August 2005
Vol. 7, No. 3

The Quivira Coalition

Education, Innovation, Restoration... One Acre at a Time

Collaborative Science: Making Research a Participatory Endeavor for Solving Environmental Challenges

by Dr. Thomas D. Sisk and Jean Palumbo, Center for Environmental Science & Education, Northern Arizona University

Research science is the poster child of individual pursuit. Popular culture portrays research as a solitary endeavor, with white-coated scientists isolated in the laboratory, off on an esoteric journey that eventually—if one is both brilliant and lucky—results in a "Eureka!" moment of insight that changes the world.

In reality, research science is more mundane, but perhaps no less isolationist.

Researchers put in long, often lonely hours doing routine tasks, sorting though countless uninteresting results and repeating problematic experiments until a bit of insight emerges. It's no wonder that research often moves forward as an individual pursuit—not many folks want to spend the wee hours of the night calibrating equipment or running statistical tests on computers.

Yet, answering the big questions in environmental science today doesn't lend itself to the kind of research that is done by one, or a few people in bright laboratories on university campuses.

Today's environmental challenges beg for large, ambitious studies conducted at landscape scales in the real world. They involve real people working at the interface between science and society, where research, policy, and management are fused, and influence how people manage the land.

From the clean-up of toxic waste to the restoration of health to fire-prone forests, environmental research is becoming a collaborative endeavor, involving land managers, elected officials, and interested citizens, as well as professional researchers. Embracing this diversity in scientific practice, while retaining the rigor and credibility provided by sound research, is the challenge of the current generation of environmental scientists.

Reaching Across Fences

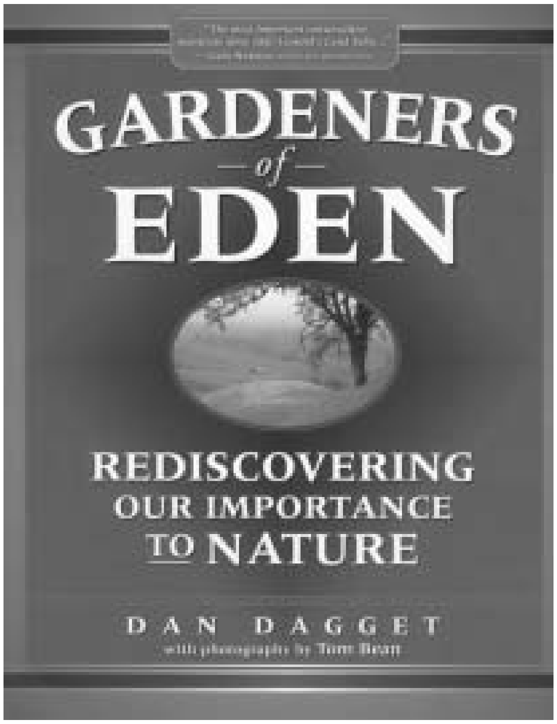
This is the third in our series, which examines the challenges and opportunities of cooperative management in the West. In this issue we examine the scientific benefits of collaboration. As the goals of scientific inquiry have changed in recent years, so has its methodology. How does collaboration aid natural resource research?

How Science Operates

Science explores the limits of our current understanding of how the world works. It advances our knowledge by testing ideas that have emerged from careful observation and personal experiences. These "ways of knowing" are organized by the human mind into patterns of understanding and intelligence.

The goal of science is to refine our understanding of natural phenomena by testing our ideas and uncovering the cause-and-effect relationships that may have far-reaching influences beyond the laboratory or a particular study site.

Continued on page 22



Eden As A Cultural Artifact

by Dan Dagget

This is the third in a series of excerpts from Dan Dagget's new book, Gardeners of Eden: Rediscovering Our Importance to Nature.

[Editor's note: In his new book, Dagget observes that before collaboration can benefit science, science must be used to surmount the main obstacles that prevent collaboration. He came to this conclusion while traveling the country showing various audiences (including environmentalists) the exceptional results some ranchers were achieving in land restoration and endangered species recovery. No matter how impressive those results were, however, the environmentalists' response was, with few exceptions, the same: Leaving the land alone would have done even better. This inspired Dagget to refer to the ranchers whose work he was presenting "the Lost Tribe" and to write the following...]

While I was puzzling with some friends about how to overcome the obstacle presented by the assumption that, no matter how well humans take care of the land leaving it alone would always do better, they suggested I read an article in the *Atlantic Monthly*. It was entitled "1491."

"It might help." they said. "At least it'll give you some ammunition."

I had almost forgotten about their suggestion when I began receiving e-mails about the same article from a slumgullion stew of contacts—from ranchers, agency people, environmentalists, advocates for indigenous peoples, New Agers and so forth.

Continued on page 3

Eden As A Cultural Artifact

(con't from page 3)

All Photos within the article are by Tom Bean.

I took the hint, read the article, and realized I had been handed exactly what I had been looking for. There it was, as plain as could be—the fracture in the monolith members of the Lost Tribe and I had been beating our heads against for years. In eye-opening examples, data, analysis, quotes, and citations, the article by Charles Mann struck right at the heart of the Leave-It-Alone assumption. Most exciting for me, many of those quotes concerned the Eden that serves as the prime example advocates of that assumption use to prove that it is accurate—the Amazon. Leave-It-Advocates assume that the Amazon was as healthy and diverse as it was when Europeans came across it because it was "untrammeled" by humans. In "1491", Mann and the scientists he wrote about were telling us the exact opposite.

"Indian societies had an enormous environmental impact on the jungle," Mann wrote. "Indeed, some anthropologists have called the Amazon forest itself a cultural artifact—that is, an artificial object.

"[T]hey [Indians] were so successful at imposing their will on the landscape that in 1492 Columbus set foot in a hemisphere thoroughly dominated by humankind."

Mann quotes Peter Stahl, an anthropologist at the State University of New York at Binghamton, who says, "[W]hat the eco-imagery would like to picture as a pristine, untouched Urwelt [primeval world] in fact has been managed by people for millennia."

Evidence that led Mann and the people he was writing about to come to these conclusions included "an archipelago of forest islands, many of them startlingly round and hundreds of acres across. Each island rose ten or thirty or sixty feet above the floodplain, allowing trees to grow that would otherwise never survive the water. The forests were linked by raised berms, as straight as a rifle shot and up to three miles long."

"It is Erickson's belief," wrote Mann, "that this entire landscape—30,000 square miles of forest mounds surrounded by raised fields and linked by causeways—was constructed by a complex, populous society more than 2,000 years ago."

Mann and the scientists he interviewed for this article believe that other habitats in the Western hemisphere that were likely created by humans include the bison plains of North America.

"Rather than domesticating animals for meat," Mann wrote, "Indians retooled whole ecosystems to grow bumper crops of elk, deer, and bison." They did this, Mann tells us, by reshaping entire landscapes, using fire "to keep down underbrush and create the open, grassy condi-

Human-made features like the berms and ditches visible in this photo of the Amazon have caused archaeologists to credit humans with making the area so hospitable to biodiversity.

Evidence of "gardeners" in what was once a marsh in the Nevada Desert.

tions favorable for game." Their efforts were so successful that: "The first white settlers in Ohio found forests as open as English parks—they could drive carriages through the woods."

Mann's characterization of some of the

Continued on page 4

Eden As A Cultural Artifact

(con't from page 3)

techniques used by the original gardeners of Eden serve as a fairly close description of what contemporary ranchers do. Most of the ranchers I know work with "whole ecosystems" and "entire landscapes" on areas that incorporate thousands, even hundreds of thousands of acres. And most of them manage those landscapes by working with animals that range over the land in a way similar to the way wild animals do.

For the ranchers I call The Lost Tribe (and for me), Mann's article provided an infusion of energy and optimism to a reserve that had been running low.

Duane Lamers gardens the ecosystems of the 777 Ranch in South Dakota by using bison as a tool.

For the Leave-It-Alone assumption, it had a different implication. If some of the most important of the iconic landscapes offered as evidence that "the only way to heal the land is for humans to leave it alone" were, in truth, created by humans, then the people who market that strategy are, at the very least, guilty of false advertising.

The "Use" Relationship

Mann's revelations and the successes of the Lost Tribe build a case for a paradigm shift in the way we think about the environment. They provide a reason and a rationale for redefining the way we look at the use of nature. Today, when nature is involved, many of us think of use as being identical to abuse. We think of the relationship between the health of an environment and the extent to which it is used by humans as a negative continuum. On the end of that continuum on which "use by humans" is at its highest value, we take it as a given that "environmental health" is at its lowest. On the other end—the end on which use by humans is low to nonexistent—we consider environmental health to be at its highest value. Wildernesses where humans "are only visitors" are considered by most of us to be the epitome of environmental health.

Viewed in terms of this continuum, the way to heal any area is to merely reduce the amount of its use by humans. Granted, it's not hard to find reasons to think this way. Use by humans has decimated our ancient forests, almost wiped out the North American bison, and is devastating the Amazon rainforest. Even ancient peoples were capable of this sort of overuse. Shortly after one group of hunters arrived in North America, 73 percent of the North American genera of terrestrial mammals weighing one hundred pounds or more became extinct.

Citing examples such as this, environmental groups wage war against efforts to "use" public lands. They tell us such "use" is unnatural and, for that reason, inevitably causes harm. Environmental philosophers tell us using the plants and animals that live on the land is "slavery," and when we use animals for food, more than a few characterize it as murder.

