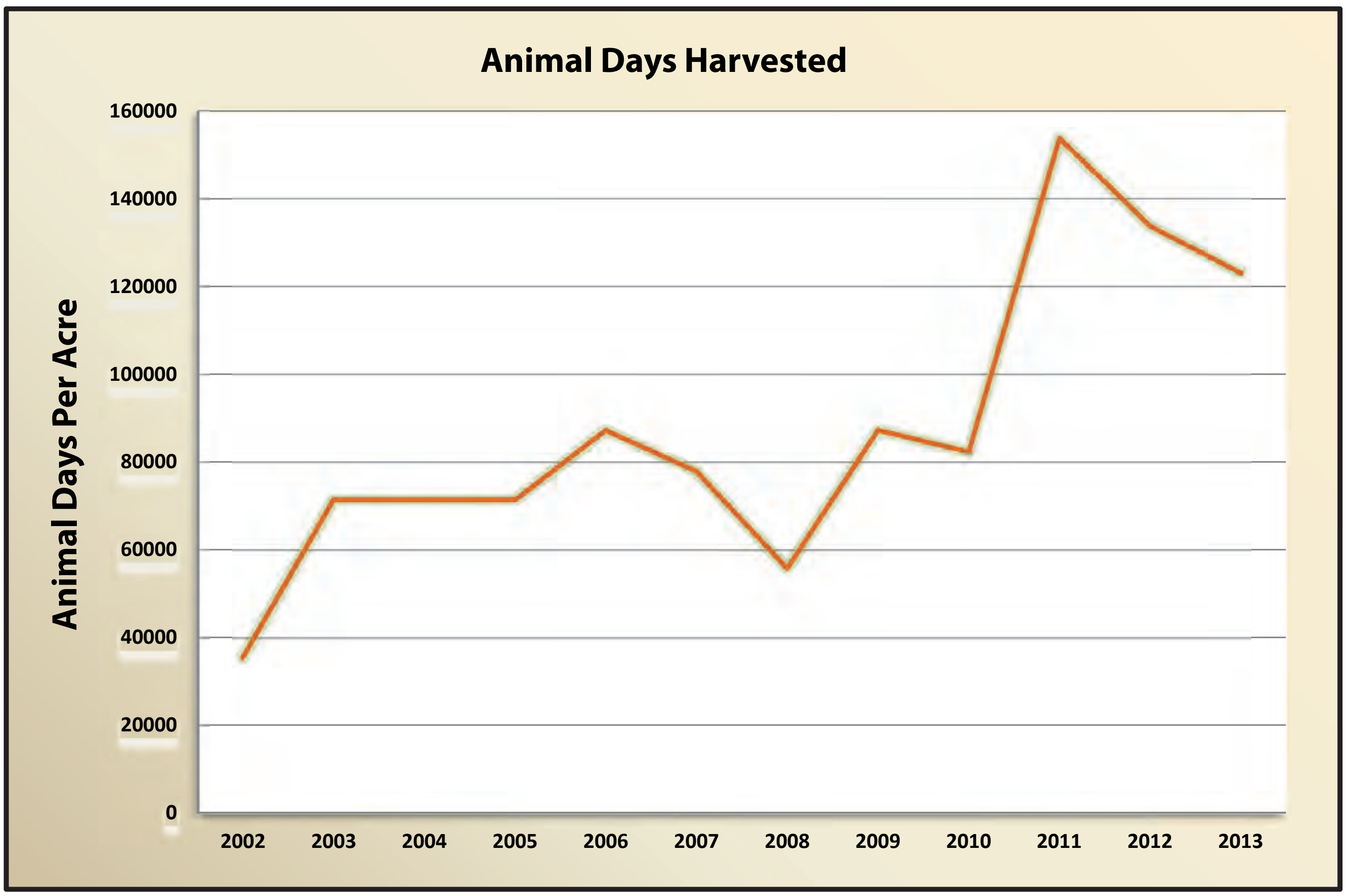

Figure 10. Animal days harvested at Ucross Ranch. These figures show animal unit equivalents of grazing by cow/calf pairs, yearling cattle and sheep. Grazing days represent one animal unit's worth of forage consumed. The stocking rate was nearly quadrupled between 2002 and 2011. It was reduced in the dry year of 2012 and lowered again in 2013 to allow for recovery from the dry year. Acres involved have remained the same.

2012, the bottom of the Donkey Draw Pasture ran water through the entire summer (Figure 11). This is yet another example of the higher state of performance attained at Ucross Ranch.

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Figure 11. A view of the Donkey Draw Pasture and its newly formed perennial stream. This photo was taken in late-August 2012, one of the hottest, driest years on record in northeast Wyoming. This channel began running water perennially in 2011, after having historically carried water only during spring runoff.

A LOOK AHEAD

How can Ucross improve upon its current position? Pastures still appear to be responding to current management practices, and desired plant species appear to be increasing in the community. These are positive signs that speak to improved plant production, higher stocking rates and increased revenue. But grazing management can always be improved, and Ucross will continue to tweak its practices to enable better performance of natural resources.

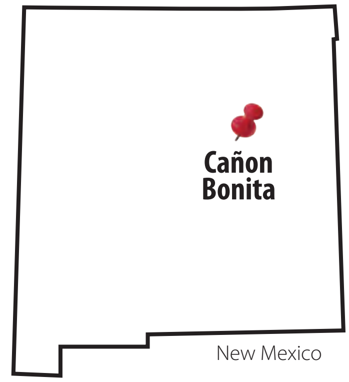
As the 2014 growing season gets underway, Ucross cannot quantify an upper limit of resource performance, for the gains appear to be continuing. Ideally, in another 10 years, the ranch will have achieved an even higher level of performance. And, such gains need not be restricted to Ucross alone, for these management practices are readily repeatable. Ucross just happens to have captured its improvements in photos and data, which tell a terrific story.

©Lauren Brown Photography

Todd Graham is a partner at Ranch Advisory Partners and has been privileged to help Ucross Ranch change their grazing management approach, redesign grazing operations and perform land health monitoring since 2002. *www.ranchadvisory.com*

Restoring Cañon Bonita Ranch in the Light of New Normals

by Tamara Gadzia, Mike Reardon and Courtney White



For landowners, the "new normal" of prolonged dry times and unpredictable moisture events means searching the management toolbox carefully for practices that go beyond resilience—which is exactly what Mike Reardon has done.

Since the late 1990s, Reardon has employed a wide variety of regenerative management tools on his family's 6500-acre Cañon Bonita Ranch, located near Wagon Mound in northeastern New Mexico. These tools include tree removal, brush clearing, prescribed fire, planned grazing, erosion control treatments, riparian restoration, water harvesting, dam building, ranch road repair and relocation, monitoring and mapping—all in service of restoring ecological health to the land in order to support a multitude of diverse wildlife. Reardon's restoration work has been highly effective, but today he faces a new challenge: how do you maintain forward progress when prolonged drought limits the use of certain tools?

Think of it as beyond resilience. A system's capacity to absorb a shock, such as a forest fire or a hurricane (or a personal bankruptcy), and then "bounce back" to something like its original condition is called resilience. It means having enough integrity to return to normal—for example, enough rain to grow grass again or enough resources to remain financially healthy. But what if a system's definition of normal changes? What if an area's annual precipitation drops by half, or when the rains do fall, they come as large flood events? What if you have access to only half as much food as you normally eat? You'll likely be thinking and behaving in ways beyond simply bouncing back. Perhaps endurance or survival might be better words.

For the Southwest landscape, experiencing the effects of climate chaos, resilience, endurance and survival come down to three issues: soil cover, water conservation and species diversity.

SOIL COVER

In 1997, an expert with the USDA's Natural Resources Conservation Service told Reardon that there were "too many trees" on his ranch. This was news to Reardon, who lives in Albuquerque and readily admits to being a novice about land health when he first started managing the ranch. Too many piñon and juniper trees, the expert said, meant an unnaturally reduced amount of open habitat for wildlife. Tree roots would hog the soil and water, preventing grass roots from taking hold and resulting in lots of bare ground. In the past, nature corrected this situ-

©Mike Reardon

Pushing trees using a front end loader.

ation with periodic, lightning-sparked wildfires, which would thin out young and dying trees. This allowed perennial grasses and annual forbs to grow instead. However, a century of fire-suppression, coupled with continuous livestock grazing management, eliminated the fine fuels that could carry wildfires. The result was widespread tree encroachment across the ranch and in similar ecosystems throughout New Mexico.

In other words, the ecological condition of the ranch was altered in a way that negatively affected the water cycle and wildlife habitat. It wasn't normal anymore.

Invasive Species Removal. With the help of his good friend, Allen Darrow, Reardon began thinning the high density of piñon and juniper trees that had become invasive over the grasslands. Early implements included handheld loppers and a chainsaw. Next up were a spin-trimmer, a front end loader and a Bobcat skid steer. Eventually Reardon hired a professional wood-cutting crew from Mexico. To date, nearly 3,000 acres have been strategically thinned, leaving a few stands in place for bird and other wildlife habitat.

Fire and Grazing. To naturally reinvigorate the grasslands in the years when forage was abundant, Reardon alternated the use of two tools: fire and planned grazing. With the assistance of neighbors and fire experts, he completed two prescribed burns over the ranch, 10 years apart. He also has an agreement with one of his neighbors: if a burn on the neighbor's property comes onto his property, that's okay, …and vice versa. These fires have effectively suppressed young piñon/juniper seedlings and saplings.

The ranch has also benefited from several sessions of prescribed dormant season grazing by cattle, with added

Top: October 26, 2008
Middle: April 18, 2009, post winter grazing by cattle.
Bottom: September 10, 2010

benefits to the land from herd effect, urine, manure, etc. These grazings were planned at four times the average stocking rate but for only four months (December through March). High density, short duration grazing acts like a "living fire," recycling old grass into manure and soil cover while keeping the carbon in the soil instead of releasing it into the air.

Water Harvesting from Ranch Roads. Roads throughout the ranch captured and moved runoff away

The Perfect Burn

In 2007 Mike lucked out. It was Spring and he had plenty of forage and found the perfect four days that year for implementing a prescribed burn across the entire ranch.

The perfect conditions included just the right:

- wind speed—light and unidirectional;
- humidity level—less than 15%;
- amount of sunlight—severe clear;
- air temperature—75° F or above;
- a well prepared fire line; and,
- a knowledgeable and well prepared crew.

Most importantly, the ranch received plenty of post-burn moisture, which was not predictable.

©Mike Reardon

from the vegetation zone it once supported. In order to return water to the land where it nourishes grass and to keep the roads dry and drivable, Reardon installed more than 100 rolling dip structures. But he didn't do it all at once. With each additional structure, he improved on design and implementation, using site-specific adaptations for soil type and slope.

WATER CONSERVATION

In the "old normal" years the average moisture regime for that region of eastern New Mexico consisted of nearly 18 inches of precipitation, with 29 percent falling as winter/spring/fall moisture and 70 percent in the monsoon season from May through September. Since 2003, this pattern has remained relatively constant, but the overall quantity of moisture has fallen by 30 percent. Over the last several years, consistent summer rains have become more erratic. For example, in September 2013, almost 50 percent of the entire yearly rainfall came in only one week. Because conditions are so different from past averages, Reardon can't predict when, how much, or how often precipitation will fall, so he holds tight to every drop—planning for rain when it doesn't and drought when it does.

How do you hold on to precipitation that falls in one or in two events instead of over several months?

©Tamara Gadzia

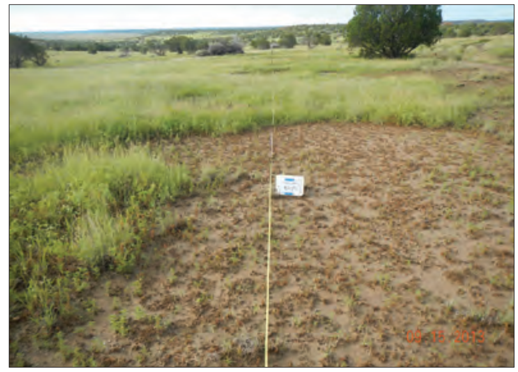
Example of a rolling dip.

1) ***Keep Your Soil Covered.*** With long recovery periods between disturbances such as fire and grazing, there is plenty of opportunity for plant growth to provide soil cover. For example, when the big rainstorm of September 2013 dropped 5.5 inches in five days, most runoff was totally free of sediment and moved slowly across the landscape. The rain had plenty of time to slowly soak into the soil.

2) ***Expand Surface Water Points.*** In order to create more dependable surface water points, Reardon has expanded the number of groundwater-fed dams and stock tanks around the ranch. To date there are 12 earthen dams and four windmill driven stock tanks helping to ensure that elk, mule deer, turkey and other wildlife are well watered and that cattle will be well distributed when they are present.

Why Here and Not There?

by Kirk Gadzia



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The ongoing drought in New Mexico has caused large areas of grassland to suffer loss of cover through the death of individual plants. The pattern of loss is a big setback and does not appear to be entirely random. My observations of many properties affected by the drought in this way indicate an almost inverse relationship to potential soil productivity and percentage of grass mortality.

