Report from the Center #5

Making the Most of Science in the American West: An Experiment

Patricia Nelson Limerick • Claudia Puska

Center of the American West | University of Colorado at Boulder

The Center of the American West: Its Purpose and Vision

The Center of the American West at the University of Colorado strives to bring together, for meaningful conversation and interaction, people as diverse as the American West itself. With the participation of ecologists and engineers, poets, professors and policymakers, students and scientists, musicians and lawyers, foresters, filmmakers, and physicians, the Center's events have become a model of interdisciplinary debate. Issues long held to be black and white reveal their nuanced shades of gray when examined from these multiple perspectives. Minds change, information is exchanged, and conversations begin. To understand the region, we believe that the exploration of the minds of its residents is as important as the inquiry into the workings of its cultures and ecosystems.

The Center of the American West is the region's most creative and innovative organization in identifying and addressing such crucial issues as multiculturalism, community building, fire policy, and land, water, and energy use. We do this through programs of research, public outreach, and engagement meant to help Westerners think about their region and their role in its sustainable future.

Enterprising and inclusive in its embrace of a wide range of disciplines and strategies of communication, the Center strives to illuminate the challenges and opportunities facing this complicated geographic and cultural area. Ultimately, we want to help citizens of the West become agents of sustainability—citizens who recognize that their actions determine the region's future and who find satisfaction and purpose in that recognition.

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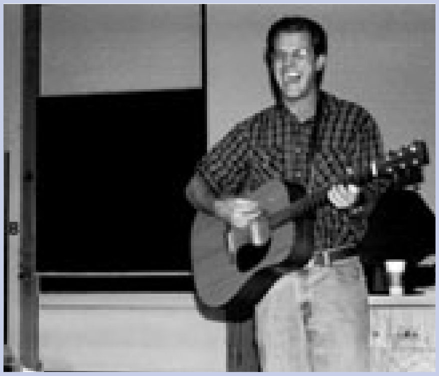


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Title page: Hayden Survey of Rocky Mountain National Park, *courtesy of USGS.*

Inside back cover: elk graze in meadow below Long's Peak, Rocky Mountain National Park, *courtesy of Rocky Mountain National Park.*

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In shaping the West's past, present, and future, no factor is more interesting and consequential than the role of science.
—Patricia Nelson Limerick

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Center of the American West

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Center of the American West

University of Colorado at Boulder

This report from the Center had its genesis in a workshop on the history of science in the American West, co-sponsored by the National Park Service and the Gilder-Lehrman Institute in May of 2002. For two-and-a-half days, we had a lively exchange on these issues with National Park Service personnel, within proximity to Rocky Mountain National Park. We hope that this report captures the high points of that gathering, and we hope, moreover, that reading it and responding to it will provide the occasion for many more such discussions throughout the West. In that spirit, we urge you to contact us with any responses, concerns, and suggestions that the reading of this report may provoke.

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Remodeling and Reconfiguring the Dream

Westerners have developed a well-cultivated talent for contention, and even under the best of circumstances, we give it plenty of exercise. But we pull out the stops and make contention our full-time operating mode when we undertake to reach decisions affecting the environment. This report explores:

1. The central position that scientists occupy in these episodes of contention, and the ways in which Westerners have drawn scientists into the fighting, whether they wanted to be there or not; and
2. The techniques we could deploy to make better use of the talents of scientists, lower the contention level, and reach more productive decisions.

By the terms of a long-running dream, scientists were going to rescue us from our feuds and quarrels. When we sank into the swamp of squabbling, we would get out of the swamp by turning the decision over to science. Scientists would research the problems that had turned us against each other, and analyze their origins and dynamics. Experts would shine a bright light on our dilemma, and that light would lead us to firm ground and solutions.

By the original dream, the scientists were supposed to provide us with the alternative to mud wrestling. Instead, sometimes over their protests and sometimes with their full consent, we have managed to pull them into the mud with the rest of us. And yet, as environmental conflicts proliferate in the West, this is no time to give up on the dream of finding guidance in science, even if that dream is a little mud-spattered.

The purpose of this "Report from the Center" is to remodel and reconfigure the dream, and thus to enhance its efficacy and to spare it from further immersion in mud. We will put history to work in this cause, for the good reason that the settlement of the West and the rise of American science are "sibling" histories. They grew up together, and you cannot understand one without the other. Plus, taking an excursion in time, away from the conflicts and contests of the present, can clarify the mind and calm the passions.