In cases in which the relationship doesn't involve humans, however, use isn't considered such a form of villainy. In fact, it's considered to be quite the opposite. In nature we refer to "use" relationships as symbioses, mutualisms, and synergies. Bees use flowers for food, and flowers use bees for pollination and reproduction, and no one calls it "slavery." Some pollinators are so essential to the reproductive function of plant species that without the "users" the "used" would almost certainly cease to exist. Predation, most of us have come to believe, is ben-

Continued on page 5

Eden As A Cultural Artifact

(con't from page 4)

eficial to prey populations. Wolves remove the old and sick from herds of elk, deer, caribou, et cetera, and keep those animals from overpopulating their habitat.

Rather than the exception, some scientists are now saying these sorts of use relationships among species are the rule. In his book, *Nature's Magic, Synergy in Evolution and the Fate of Mankind,* Peter Corning quotes ecologist Judith Bronstein as saying "Mutualisms ... have finally come to be recognized as critical components of ecological and evolutionary process.... Every organism on earth is probably involved in at least one and usually several mutualisms during its lifetime."

"Symbiosis is not a marginal or rare phenomenon," writes ecologist Lynn Margulis in her book *The Symbiotic Planet, A New Look at Evolution*. "We abide in a symbiotic world."

The "use relationship", therefore, is one of the most important and universal relationships within nature. It is, in fact, the relationship that forms the warp and woof of those webs of interrelatedness and interdependence we call ecosystems.

If that's the case, which it seems to be, it makes no sense to say the only way humans can relate to the land in a "natural" way is to leave it alone—to not use it. In fact, it is more correct to say the opposite—the only natural way to relate to the land is to use it. And, it makes no sense for people who call themselves environmentalists to refuse to collaborate with people who use nature because leaving it alone would get better, i. e., more "natural," results.

That is how science leads us to collaboration.

It is also one way, perhaps the most important way, in which collaboration leads us to science. People who sit back and dismiss the benefits of using nature for a reason that is not only doctrinaire but wrong, are incapable of engaging in science. Their feedback loops are closed. How can you receive feedback when you will only accept one answer—that the only way to heal the land is to leave it alone? By opening these people to collaboration, science opens their eyes to receive feedback, i. e., to actually observe and learn from the effects of our actions on the land rather than merely to force-fit them into a preconception. The importance of that is beyond measure because feedback, or openness, is the essence of all functional relationships—scientific, collaborative, natural, utilitarian, and otherwise.

In The Way We Lived, California Indian Stories, Songs and Reminiscences, Native American advocate and historian Malcolm Margolin wrote, the landscape of old California, in other words, meadows, oak savannahs, park-like areas of great Boled oaks and clear understory was not a natural landscape. It was a landscape created by people, in many ways as artificial as the farmlands of Europe. Thus, when Spaniards and then others first arrived in California a couple of centuries ago, they did not find (as they fondly imagined) a pristine wilderness. They found what was in many ways a garden, a land very much shaped by thousands of years of human history and adapted to human needs.

Substantial funding for this Newsletter was provided by the Environmental Protection Agency in cooperation with the New Mexico Environment Department – Surface Water Quality Bureau.

State-and-transition models 101: a fresh look at vegetation change

by Dr. Brandon Bestelmeyer and Dr. Joel Brown / USDA-ARS and NRCS at the Jornada Experimental Range

State-and-transition models are part of a new framework for evaluating the condition of rangelands, anticipating vegetation change, and planning land management. Government agencies, scientists, non-governmental organizations, and ranchers are involved in developing this framework.

Why should you care?

First, a clear understanding of vegetation change is critical. It lies at the center of the conflict (and cooperation) with which many of us are involved. It affects our bottom line, our interactions with others, and our ways of life. If you have ever wondered why vegetation has changed the way it has, what it used to look like, or what it could look like in the future, then you could probably use a state-and-transition model (hereafter, STM).

...“a clear understanding of vegetation change is critical. It lies at the center of the conflict (and co-operation) with which many of us are involved. It affects our bottom line, our interactions with others, and our ways of life.”

Second, it is important to realize that both new scientific and policy developments will be connected to the concepts underlying STMs. Even an Undersecretary of Interior Department and the director of the Bureau of Land Management (BLM) have publicly advocated the uses of STMs. The Nature Conservancy is also using STMs to prioritize conservation efforts.

Alongside rangeland health, STM concepts will be part of the common language of natural resource management for years to come.

Are STMs as new, impressive, and incomprehensible as they sound? Not really. They are called “models” not because they involve elaborate computer simulations, but because they are a formal statement of how we think a system works. They are built on many existing concepts and some new ones.

The most significant features of STMs, as we see it, are threefold: 1) they have started us thinking critically (again) about vegetation change, 2) they better represent the breadth of factors that we know structure rangelands, and 3) they involve a participatory element that gets scientists, agencies, ranchers, and environmentalists talking.

A Brief History

“The process of rediscovery might be as follows: a young, inquisitive, and original man might one morning find a fissure in the traditional technique of thinking. Through this fissure he might look out and find a new external world around him. In his excitement a few disciples would cluster about him and look again at the world they knew and find it fresh. From this nucleus there would develop a frantic new seeing and a cult of new seers who, finding some traditional knowledge incorrect, would throw out the whole structure and start afresh. Then, the human mind being what it is, evaluation, taxonomy, arrangement, pattern making would succeed the first excited seeing. Gradually the structure would become complete, and men would go to this structure rather than to the external world until eventually something like but not identical with the earlier picture would have been built. From such architectures or patterns of knowledge, disciplines, ethics, even manners exude. The building would be complete again and no one would look beyond it—until one day a young, inquisitive, and original man might find a fissure in the pattern and look through it and find a new world. This seems to have happened again and again in the slow history of human thought and knowledge.” - J. Steinbeck. 1948. Foreword to Between Pacific Tides, 2nd ed.

As Steinbeck describes, state-and-transition models are a product of the plodding and cyclical scientific enterprise.

Continued on page 7

Typically, we contrast the STM approach with the older "succession-retrogression" approach based on a seminal paper by Dyksterhuis (1949), which, in turn, was based on the theory of *succession* developed by ecologists in the early 20th century.

A key assumption was that plant communities changed smoothly and reversibly with changes in climate and grazing pressure. With continuous heavy grazing, the palatable "decreasers" decrease, the unpalatable "increasers" increase, and weedy "invaders" invade (i.e., *retrogression*). When undisturbed, the decreasers are superior competitors to the increasers in particular soil and climatic conditions. So we adjust stocking rates and distribution and the invisible hand of succession moves the plant community back toward the decreaser-dominated equilibrium, the so-called *climax community*.

Among the most significant contributions of the succession-retrogression approach were the concepts of the *range condition class* and *similarity index*, still commonly used by the Natural Resources Conservation Service (NRCS) and BLM.

The similarity index provided a continuous measurement of the degree of departure from the idealized climax community by measuring the collective deviation in the production of individual plant species.

The inverse of this deviation was the "similarity" that ranged from 0 to 100%. By breaking these values into four categories, each with a 25% spread, we arrive at the range condition class (poor, fair, good, or excellent). Thus, production values for the climax community provided a benchmark to which another plant community could be unambiguously compared.

The class and index translated a *scientific theory* (a scientific idea with strong empirical support) into an easily understood tool. We could use it to grasp and communicate how our land was doing. This was applied ecology in its purest sense and such application to land management was revolutionary.

This approach worked well as a basis for rangeland evaluation and management in regions that inspired the theory of succession, such as in the tall and midgrass prairies of the central United States. In the drier western United States, however, range managers recognized the limitations succession theory soon after it took hold.

"Where overgrazing has reached the stage where mesquite sandhills are being formed it will be difficult to restore the range. Effort should be made to detect the breaking down of the range much earlier, or as soon as the annuals and short-lived perennials begin to increase and the good grasses to decrease." - *J. T. Jardine and C. S. Forsling. 1922. Range and cattle management during drought. U.S. Department of Agriculture Bulletin No. 1031. Government Printing Office, Washington DC.*

Productive grasslands were changing to shrublands or annual grasses and they were not recovering when rested according to successional theory.

Rangeland managers of the time recognized several factors that might prevent successional processes, including soil erosion, the competitive effects of established shrubs, high rodent densities and their herbivory, and drought (Fig. 1).

Fig. 1: Part of an area on the Jornada Experimental that was fenced from rodents and livestock in the 1930's in hopes of recovery. In mesquite dunelands, however, abiotic forces predominate and preclude the recovery grassland even after 70 years. (photo courtesy of USDA-ARS)

Through a series of failed restoration experiments, they also learned how difficult it is to overcome these processes, since they act synergistically with one another.

Continued on page 8

State and Transition Models 101

(con't from page 7)

Nonetheless no alternative could match the utility of the succession-retrogression approach for communicating the need for appropriate management, so it was adopted despite its imperfections.

Mark Westoby, an Australian ecologist who attended Utah State University, analyzed the limitations of the succession-retrogression model for arid rangelands and arrived at the same basic conclusion as that of the Jornada rangeland scientists of the 1920s-40s: there is more to rangeland dynamics than succession.

..."there are multiple forces that govern rangeland change, these forces vary in space in time, and resulting change is not always smooth."