On the Cañon Bonita Ranch our monitoring transects cover different soil and vegetation types. Death of grass plants was noted in all areas, but the heaviest loss was noted in the deepest, most productive clay loam soil type of the bottomlands. Before the drought, this transect area was dominated by a very dense cover of western wheatgrass and blue grama, along with several other species of grass and forbs. From 2011 to 2013, the drought reduced the live vegetative cover from a high of 23 percent down to 5 percent (-18 percent), but this did not create more bare ground, which instead remained constant at 2 percent. Dead vegetation and old leaves were recorded as litter cover, which increased correspondingly from 75 percent to 93 percent (+18 percent).

One possible explanation for this pattern of plant die-off is based on knowledge of plant physiology and the behavior of soil types in response to drought conditions. When perennial grass plants are dormant, they rely on stored food reserves in the plant to continue their life process until conditions are again adequate for the growth of new leaves (much like a hibernating bear depends on fat reserves). Only new green growth and photosynthesis can replenish these reserves and help the plant survive extended periods of dormancy. If the plant uses up all its reserves before conditions are adequate for new growth, the plant will die.

Also, the soil type where die-off occurred is high in clay and silt content. These tiny soil particles can hold lots of moisture when moisture is adequate, and when conditions become very dry, they hold on extremely tightly—so tightly that grass roots cannot extract whatever moisture remains. In addition, sometimes in drought these soils crack deeply, and moisture may escape from this exposure.

The net result of combining these phenomena seems to be that the best soils lose the most cover during a drought. There is a threshold here that depends on several factors, but it has been widely observed in many areas during the current drought.

Fortunately, these productive soils have the potential to recover rather quickly. When conditions of average rainfall return (hopefully very soon!), I believe that these areas will repopulate quickly. The chance they'll need is a recovery period that will allow root reserve reestablishment and seed production. Fortunately, many of the plants—such as western wheatgrass and vine mesquite—reestablish quickly through the spread of above and below-ground reproduction.

3) ***Restore Degraded Creeks and Wetlands.*** Through historical and past manipulations and agricultural uses, Cañon Bonita Creek has downcut and degraded over time, causing wet meadows to dry out and the water table to fall. Currently, the meadow that adjoins Cañon Bonita supports primarily upland grass species like blue grama. By raising the water table, riparian species will increase within the creek, and the meadow will begin to grow wetland species of forbs and grasses that have higher protein content than upland species. This increase will provide a year-round supply of nutritious food, surface water and cover for elk and other wildlife during normal and drought years. The major concept is to slow the surface water flowing off the mesas and over the ranch. Keeping as much water as possible on the ranch and in the soil and having it slowly release over time is key.

Since 2007, Reardon has implemented a five-phase Cañon Bonita wetland and riparian restoration project which employs many of the innovative practices pioneered by Bill Zeedyk (Zeedyk Ecological Consulting, LLC). Zeedyk and Craig Sponholtz (Watershed Artisans, Inc.) began the process of designing and implementing restoration treatments for a two-mile reach of Cañon Bonita Creek in order to 1) decrease stream bank erosion and downcutting, 2) raise the water table, 3) reconnect the creek to its floodplain, 4) rewet adjoining wet meadow, 5) increase the amount of live water, 6) increase forage species, 7) restore the vigor of wetland vegetation, and 8) increase cover for wildlife. Raising the channel bed was the right treatment for the upper section of the creek and induced meandering for the lower reach. But the middle reach presented problems. An earthen stock tank, built years ago, had cut off the supply of water that had originally poured onto the wetland. Taking time to make a careful decision about how to put the water back on the floodplain was critical.

In addition to a thorough design, implementation has required permitting and clearances from the Army Corps of Engineers, New Mexico Environment Department, U.S. Fish and Wildlife Service (Threatened and Endangered Species) and New Mexico State Historic Preservation Division (archeological clearances). Treatments include inducing meandering and channel bed aggradation, relocating the main road out of the valley bottom, redesigning road crossings, installing water-harvesting rock structures in canyon side channels and thinning 27 acres of overgrown canyon vegetation.

2 miles of Creek Restoration Treatments

- 66 grade control/headcut structures (filter weirs, one rock dams, cross-vanes and Zuni bowls)
- 10 boulder baffles
- 3 cross-vanes as grade control for road crossings
- 2 earthen dam spillways lowered, or altered to allow increased channel flow

Micro-habitat Enhancement: Grade Control Rock Structures on 5 Side Drainages

Drainage	Structures	Photo Points	Miles
Behind House Draw	13	12	.23
Little House Draw	10	8	.18
Luna Draw	13	11	.20
No Name Draw	1	1	.04
Big Tank Ridge	13	13	.42

PROJECT IMPLEMENTATION: A TEAM APPROACH

Reardon's best advice for restoration on this scale is to pull together a cadre of friends, relatives, local experts and various funding sources and to create partnerships with government agencies and agricultural and envi-


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December 2006, before Zuni Bowl headcut control treatment.


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September 2013, Zuni Bowl constructed November 2008.

ronmental organizations. He says that he could never have accomplished all of this restoration without the encouragement, hard work and dedication of his wife Liz, son Spencer and good friend Allen Darrow. Even after 18 years and 10-plus flat tires on the loader, Darrow's love of the land, enthusiasm, sound advice and ability to visualize the end result provides Reardon with constant encouragement and motivates him to continue his restoration efforts.

Reardon's knowledge expanded with a course in Holistic Management taught by Kirk Gadzia of Resource Management Services. Gadzia and Reardon now work together annually to collect vegetation data. In addition to contracting Zeedyk and Sponholtz to implement on-the-ground treatments, Reardon also contracts Joey May (collector and mover of rocks extraordinare), Sweat Enterprises (wood cutters), an Arizona rock crew and the Quivira Coalition (permitting applications, mapping and photo documentation).

FUNDING

Reardon is so committed to his restoration efforts that all income generated from the ranch (elk and deer hunts, grazing leases, etc.) go directly to regenerating land health and biodiversity. He is also proactive (a "get 'er done" kind of guy). He has secured and continues to pursue funding from various sources, including grants from the Rocky Mountain Elk Foundation, Wild Turkey Federation, Partners for Fish and Wildlife, Quivira Coalition and Reardon family members.

DATA COLLECTION

Why monitor and map? Reardon and his partners collect data to show change over time (comparing normal, wet and drought years), for reports to granting and permitting agencies, and also to include in applications for future funding. Some changes can be seen with the naked eye, but by monitoring vegetation and recording results, tracking rainfall amounts, taking annual photographs, recording personal observations, making notes on a calendar and photographing wildlife using motion sensor cameras, Reardon can capture changes that are harder to observe, and he can express all changes in numbers.

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Partners in restoration: (from left to right) Kirk Gadzia, Bill Zeedyk, Allen Darrow and Joey May.

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Tamara Gadzia and Suzan Sherburn retaking monitoring photo point No.18, September 2011.

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Patricia Hancock (left), Mary Ristow (center) and Deanna Einspahr (right), scanning for birds during the base line survey, May 23-26, 2014.

Cañon Bonita Ranch Transect Data—Average Percent Change 2010-2013													
Transect Name	Bare Ground	Litter	Live	Blue Grama	Sideoats Grama	Silver Bluestem	Galleta	Three Awn	Vine Mesquite	Western Wheat	Halls Panicum or other grass	Forbs	Snake-weed
Big Oak Stand	14%	0%	-8%	4%	-15%	0%	2%	-2%	0%	0%	-2%	13%	0%
Funny Hill	15%	-3%	-12%	-27%	0%	0%	27%	-3%	0%	0%	-3%	6%	0%
Clyde's Tank	17%	2%	-14%	4%	1%	4%	-1%	-1%	0%	0%	-1%	-5%	0%
Spring House	9%	12%	-21%	-34%	-1%	-19%	7%	0%	0%	0%	23%	24%	0%
House	-1%	11%	-12%	31%	0%	0%	0%	0%	4%	-33%	11%	-13%	0%
Average all years	11%	4%	-13%	-4%	-3%	-3%	7%	-1%	1%	-7%	6%	5%	0%

Figure 1. Vegetation monitoring transect data. Average Percent Change 2010-2013.

1. Alkali sacaton
2. Barnyard
3. Big bluestem
4. Black grama
5. Blue grama
6. Bluestem
7. Bottlebrush squirreltail
8. Buffalograss
9. Canada wildrye
10. Cane bluestem
11. Cheatgrass
12. Deer muhly
13. Fall Witchgrass
14. Foxtail barley
15. Galleta
16. Hairy grama
17. Hairy tridens
18. Hall's panicum
19. Hooded windmill grass
20. Indiangrass
21. Indian ricegrass
22. Junegrass
23. Kentucky bluegrass
24. Little barley
25. Little bluestem
26. Littleseed ricegrass
27. Mat muhly
28. Meadow fescue
29. Mountain brome
30. Mountain muhly
31. Mutton bluegrass
32. Needle and thread
33. New Mexico feathergrass
34. Pine dropseed
35. Pine muhly
36. Pinon ricegrass
37. Plains bristlegrass
38. Purple threeawn
39. Purple lovegrass
40. Redtop
41. Rescuegrass
42. Ring muhly
43. Rushes
44. Sand dropseed
45. Sedges
46. Sideoats grama
47. Silver bluestem
48. Sleepygrass
49. Slender wheatgrass
50. Spike dropseed
51. Spike muhly
52. Switchgrass
53. Tall wheatgrass
54. Tumble windmill grass
55. Tumblegrass
56. Vine mesquite
57. Western wheatgrass
58. White tridens
59. Wolftail (Texas timothy)

Figure 2. Fifty-nine grass species found on Cañon Bonita Ranch.

- ***Upland Vegetation and Bare Ground Monitoring*** (Figures 1 and 2). Since 2003, Reardon and Gadzia have collected data annually from five upland vegetation transects and one that crosses the creek, providing both channel aggradation and vegetation data (although they were unable to collect 2013 data due to flooding). Despite several years of drought conditions, within a 10 year period, the ranch went from almost a monoculture of Blue grama to 59 different grass species. From 2009 to 2012, the channel bed aggraded two inches, and this number probably increased after the September 2013 flood event.
- ***Moisture Data Collection*** (Figure 3)**.** Reardon is addicted to watching the weather and the local radar—and the rain gauge. With every visit to the ranch, he documents how much and when it has received moisture, diligently marking the data on a calendar in the ranch house pantry.

Cañon Bonita Ranch Rainfall Data													
Year	**Jan**	**Feb**	**March**	**April**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Total**
2003	0	0.25	0.25	0	0.2	1	1.1	1	1.5	0.5	0	0	5.8
2004	0.5	0.5	0.8	5.5	0	0	6.5	1.5	1.9	1.5	1	0.2	19.9
2005	0	1.4	2	0.63	2.15	1.9	0.5	3	1	0.5	0	0	13.08
2006	0	0	0	0.25	0.8	0.2	0.37	10.75	0.7	1	0.2	1.1	15.37
2007	1.4	0.3	0.7	0.6	3	2.25	2.6	1.9	0.4	0.2	0	0.7	14.05
2008	0	0.3	0.3	0.4	1	0.7	4.25	1.9	2.45	0.75	0.3	0.3	12.65
2009	0	0	0.25	0.75	0.5	0	5.6	0.3	0.85	1.65	0	0.6	10.5
2010	0	2	2	0	0.95	2	2.75	0.2	2.4	1.42	0	0	13.72
2011	0	0.25	0.6	0	0	0.1	2.1	5.9	0.94	0.2	0	0.95	11.04
2012	0	0	1	0	2.6	1.4	0.4	0.2	0.73	0.32	0.32	0.32	7.29
2013	0.08	0.27	0	0	0.28	0.33	5.08	1.85	5.9	0	0	0	13.79
Avg.	**0.2**	**0.5**	**0.8**	**0.8**	**1.1**	**1.0**	**2.6**	**2.7**	**1.3**	**0.8**	**0.2**	**0.4**	**12.3**
Normal Precipitation (VALMORA Weather station, 18.11 miles from Wagon Mound)													
Inch	**0.45**	**0.42**	**0.81**	**1.01**	**2.08**	**1.91**	**3.36**	**3.23**	**2.1**	**1.17**	**0.76**	**0.58**	**17.88**

Figure 3. 2003 - 2013 rainfall/snow amounts.

1. American goldfinch
2. American kestrel
3. American robin
4. Ash-throated flycatcher
5. Barn swallow
6. Black-chinned hummingbird
7. Black-headed grosbeak
8. Blue grosbeak
9. Blue-gray knatcatcher
10. Brown-headed cowbird
11. Bullock's oriole
12. Bushtit
13. Canyon towhee
14. Canyon wren
15. Cassin's kingbird
16. Cassin's sparrow
17. Chihuahuan raven
18. Chipping sparrow
19. Cliff swallow
20. Common nighthawk
21. Common poorwill
22. Common raven
23. Dark-eyed junco
24. Downy woodpecker
25. Green-tailed towhee
26. Hairy woodpecker
27. Hepatic tanager
28. House finch
29. Juniper titmouse
30. Killdeer
31. Lark sparrow
32. Lesser goldfinch
33. Long-billed curlew
34. Mountain chickadee
35. Mourning dove
36. Northern flicker
37. Northern mockingbird
38. Plumbeous vireo
39. Rock wren
40. Say's phoebe
41. Spotted towhee
42. Turkey vulture
43. Violet-green swallow
44. Warbling vireo
45. Western bluebird
46. Western kingbird
47. Western meadowlark
48. Western scrub-jay
49. Western wood pewee
50. Wild turkey
51. Accipiter sp.