For reasons growing from the region's history, the West has a spectacular talent pool of environmental scientists. Judging by the proportion of environmental scientists to the general population, this region has within its borders the human resources to lead in steady, farsighted, and scientifically-informed decision-making. The existence of all those scientists—trained, skilled, certified, champing at the bit for research projects in which to invest their abundant energies—constitutes an enormous regional asset. What we have to do is figure out how to make the most of this treasure of human talent already in place in universities, federal and state scientific agencies, and nongovernmental organizations throughout the West.

To realize this regional advantage, the Western public must come to a better understanding of scientists, and scientists must come to a better understanding of the public. That educational assignment may sound a little dreary, as if we are offering our readers a bowl of gruel followed by a castor oil chaser, but truly, your prospects as readers of this report are much more appealing. In shaping the West's past, present, and future, no factor is more interesting and consequential than the role of science.

Rather than making the most of the scientists in their midst, Westerners have fallen into the habit of repetitive performances of a tedious play we will call *Dueling Experts*. One group of actors comes on stage, declaring an action or policy they want and proclaiming that it is time for partisan, "interest group" squabbling to yield to the objective research of

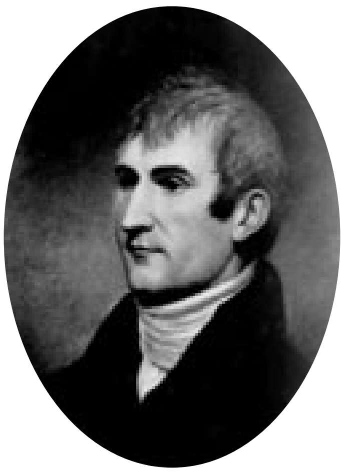
> *"Yet, in the real world, our expectations for science in policy-making are often confounded. Rather than resolving political debate, science often becomes ammunition in partisan squabbling, mobilized selectively by contending sides to bolster their positions. In such cases, the scientific experts on each side of the controversy effectively cancel each other out, and the more powerful political or economic interests prevail, just as they would have without the science."*[1]

Dueling Experts

A headline from the Associated Press on March 21, 2002, draws our attention to several proposals before Congress: "Bills Would Define 'Sound Science.'" When Congress undertakes to draw the line between sound science and unsound science, we see a center-stage performance of the play described here, *Dueling Experts*, presented by a very prominent and notable cast, but still evading some big questions about the best use we can make of scientists in our public debates.

science. A number of scientists are summoned; they study the issue and deliver their findings. The first group of actors examines these findings to see which scientists agree with their position. They label the findings they *like* as "good science" and "sound science," and label the science they *don't like* as "junk science" or "value-laden science" or "biased science." At the opposite side of the stage, meanwhile, a group of opponents busily reverse the labels, condemning the science that the first group applauded and applauding the science that the first group condemned.

Wasting science's potential to play a positive role in dealing with this region's conflicts and problems, this script is on schedule for a rewrite.



Meriwether Lewis.

A Very Big Research Project

In 1803, President Thomas Jefferson gave Meriwether Lewis instructions for his expedition to the Pacific. Jefferson told Lewis to pay attention to everything under the sun, but also including the sun. Even a partial list of the items that Jefferson asked Lewis to observe and report on conveys a sense of the breadth and ambition of the nineteenth-century agenda for naturalists in the field.

- The courses of rivers and streams
- Astronomical observations to ascertain latitude and longitude ("to be taken with great pains and accuracy")
- For each Indian tribe, the territories, intertribal relations, language, traditions, monuments, agriculture, fishing, hunting, war, arts, food, clothing, domestic accommodation, diseases, remedies, "peculiarities in their laws, customs, and dispositions," and articles of commerce
- The "soil and face of the country, its growth and vegetable productions"
- The "animals of the country," including the remains of those that might be extinct; "the mineral productions of every kind"

On top of all these terrestrial observations, Lewis was instructed to report on the climate, "as characterized by the thermometer, by the proportion of rainy, cloudy, and clear days; by lightning, hail, snow, ice; by the access and recess of frost; the winds prevailing at different seasons; the dates at which particular plants put forward, or lose their flower and leaf; times of appearance of particular birds, reptiles, or insects."[2]

In these very comprehensive terms, the rise of scientific specialization and the increasing narrowness of research agendas in the twentieth century can present themselves as welcome escapes from a large-scale headache and an excessive work load.