Westoby and two other noted aridlands ecologists, Brian Walker and Immanuel Noy-Meir, published the seminal paper on STMs in 1989. This paper had a simple message: there are multiple forces that govern rangeland change, these forces vary in space in time, and resulting change is not always smooth. So why not adopt a flexible model to describe rangelands this way?

The STM did this by conceptualizing vegetation as existing in relatively discrete states, defined based on management need. Changes among these states were described as transitions that could incorporate rich detail on the interactions of several processes such as seed production, rainfall timing, and grazing pressure. Alternative scenarios and uncertainties could be represented.

The information in transition narratives could be used to plan for climatically-driven hazards or opportunities for restoration. The STM was not burdened by adherence to any particular theory and could incorporate succession-retrogression as well as soil erosion-induced contraints. STMs were thought of as a simple and flexible language to describe the many causes and directions of rangeland change.

The development of state-and-transition models

By the end of the 1990s, leaders within the NRCS were promoting the development of STMs in rangeland areas across the country. This is now being accomplished through workshops involving a variety of rangeland professionals, literature reviews, monitoring data, and interpretations of management actions.

This development is linked to revisions of "ecological site descriptions" (ESDs) that were also conceived by Dyksterhuis in the 1940s and implemented by the NRCS.

Ecological sites are a classification of land types based on differences in soils and climate. A region could have from, say, 8-30 ecological sites (Fig. 2) depending on how plant communities on different soils respond to climate and management.

The ESD concept continues to be very important for the development of STMs, because it is well known that the processes

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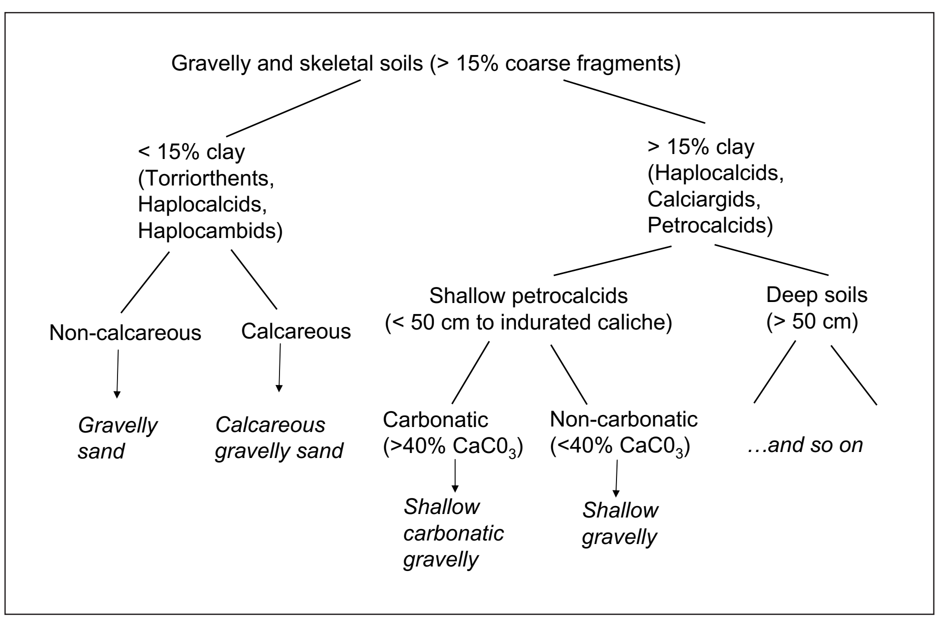

Fig. 2. Part of a key to Ecological Sites. Each couplet in the key describes a contrast that contributes to differences in vegetation composition and change in rangelands. The terms under the % clay couplet are classifications used in soil taxonomy. Soil taxonomy can be very useful in developing Ecological Sites.

State and Transition Models 101

(con't from page 8)

causing transitions vary among soils and climate zones. So, STMs are being developed for each ESD and in some cases the ESD classifications are being revised to better accommodate the STMs.

Models consist of a state-and-transition diagram, detailed text description of states and transitions, and photographs of states. The structure of each model diagram and components has followed a basic format developed by the NRCS and its partners (Fig. 3).

For each model, *plant communities* recognized by dominant species are used as the basic units (the small boxes). Communities that are grouped together within *states* (the big boxes) are hypothesized to replace one another along traditional succession-retrogression pathways.

For example, within a state, heavy grazing may result in dominance by unpalatable grass species, but reduced grazing intensity will initiate relatively rapid recovery of palatable species (the dashed arrows). Short-term fluctuations in climate (e.g., heavy spring rains during one year) may have similar effects by favoring different species.

Thus, facilitating practices (grazing management) can be used to promote a particular community type within a state. Or you may just have to wait for the right kind and amount of rain. These dashed arrows are called *community pathways*.

Highly resilient ecological sites, such as those featuring highly fertile soils and an evolutionary history of grazing (e.g., Midwestern tall-grass prairie), may have only one state and the relationships among plant communities at a site are adequately described by the succession-retrogression model.

In less resilient communities (e.g., arid southwestern desert grasslands) recovery within management timeframes (around 30

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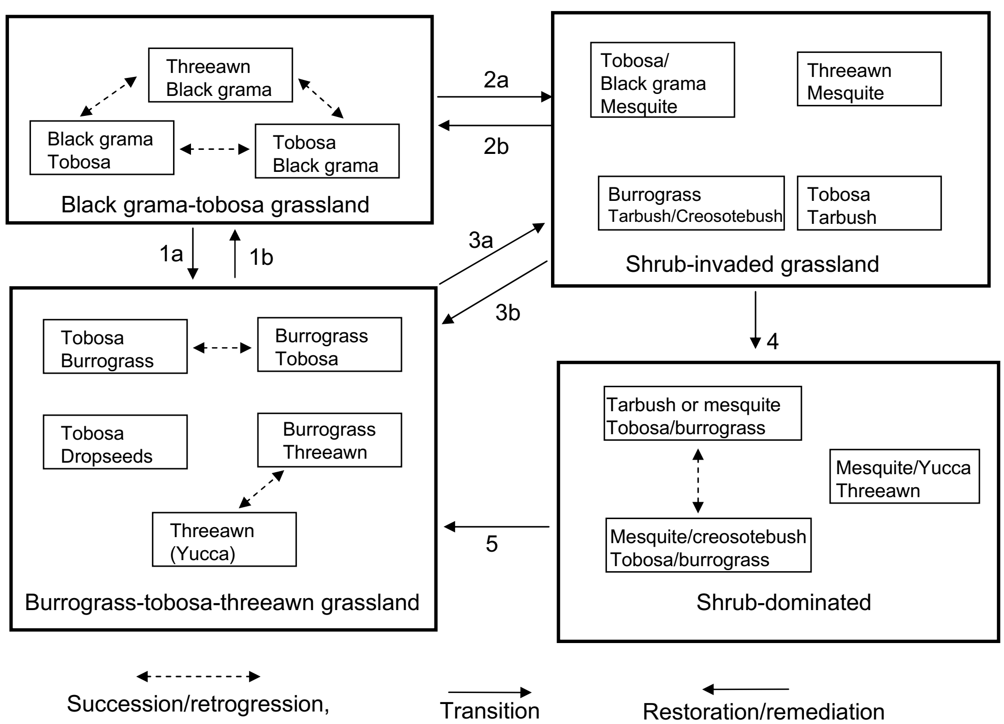

Fig. 3. A state-and-transition model for the Loamy ecological site in the southcentral/southwestern Chihuahuan Desert of New Mexico. Black grama is palatable to cattle for a longer duration than the other species and is comparatively sensitive to grazing pressure. Tobosa and burrograss tend to become dominant with high grazing pressure on finer soils (e.g. loam and silt loam) whereas threeawns become dominant on slightly coarser soils (fine-sandy loams). These soil-based differences are represented by small boxes without arrows. Mesquite tends to invade on coarser soils, whereas tarbush and creosotebush invade on finer soils and calcareous soils that are currently circumscribed within this ecological site. See http://www.nm.nrcs.usda.gov/technical/fotg/section-2/ESD.html for other examples with greater detail in New Mexico. Note that several regions have not yet been completed.

1a. Continuous heavy grazing, soil fertility loss, erosion and sand loss. **1b**. Soil stabilization, soil amendments
2a. Shrub invasion due to overgrazing and/or lack of fire. **2b**. Shrub removal, restore grass cover
3a. Shrub invasion. **3b**. Shrub removal
4. Persistent reduction in grasses, competition by shrubs, erosion and soil truncation
5. Shrub removal with addition of rock dams, soil agradation with time, seeding.

State and Transition Models 101

(con't from page 9)

…"at a certain point in the reduction of grass cover, there is no turning back because the force of erosion or other constraints have grown too strong."

years) may be achieved only through relatively intensive practices, if recovery is possible at all, once dominant species are locally extirpated, highly competitive species invade, soil is degraded, or hydrology altered. These kinds of changes are referred to as *transitions* to a new state.

After a transition, the rules of ecosystem function have changed. Intensive practices to change them back vary widely in their costs, and include seeding, the removal of competitive species, or the addition of soil amendments.

Some changes, such as when entire layers of soil have been eroded away to expose rock or infertile soil horizons, cannot be reversed with any reasonable amount of effort.

The critical distinction between "shifts among communities" and "transitions among states" is used to communicate when significant external inputs are needed for recovery of previously dominant species.