Long-billed curlew.

Canyon wren.

Figure 4. Baseline data from May 2014 bird survey.

- ***Wildlife population surveys*** (Figure 4)**.** Reardon also records all personal sightings of elk, deer and turkey. He has up to four motion-sensor cameras running continuously near watering points and checks them on most visits to the ranch. In May of 2014, volunteer birders conducted a spring migration baseline bird survey for the ranch. Fifty-one species of birds were identified and 519 sightings were recorded over a 3 day period.

- ***Project Documentation***. There are currently 60 photo points along restoration sections of Cañon Bonita Creek, most marked with T-posts. At each of these points, photos of upstream and downstream views are taken annually in mid-September and, when possible, during flow events. The photo documentation book is left at the ranch so that visitors can walk the creek and stop at each T-post

CAŇON BONITA CREEK - PREPARED FOR RAIN - SEPTEMBER 2013 FLOOD EVENT

Top: Waters flowing into the Bass Pond. The Bass Pond spillway was lowered to allow more flow in the creek and to spread it across the meadow surface. **Left:** Surveying the level of the lowered spillway during construction, June, 2012. **Right:** outflow of water from the Bass Pond during the September 2013 flood event.

"Beneficial riparian vegetation is exemplified by the various species of willows. Their many supple stems bend over during flood events and protect the streambanks and floodplains from surface erosion by creating a low velocity zone right at the surface of the ground." — *Let the Water Do the Work* by Zeedyk and Clothier 2009. **Left:** Photo Point 18 - upstream taken September 14, 2013 at 10:01 am. **Center:** Photo taken September 15, 2013 at 5:36 p.m. **Right:** Same day at 6:28 p.m.

From left to right: During the September 2013 flood event, water filled the House Pond, flowed into the constructed spillway and the overflow channel, soaked 6.5 acres of wet meadow, flowed over the Zuni Bowl (page 14) and then re-entered the lower channel reach of Cañon Bonita Creek.

to compare the area before and after restoration treatments. As each phase has been completed, UTM coordinates for each structure or treatment are collected and used to create a restoration map using Google Earth, another great tool in the toolbox.

NO GOOD DEED GOES UNREWARDED

Reardon has been acknowledged for his hard work and restoration efforts. In 2008, he was one of two recipients of the Quivira Coalition's annual Burch Award. In 2011, the Natural Resource Conservation Service's Conservation Stewardship Program (CSP) awarded him a four-year grant. And in 2013, he received the New Mexico Riparian Council's John P. Taylor Lifetime Achievement Award.

SUMMARY

Reardon succeeded in rebuilding resilience on Cañon Bonita Ranch. Despite the drying trend that began in 2002, in 2002-2007, deer, elk and wild turkey populations continued to rise. Things were returning to normal.

Except that the drought went on and on—and looks to keep going on.

Today, year round water in the creek is rare, but there is still a continual trickle in the spring area. A relic population of Ponderosa Pines is dying, along with a few micro populations of perennial grasses. Some wildlife populations are in decline, and in particular, wild turkey populations have dropped by 75 percent. Piñon and juniper are also dying, but in this situation, that's not such a bad thing. Like wildfire, drought has probably also played a major role historically in maintaining grassland ecosystems.

As for the land management toolbox— prescribed fire is off the table, and grazing by cattle is limited to selected areas of the ranch. Keeping the soil covered is now more important than ever.

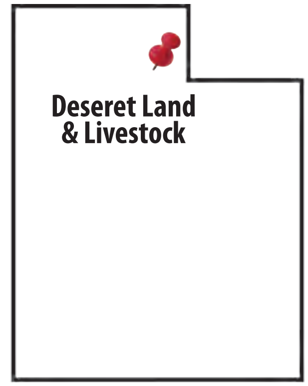
On the good news front, there is still plenty of ground cover holding the soil in place, capturing "airmail topsoil" during local dust storms and any raindrop that falls from the sky. The wetland and riparian restoration project has kept the ground moist, where otherwise it might have gone dry, and continues to dissipate the erosive forces of an unexpected flood event like the one the ranch experienced in September 2013. During the week of the annual monitoring and photo documentation, 5.5 inches of rain fell. How fortunate the team was to witness the creek and canyon run at flood stage. All treatments held and did their job!

For Reardon, all of this points to lessons learned for the new normal of "hotter and drier with chaotic moisture events" and for going beyond short-term resilience and into the world of long-term resilience. "Use your time effectively," he says, "focus on sweet spots, have a plan, pull together a diverse group, be willing to listen and learn, trust the data, be willing to admit mistakes, be proactive, become land literate, and get ready for the next storm—dust, rain, snow, whatever mother nature brings. It will rain again!"

I learned that bare ground was enemy number one, so I do everything I can to get grass to grow. And not just any grass, I want perennials and I want as much diversity as possible.
—Mike Reardon

Observations on Land Health, Wealth and Wildlife: Thirty Years at Deseret Ranch

Rick E. Danvir, Basin Wildlife Consulting, with
Gregg E. Simonds, Open Range Consulting, and
William J. Hopkin, Utah Dept. of Agriculture and Food



Utah

Thirty some years ago, as a recent college graduate with a degree in Wildlife Science, I [Rick Danvir] was fortunate to begin work as a wildlife biologist at Deseret Land & Livestock, a ranch located in northern Utah. Having grown up an easterner and having worked for state wildlife agencies, I was as green as could be when it came to ranching.

Most of my professional experience had been studying and managing bears, which sometimes developed a taste for sheep. At the time, I figured they might be justified. After all, the sheep were in bear country eating bear food. All's fair… As I began to learn how this ranch operated, however, I came to believe that well managed livestock and ranches are a key to wildlife conservation and management in the west. I was fortunate enough to work alongside some innovative ranchers. Many of my peers remained less than impressed with ranching, particularly public land grazing.

A rift still exists between some who feel that rangelands and the species living there would be better served by managing for desired rangeland conditions and others who favor removing livestock and letting nature be. But intermittent herbivory (grazing) and fire have been increasing herbaceous plants and thinning chemically-defended woody plants in arid rangelands for millennia (Augustine and McNaughton 1998). Thus, the condition and trend of rangelands in North America have for a very long time been at least partly the result of man's management (or mismanagement) of fire and of native and domestic herbivores (West 1999, Bonnicksen 2000).

For the past 30 years (and counting) the staff at Deseret Land & Livestock has applied fire and herbivory, creativity and other "tools" to improve land health and provide value to the people and wildlife that depend on these lands. We believe that the observations presented here demonstrate that management based on sound economic and ecological principles can improve land health and resiliency, conserve wildlife habitat, feed people and generate wealth.

THE LAY OF THE LAND

The Deseret ranch (DLL) includes 215,000 acres of private and public land in northeastern Utah. It hugs the Utah-Wyoming border north of Interstate 80. The eastern half of the ranch is flat to rolling sagebrush-steppe, with elevations from 6,500 to 7,000 feet. Annual precipitation averages 10 inches, the wettest months being September, April, May and June. Ninety percent of DLL forage growth occurs in May and June. Dominant sagebrush-steppe

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Mid-elevation sagebrush-grassland.

vegetation includes Wyoming or basin big sagebrush over either crested wheatgrass (planted in the 1960's) or mixed native grasses and forbs (Danvir 2002).

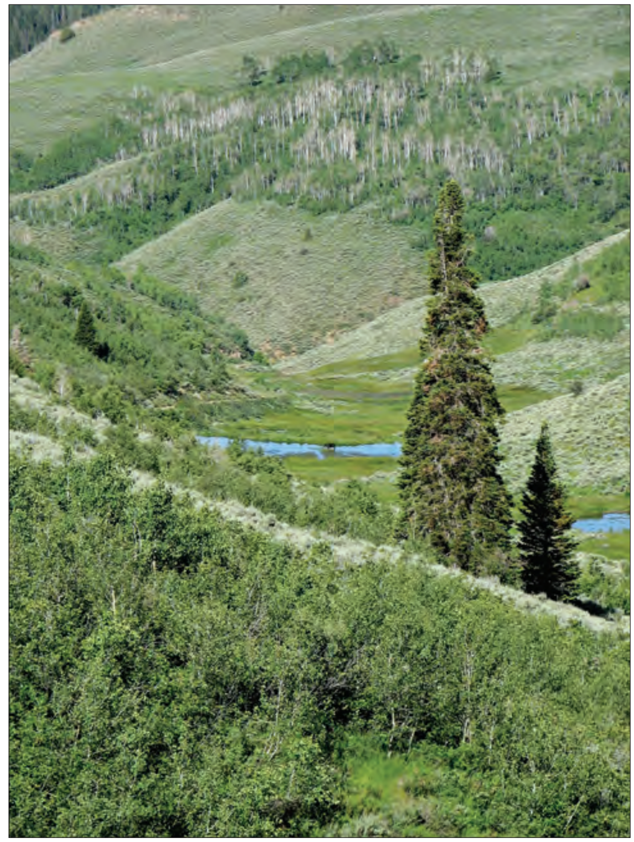
The western half of the ranch is more mountainous terrain, with elevations ranging from 6,200 to 8,700 feet and rainfall increasing from 15 to 35 inches, east to west. Vegetation includes a diverse and interspersed mix of aspen, conifers, mountain meadows, mountain big sagebrush and diverse woody and herbaceous species (grasses and forbs) (Danvir 2002).

Written accounts (Russell 1955, Rawley 1985) and archeological evidence (Shields 1968) indicate that large ungulates—including elk, mule deer, bighorn sheep, pronghorn and bison—historically foraged on DLL and vicinity. DLL has been privately owned since 1891. The ranch was originally managed for sheep and wool production, accommodating upwards of 45,000 ewes annually (McMurrin 1989). Since the 1950s, cattle have been the principal livestock.

Prior to 1979, DLL pastures were grazed by cattle throughout the entire grazing season, April through October. Cattle were fed 2.5 tons of hay November through March, and calving occurred in March. By the late 1970s, cattle production, range health and ranch profitability were flagging, which prompted the ranch owners to consider other uses, including commercial and residential development (Wolfe et al. 1996). But after assessing the production capabilities of the ranch, management became convinced that we could be profitable and improve the land's ecological condition (Wolfe et al. 1996).

FUNDAMENTAL MANAGEMENT CHANGES

In the late 1970s, ranch manager Gregg Simonds introduced a holistic management philosophy on the ranch (Savory 1988). The ranch team worked together to develop whole-ranch grazing plans designed to achieve range health, livestock performance, wildlife habitat and other goals. We planned, implemented, monitored and re-planned. Gregg realized that, ultimately, success hinged on having the right people, those with the means and motivation to perform. Enter Bill Hopkin. Bill describes those early years this way: "We were budgeted to lose money, and we achieved our goal." This had to change.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Moose and beaver ponds on the ranch.

Gregg often said, "If you can't measure it you can't manage it." So we identified and monitored indicators of livestock performance; wildlife condition, abundance and diversity; range response; and ranch financials. We built annual and multi-year plans, with ecological and economic goals and indicators for wildlife, livestock and land. Monitoring results were reviewed relative to goals, and subsequent management practices were refined based on these findings.

We decided early on that the most highly leveraged actions we could take were to increase vegetative cover and vigor, especially herbaceous plants, thus increasing water infiltration and soil moisture-holding capacity (i.e. soil organic or carbon content). More live plants and litter would equal less bare ground, moving us in the right direction, and thus bare ground became our most important indicator of land health.

From 1992 through 1998, we compared vegetative (biomass) production in DLL native sagebrush communities (grazed versus un-grazed), using replicated grazing exclosures (Ritchie and Wolfe 1994a, Danvir et al. 2005). Aoude (2001) compared costs of various treatment methods (burns, plantings and tebuthiron) with returns, in terms of increased herbaceous biomass, plant and wildlife species richness, and abundance. More recently, Open Range Consulting (ORC) has used GIS technology to assess 35 years of riparian and upland condition and trend (percent bare ground, litter, herbaceous and shrub) on DLL and other areas as part of ongoing research on the greater sage grouse (GSG), funded through the NRCS Sage Grouse Initiative (SGI-NRCS) (ORC 2013). This analysis allowed us to accurately assess range condition and trend on the entire ranch from the present to as far back as 1976.

In 1984, DLL, Utah Division of Wildlife Resources (DWR), the Bureau of Land Management and Utah State University (USU) began what my wife calls, "the never ending sage grouse study," and DLL decided to use GSG as another indicator of rangeland health. We monitored abundance (lek counts), production and survival, seasonal grouse distribution and habitat use, and foraging behavior and assessments of management effectiveness (Hunnicutt 1992, Homer et al. 1993, Ritchie et al. 1994b, Danvir 2002). Studies have continued up to the present. SGI-NRCS and USU are currently comparing grouse populations and range condition on the ranch in an ecologically similar but traditionally grazed area.