The American West—The Ideal Laboratory

To the government scientist, the West was a vast natural laboratory—a bonanza of exotic specimens and wonders of nature whose meaning and interconnectedness it [was] the job of science to describe.[3]

When Americans took up the project of remembering Western history, they chose to concentrate their attention on a few select types: the fur trapper, the grizzled prospector, the schoolmarm, the cowboy, the prostitute, the gambler. With the conspicuous exception of the admired, lionized, and nearly beatified Major John Wesley Powell, naturalists and scientists retreated to the edge of memory. In popular culture, they vanished entirely; Hollywood's movies do not feature scientists putting aside their barometers or collectors' nets and heading down to Main Street for a showdown. John Wayne never played a botanist.

And yet the naturalist and the scientist were Very Important Persons in the shaping of the American West. Their historical stock may have collapsed on the market of popular attention, but their actual significance in history began at the level of "enormous" and increased over time.

The men who took on the national assignment of exploring the West were, to varying degrees, trained as naturalists or scientists. Thomas Jefferson schooled Meriwether Lewis in the techniques of observation and collection, sending him for training with the experts of his day. The goals of empire—to assess territory, to anticipate the nation's future expansion, to make diplomatic overtures to Indian tribes—overlapped closely with observation of nature. The U.S. Army Corps of Topographical Engineers sponsored expeditions into the West that combined military concerns with recording of natural phenomena and collecting of specimens. During his various exploring expeditions in the 1840s, John C. Frémont noted plant species and took atmospheric readings, mixing in scientific notations with adventure and romance. As historian Keith Benson notes, "After 1850, virtually every government survey, including those sent out by the army and the navy, was charged with collecting specimens of plants and animals . . ."[4] Authorized in 1853, a number of exploring parties surveyed the West for possible routes for a transcontinental railroad, and naturalists were important participants in those expeditions. By the 1870s, three substantial, federally-sponsored, civilian-led surveys were operating in the West, led by Ferdinand Hayden, Clarence King, and John Wesley Powell (as well as an army survey, led by George Wheeler). The West had delivered on its promise, in Goetzmann's term, as a "vast natural laboratory," providing spectacular opportunities to build careers and reputations. Indeed, many Western landscapes seemed almost designed and prepared for scientific attention; aridity left landforms exposed and open for study. As historian Robert Bruce observes, "In the Southwest especially, the evidence of geological events was written large. Geologists did not need to jump to conclusions; conclusions jumped at them."[5]

What was the mission of these nineteenth-century observers and transcribers of nature? The explorers were scouts for development, conducting an inventory and assessment of the region's resources. They were active agents in the nation's expansion, putting together a catalog of the elements of nature that could be developed for individual and national profit. To a large degree, theirs was a "Come and Get It" enterprise, listing the region's assets, their

The Powell-Ingalls Special Commission meeting with Southern Paiutes near St. George, Utah, 1873. Powell is standing at far left. *Courtesy of USGS.*

A Preference for Good News

In 1848, John C. Frémont's fourth expedition was a solid disaster. He attempted to find a railroad route through the southern Rockies, venturing into very difficult terrain in winter. Out of the thirty-three originally in the party, eleven men died, and survivors accused one another of cannibalism and desertion. Frémont's reporting of the outcome took some liberties with the reality: "The result," Frémont said, "was entirely satisfactory. It convinced me that neither the snow of winter nor the mountain ranges were obstacles in the way of the [rail]road."[6] The desire to give a favorable report to one's sponsors, as this example indicates, played a significant role in the written records of exploration, though few have equaled Frémont in this zone of achievement.

Photo courtesy of historichwy49.com.

Hayden Survey of 1871 in Yellowstone National Park, Wyoming. *Courtesy of USGS.*

. . . the naturalist and the scientist were Very Important Persons in the shaping of the American West.

locations, and the best routes of approach to them. In that dimension, these naturalists were wholehearted participants in the campaign to add the West to the nation's holdings.