The emergence of significant barriers to recovery as vegetation changes is referred to as a *threshold*. The most significant thresholds are usually related to feedbacks between plants and soil quality. As the cover of grasses declines, for example, erosion rates increase as bare ground becomes connected across broader spatial scales. Australian ecologists have referred to this phenomenon as "landscape leakiness" in which essential nutrients and water that were formerly captured in the production of plants are increasingly lost from an area (Ludwig and Tongway 1997).

Our current understanding of such phenomena is that at a certain point in the reduction of grass cover, there is no turning back because the force of erosion or other constraints have grown too strong. This indicates that a transition is inevitable. We have had a difficult time figuring out how to define this "point" in different ecological sites.

How are state-and-transition models used?

The models are being used in at least three ways: 1) for communication and interpretation of indicators, 2) as an aid in the standards and guidelines assessment of the Bureau of Land Management, and 3) as a guide to new scientific studies.

With a soil map, STM, and photographs in hand, a range conservationist can sit at a rancher's kitchen table and the two can sketch out the possibilities for the future.

An example: 'Here is your map of soils. This entire slope is mapped as the Hap soil which is classified to the Gravelly loam ecological site. Here is the model for Gravelly loam, and here are some photos and data for cover and composition of the states. Now let's go to the field-what is the cover and composition in the pastures, what indicators do we see (e.g., rangeland health indicators; Pyke et al. 2002) such as pedestalled plants, rills, or little shrubs. Now we assign this land to a state. Let's look at where we could be under different future scenarios: a midgrass grassland or an eroding shrubland with grasses bunched up under the creosotebush. With this strategy, maybe we can move this towards a midgrass grassland…'

In a similar way, a map of ecological sites and states can be used to guide assessments of rangeland health on public lands, especially when supplemented with medium-to-fine resolution satellite imagery or aerial photography.

In southern New Mexico, the BLM and its partners are developing such maps to prioritize areas where ground visits would be most useful. Areas that have clearly moved into highly degraded states are unlikely to be recovered with any recommended change to grazing management and thus require more intensive treatment.

Ecological sites (such as grasslands on rocky hills) that have a lower frequency of degraded states may also be regarded as lower priority for intensive field sampling. Susceptible ecological sites that show possible signs of change—such as patchy, fragmented grassland on sandy soils—would be a high priority for a closer look. Thus STMs can contribute to a triage approach in rangelands at risk during drought periods.

Continued on page 11

State and Transition Models 101

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STMs have served as powerful organizational tools for scientists and managers. At the end of a literature review and expert workshop, we inevitably arrive at the conclusion that we didn't know as much as we think we did. And we may have thought we didn't know very much to begin with!

But STMs replace a general feeling of ignorance with a roadmap showing exactly where the gaps in our knowledge are. With a map of ESDs, we can also show how much land area is affected by a knowledge gap. This is very useful for the prioritizing the nature and location of future studies.

STMs are useful simplifications for communication about rangeland change, but they are simplifications nonetheless. Current and future research will change the way we look at rangelands and STMs.

We are accustomed to seeing rangelands, and their states and transitions, at human scales. We often recognize the cover and kinds of plants, but little else. Recent work indicates, however, that many critical processes driving rangeland change occur at finer and broader scales and involve soils.

The speed at which a small piece soil crust from a bare patch decomposes in water may tell us about the restoration potential of a landscape. The context of a pasture seen from a satellite image may indicate erosion processes acting over several interconnected ranches that may limit local management options. Our concepts about assessment, monitoring, and interpretations are only beginning to incorporate the fruits of new science and technologies, so expect STMs to improve.

... "STMs replace a general feeling of ignorance with a roadmap showing exactly where the gaps in our knowledge are."

Suggested Readings

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‘A West That Works’

by Courtney White

The Jornada Experimental Range

The first time I heard Dr. Kris Havstad give a presentation on desert ecology he began his talk in the back of the room – literally.

His point was figurative as well as literal – that for too long scientists were most comfortable in the back of the room, listening attentively, but politely disengaged from the controversies surrounding natural resource management in the West. The reasons for this detachment, he noted, included a concern about incomplete knowledge, a fear of getting dragged into politics, an aversion to conflict, and even a certain shyness.

As Havstad said these things he walked slowly to the front of the room.

This was also meant to illustrate a point – that it was time for science to be out front, to be engaged, to be useful. In Havstad’s opinion the main role of scientists, especially government scientists, such as those who work under his supervision at the USDA’s Jornada Experimental Range (JER) in Las Cruces, New Mexico, is to deliver their knowledge in ways that have impact in the real world.

“If we’re not relevant,” Havstad said recently, “then the public should bag us.”

It is a typical statement from a man who has gained a well-earned reputation as an articulate spokesperson both for the role of science in society and for explaining how arid ecosystems work. An opportunity to combine the two was one of the reasons Havstad left a professorship at Montana State University and took the job as the boss of the JER in 1994.

“The tradition within the research community has been to publish,” said Havstad. “Today, the goal is to deliver and have impact.”

Eight years ago, when Havstad began walking the talk, which included becoming a founding Board member of The Quivira Coalition, the idea of relevant science was somewhat radical, especially the holistic (meaning ‘whole systems’) approach exercised by the JER scientists.

Moreover, the tenor of the times was not exactly ripe for thoughtful analysis. The political climate was confrontational, the struggle between ranchers and environmentalists had reached a crescendo, and anti-federalist feelings in rural counties ran high.

It’s no wonder scientists felt safe in the back of the room.

It took some courage, therefore, for the JER researchers not only to step forward but also to find creative ways to break down old stereotypes. Fortunately, Havstad had help, including Dr. Jeff Herrick, a soil scientist who led the effort to rethink monitoring protocols, and Dr. Ed Frederickson, an animal scientist who has taken the JER’s traditional focus on cattle in new directions.

Perhaps the best way to explain this new approach is to repeat a phrase I heard Havstad use often, with acknowledged irony, when opening a meeting with ranchers and other private citizens at the time:

“We’re from the government and we’re here to help.”

Old School

It is almost a cliché to say that summarizing the complexity of rangeland science at the start of the 21st century is as difficult as summarizing the desert itself. The more we learn, it seems, the more we realize how little we know. And if the goal of achieving ecological understanding isn’t enough, add to it the job of communicating this knowledge to growing and diversifying lay audiences and you have a recipe for a Tall Order.

Adding to the difficulty is the changing nature of rangeland research itself. Until recently useful science at the JER meant research that supported agricultural aims, specifically the goal of raising cattle in an arid environment. In fact, the principle reason the 190,000-acre Jornada

Continued on page 13

“The tradition within the research community has been to publish,” said Havstad. “Today, the goal is to deliver and have impact.”

The Jornada Experimental Range

(con't from page 12)

Dr. Kris Havstad explains new monitoring protocols during a workshop on a ranch in northern Catron County (photo by Courtney White)

Ranch, located north of Las Cruces, became government property in 1911 was so scientists could study the damage done by overgrazing in the desert and consider mitigation strategies.

There was a lot to consider. The Boom Years (1880-1920) of the livestock industry, characterized by large numbers of animals and few controls, had decimated the range across the Southwest. Throw in periodic drought, and you had a serious problem.

Widespread alarm at the time over soil erosion, loss of vegetative cover, and other grazing-related maladies prodded the U.S. government to take remediative action, including the creation of the old Soil Conservation Service (now the NRCS) to assist private landowners. It also set researchers, such as those at the new Jornada station, to work on the problem of deducing a 'better way' to raise livestock in the desert.

They're still deducing.

What changed in the intervening years was the rise of ecology. However, in the beginning this young discipline was directed to maintain focus on livestock, especially on the issue of increasing forage production. But there was an unintended consequence – new knowledge began to rub against old thinking.

"We tried various silver bullets over the years to solve certain problems – herbicide, Lehman's lovegrass, prescribed burning," said Havstad, "but research revealed that if it isn't done right, it may be a waste of time."

"Rangelands involve thousands of variables and millions of interactions among those variables," said Havstad. "They don't 'behave' in predictable ways, they defy easy, quick, simplistic solutions or responses and they challenge specific blueprints for their management. That's the conundrum. We need years of scientific study, but the land manager is expected to provide quick, correct, and practical answers."

One significant change brought about by ecological understanding has been the broad shift within the science community from the idea of a 'balance of nature' – where natural forces are engaged in a constant effort to maintain equilibrium – to the idea of the 'flux of nature' – where the role of disturbance, or 'pulses of energy' such as fire, wind, and animal impact, is seen as key to the maintenance of land health.

This shift in thinking led the JER researchers to shift the definition of useful science.

"It's not about creating more forage for

Continued on page 14

The Jornada Experimental Range

(con't from page 13)

"The point of the training, and really of all our work," said Herrick, "is the assumption that what we value from land, such as livestock use or recreation or hunting, depends on three attributes: soil and site stability, hydrologic function, and biotic integrity. Without that healthy foundation you'll never reach true sustainability."

cattle anymore," said Havstad. "Our mission is to improve our knowledge of ecosystem processes as a basis for management and remediation of desert rangelands."

Teachable Moments

Believing that a basic understanding of ecological processes is a prerequisite for prudent decisions by land managers, the researchers at the JER started over, in a sense, at the level of soil, grass, and water.

"What we've learned since the 1950s," said Havstad, who like many scientists, tends to talk in lists, "is a better understanding of ecological principles, the mechanisms that drive ecological change, and the characteristics of ecological sites. That means today we should: one, understand the ecological processes in specific environments; two, know local conditions that modify those processes; three, monitor to evaluate responses; and four, adjust management."