Indices of big-game abundance, habitat use, herd composition, production, condition and age of harvested animals are collected annually by DLL staff. DLL also partnered with DWR and USU to conduct studies of small mammal abundance, distribution and ecology (Beck 1994, Moroge 1998, Aoude 2001). A DLL bird species list has been compiled, "Breeding Bird Surveys"; wetland bird surveys are conducted annually; and sagebrush treatment effects have been studied (Aoude 2001, Norvell et al. 2014).

GRAZING MANAGEMENT

Under the new plan, range grazing practices changed significantly. Years of season-long grazing had reduced ground cover, particularly near water sources. Grazing

Cattle grazing low elevation meadow habitat.

was planned to improve livestock distribution, plant recovery and land health. We wanted to increase rest-recovery periods and shorten grazing periods, which meant grazing larger herds. Because herd size in arid lands is limited by water availability, we needed a water plan in order to create a grazing plan. Herd size increased and pastures were added as water became available .

Currently, as with traditional grazing management, DLL's cattle stocking rate is determined based on available forage resources, livestock and wildlife performance goals, and desired range condition. Planned (time-controlled) grazing differs from prior DLL grazing in the way livestock are moved and distributed across the landscape. Grazing plans focus foremost on providing periods of rest between grazing periods during the active growing season. Because 90 percent of forage growth occurs from May through June, pastures are generally grazed once a year, with roughly 20 percent of pastures receiving full rest each year.

Rest and recovery from grazing during the growing season was essential to achieving our most important range goal, which was to increase herbaceous plant biomass both above ground (forage, cover) and below (increased soil carbon). Increasing plant vigor and soil carbon facilitated a cascade of good things (i.e. water infiltration, wildlife habitat, forage and profitability).

TIME AND TIMING

Once pasture rest was planned, grazing plans were developed based on the principles of time and timing. "Time" refers to the length of time plants are exposed to grazing and "timing" to the season of use (Savory 1988). We achieve grazing timing goals by changing the month or season of use of individual pastures between years. The duration of grazing periods (time) is designed to minimize re-biting of individual plants, ideally livestock are moved to the next pasture before herbaceous plants have re-grown sufficiently to be bitten a second time. In reality some re-biting occurs during rapid growth (May-June), hence the importance of changing the timing between years. During rapid growth, range pastures are generally grazed fewer than 10 days. In seasons when herbaceous plants are growing slowly or dormant, little re-biting occurs and grazing periods may be longer.

At DLL, shortening the grazing periods required more pastures, fewer herds and higher stock densities (a few large herds moving quickly through many pastures in a year). DLL runs 3 to 5 cattle herds of 1,000 to 3,000 cows per herd. At a given time, cattle are concentrated on 10 to 20 percent of the range, which allows plants on the remainder of the ranch to grow or rest. Cattle (and other ungulates) at higher densities are less selective in their food habits and begin to include plant species not grazed or grazed infrequently at lower densities (Savory 1988, Provenza 2003). Whereas selective herbivory by ungulates leads to increased dominance of woody plants, intensive herbivory can maintain or increase the dominance of herbaceous plants (Augustine and McNaughton 1998). DLL managers use range rest, stock density, grazing time and timing to influence forage quality, plant density, species composition and the structure of the plant community (Savory 1988, Severson 1990, Danvir and Kearl 1996).

GRAZING COMPARISON

%Cover	*Planned DLL*	*Season-long*
Herbaceous	24%	14%
Litter	32%	22%
Bare Ground	26%	37%
Shrub	18%	27%

Table 1: Comparison of vegetative cover values on semi-desert loam soils, DLL planned grazing versus the season-long grazed Comparison Area (CA).

RANGE CONDITION, TREND AND MANAGEMENT

Riparian areas at DLL have shown increased herbaceous plant cover and decreased bare ground since 1979. In most cases, riparian vegetation increased, streams narrowed and meanders formed while siltation and bare ground decreased (Wolfe et al. 1996).

Upland range healed more slowly in our cold, arid environment. The first positive sign that planned grazing was working was grass seedlings growing in the once bare ground between sagebrush plants. More waves of seedlings came along, and in 10 to 15 years changed the ranch from a landscape dominated by sagebrush and bare ground (with just a few desirable plants hiding under the brush) to one on which herbaceous plants and litter dominate the interspaces between shrubs.

We built and monitored replicated, un-grazed exclosures and paired grazed areas. The grazed areas actually developed the better grass-forb-shrub mix. The un-grazed exclosures had greater shrub production, similar grass production and fewer forbs than the paired cattle-grazed areas (Danvir et al. 2005).

In Table 1, a GIS analysis comparing shrub-steppe range condition and trend on DLL with the season-long grazed Comparison Area (CA) showed significant differences in ground cover by functional group (i.e. herbaceous, litter, bare ground and shrub cover) (ORC 2014).

DLL shrub-steppe sites had more litter and herbaceous plants and decreased bare ground and shrub cover than CA rangelands of similar elevations, soil type and precipitation (ORC 2014). More than sixty miles of lowland riparian habitat on DLL and CA were also compared in 1976 and 2009. In 1976, DLL and CA each had riparian vegetation on only 10 percent of the potential riparian area. By 2009, DLL riparian vegetation had more than doubled, while CA remained the same, except in riparian grazing exclosures. Riparian cover at DLL exceeded riparian cover in the CA grazing exclosures after ten years of planned grazing. The importance of planned grazing at DLL may be summed up this way: Planned grazing allowed us to double the stocking rate and nearly double the cover of herbaceous plants.

Range treatments without grazing control are at best disappointing and short-lived, and sometimes they are destructive. From 1993 to 2009, patches of DLL sagebrush were thinned or removed by wildfires, prescribed burns, tebuthiron (Spike), targeted grazing and mechanical range treatment practices (Boyd et al. 2011, Dahlgren et al. 2014). In combination, brush cover was reduced on 1 to 2 percent of DLL's sagebrush-range annually. Treatments were designed to achieve one or more of the following objectives: 1) increase herbaceous production and plant species richness, 2) create interspersion (complexity) of shrub ages and vegetative conditions, and 3) reduce fuel loads or create "green-stripping" to decrease catastrophic wild fire risks while maintaining adequate sagebrush cover for grouse and other sagebrush-dependent species.

Treatments averaged fewer than 500 acres and were primarily located in the mid- to high-elevation Basin and mountain big sagebrush areas with less than 25 percent shrub cover (Dahlgren et al. 2014). Forb biomass (a significant source of crude protein and calcium) has been shown to decline with increasing shrub cover in mountain sagebrush communities (Whitehurst and Marlow 2013). Treatments have relatively high edge-to-area ratios, include islands of untreated sagebrush and are patterned to achieve the structural effects of a cool season sagebrush burn.

Aoude (2001) found that herbaceous biomass increased in sagebrush stands following all range treatments. Herbaceous biomass was generally increased by three to four times in disked plantings and two to three times in other treatments. Plant species richness (particularly forbs) increased significantly in tebuthiron treatments, disked plantings and higher elevation fall burns (Aoude 2001).

Cattle production practices were modified to develop a better fit between DLL's cattle and climate. We shifted from cow-calf to cow-calf-yearling to provide stocking rate flexibility and another class of livestock with different foraging and grazing habits. Taking a lesson from native grazers, calving began in April to better align nutritional requirements of pregnancy, lactation and breeding with peak range-forage values. Bill and Gregg reasoned that an ecological and economically adapted cow was one that had and weaned a calf every year with minimal fossil fuel input (hay feeding). Ranch bulls were developed from cows less than eight years old that had never been fed hay and had always weaned a calf. These animals were a reflection of the land they stood on. Bill and Gregg also selected cows for calving ease and began weaning earlier (September). Their goal was to increase pregnancy and weaning percentages while lowering supplemental feed costs. By aligning cattle size, reproductive and nutrient requirements with the environment, pregnancy rates, weaning rates and calf daily gains increased and production costs decreased (Simonds 1995, Wolfe 1996).

DLL irrigated lands comprise less than 5 percent of the ranch acreage but produce 50 percent of the cattle forage. In 1978, 80 percent of ranch expenses came from growing and feeding hay. Although growing and feeding hay had been the norm since the 1800s, we decided to "declare war on hay." When we measured hay production and nutrient content by pasture, we learned it was cheaper to buy hay than grow it on 50 percent of our fields! Thus, we purchased hay, focused irrigation expenses on the most productive pastures and began winter grazing on standing hay and windrowed piles. Fed hay was reduced from 2.5 tons to one-half ton of hay per cow each winter. We went from three hay crews with

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Greater sage grouse choose a mix of grass and shrub cover in summer.

28 tractors to no hay crews. In the occasional "winter from hell," we purchase hay.

DLL has remained profitable since it adopted this approach. In combination, the changes made to irrigated land and cattle management decreased winter hay costs by half, decreased cost of calf production and significantly increased cattle profitability (Wolfe 1996, Danvir 2005).

WILDLIFE MANAGEMENT

It became apparent to us early on that DLL needed to capitalize on both livestock grazing and wildlife recreation if we were to remain economically viable. Wildlife recreation revenues, generally a third of ranch net revenue, are invaluable in years of poor cattle prices and provide DLL managers with the means and motivation to manage for wildlife.

In cooperation with DWR, the ranch began managing big game for sustainable fee-hunting (Wolfe et al. 1996). This meant managing the age structure for mature male deer, elk, pronghorn and moose, coupled with female harvest to maintain population size. Any way we analyzed it, a mix of wild and domestic ungulates (multispecies grazing) was the only way to remain economically and ecologically viable (Ritchie and Wolfe 1994a, Danvir and Kearl 1996). Wildlife revenue-generating enterprises eventually included fee-fishing and guided bird-watching programs.

Management practices for greater sage grouse (GSG) at DLL evolved from our monitoring results. Greater sage grouse in Rich County generally winter in sagebrush 16 to 24 inches tall and 20 to 30 percent shrub cover (Homer et al. 1993). They choose taller or shorter brush depending on snow depth (Danvir 2002). Grouse use large unbroken patches of sagebrush for winter and nesting, sagebrush interspersed with insect-rich herbaceous patches for early brood rearing and green, forb-rich areas to finish the summer before they move to winter sagebrush and start over again (Hunnicutt 1992). Nesting hens select uniformly dense sagebrush stands, while broods select highly diverse areas with patches of sagebrush cover interspersed with grassy openings and meadows. Basically, grouse need a variety of habitat to fulfill their annual needs and survive unpredictable weather events.

Comparing DLL and adjacent areas over the past thirty years suggests planned grazing increased herbaceous cover, lek persistence and mean brood sizes on DLL, and this was presumed to be due to better water cycle, healthier soils and more green groceries (Dahlgren et al. 2014). The percentage of leks remaining active for the entire study period and mean brood sizes on DLL were more than double those on the paired comparison area. It appears that grazing for healthy, herbaceous plants benefits greater sage grouse, other wildlife, watersheds and ranchers.

We noticed that both grouse broods and pronghorns with fawns selected forb-rich areas in summer. Animals concentrated in forb-rich patches, such as riparian areas, scattered swales, reclaimed roads, well pads and alfalfa fields—especially in dry summers. We wondered if grouse might be limited by lack of forb-rich areas (for brood rearing and drought survival). Since we felt a need to open up some of the denser sagebrush stands to increase forage for cattle and elk, we did so in a manner that we hoped would provide suitable habitat for grouse and other sagebrush obligates. We wanted more forage for cattle and elk, but not at the expense of shrub-dependent species.

Grouse populations appeared to respond positively to range treatments from 1994 to 2004, and this correlated positively with cumulative acres treated


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Pronghorn antelope use forb-rich meadows in summer.

(Danvir 2005). Surveys revealed that grouse (mostly hens and broods) were seven times more abundant in forb-rich burned or planted treatment areas than in paired control areas (Danvir 2002). Eighty percent of grouse observed in treatments were within 180 feet of the treatment edge. Alfalfa was the most consistently occurring plant species at grouse feeding sites in planted treatments (Danvir 2002), but broods concentrated similarly in burns. Still, weather drives the system. Lek attendance and chick production declined severely from 2011 to 2013, in response to cold wet weather in May and June (Dahlgren et al. 2014).

BIG GAME AND OTHER MAMMALS

Our experience is that cattle and big game abundance are not mutually exclusive; in the past thirty years, both have increased at DLL. Adult elk doubled from 1,000 to 2,000. Pronghorn increased from 100 to 800. Mule deer and moose remained at about 2,500 and 100 respectively. During this period, we also doubled the number of mother cows from 2,500 to 5,000. Big game production, body weights and antler mass remained at or above target levels. Five to ten percent of the big game population is harvested annually by a mix of fee-paying and free-access hunters. Danvir and Kearl (1996) compared forage harvested by wildlife and livestock in the Morgan-South Rich DWR big game management unit past and present and concluded that more forage is harvested and range condition has improved with multispecies herbivory (cattle, sheep, elk, mule deer, moose and pronghorn) than occurred with essentially single-species grazing by sheep in the early 1920s.