And yet scouting for economic development was only one aspect of their activities. They also experienced and recorded wonder at the novelty and beauty of the sky, landforms, waters, rocks, plants, animals, and weather of the West. They wrote, often exuberantly, about what they saw. In the manner of nineteenth-century science, they were ardent collectors, securing, preserving, and sending home specimens of the West's animals and plants. They were, in other words, compiling a record, both written and material, of the wealth of the western half of the continent, a kind of wealth that did not always register within narrow categories of economic value. The record they assembled of nature's abundance would provide the measure of what would be lost if economic development proceeded without restraint.

Did these men carry the credentials of scientists? This is a complicated question, since the emergence of practices for training and certifying specialists in various fields of knowledge occurred in the nineteenth century, in the same time period as the exploration of the West. The careers of individuals working in the West capture this mounting trend of professionalization. In the middle of the nineteenth century, in the eastern United States, a group of men who defined themselves as career scientists in particular fields had begun to organize themselves into professional associations and to systematize the process for training and credentialing apprentices. Not infrequently, physicians moved into second careers as naturalists when they joined exploring expeditions. The exploration of the West remained a domain where men could create their professional status from scratch, establishing their reputations, not by their distinguished academic credentials, but by their vigor and success in collecting specimens, writing reports, and securing support from that most important patron of science—the federal government.

An unmistakable characteristic of nineteenth-century scientific practice was its association with the federal government and its dependence on federal funding. In our own times, it is not uncommon to hear people lament the fact that science has recently "become" politicized. A historical perspective reminds us that science became politicized several centuries ago, if "politicized" means "associated with the purposes and goals of the nation, and caught up in internal and external struggles to shape those purposes and goals." Indeed,

The Anxiety of Professionalization—The Nature-Lover Within

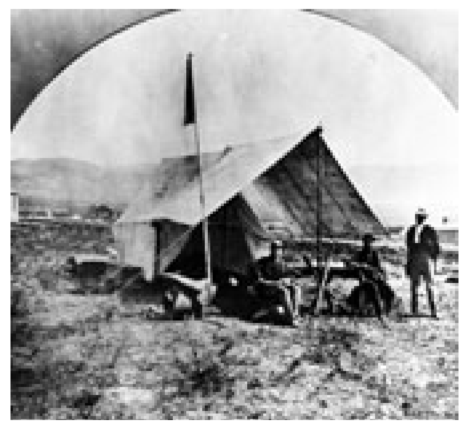
Unlike many of his fellow explorers and surveyors, Clarence King, who would be the first director of the U.S. Geological Survey, earned an academic degree in science; he had graduated from the Sheffield Scientific School at Yale. This did not, however, free King from anxieties over status; in the early 1860s, the regular Yalies ("academics") saw the "scientifics" as an inferior group and maintained a clear distinction. And then, once King was in the field as geologist with Josiah Whitney's California Geological Survey, his troubles took a new turn. [7]

In his first professional job, King worked earnestly to present himself as a real scientist, and to make it clear that he was not that poor excuse for a human being, "a nature lover." "The paleontologist of our survey, my senior in rank and experience," King reported in *Mountaineering in the Sierra Nevada,* had evidently smoked him out. Speaking "rather in sorrow than in unkindness, yet with unwonted severity," the paleontologist said of King, "I believe that fellow had rather sit on a peak all day, and stare at those snow-mountains, than find a fossil in the metamorphic Sierra." "Can it be?" King said he asked himself, "Has a student of geology so far forgotten his devotion to science? Am I really fallen to the level of a mere nature-lover?" King wrote about this problem of split identity—true scientist vs. nature-lover—in a playful tone, but it presented a real concern for him. "I was delighted," he said of another occasion in the Sierras, to ride along and simply enjoy the view, "for this is a respite from scientific work, when through months you hold yourself accountable for seeing everything, for analyzing, for instituting perpetual comparison, and as it were sharing in the administering of the physical world."[8] The observer of twenty-first-century environmental scientists cannot avoid a moment or two of wondering how much King's sense of dividedness—the nature lover and the scientific analyst uneasily co-habiting in the same mind—might still be at work in scientific practice today.