In a nutshell: adaptive management.

The tools that the JER, in cooperation with many other researchers, has helped to develop include: (1) Ecological Site Descriptions – which help communicate how ecological processes vary over time, climate, and soils in particular places; (2) State-and-Transition models – which summarize how particular processes combine to produce reversible and irreversible changes; and (3) Rangeland Health Indicators – a qualitative assessment protocol which enables land managers to evaluate actions, including approaching potential thresholds.

They also helped to develop a quantitative monitoring system that precisely measures watershed function over time.

By going back to basic ecological processes, these tools are designed to answer real-life questions – what is the land capable of supporting? What is the system lacking? What management strategy is appropriate?

And indirectly, but no less importantly: who will do the work?

"Repetitive behaviors on a landscape that are a function of soils, topography, aspect, climate, and organisms, create capacities and potentials," said Havstad. "Understanding those repetitive behaviors is the key to management."

So is communicating those behaviors. The trick, according to Havstad, is finding "teachable moments" – when and where you can actually have an impact.

One of the researchers on the front lines of finding these moments is Dr. Jeff Herrick, one of the principle authors of the new rangeland health monitoring and assessment protocols.

"It's all about better understanding the land and how our actions might affect it, and then communicating," said Herrick. "You can develop the best tools, but if you can't communicate them then you aren't helping."

Herrick does his part by leading a great deal of training, mostly on the assessment system these days, for government land managers, conservationists, ranchers, and other landowners.

"The point of the training, and really of all our work," said Herrick, "is the assumption that what we value from land, such as livestock use or recreation or hunting, depends on three attributes: soil and site stability, hydrologic function, and biotic integrity. Without that healthy foundation you'll never reach true sustainability."

In other words, useful science-based land management, according to Herrick, Havstad and others, means: (1) defining the ecological potential of particular piece of land; (2) assessing the current status of that land relative to its potential; and (3) monitoring to document changes over time, especially in response to management activities.

It all starts with soil, grass, and water.

Value

One of the messages that Kris Havstad voiced when he walked from the back of the room to the front, years ago, was that from a scientific perspective the "debate" over livestock grazing in the Southwest was largely over.

In November 1999, Kris Havstad sum-

Continued on page 15

The Jornada Experimental Range

(con't from page 14)

marized this message in an issue of The Quivira Coalition's newsletter:

"We now know that many of our rangelands have been overgrazed, that some areas remain in degraded states despite adequate rainfall, and that some rangelands shouldn't be grazed by livestock. Yet, we also know fairly clearly that livestock grazing of rangelands can be a sustainable practice for many sites, for many seasons, and for many years. Extensive experimentation has illustrated that grazing can be managed and the integrity of rangelands ecosystems, in terms of their ability to produce, capture and store nutrients and to conserve soil resources, can be maintained."

In other words, the ecological function of rangelands, if maintained, can support a societal value – livestock production. That was settled. The next step, he wrote, was to explore the ecological processes in more detail in order to provide the basis for their proper management.

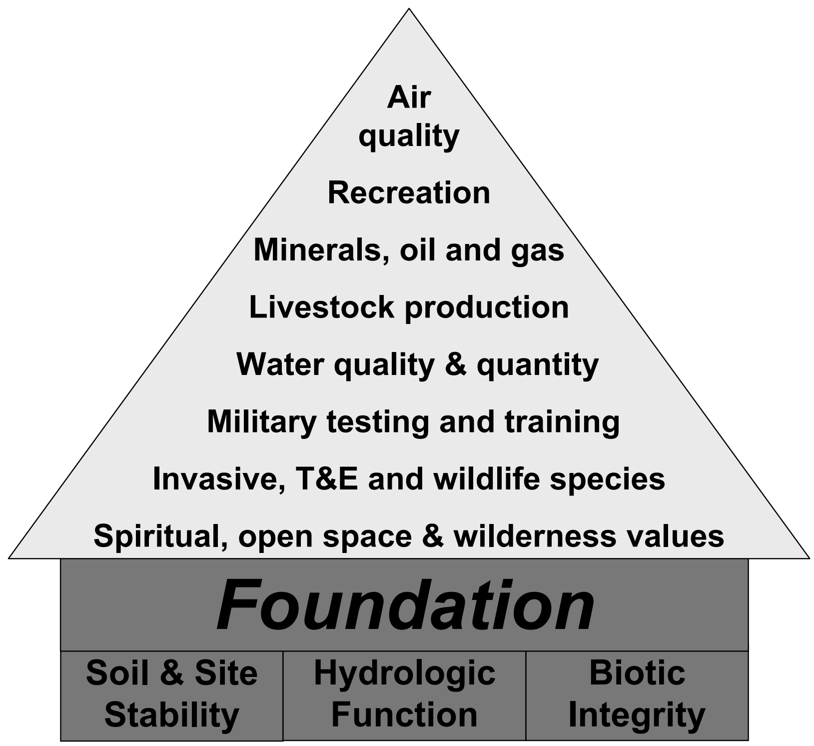
According to Havstad, however, what could not be done was provide a 'silver bullet' for livestock management in arid environments. He compares it to the science of raising a child:

"There is no clear scientific basis supporting a specific 'blue-print' for a parent to follow in rearing a child…a single methodology derived from hypothesis-based scientific experimentation that services all possible combinations of parents, children, and environments does not exist."

"Like the science of children," he continued, "we have an impressive knowledge base for rangelands. Yet, like human nature, there does not exist a single science-based blueprint for how we interact with our environment."

This is important for two reasons: first, it demonstrates that rangeland management, like parenting, will always be more art than science. In other words, science can inform, but not dictate, our decisions. Second, since these decisions will always be based primarily on societal values – culture, politics, economics – useful science means making clear as possible the functions that supports these values – much the way medicine and psychology are used to raise healthy children.

For example, the JER recently began to focus on another societal value: sustainability. Achieving this value, which Havstad defines as "the maintenance of ecological integrity over time," is especially important not only if we intend to continue to use arid landscapes into the future, but also for wider issues involved in the human/nature relationship. Therefore, the goal of sustainable use in the desert is immediately relevant.



Example of how societal values are supported by land health (courtesy of Dr. Jeff Herrick, USDA-ARS Jornada Experimental Range)

"Sustainable use can be defined as an appropriation of production, such as biomass used by grazing livestock, for instance," said Havstad, "that allows for natural processes to replace appropriated materials."

In other words, we must give back what we take, either by letting it happen naturally, through photosynthesis for example, or through restoration activities, if possible. In either case, it means that levels of use – all use – must be gauged by the natu-

Continued on page 16

The Jornada Experimental Range

(con't from page 15)

ral limits of an ecosystem.

That's the theory – the practice is more complicated. Useful science along these lines is difficult to achieve because while ecosystems exist at tremendous scales, both in time and space, we tend to view them, for obvious reasons, at human-friendly scales. This means the tools available to land managers are limited to only a few components of a landscape.

Such as plants.

"There is much we can't control, but we can control plants," said Havstad, "and we know a great deal about plants. Water too, especially the water cycle in arid environments. We can base our management actions on how we impact properties of these landscapes that are related to these key processes."

"Sustainable use can be defined as an appropriation of production, such as biomass used by grazing livestock, for instance," said Havstad, "that allows for natural processes to replace appropriated materials."

And that's where livestock grazing comes in – as a tool for the maintenance of key ecological processes. It is, in fact, one of the few tools land managers have, along with fire, rest, and certain forms of technology, to ensure the maintenance of these processes over time. We could 'leave well enough alone' too – let nature take its course. But that's not an option in many places on the planet anymore.

For example, take desertification – a sustainability concern for one-third of the globe. It is characterized by the unnaturally rapid loss of soil's protective plant cover, resulting in erosion by wind and water, which threatens the very processes that sustain life.

If we are to reverse desertification – and many people think we need to – then we have to think about plants, as well as the proper use of land management tools that encourage their health, including well-managed livestock grazing.

In sum, function and value – ecological integrity and human use – are now inseparably intertwined, especially under the spreading threat of global climate change.

Animals

What role might livestock play in this emerging concern for sustainability?

At the JER, this question is very much on the mind of Dr. Ed Frederickson. For starters, he wants to know how beef cattle use landscapes and what their impacts are over time.

"It's an interesting question, in part, because there really aren't any specific answers," said Frederickson. "Like most ecological questions, every component of the system being studied is changing at various rates. The situation is never the same at any two points in time. Animals are learning, their social interactions constantly shifting, and physiological needs are adjusting to varying internal and external conditions every moment. Likewise, their environment is even more dynamic."

Why research a question to which there are no answers? Frederickson cites Simon Levin's book "Fragile Dominion" in which the first commandment of environmental management is to "reduce uncertainty." It's the same reason we watch the weather forecast on TV – for peek at the future. Increased certainty allows land managers of all stripes to make decisions that will have more reliable outcomes, which increases our ability to achieve sustainability. However, as Frederickson notes, we should be aware of Levine's second law of environmental management: "expect surprise."

The uncertainty Frederickson is trying to reduce specifically is how livestock alter landscape soil nutrients and seed distribution. This is important, according to Frederickson, because research has demonstrated that livestock hastened the conversion of 94 million acres of desert grassland in the United States into mesquite shrubland not simply through overgrazing, but alsothrough seed dispersal.