Pronghorn fawn production and populations also increased, correlating positively with cumulative acres of burned or planted treatments on DLL from 1995 to 2001 (Aoude and Danvir 2002). Burned or planted areas were used preferentially by doe-fawn groups. With a combination of treatments, planned grazing and targeted hunting, we were able to do away with a long-term elk-feeding program on DLL in all but the severest winters (Mangus 2011).

A number of positive ecological relationships became apparent when we managed for a diversity of mammalian species. Rather than viewing beavers, cougars, coyotes and prairie dogs negatively, we allowed them to flourish where they were a benefit and only controlled them when absolutely necessary. A number of DLL mountain valleys have had continuous populations of beavers for decades, resulting in raised water tables, multi-aged aspen patches, active dams and old dams that have morphed into meadows. In dry summers and cold winters, native Bonneville cutthroats take refuge in the deeper waters of active beaver dams, which also provide watering holes for livestock and big game.

Although coyotes preyed on grouse, they also reduced the abundance of smaller, more abundant nest predators, such as foxes and skunks. This probably increased nesting success (Danvir 2002). By keeping populations of jackrabbits in check, coyotes may also have reduced the abundance of golden eagles, the principle predators of adult grouse (Danvir 2002, Mezquida 2006). White-tailed prairie dogs provided forb patches, burrowing owl habitat and raptor prey, and also functioned as slow-motion rototillers, cycling deep mineral soils back to the surface. Moroge (1998) and Aoude (2001) monitored small mammals on range treatments of various sizes and found no negative effects on either abundance or species diversity.

Mark Stackhouse of Westwings (*http://westwings.com*) recorded more than 275 species of birds on DLL. In 2002, the Audubon Society designated DLL as a Utah Important Bird Area and later as a Global Important Bird Area. Aoude (2001) found no difference

Beaver dams create habitat, forage and water sources as well as organic-rich carbon sinks.

in avian diversity between treated and untreated controls. Norvell et al. (2014) found sagebrush songbird populations persisted within treated areas but cautioned against excessive brush removal.

CONCLUSIONS

We believe that planned grazing and appropriate vegetation treatments increased grouse and pronghorn antelope populations and maintained an abundance of other plant and wildlife species, as well. Revenue from wildlife recreation and livestock production paid the "learning" and management costs of this program. DLL has remained profitable for nearly 30 years. This would not have come about without the creative, coordinated actions of ranch personnel, agencies and neighbors, who adopted and achieved shared goals.

Our story is not unique. This approach has worked and can work again elsewhere, on public and privately owned lands, when 1) grazing, behavioral, economic and ecological principles are understood and applied, 2) conservation-minded organizations and ranchers join forces to create healthy landscapes and 3) policy makers recognize and facilitate a "Radical Center" approach. Range management is a process, not an event, and therefore principle-based management practices must persist and adapt to sustain the lifestyle, biodiversity, soil, water and landscapes owed to future generations.

Our experience suggests that wild and domestic herbivores can co-exist on and sustain healthy sagebrush range, if properly managed. We also suggest that undesirable range conditions are generally the result of undesirable management practices. Ranchers can play a crucial role in wildlife conservation when they are properly motivated. It is essential that regulatory agencies reward, facilitate and support conservation-minded landowners, for when landowners are assured that conserving wildlife species is beneficial to them, they will get it done.


Rick Danvir's career began in wildlife research at state game agencies and universities before he settled into the job of wildlife manager at Deseret L&L and Deseret Western Ranches. He continues to assist ranchers and private landowners through his consulting firm, Basin Wildlife Consulting, and as Wildlife Program advisor to the Western Landowners Alliance. Rick currently resides in Casper, Wyoming.


Gregg Simonds' career, in addition to his time as manager of Deseret L&L and Deseret Western Ranches, has included range management consulting through his company Open Range Consulting. For the past two decades he has focused on creating a statistically and economically feasible method for measuring range condition and trend on entire landscapes. He is a resident of Park City, Utah.


William Hopkin's career includes stints as cattle manager and general manager at Deseret L&L and then as general manager of Deseret Cattle and Citrus in Florida. For several years he was director of the Utah Department of Agriculture and Food's Grazing Improvement Program (GIP). Currently he continues to work with Utah GIP while operating his own ranching and consulting firm, Grazerite, LLC. He lives in Woodruff, Utah.

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The Next Generation of Land Health Researchers

Craig Conley, Ph.D., Natural Resource Management, New Mexico Highlands University, Las Vegas, New Mexico

The following two articles are written by the next generation of restoration researchers. Both are students in the Natural Science graduate program at New Mexico Highlands University. They are taking on the much needed but often overlooked task of measuring and monitoring the performance of various restoration and management practices that contribute to land health. From the standpoint of a teacher, they are providing the most satisfying feedback possible. They are taking concepts learned in the classroom and applying those concepts to real world challenges.

This work is the important bridge between practice and science. Beginning in 2000, Bill Zeedyk and a group of brave volunteers and dedicated students such as Craig Sponholtz, created a new way of managing surface hydrology and restoring degraded landscapes in the Southwest. Bill talked a lot about putting what little water we had in the dry Southwest to work instead of it creating deeper gullies. He also talked a lot about the interactions between surface runoff and what was happening with water below the surface. His restoration practices were built around keen observation and an acute sense of how water flows across the land. Every project was a new experiment. Some treatments worked, some didn't, but all taught us something. What many of these early experiments lacked, however, was scientific data. This is the next big challenge that students like Jessica and Shantini are taking on.

Jessica is tackling the mysterious world of soil moisture. If the climate scientists are correct and there are fewer, more extreme precipitation events in the future and if precipitation shifts more from snow to rain, then understanding and managing soil moisture in relation to grazing becomes invaluable to maintaining healthy land. Managing for healthy land in this new era requires more than just measuring the amount of rainfall you get during the growing season. If soil carbon is one of the key strategies for addressing climate change, then understanding and managing soil moisture is one of the keys to getting carbon into the soil.

Shantini is taking a second look at the almost one hundred one-rock dams built on the Rio Mora National Wildlife Refuge over a period of more than ten years. This large number of different structures provides a unique laboratory to begin telling the rest of the story with data. This systematic analysis of existing structures will be invaluable for training future generations who may not see water flowing over dry ground as easily as Bill does.

There is still much to learn about the grass and soil, and the carbon puzzle, but I am confident that with work such as Shantini and Jessica's, there is hope.

Jessica Parker is a graduate of Colorado State University with a BS in zoology and human dimensions of natural resource management. She is finishing her MS at New Mexico Highlands University in environmental science and management with a focus on building social and ecological resilience at the local scale by connecting science with land management decisions. She currently works as an ecological consultant in climate and hydrology monitoring for private landowners in New Mexico and Colorado.

Shantini Ramakrishnan is a graduate student in biology at New Mexico Highlands University in Las Vegas, and the research and restoration coordinator for the Denver Zoo, based at Rio Mora National Wildlife Refuge.

From Rainfall to Rotational Grazing: Ecohydrological Monitoring for Proactive Rangeland Management

By Jessica Parker, New Mexico Highlands University, Las Vegas, New Mexico

INTRODUCTION

The rangelands of the Southwest have undergone extensive degradation from the combined influences of agriculture, overgrazing, and climate change. Historical land uses, coupled with a highly variable climate, have created an increasingly fragile and complex era of rangeland management, in which the health of the land and the ranching economy are intricately intertwined. Where drought has become part of day-to-day living, ranchers and rangeland managers are turning to new approaches to land stewardship that stimulate long-term resilience of both a landscape and a way of life. The need for climate and hydrology monitoring is now more imperative than ever for more effective management decisions in this time of increasingly unpredictable environmental change.

MONITORING FOR PROACTIVE MANAGEMENT

A case study from Piojo Ranch in northern New Mexico is presented to demonstrate how rangeland managers can take advantage of a comprehensive and integrative approach to ecohydrological (climate and hydrology) monitoring. In recognition of the need to develop more proactive approaches for ranch management that anticipate and transcend unpredictable changes in climate, this project was developed by ecologist Dr. Charles Curtin, ranch owner Judith McBean, ranch manager Clint Hoss, and New Mexico Highlands University student Jessica Parker.

Arid rangelands are complex ecosystems that are shaped by the interactions among the driving forces of climate, soils, grazing, and fire (Figure 1), among others (Curtin 2008). Two of these processes, grazing and fire, are directly under the control of the manager and can be used to achieve specific objectives as part of a comprehensive management approach that builds off the relationship between climate, soils, and vegetation.

The key to this approach is to understand the connection between climate, hydrology, and land management through high-resolution, real-time monitoring. Managers have the opportunity to go beyond "reading the landscape" using vegetation assessments to understanding what is happening both in the atmosphere and below the ground—two areas that directly influence rangeland production. In effect, ecohydrologic monitoring allows the land manager to leverage the complex interactions between climate, soil and

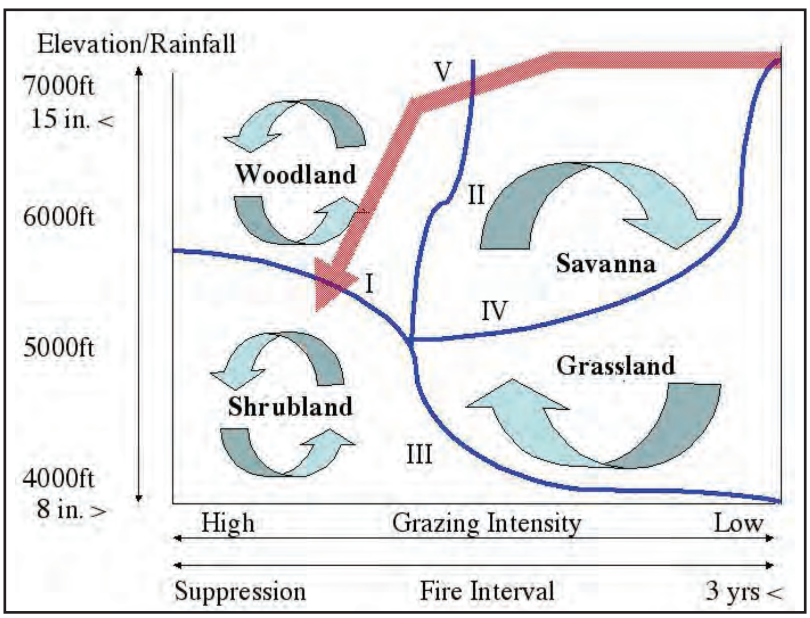

Figure 1. The four-box model (Curtin 2008) demonstrating how arid rangelands are dynamic ecosystems created by the large-scale interactions among climate, soils, fire, and grazing. Weather and soils determine how the rangeland will respond to grazing and fire, and can be tracked through on-the-ground digital monitoring to provide key information for management decisions. The red line shows how healthy rangelands degrade into shrublands.

(Unless otherwise noted, all graphics and photos in this article are courtesy of Jessica Parker.)

vegetation for more ecologically and economically sustainable management. Rather than making reactive decisions to changes that have already occurred on the landscape, the manager now has a new tool for making proactive decisions that anticipate future changes *before* they actually happen. Equipped with weather and soil moisture information, the manager can match grazing and other land management decisions to new weather scenarios.

CLIMATE – SOIL – VEGETATION

Piojo Ranch is located in Watrous, New Mexico, and contains a rich mosaic of land forms and ecological systems at the transition zone between the sweeping landscape of the Great Plains and the foothills of the Sangre de Cristo Mountains (Figure 2). The ranch presents a unique opportunity to conduct climate and hydrology monitoring across a diverse landscape and multiple land uses to demonstrate how the climate-soil-vegetation interactions shift depending on the ecology and management systems under study. Encompassing 2100 acres—1500 acres of native range and 600 acres of irrigated pastureland—Piojo Ranch has established a highly integrated, sustainable grazing system, combined with 80 acres of no-till, cereal grain cropland.

A network of Decagon™ micro-climate and soil monitoring equipment has been established across native upland range and floodplain pastures along the Mora River to measure precipitation; temperature; vapor pressure; relative humidity; wind speed and direction; soil moisture; and soil temperature (Figure 3). Specifically, the effectiveness of precipitation events in generating warm-season forage production through quantification of evapotranspiration (ET) rates, runoff volume and rates, plant available water (PAW), and soil moisture retention curves at depths of six and eighteen inches is being studied. For every precipitation event, the amount, timing, intensity, and duration of the event is recorded.

In the pasture where a station is located (based on the hydrologic soil type, rainfall characteristics, and size and condition of the pasture) the rate, volume, and velocity of runoff generated by the event is estimated. Other climate variables, including relative humidity, vapor pressure, temperature, wind speed, and direction, come into play in gauging how effective a rainfall event is in producing vegetation. This is where soil moisture becomes an important factor.

High aridity in the Southwest is not only a function of low precipitation, but is generated by intense solar radiation (from the high elevations), low relative humidity, high temperatures, and abundant wind. These climate variables are tracked in order to estimate the amount of evapotranspiration occurring; in essence, how much

Figure 2. Piojo Ranch contains both native upland range and irrigated pastures along the Mora River near the junction of the mountain and Cimarron branches of the Santa Fe Trail.

Figure 3. A Decagon™ micro-climate and hydrology monitoring station at Piojo Ranch provides instant information on weather and soil conditions.

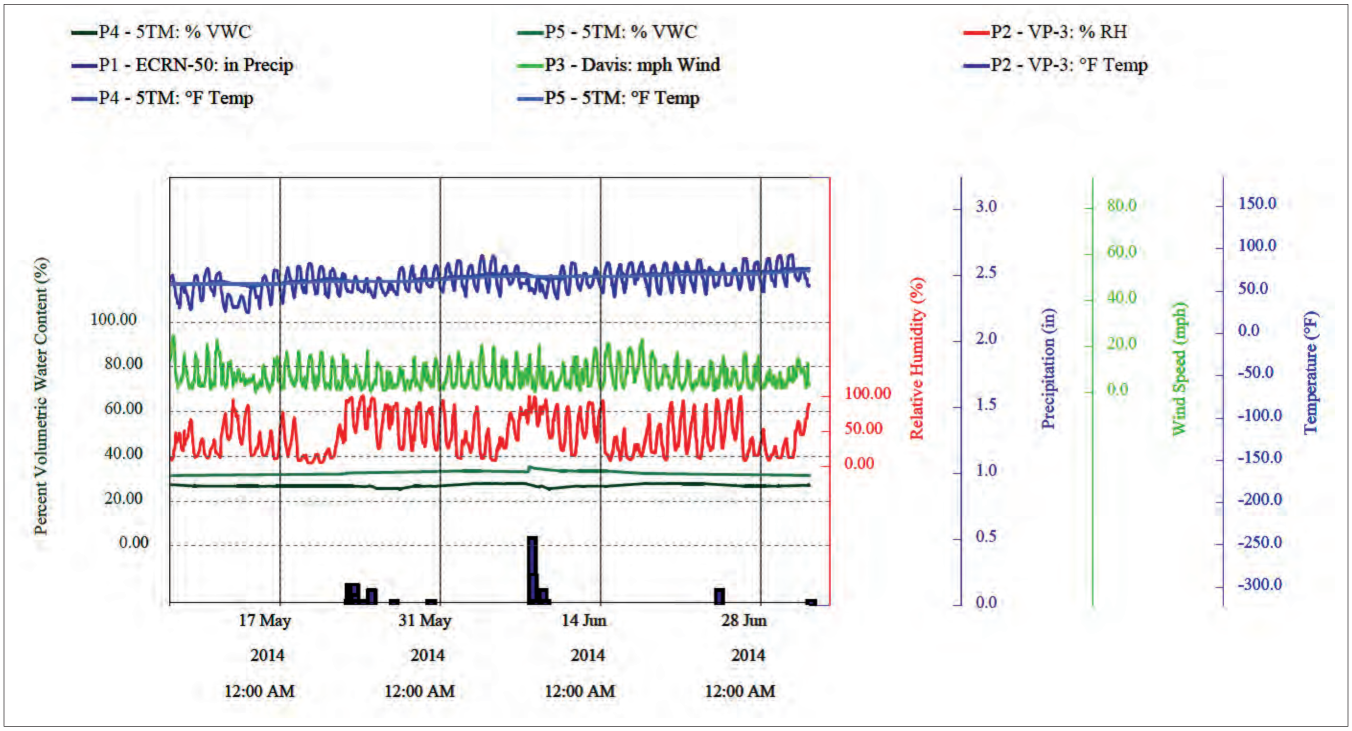

Figure 4. Baseline information on weather and soil moisture for the pre-monsoon period in 2014. Monitoring provides real-time information on current conditions and trends over time to help managers track the most important influences on forage production.

water is being lost from the land to the air. Even with abundant rain, high evapotranspiration rates may result in a net loss of water from the land with little available in the soil to fuel plant growth. Therefore, it is not simply enough to know how much rain has fallen in estimating forage production. Evapotranspiration and soil moisture are key components in the climate-soil-vegetation relationship and must be known in order to predict how a pasture will respond to a rainfall event. Just as we now know that rain does not follow the plow, we are also learning that grass does not always follow rain.

Soil moisture is key in understanding the relationship between rain and grass growth. For example, the unexpected late-monsoon storms in northern New Mexico last September were quoted as being "too little, too late" to provide relief from the severe and persistent drought in the region. However, this is more a reflection of what is visible on the surface, rather than what is actually occurring below the ground. When the storms arrived, soil moisture was relatively low (<18%), resulting in high infiltration and percolation into the ground. Although the 2013-2014 winter was warm and dry, soil moisture stayed relatively high throughout the spring due to the high storage capacity of clay soils and the lack of moisture utilization by the plants during the dormant season. Pre-monsoon soil moisture levels were 18-21% in 2013, compared with 28-32% in 2014. Soil moisture is therefore the bridge between weather and forage production. However, knowing the amount of soil moisture is not enough to predict how the plants will respond. The characteristic of the soil type plays a role in determining how plants interact with subsurface water.

The volume of the water in the soil that is available for use by plants is related to the measure of plant available water (PAW), a function of the texture of the soil. When soil moisture falls in the range of PAW, it can be utilized by plants for growth. When it drops to the bottom of the range, a wilting point is reached and plants are no longer able to extract the water they need from the soil. Precipitation effectiveness is therefore the result of intricate relationships in the soil which can only be understood through real-time measurement and monitoring. Monitoring data provides a valuable evaluation of land health and empirically demonstrates

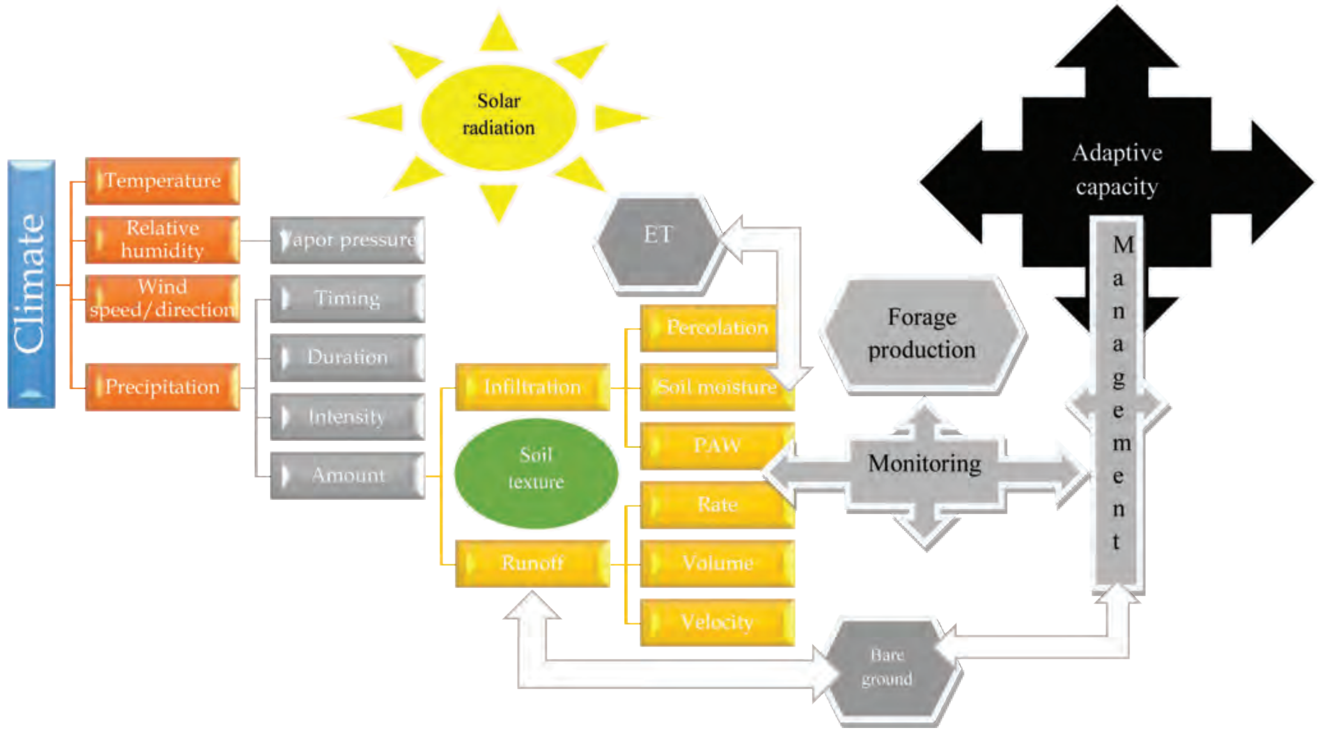

Figure 5. Rangeland health and productivity result from the interplay between climate, soil hydrology, and land management. Monitoring is a key leverage point that grounds management decisions in the daily dynamics of the atmosphere and the land. When management is based on monitoring and an understanding of climate-soil-vegetation interactions, managers enhance their capacity to adapt to and capitalize on change.

where improvements in land condition can be made in order to increase the infiltration, storage, and utilization of moisture in the soil. With this information, land managers can make more informed and proactive management decisions that benefit the health of the land and economics of the ranch (Figure 4).

FUTURE DIRECTIONS

Using this baseline monitoring, Piojo Ranch will be experimentally testing management scenarios related to cattle stocking rates and grazing rotations to develop an adaptive management framework for more resilient rangelands under high climatic variability. Based on these indicators, a proactive management and restoration plan can be developed as part of a regional demonstration pilot program, using tools such as road rehabilitation and grazing system analysis. Monitoring can indicate where management can improve land health through reductions in the amount of bare ground to decrease evapotranspiration or road rehabilitations to reduce the amount, velocity, and effects of runoff. Linking management decisions with real-time climate and soil indicators is at the cusp of a new era of rangeland management in which an in-depth understanding of complex climate-soil-vegetation interactions is pro-actively leveraged against increasing unpredictability (Figure 5).

REFERENCE

Curtin, C.G. (2008) Emergent properties of the interplay between climate, fire, and grazing in desert grasslands. *Desert Plants*, 24, 2-52.

Quantifying Arroyo Restoration at Rio Mora National Wildlife Refuge

By Shantini Ramakrishnan, New Mexico Highlands University, Denver Zoo, and the Rio Mora National Wildlife Refuge, Mora, New Mexico

Water is one of the most coveted resources in the Southwest, and it can also be its most destructive force. Too little, too late, and we have drought conditions. Too much, too quickly, and we have flooding and erosion. A slow soaking rain is a rare and precious event that encourages water infiltration. When the spaces between soil particles are filled with water, the water becomes available for vegetation growth, and in turn, roots stabilize the soil. When the soil becomes saturated, surplus water accumulates in depressions in the ground creating ephemeral pools. When rain falls faster than the soil's ability to soak it up, the water runs off the surface flowing downhill. The steeper the hill, the faster the water runs. When the slope is steep enough, rivulets form and a positive feedback loop begins. The steeper the slope, the greater the erosion, thus creating a still steeper slope and higher rates of soil loss. In arroyos, this positive feedback loop is responsible for creating deep channels that concentrate water flow and increases its velocity, moving water quickly away from soil and vegetation. This reduces soil infiltration rates, starving vegetation, increasing bare ground and de-stabilizing soils: ideal conditions for ever-increasing erosion.

Much of Bill Zeedyk's work is based on reversing this pattern (Zeedyk and Clothier 2009). We cannot control precipitation events—timing, intensity and duration—but we can manipulate the water once it hits the ground. Well-designed rock structures slow down the water, thus reducing its erosive power. This encourages soil deposition and infiltration, while reducing soil loss.

At the new Rio Mora National Wildlife Refuge (formerly the Wind River Ranch), in Watrous, New Mexico, there are about 100 headcuts throughout 11 primary canyons (Figure 1). More than 150 one-rock dams and a variety of other types of channel restoration structures have been built at the Refuge (Figure 2, page 36).

(Unless otherwise noted, all graphics and photos in this article are courtesy of Shantini Ramakrishnan.)