"This research permits researchers like Deb Peters and Sandy Tartowski in our group to use modeling to detect emergent ecological patterns or properties and predict future landscape directions given a range of potential scenarios," said Frederickson, "which will allow us to determine how grazing animals shape plant communities."

There's another question on Frederickson's mind: what is the best cow for arid ecosystems? He suspects that Cri-

Continued on page 17

ollo cattle – a lighter animal adapted to arid lands and brought to the Southwest over 450 years ago by the Spanish – may be the answer.

"My interest in these animals began while reading a ranching magazine published early in the last century," said Frederickson. "In this publication, a rancher was concerned about bringing Hereford cattle into New Mexico since the little Spanish cattle could "rustle up grub" better than any other cow he'd seen. In a world of increasing energy costs, and human competition for grains, an animal that can rustle up its own grub might be just what the industry needs."

To find out, Frederickson and Mexican researchers selected semi-wild Criollo cattle from the Copper Canyon country of northern Mexico and brought them to the JER. The goal is to understand what behavioral and physiological traits allow Criollo to persist in arid environments. For instance, does their relative 'wildness' give them an adaptive advantage when it comes to disease?

He also wonders what role Criollo cattle might play in the development of alternative livestock production systems that fit desert environments. Could they be good 'grassfed' animals that might become a part of the burgeoning health food market?

All of this leads Frederickson to a philosophical thought:

"I believe my primary role is to discover and organize knowledge, then to share this knowledge with others."

Frederickson's goal is to help entrepreneurs with new knowledge – though he'll leave the entrepreneurship to the experts.

"Prescriptive, or rigid, production systems lead to greater dependency on others and ultimately fragile systems," he said. "Knowledge based systems lead to creativity and a greater ability to adapt to change. This is important. While the beef cattle industry in the United States is highly efficient, it also has become increasingly centralized and rigid. This leads to a system that is vulnerable to collapse in response to catastrophic events. By promoting increased entrepreneurship, the system will become more diverse and increasingly modular with time; thus, it will be more resilient."

In a sense, the circle is closed: resiliency is also the key to ecological integrity, which is the foundation for economic sustainability.

Continued on page 18

Criollo cattle photographed in the remote Sierra Tarahumara (Copper Canyon) area Chinipas, Chihuahua, Mexico (courtesy of Dr. Ed Frederickson).

The Jornada Experimental Range

(con't from page 16)

The Jornada Experimental Range

(con't from page 17)

Landscape Scale

Being useful means not sitting still for very long. In the case of the JER, this means tackling new, and pressing, frontiers, including how ecological processes work at landscape scales, how to effectively conduct restoration, understanding the ecological effects of land fragmentation, and continuing to explore how to mesh ecological flexibility with economic flexibility.

To accomplish these goals the scientists at the JER are taking an increasingly collaborative approach. Under Havstad's direction, for example, all the scientists convene regularly in order to share their latest research as it pertains to overarching issues, such as developing land health indicators that work at landscape scales.

Dr. Jeff Herrick leads a monitoring workshop, 2002.

"You work for the good of the group," said Jeff Herrick. "To the extent possible, egos are jettisoned. Collaboration is the new paradigm."

All the researchers at the JER understand, of course, that collaboration is also the key to getting anything done on the ground at landscape scales in the West.

"Fifteen years ago the question to us was: tell me how rangelands work," said Havstad. "Today, the question we get asked is: how do we restore and maintain these systems?"

That means people. Which means collaboration. And economics.

"What we've learned is that the trouble has not been with the tools," continued Havstad, "but how we have used them without a landscape ecological perspective. But that's changing. There's a movement now – it's not just scientists. Politicians are talking about it, so are business leaders. It's going global too. Range health manuals are being translated into Mandarin and Mongolian as we speak."

Naiveté isn't an issue: everyone knows it will be difficult to accomplish landscape scale restoration, if, for no other reason, the challenge we all face from the long tradition of managing the West by "fractions" as Havstad puts it – meaning the fragmentation of lands among various private, state, tribal and federal owners.

But this too is changing as tools such as Grassbanks, for example, allow management to be coordinated over larger landscapes. And there is little doubt that the JER will be right in the thick of this change as well, being useful.

Since indicators are such an important part of the JER's effectiveness, here is an indicator that I like to use when contemplating their success: when I first met Kris, Jeff, and Ed they worked out of trailers in a parking lot on the New Mexico State University campus. And there were only eighteen people involved.

Today, the JER resides in a large new building and has over 80 people employed or associated with it. This type of growth doesn't happen by accident, or simply by effective lobbying. It happened because people are beginning to understand, thanks to the work of the JER scientists and others, that land health is the foundation to social and economic health.

It might start with soil, grass, and water, but it includes people as well.

Or as Kris Havstad put it: "To be truly sustainable, we must be educated and practiced observers of our environment."

The Far Horizon

by Courtney White

For a while now I've been dogged by a Socratic question: who am I?

This has become a pressing concern because we live in a world of 'ists,' as in 'specialist' or 'generalist' – which are teams, essentially, complete with uniforms, rules, and expectations. And in our culture, if you're not on a team, you're probably on the sidelines.

For a long time I resisted signing up with any particular squad. Part of it was a college-bred skepticism of group orthodoxy in general, but most of it was indecision. Which team should I choose? Who would have me? The teams on my particular playing field included conservationist, environmentalist, naturalist, ecologist, scientist, and archaeologist.

I am not, and cannot be, a scientist. My predisposition leans toward the right brain. Even archaeology was a stretch – I preferred the romantic parts of hiking and camping in the desert over the artifacts and analysis. Birding is not in my nature, though I've recently taken an interest in plant identification. Still, I'd make a second-rate naturalist at best.

I've never considered myself an environmentalist, at least professionally. Part of it is how I defined the word 'environmentalist' – as someone dedicated to the *defense* of nature and people. Look at the vocabulary of environmentalism: defend, save, preserve, fight, protect, shield, sue. This is necessary work, but it's not my cup of tea.

I should have joined the 'conservationist' team, but I decided early in the game not to. For starters, I was never attracted to the word 'conserve' which the dictionary defines as the effort "keep in a safe place." Historically, this was exactly the aim of much conservation work – to keep safe what we valued in the natural world through parks, wildernesses, forest reserves, 'conservative' farm practices, and the like.

This is necessary work too, but it's not enough. To paraphrase Aldo Leopold, conservation is more about fixing the 'pump' than the 'well' – meaning the real challenge in front of us is not environmental, it's social and economic. Our ecological ills are manifestations of societal maladies and they won't be fixed until we employ social remedies. Conservation can't do that alone, as nearly 150 years of hard work has demonstrated. Nor can it do the job in partnership with environmentalism. Protect and defend are not enough.

I knew early that I wanted to fix the 'well,' not the 'pump' or at least try, so I began to look for another team. I quickly discovered that this meant finding another playing field as well. Eventually, I found both; and after scrimmaging and studying the rule-book (such as it is) for a few years, I think I'm ready to sign a contract.

I am a restorationist.

"For the duration of our time on the planet… restoration will be the great task."

\- Kenneth Brower, in an Introduction to 'A Sand County Almanac'

Bill Zeedyk leads a Volunteer Restoration Workshop on Largo Creek.

Redemption?

First and foremost, I am attracted to the language of restoration. Taped to my computer is a postcard that I found in a local coffee store. It depicts an ill-looking planet Earth, with its tongue hanging out, imprinted with the message: "The world could be in better shape." Surrounding this image are words: renew, heal, reaffirm,

Continued on page 20

The Far Horizon

(con't from page 20)

"As for the gift, the basis for solidarity with nature, the restored ecosystem is perhaps as close as we can come to paying nature back in kind for what we have taken from it."

nurture, rekindle, revitalize, repair, revive, mend, soothe, rebuild, fix, regenerate, reinvigorate.

As the son of a doctor, these words have powerful appeal to me. As an author (not an 'ist' I note), I know they are the essential raw material for communication and teaching. They are part of the 'common language that describes the common ground below our feet.'

They are also words of action – positive, progressive, healing action. They are words of advancement, not defense or keeping safe, and as such give people direction and hope. It involves us in a 'giving' rather than merely a 'taking' – a giving back to nature, an honoring, while we necessarily continue to take nature's bounty.

They are also words of redemption.

We have taken much from the natural world, often with tragic consequences, and we continue to take at an accelerating rate. Restoration is a way to redeem our behavior – a kind of moral exercise, if you will. Perhaps "salvation" is too strong of a word to use, but it points us in an interesting direction.

It's an opinion shared by William Jordan in his book "Sunflower Forest: Ecological Restoration and the New Communion with Nature" (University of California Press 2003). It is a book, by the way, that uses the word 'restorationist' so frequently that it suggests a larger team on a larger playing field than I suspected.

"Everything we have, we take from nature," he writes, "sometimes by persuasion or collaboration, sometimes by outright theft. Either way, the debt we incur is, or at least ought to be, a constant concern. For many, restoration is an attractive idea because it offers a way of repaying this debt."

Jordan considers restoration to be a 'gift' back to nature, both in the restored ecosystem and in the greater understanding and self-awareness that restoration creates among its practitioners. It is a redeeming gift, a gift of reciprocity – we give so that nature may give back – not a one-way gift of charity or commerce. Restoration is an unending exchange of goods and services with the natural world. It is not, Jordan says, about settling accounts.

He goes on to say that the trouble with environmentalism and conservation is that there is no exchange of gifts in their actions.