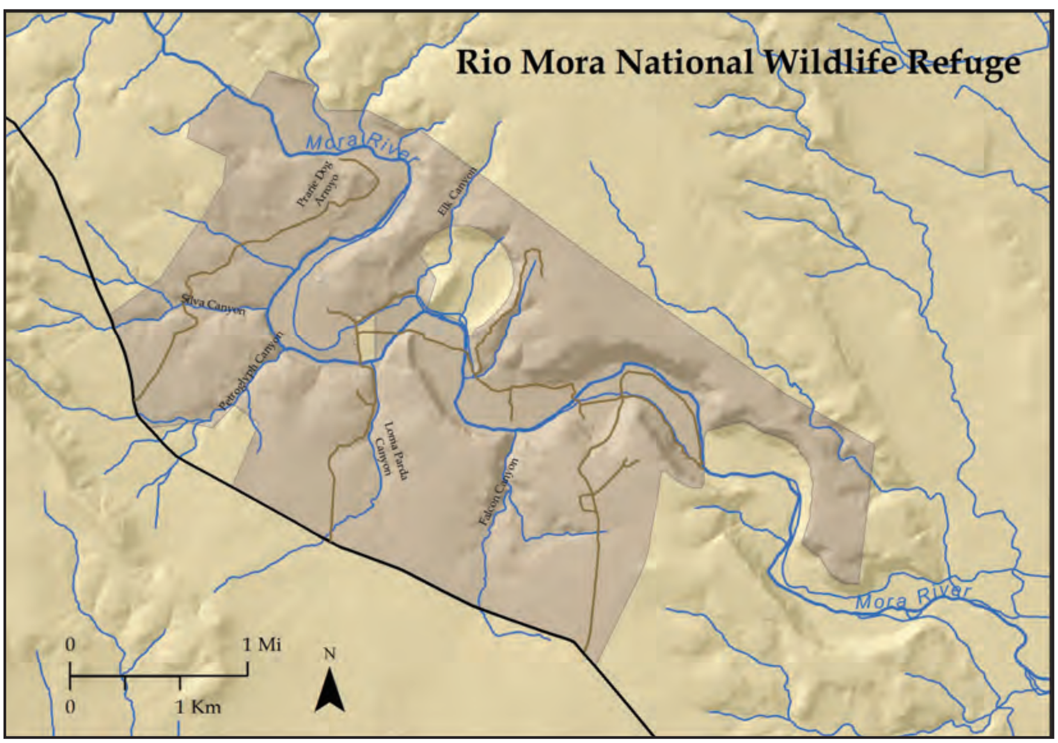

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Figure 1. Rio Mora National Wildlife Refuge in Watrous, New Mexico, is located in Mora County. Eleven canyons feed into a five-mile stretch of the Mora River.

©Courtney White

Figure 2. Bill Zeedyk describes design and function, and how to construct a One Rock Dam at a May 2010 workshop at Rio Mora Wildlife Refuge (Wind River Ranch in 2010).

Figure 4. At Silva Canyon, one-rock dams have raised the arroyo bed which now resembles a vegetated gentle swale at Rio Mora National Wildlife Refuge in Watrous, New Mexico.

Figure 3. Ephemeral pools and willow stands are common features at Loma Parda arroyo at Rio Mora National Wildlife Refuge, where a series of one-rock dams (bottom right) were built.

Figure 5. Restoration efforts at Silva Canyon. Parts of the arroyo have degraded to bedrock. Work crews such as this annual forestry field course from Oklahoma State University provide much needed support and human resources for restoration activities at Rio Mora National Wildlife Refuge.

This quantity and diversity of structures and contexts creates an ideal opportunity to study the effectiveness of these structures in achieving ecological goals.

The impact of restoration efforts in these canyons has been promising. A series of pools at Petroglyph and Loma Parda canyons may provide important breeding habitat for amphibians, support willow stands, and become a microcosm of moist habitat in a semi-arid landscape (Figure 3). At Silva Canyon, one-rock dams have successfully raised the bed of the channel through high rates of sedimentation. Parts of the arroyo are now a vegetated gentle swale (Figure 4), while other parts of the canyon have eroded down to bedrock and are in need of restoration (Figure 5). Annual photo points provide compelling evidence of stemming erosion, but this evidence lacks quantitative power. While restoration design will always be a blend of art and science, quantitative benchmarks are needed to support visual evidence of the apparent success of one-rock dams.

Monitoring activities can help us quantify reduced erosion and aggrading arroyos through rock structures. Monitoring can also tell us how to improve the application of specific structure types in specific locations over time. Monitoring data should support the ongoing evolution of these approaches. While simple in concept, monitoring in dynamic channels subject to erratic and extreme storm events poses many challenges. Just as the restoration methods have evolved, so too has our ability to monitor. Photo points have been supplemented by longitudinal and cross-section data. Vegetation surveys provide another indicator of success. Access to low cost continuous soil moisture monitoring and rainfall measurements further enhances the monitoring tool kit. However, with any natural resource experiments, we have to carefully select what and where to measure.

A well-designed research project may help us understand if these restored arroyos are creating healthy habitat and establishing long-term land health. This is important because disturbed sites can sometimes become a hotbed for invasive species colonization, resulting in unintended consequences. A research project might entail gathering baseline data of arroyo morphology, along with flora and fauna utilizing the unrestored arroyo. Following the implementation of restoration to stem erosion, sampling flora could help us gauge how the restoration has enhanced the habitat and its diversity. Longer term surveys might include sampling for fauna, such as invertebrates, reptiles and amphibians, small mammals, and ungulates.

To effectively quantify the restoration work at Rio Mora National Wildlife Refuge, the refuge is employing a three-step process: research, monitor, and evaluate. Our current efforts are focused on implementing a standardized protocol for monitoring erosion in restored and unrestored arroyos. Such baseline data will be used in landowner workshops to share experiences for improved restorations, as well as justification for research. Additionally, the refuge in consultation with Bill Zeedyk, is designing a master restoration plan.

BACK TO BASICS

At a minimum, every rock structure should slow water down and encourage soil particles to precipitate and deposit. Soil deposition elevates the arroyo bed and reduces the slope. A reduced slope reduces the erosive potential of arroyos. Rainfall, sedimentation, slope, and erosive potential are the variables being studied.

Rain gauges are the easy choice for measuring precipitation. Research-grade digital rain gauges are supplemented by garden-variety graduated cylinders. The other components can be determined through repeated cross-sectional and longitudinal profiles. Cross-sectional and longitudinal profiles can tell us the volume of soil gained from rock structures, such as one-rock dams, and conversely, the amount of soil lost from unrestored gullies (Figure 6). Longitudinal profiles can also quantify the reduction in slope over time (Figure 7, page 38). Deciding how to measure cross-sectional and longitudinal profiles depends on the resolution needed, plus available time and effort. A number of options are being explored, as described in Table 1, page 38.

Reducing erosion alone is insufficient. We need to create a meaningful measure of success for restoration rock structures, design an efficient and effective monitoring program to quantify success over time, and use these quantifiable variables to inform and evaluate structural designs that better meet restoration goals. The ultimate goal is to create new habitat and heal the land through grade-control structures that reduce erosion.

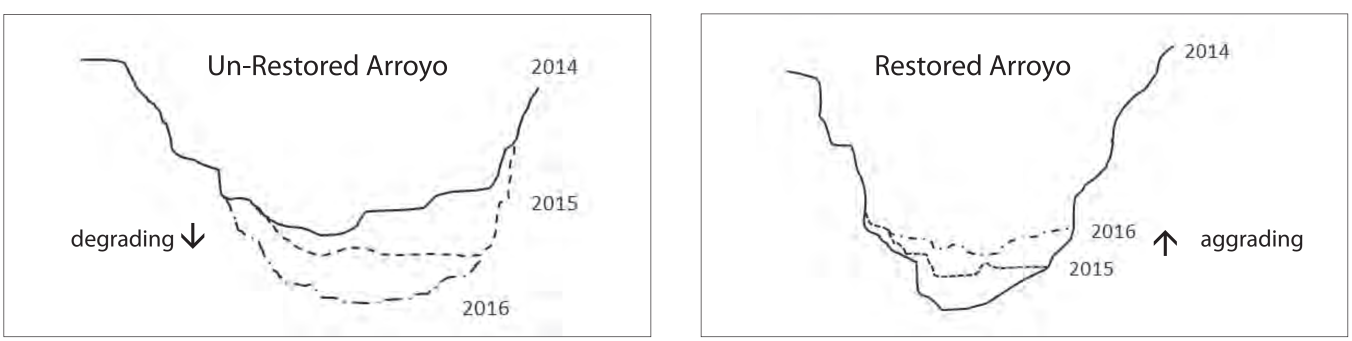

Figure 6. A schematic of a projected cross-sectional profile can be used to quantify annual soil deposition, i.e., actual volume of soil that is gained through restoration efforts over time. A similar profile in an unrestored arroyo could also estimate the volume of soil lost from erosion.

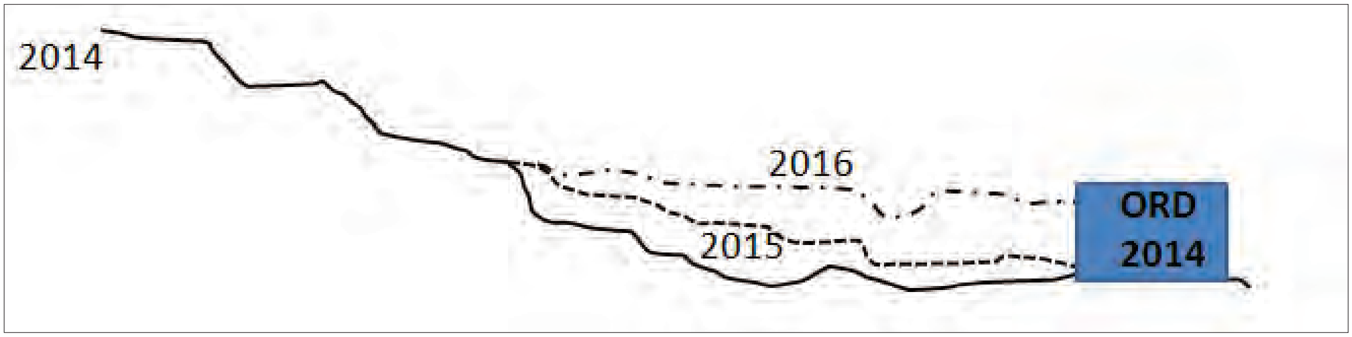

Figure 7. A schematic of a projected longitudinal profile that can quantify the reduction in slope over time, as a result of rock structures, such as one-rock dams (ORD). These structures slow down water, and allow for sedimentation, which raises the bed of the gully. A reduced slope decreases runoff velocity and diminishes the erosive power of water.

Methodology	Description	Resolution	Pros	Cons
Aerial LIDAR	Utilizing Light Detection and Ranging (LIDAR), this technology uses the reflectiveness of light to map out ground cover	1m^2	Gain a lot of data in a single flight that pertains to slope, vegetation cover, amount of bare ground, etc.	Expensive; skilled expertise needed to interpret mountain of data
Total Station	Tried-and-true surveyor technique, providing three-dimensional measurements	1 cm^2	Accurate, dependable measurements	Time intensive; equipment is only as good as its operator and training is required
Optical Level/Laser Level	Surveying technique, providing two-dimensional measurements	1 cm^2	Accurate measurements, relatively easy to train an operator and implement	Lose z-dimension
Mobile LIDAR	New technology utilizing reflectivity of light; designed to be mounted on drones but can be mounted on tripods to capture 40-meter stretches	1 mm^2	Novel, fine scale	Untested technology, which may be finer scale than necessary

Table 1. Monitoring protocols to quantify restoration efforts at Rio Mora National Wildlife Refuge in Watrous, New Mexico, depend on time, financial resources, and required resolution. A number of methods are being explored currently to determine the most reasonable methodology to employ for this monitoring program.

REFERENCE

Zeedyk, W.D. and Van Clothier (2009) *Let the Water Do the Work: Induced Meandering, an Evolving Method for Restoring Incised Channels*. White River Junction, Vermont: Chelsea Green Publishing, 2nd edition, 2014.

Grassland Stakeholders Survey Summary

by Mollie Walton, PhD, Quivira Coalition, Land and Water Program Director in conjunction with the Arizona Chapter of The Nature Conservancy

In spring 2014, the Quivira Coalition had the privilege of speaking to grassland stakeholders throughout Arizona and southeastern New Mexico to gather information that will help ensure the ecological vitality of grasslands and the economic viability of people who depend on them. Grasslands are resilient systems, but much of the original grasslands in the United States have disappeared.

Only about 1 percent of tallgrass prairie, 24 percent of mixed grass prairie and 18 percent of shortgrass prairie remain intact. Intentional stewardship of these remaining grasslands by those who benefit directly from them is important in order to maintain the heterogeneity, biodiversity and ecosystem services that they provide.

Quivira conducted the in-depth survey on behalf of the Arizona Chapter of The Nature Conservancy. Grasslands stakeholders were asked for their assessment of current threats to native grassland habitats and what they would consider the most useful progressive management techniques for maintaining or improving the grasslands in Arizona and the "boot heel" of New Mexico. Stakeholders were divided into four groups: 1) ranchers and land managers, 2) grassland experts, 3) conservation groups and 4) agency personnel. They were queried through an electronic survey, contacted by email or spoken with directly. The full methodology and comprehensive results for the study are included in a 45-page final report to the Arizona Chapter of The Nature Conservancy.

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Keeping the next generation cool.

RESULTS

The survey data provided insight into which management techniques are working on grasslands and helped to identify factors that might be working against sustaining native grasslands in the Southwest.

Table 1 presents a list of the most important Best Management Practices (BMPs) by each stakeholder group, comparing them side by side to show the areas of overlap between stakeholder solutions and the areas of difference. For instance, the ranchers/land managers rank three items high on the list that do not appear in the top ranking for any other stakeholder group. Similarly, agency personnel have three highly ranked items that do not coincide with the top ranking for any other group. That said, the first four methodologies in the table are universally agreed upon across all four stakeholder groups.