"We can take from nature but can never give back," Jordan writes of these two paradigms. "We accept its gifts of food, materials, place, and beauty but never offer back the clinching gift that would establish a basis for solidarity…and because we never risk the offering of a gift, we have no need for sacrifice…"

In contrast, restoration is all about giving.

"As for the gift, the basis for solidarity with nature, the restored ecosystem is perhaps as close as we can come to paying nature back in kind for what we have taken from it."

Lessons

For over twenty years, Jordan directed the Education Program at the University of Wisconsin's Arborteum, home to an experiment in prairie restoration that began back in the 1930s, under the guidance of Aldo Leopold. When Jordan started working at the Arboretum, however, very few people in the nation were doing restoration. Environmentalists almost universally ignored it, he notes, considering it at best as a distraction from the serious work of preservation, and at worst a threat.

Environmentalists didn't like restoration because they believed that the 'naturalness' of wild places was irreplaceable. The hand of man could only harm, not restore, the state of nature. Jordan believes this line of reasoning had devastating consequences.

"It implied that conservation was a one-way street," he writes, "essentially nothing more than a delaying action, that might slow the inevitable decline of natural landscapes toward eventual extinction but can never reverse it. It also conveyed the idea, often expressed quite explicitly by environmentalists, that the influence of human

Continued on page 21

Volunteers "cupcake" toast to completed restoration work on a wet meadow in the Comanche Creek Watershed, Valle Vidal unit of the Carson National Forest, NM.

(con't from page 21)

beings on natural landscapes is invariably negative and destructive; though we may take from such a landscape, we can never give anything back."

But giving something back is exactly the point of restoration, and why it appeals to Jordan. Not only does it offer the opportunity to reverse environmental degradation, it also offers *hope* – something the environmental movement sorely lacks.

"Since restoration is an active process – in fact, a kind of gardening – it offers something that eluded environmentalists for the better part of a century – a way to "use" classic landscapes, such as prairies and forests, actually participating in their ecology, without changing their character or using them up."

By the early 1980s, Jordan realized that the work at the Arboretum was crucial. "It combined the best elements of two forms of environmentalism – the conservationist's willingness to participate in the ecology of a natural landscape, and the environmentalist's insistence on the inherent value of that landscape, independent of its value to humans – into a single act that linked engagement with total respect. This act, it seemed to me, provided the basis for a new kind of environmentalism."

Once upon a time, I thought so too – that a "new environmentalism" was in the offing. I've come to the conclusion, however, that environmentalism is genetically predisposed to certain types of activities, the defense of nature for example, and indisposed to other work, such as restoration. Asking it to change would be like asking a gazelle to slow down.

It is the same with the conservation movement – it doesn't need to change as much as it needs to be cognizant of its boundaries, where 'protection' begins and ends, for example.

We need a new movement – a restoration movement – with new language and a new 'ist' – to compliment the old movements and begin the gifting.

I'll be a restorationist. And I am confirmed in my resolution by a simple unorthodox fact: My computer's spellchecker doesn't recognize the word.

Collaborative Science

(con't from page 1)

Take, as a practical example, the weather. Many of us have spent countless days observing and experiencing the peculiarities of weather patterns, and some of us are pretty good at predicting what will happen in an hour, or two, or even the next day.

Through observation and the testing of initial predictions, climatologists have developed a deeper understanding of the weather, which allows them to predict events days, or even weeks, into the future. While far from perfect, their ability to predict weather events improves year by year and surpasses most people's best guesses.

Similarly, science can help validate, improve, and build upon the understanding gained from personal experiences in land management. By pooling information gathered from many people in many places, we can discover general patterns across the landscape, as well as the processes that govern them.

In the same way that we benefit from the climatologist's continually improving capacity to forecast the weather, we can benefit from our enhanced understanding of the likely impacts of land management actions, from livestock grazing to forest thinning, to watershed protection.

Cattle grazing on Diablo Trust research plots, part of one of the longest data sets from a replicated, controlled experiment on the effects of livestock grazing on plant communities. Details are available online at www.envsci.nau.edu/sisklab/grazing (photo courtesy of Tom Sisk)

The Move Towards Collaborative Research

To some degree, the move toward more inclusive, collaborative approaches to research has been forced upon us. Much of scientific inquiry has traditionally been based upon the paradigm of "pure science," the investigation of natural phenomena, carried out independently from any consideration of practical utility (Sarewitz 1996).

As Vannevar Bush proposed in 1945, science and society were engaged in a 'social contract,' through which society gave science generous financial support and a high degree of autonomy about what to study; and in return, science provided substantial benefits to society in the form of an accumulating knowledge that would, inevitably, lead to progress and prosperity.

This view valued "pure" science over applied science—it tended to separate science from the rest of society (Byerly and Pielke 1995). Collaborative science provides us with an opportunity to move research into the mainstream of society, where it can benefit from, and contribute to a broader understanding of emerging social and ecological challenges.

We can all benefit from this broadening participation, especially now, when science, as a public pursuit, has fallen on hard times. National polls consistently show that, while scientists are considered to be credible and well respected, public trust in scientific results and recommendations has declined markedly since the 1960's (Sarewitz 2004).

The probability-based, hypothesis-testing approach that underlies classical science has provided the ammunition which threatens to hobble its continued progress. This is because science recognizes uncertainty. Seldom do scientists "prove" things true. Instead, they reduce uncertainty, thereby increasing confidence in the most likely outcome or explanation.

But in our legalistic, "innocent until proven guilty" approach to policy, uncertainty is falsely equated with a lack of

Continued on page 23

knowledge, and people fail to appreciate—or wrongly interpret—the results. Seemingly conflicting scientific findings, on everything from the health effects of butter to the impacts of global climate change, have left the public wary of scientific results that they suspect have been used to bolster special interests and political agendas.

The debate over global climate change is a poignant example. For years politicians have argued that the scientific evidence was inconclusive as to whether our planet was warming, and what the causes were. In fact, a preponderance of evidence has suggested that people, burning fossil fuels, are responsible for the changes in atmospheric chemistry, which basic laws of physics tells us will lead to warming and climatic change.

It took years for the real science to finally surface above the furious lobbying efforts of the energy industry and others, but when it did, the implications were undeniable. Now, even the most skeptical politicians reluctantly admit that global warming is a major international issue; and virtually every prestigious scientific association around the world has issued warning statements and policy advice.

Other environmental issues, including deforestation, desertification, and groundwater depletion, similarly rest on a strong body of science, and are emerging as key social issues that will demand the highest level of creativity and insight from our leaders, from the local to the global stage.

Collaborative research breaks down the traditional paradigm of "pure science". At its best, collaboration enlists the strengths of science in a focused effort to resolve real problems and important issues.

Through collaboration, other sources of knowledge—traditional knowledge, local experience, and historical practices—are brought into the scientific process and subjected to rigorous scrutiny; what emerges is a more comprehensive examination, a sorting and synthesis of knowledge that honors different sources of information.

By incorporating local ecological understanding in the early stages of planning and research, scientists can design more meaningful, focused studies. Science becomes more practical. The bridge between science and application is shortened, and all participants in the collaboration are invested in, and have ownership of the final research results.

NAU students collecting data on plant communities.

Societal Benefits of Collaborative Research

For the most part, so-called scientific controversies are actually social controversies.

Every group in society operates under its own set of paradigms—the ways of thinking, unstated rules, and assumptions or beliefs that define the boundaries we operate in. These paradigms often limit people's perceptions and their ability to see the other side of issues, presenting a formidable barrier to the resolution of environmental problems.

By enlisting science in collaborative efforts to address our shared land management challenges, these paradigms can be challenged, examined and reshaped in a constructive manner. Collaborative research can foster productive, positive discourse and encourage people to listen to each other, engendering trust among diverse participants.

Citizens benefit through a growing understanding of science and how it operates;

Continued on page 24

Collaborative Science

(con't from page 23)

"Collaboration can be intoxicating, particularly when traditionally opposing groups find common ground for dialog and negotiation. But agreement is not truth, and the excitement of consensus does not make a false conclusion true."

and society benefits as complex problems are addressed. Successful collaboration can reinstill public faith in science.

Take the controversy over livestock grazing, for example. While all involved—ranchers, environmentalists, researchers, and agency professionals—share the goal of managing grasslands for long-term sustainable use, the conflicting paradigms of the different groups have made it nearly impossible to arrive at solutions that are acceptable to all.

In the face of this impasse, collaborative efforts have sprung up around the country. These efforts are informed by science and based on the indisputable fact that all of the groups involved share the same overarching goal—a healthy environment that can continue to supply the ecosystem services and intrinsic benefits that enrich our lives. Where these efforts engage in scientific inquiry to better understand how ecosystems function, they usually succeed; purely political approaches almost always fail.

Another example is the move towards the restoration of dense, fire-prone southwestern forests.

Some view the community-based, collaborative process described in the Healthy Forest Restoration Initiative (HFRI) and related efforts as a smokescreen for bypassing the federal environmental review

Continued on page 25

Landscape Assessment and Forest Management

More than a century of logging, livestock grazing, fire suppression, road construction, and predator control has significantly altered and degraded southwestern ponderosa pine forest ecosystems (Allen et al. 2002, Covington and Moore 1994, Swetnam et al. 1999, and others).

The result has been lower productivity in these forest ecosystems, as well as decreasing wildlife habitat, declining watershed values, and exotic species invasions.