From Quivira's perspective, one of the most heartening responses to the question "What is the Best Management Practice (BMP) for maintaining and restoring grasslands?" was that "mentoring the next generation of grassland stakeholders" was ranked among the most important BMPs by all four stakeholder groups. This is valuable feedback for Quivira's New Agrarian Program, which creates apprenticeships for the next generation of farmers and ranchers. These apprenticeships are specifically designed to offer hands-on training in all aspects of resilient ranching and farming.

Stakeholder groups were also asked about the BMPs for which they would like to have more information. Ranchers and land managers wanted more on diversification of agricultural business practices; conservation stakeholders were interested in learning more about supplemental feeding; and agency stakeholders wanted more information about suppliers for grassfed beef markets.

Another result that resonated with Quivira was the answer to the question, ***What would be the best***

The top rated methods for maintaining and restoring healthy grasslands ranked across all stakeholder groups.

Method	Rancher/Land Manager	Grassland Expert	Conservation Group	Agency Personnel
Prescribed grazing	■	■	■	■
Drought management planning	■	■	■	■
Erosion control	■	■	■	■
Improved monitoring of grassland health	■	■	■	■
Mentoring for the next generation of grassland stakeholders	■	■	■	■
Prescribed fire	■	■		■
Brush control	■		■	■
Increased access to technical assistance		■	■	
Active watershed groups		■	■	
Access to current information on grassland management		■		
Water infrastructure improvement		■		
Conservation easements			■	
Increased grassland conservation funding in the farm bill			■	
Establishment of grassbanks or swing allotments				■
Invasive weed management				■
Staffing levels of federal agencies				■
Changes in state or federal policies	■			
Increased flexibility on federal grazing permits	■			
Payments for ecosystem services	■			

Table 1. There were 32 Best Management Practices (BMPs) and stakeholders were asked to rank the importance on a scale from **Not Important**, **Slightly Important**, **Important**, **Fairly Important**, **Very Important** and **No Opinion**. These categories were given a numerical rank and the BMPs that were most often ranked as very important are included in this table.

collaborative model to sustain grasslands? The majority of stakeholders said that watershed groups were the collaborative model of choice. This was closely followed by rancher-to-rancher collaborative groups such as the Malpai Borderlands Group and the Altar Valley Alliance. Since 2001, Quivira's Land and Water Program has served as a member and leader of the Comanche Creek Working Group and has helped restore ecological resilience at a landscape level to the Comanche Creek Watershed, located within the Valle Vidal Unit of the Carson National Forest, New Mexico.

The most important question we asked in our in-person interviews was ***Why have collaborative management groups, such as the Mailpai Borderlands Group, not been replicated across every watershed and working landscape?*** The answer is seemingly obvious: "We need champions to lead these groups." Successful groups are led by selfless individuals who have the unique qualities necessary to sustain a vision while working with diverse stakeholders. Even if a collaborative management group could benefit them in the long term, many ranchers and land managers are too busy "putting one foot in front of the other" on their own operations to spend time contributing to another organization.

One of the solutions proposed by grassland stakeholders was regional, state and federal level policy changes that would allow public funding to support individuals who lead collaborative groups. Without

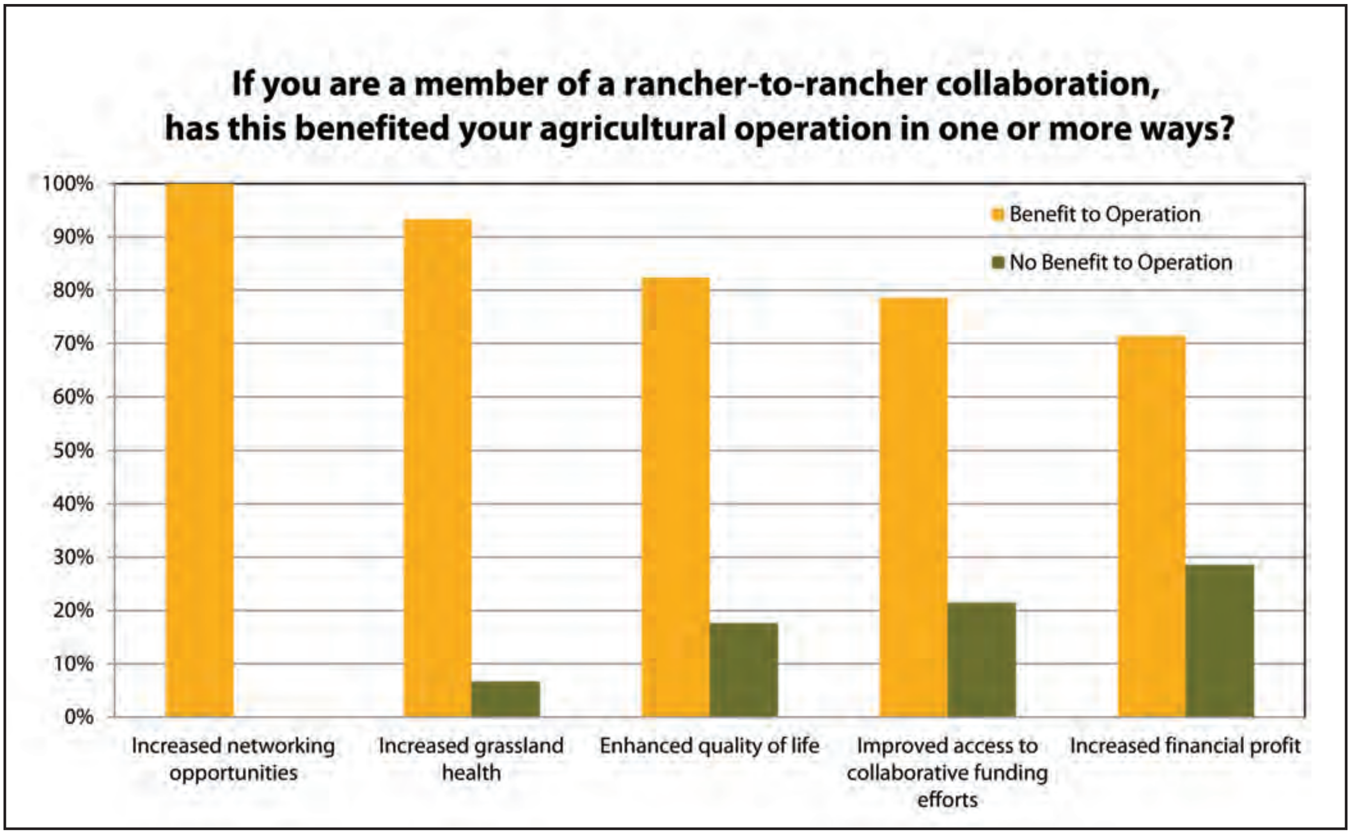

Figure 1. Benefits of belonging to a collaborative group.

support for their efforts, these **champions** often must choose to dedicate their substantial skills and effort elsewhere.

Stakeholders in the land management category were also asked, ***What, if any, benefits did you experience from being part of a collaborative group?*** Most reported substantial benefits from their interaction with collaborative groups (Figure 1). This was another indication that Quivira's support for collaboration within and between stakeholder groups—an expression of our commitment to building the "radical center"—is of value to our community.

It doesn't take an intensive data collection and compilation exercise for Quivira to recognize the immeasurable value of good land stewardship. However, the results of this survey reassure us that we are on the right path and make us even more appreciative of the innovative and tireless grasslands stewards we are privileged to know, including those we met in the course of this task.

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Collaborative land health assessment.

ACKNOWLEDGEMENTS

We wish to extend our deep gratitude to Bob Rogers, Frank Hayes and Karla Sartor for their work on the survey. We would also like to acknowledge the deep care that each of our survey respondents invested in their thoughtful responses to our long and complicated survey. Thanks to all of you and to the Arizona Chapter of The Nature Conservancy and their funder, who made this project possible.

QUIVIRA COALITION

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3. organization (agency, business, school, nonprofit)
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Membership includes discounted registration fees for the Quivira Conference (for households, all family members; for organizations, up to 10 employees). That's a real savings! Each membership will also receive one copy per issue of Quivira's Journal, *Resilience,* and our monthly eNewsletter.

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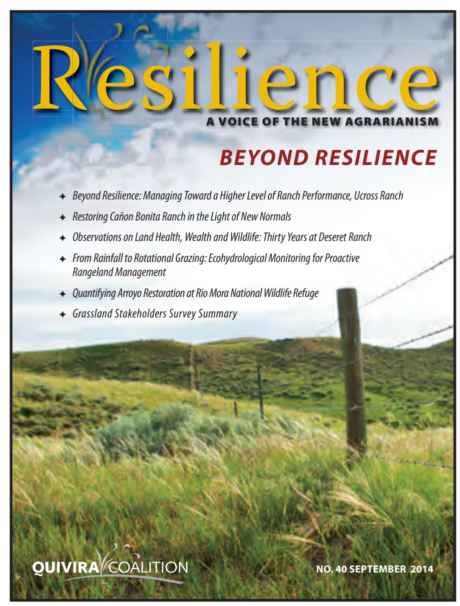

THANK YOU FOR YOUR SUPPORT!

BACK TO THE FUTURE

At the 2014 Quivira Conference, we'll focus on concepts and practices that are "old and yet new"—and we'll have fun doing it! "Back to the future" is part of the burgeoning regenerative agriculture movement, whose aim is to restore soil, land, ourselves and our communities to health and happiness via naturally renewing processes. In some cases, this means reviving or expanding time-tested practices; in others it means adopting new technologies and ideas appropriate for regenerative goals. We are linking arms with the larger global celebration of the International Year of Family Farming and have tasked ourselves with the goal of helping to raise the profile of family farmers (and ranchers) and the significant role they play in alleviating hunger and poverty, providing food security and nutrition, improving livelihoods, managing natural resources, and protecting the environment. We have selected speakers for our conference who represent the diversity of the regenerative agriculture movement around the globe. Join us for three days of inspiring presentations and conversations. The time for *Back to the Future* thinking is now!

RANCHING IN NATURE'S IMAGE – Wednesday, November 12, 12:00-5:00 p.m.

Gabe Brown and his son **Paul** will share what they learned as they regenerated a degraded ranch through Holistic Practices. In 1991, when the Browns purchased their ranch (east of Bismarck, North Dakota), it had a carrying capacity of 100 cow/calf pairs. The degraded soils had organic matter levels less than 2 percent and rainfall infiltration rates were less than one-half inch per hour. Today the ranch carries 350 cow/calf pairs and 400 to 800 yearlings. Organic matter levels have increased to more than 6 percent and infiltration rates are now 8 inches per hour. The Browns have regenerated their landscape without the use of synthetic inputs. The Browns follow the same natural pattern that occurs in nature—where diverse species working together sustain healthy ecosystems—using diverse livestock to address their resource concerns. This has given them a high quality of life while allowing for the transition of the ranch to the next generation, and their focus on regeneration has drawn the attention of groups worldwide.

COLLABORATIVE WETLAND RESTORATION IN THE SOUTHWEST – Wednesday, November 12, 8:00 a.m. to 5:00 p.m.

Wetlands in the Southwest are increasingly precious in a drying landscape, from high mountains to low plateaus. Addressing wetland degradation issues has the potential to benefit the health of entire watersheds, not just the wet areas. As climate change strongly influences the success of restoration projects, it is ever more important to combine efforts and ideas to bring these essential ecosystems back to health. This one-day workshop is anchored by restoration specialist, Bill Zeedyk. Other speakers—from a variety of backgrounds, including nonprofit organizations, volunteer groups, small businesses, ranches and other private land holdings, and public land management agencies—will share their experiences with collaborative wetland restoration.
Presented by Quivira in collaboration with the New Mexico Environment Department-Surface Water Quality Bureau and partially funded through an Environmental Protection Agency Wetland grant.

PLENARY SESSIONS SPEAKERS - Thursday and Friday, November 13-14, 8:00 a.m. to 5:00 p.m. daily

- **Norine Ambrose,** Executive Director of the Alberta Riparian Habitat Management Society, Canada
- **Dorn Cox,** Farmer, Founding Member and Board President of *FarmHack. net*, New Hampshire
- **Christian Dupraz**, **PhD**, Agroforestry Scientist, France
- **Christine Jones, PhD**, Soil Scientist, Australia
- **Paul Kaiser,** Farmer, Singing Frogs Farm, California
- **Fred Kirschenmann,** Farmer, Author, Professor and Internationally Recognized Leader in Sustainable Agriculture, Iowa
- **Winona LaDuke,** Author, Activist, Environmentalist and Executive Director of Honor the Earth and White Earth Land Recovery Project, Minnesota
- **Bill McDonald,** Rancher, Executive Director, Malpai Borderlands Group, Arizona
- **Nicholas Nelson,** Director of the North American Office of the United Nations Food and Agriculture Organization, the Lead Agency for the International Year of Family Farming, Washington, DC
- **Jo Robinson,** Bestselling Investigative Journalist, Washington
- **Judith Schwartz,** Writer and Author, *Cows Save the Planet*, Vermont
- **Robin Seydel,** Consumer, Health and Environmental Community Organizer, New Mexico
- **Gregg Simonds,** President, Open Range Consulting, Utah
- **Courtney White,** Quivira Coalition, New Mexico

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