Even more significant, however, are the changes in fire regimes. Small, frequent, low-intensity fires, once common in ponderosa pine forests, have given way to large intense wildfires that wreak destruction on both wildlife and human communities—the result of a century of fire suppression, and a severe drought that has persisted over the last decade.

At the same time, the human population of Southwestern states has rapidly increased. The continued extension of human communities and infrastructure into forested regions, combined with degraded forest conditions, has generated high risks for destructive wildfires that cannot be addressed through traditional fire suppression and forest management approaches.

Concern about wildfire and an increasing awareness of the important values supplied by healthy forests have emphasized the need for ecosystem restoration.

In northern Arizona, the Forest Ecosystem Restoration Analysis project (ForestERA) is supporting landscape-scale assessment through a public process that incorporates the values and insights of diverse participants, including decision makers, scientists, activists, and the interested public.

By making sound science available in an easily accessible form, and by involving the broadest range of collaborators possible, the ForestERA team has forged a new capacity for landscape assessment that complements existing forest planning efforts and links national and regional objectives with the practical world of project-level forest management.

Drawing from the scientific insights and methodological advances of landscape ecology and conservation biology, the ForestERA project employs analytical approaches that integrate diverse types of information—from forest and watershed conditions, to wildlife needs, to public values and regional economic and demographic trends.

Utilizing the technical capabilities of geographic information systems and spatial statistics, ForestERA supports planning at the landscape scale—the scale at which the region's largest wildfires are occurring.

ForestERA conducted a trial run of this collaborative approach to science-based planning during two 3-day workshops hosted in Flagstaff, Arizona, and two follow-up "virtual workshops" hosted on ForestERA's website (www.forestera.nau.edu).

The workshops focused on the Western Mogollon Plateau Adaptive Landscape Assessment (WMPALA) to guide landscape-scale forest restoration and community protection plans for the 1.3 million-acre western Mogollon Plateau region of northern Arizona, one of the largest contiguous stands of ponderosa pine in the country.

Left: Prescribed fire, which removes accumulated ground fuels, is one of the techniques used to restore ponderosa pine forests (photo courtesy of Tom Sisk)

Collaborative Science

(con't from page 24)

required by the National Environmental Policy Act and for dumping the public comment and appeals process. Others, however, see it as a means for increasing public participation in forest management.

What the HFRI offers, though, is the opportunity for citizens to enter into a collaborative, science-based process that engages diverse perspectives and seeks new ideas for solving the escalating problems posed by destructive wildfires and degraded forest ecosystems.

Collaboration is a process of pooling knowledge, experience and resources. It offers scientists a way to address questions that are out of reach for the individual investigator.

Typically, ecologists conduct their experiments in those small plots; and the results don't readily "scale up" to apply to management issues affecting whole landscapes. The big questions in applied ecology, like how best to manage our forests and grasslands, need to be addressed at much broader spatial scales, scales that are more relevant to the decisions that land mangers must make.

The costs of such studies can be prohibitively high. Sound scientific design requires that researchers replicate their experiments. This means they will need access to numerous, large plots of land. Furthermore, experimental treatments implemented on this scale can be very costly.

Collaborating with people who actually manage the land is a way to pool resources. Ecologists working with ranchers, for example, can do experiments by manipulating stocking rates and moving cattle in accordance with a plan designed to accelerate our learning. The result is more meaningful—and more useful—science.

Science and the Potential Pitfalls of the Collaborative Process

Despite the need for a broader understanding and involvement in applied science to guide management, it is import to recognize that the collaborative process can be subject to abuse.

Collaboration can be intoxicating, particularly when traditionally opposing groups find common ground for dialog and negotiation. But agreement is not truth, and the excitement of consensus does not make a false conclusion true. Moreover, collaborative processes can be driven by fixed political objectives. An astute or charming leader can skillfully organize a group of well meaning citizens into a political force that blindly supports a particular course of action.

WMPALA workshops 2004

In 2004, participants representing federal, state, and local resource management agencies, environmental organizations, academic research institutes, local government, and the public, convened to identify and prioritize landscape features in the WMPALA region that they felt were in critical need of protection from destructive wildfires.

The stakeholders split into four groups, comprised of people from different organizations who brought different values to the task of identifying forest areas most in need of management attention. Working independently, the groups first identified landscape features or areas they felt were of particular importance. They assessed the risks those areas faced from the threat of large, stand-replacing wildfires, and then classified as priority areas those where high importance and high risk coincided. Each of the groups used different strategies to identify critical landscape features.

Following the workshop, ForestERA staff refined the prioritization maps developed by the four groups and combined them to produce a "synthesis map". ForestERA presented the results during a virtual workshop. Workshop participants provided feedback on the data used, the identification/prioritization process, and the next steps to be taken in the WMPALA process.

The goal was to develop landscape-scale management action scenarios, based on the prioritized maps developed during the first two workshops, that could assist decision-makers in site-specific planning within a broader landscape context. Utilizing ForestERA datasets and analysis techniques, the groups developed: 1) topic-based restoration planning guidelines (topics included community protection, fire management, watershed restoration/protection, and wildlife habitat restoration/protection); 2) four separate management action scenarios for the Wildland Urban Interface (WUI); and 3) four separate management action scenarios for Wildland areas.

Right: One of the four groups of stakeholders working together during the Feb. '04 workshop to identify and prioritize areas on the Western Mogollon Plateau in need of protection from destructive wildfire (photo courtesy of Tom Sisk).

Many scientists have seen too many instances where scientific arguments have been used to prop up political ideology, and as a result, tend to shun working with the public. Similarly, public interest groups and land managers are also often skeptical of self-congratulatory "collaborative decision making" because it can be a cover for

Continued on page 26

Collaborative Science

(con't from page 25)

a largely political agenda.

Collaborative efforts can also be self-validating, particularly when the groups are comprised of like-minded individuals. For example, an auditorium full of ranchers, scientists, and grazing consultants may affirm the benefits of doubling stocking rates in riparian areas, but that does not mean that doing so will not devastate cottonwood and willow bosques along rivers, and elevate erosion rates and eutrophication.

Conversely, a convention of environmental activists may call for the cessation of livestock grazing on public lands, but that does not mean that ecosystem recovery will follow livestock removal. This is where science can help. By working within a rigorous scientific context—stating problems clearly, exploring alternative solutions, evaluating the evidence, and selecting actions that are most likely to advance real solutions—science can keep the collaborative process "honest"; that is, it can encourage a healthy examination of preconceived beliefs and biases.

It also provides a proven process for objective examination of problems and their possible solutions. Participation in the scientific process is a good way to get all ideas out on the table, and to give each a fair hearing. Then, and only then, can a diverse group move on to the real work of evaluating problems and devising solutions. This sort of participatory science can strengthen the collaborative process and decrease the likelihood that it will be hijacked for political purposes.

Collaborative Science/
Collaborative Management

Science should not be a narrow realm inhabited only by experts. It is one of the most powerful means for increasing our understanding of the world—and our place in it—and has repeatedly led to rapid progress on very practical issues.

Collaborative science, growing out of public participation in research, can invigorate management by engaging more people with more ideas in a problem-solving approach.

This is what the scientific method is par-

Table 1. Scientists, managers, landowners, and public interest groups often disagree on the role of science in land and resource management. Researchers attempting to illuminate controversial issues should strive to understand the conflict, and assess the potential contributions of new research before launching investigations. Our experiences suggest the following sequence of steps for developing research projects that address scientific issues underlying conflict.

Steps for Turning Conflicting Claims into Questions, and then into Testable Hypotheses

- Study the controversy; understand the conflict.
- Restate contradictory claims as questions or hypothesis.
- Discuss questions/hypothesis with all parties.
- Get "buy-in" on research approach from the affected parties. If unsuccessful, repeat previous step, or change the approach.
- Design research through an open process, with opportunities for discussion and dialog.
- Initiate the study and guard scientific independence.
- Maintain channels of communication and provide regular updates

Source: Sisk et al. 1999

Continued on page 27

Collaborative Science

(con't from page 26)

ticularly good at: sorting through alternative ideas, using good data to test competing theories and identifying the most plausible hypotheses, which, in turn, informs on-the-ground actions. We have little to lose and much to gain by broadening participation in the scientific enterprise, as long as the primary commitment is to learning, rather than to propping up particular beliefs.

The broader the participation in science, the more likely it is to be accepted and appreciated; and a society that understands the power (and limitations) of science is better equipped to take on emerging challenges.

Nowhere is this relationship more important than in managing land and natural resources.

Collaborative science can restore trust by honoring the participation of diverse elements of our society, while acknowledging the particular roles to be played by specialists. By improving our understanding of how nature works, and empowering people with that knowledge so they can better solve problems, collaborative science offers us a more hopeful future, where the best information is "owned" and applied by many people on a daily basis, as they undertake the real-world challenges of managing our land and water and producing goods and services in a sustainable manner.

Historically, land management has been a grand, unplanned experiment, where everyone did their best, without the benefit of scientific approaches and the understanding they generate. Individual experience and cultural traditions have served us well in the past, but today's challenges are too large, and the consequences of poor decisions too damaging, to rely on trial-and-error learning.

By bringing science back into society via collaborative approaches to research and management, we can pursue pressing environmental challenges in a more rigorous and effective manner—a more intelligently designed management experiment. We can learn more—and learn more quickly—about the natural world, and about ourselves.

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