Clarence King. *Courtesy of USGS.*

from a historical perspective, one could argue that science today is notably less "politicized" than it was in past centuries. Imperial powers sponsored the expeditions of early European scientists, and the United States adopted this practice soon after the nation's founding. Throughout the nineteenth century, scientists pursuing opportunity had to jockey for support and validation in the arena of politics, currying favor with Congress, the Army, the Secretary of the Interior, the voters, and sometimes, the President. To regret a loss of innocence in the practice of science today requires regretters to shut their eyes to history. The historical record cuts short the effort to believe in a past period of innocence, when scientists followed the mandates of pure curiosity and did their work in an arena sequestered and quarantined from the interests and pressures of the state.[9]

By the last part of the nineteenth century, explorers and naturalists recognized how rapidly economic development was transforming the West. In the minds of many of them, the best service that scientists could render was to collect specimens and record conditions before they were lost to historical change. But these activities made them ponder the question, "Do we know that all we can do is preserve relics and fragments of what was here? Is there no point in trying to save habitats and landscapes?"[10] In a very consequential change, the scientists, once the allies of economic development or at least passive accepters of that mandate, were beginning to shift sides and build the foundation for conservation and preservation. That shift in allegiance would, over time, leave some Westerners puzzling over the question, "Which side are the scientists on?" This mixed historical legacy alone could explain why environmental scientists are in the hot seat in today's New West: the professional activities of their predecessors gave both the advocates of environmental preservation *and* the advocates of economic development reason to claim the scientists of the past as their legitimate founding fathers.



T. H. Sullivan photo of Clarence King in a camp near Salt Lake City, Utah, 1868. *Courtesy of USGS.*

John Wesley Powell Professionalizes Science and Thereby Renders Himself Outmoded

Major John Wesley Powell with the Pauite Tau-ruv, Uintah Valley, Utah. *Courtesy of USGS.*

John Wesley Powell. *Courtesy of USGS.*

As a founding father of scientific practice in the American West, John Wesley Powell was a high achiever. In 1869 and 1871, John Wesley Powell led the first descents of the Colorado River. In the 1870s, he headed one of the major federal surveys of the West. In 1879, he published the influential study, *Report on the Lands of the Arid Region of the United States.* He became the second director of the United States Geological Survey and the founding director of the Bureau of Ethnology. Powell, his biographer Donald Worster declares, had become "the government's leading scientist."[11]

What course led him to that remarkable status, and what became of that status, once he had achieved it?

When a census taker in 1860 asked the young John Wesley Powell for his occupation, Powell responded, "Naturalist." What training qualified Powell to take that title? Typically for his time, Powell's "credentialing" process was informal and improvisational. As a child, he had the good fortune of finding a mentor, a local man interested in the workings of nature. Powell took a few science classes in Midwestern colleges, though he did not graduate from college. He became an enthusiastic collector of specimens. These activities proved sufficient to qualify him for a teaching position at a small college, and for the status needed to lead expeditions of exploration into the West.

Powell, then, was a preeminent example of the amateur naturalist evolving into the professional scientist, and especially of the amateur who, exemplifying the parallel expansion of science and the development of a region, found his opportunities for "academic advancement and scientific recognition" in the West. Like his counterparts in the civilian side of the big survey business, Clarence King and Ferdinand Hayden, Powell found he had to "attract support from that wealthy patron of science and exploration in Washington, the Congress." Increasingly, in a change that stood for a much larger pattern in the history of Western science, field explorer Powell evolved into Washington lobbyist, networker, and bureaucrat Powell.[12]

Lobbying for funding and recognition for science, Powell played a huge role in professionalizing and routinizing scientific practice. And yet, as his biographer notes, by the time that Powell was fighting his hardest battles on behalf of science, he had only "weak support" from "the scientific community." His "days as geologist were well behind him"; by the 1890s, "the science of geology had become more specialized than ever," and Powell "had become outmoded and unsuited to direct an agency oriented toward research." Powell had spent his career acting on "his desire to enlarge the leadership role that science played in a modern democracy" and directing his actions by the "extraordinary confidence he placed in science as a redeeming agent." Powell's story offers something approaching a parable on the ironic changes in science in the late nineteenth century, as a number of its founders and leaders took a quick trip to unplanned obsolescence, a consequence of changes they themselves had initiated. By the end of the nineteenth century, "learned societies, once accessible to anyone of appropriate social standing, were pretty much closed institutions. . . . A gulf opened between the science communication that was felt to be appropriate between scientists and the popularization that the society could appreciate."[13] While the more sophisticated and credentialed scientific specialists moved into positions of leadership, Powell stood on the side of the gulf that was receding into the distance of time.

A Cure for Nostalgia: Dueling Experts of the Past

On occasion, the biographies of real and actual people can make a reader wonder if she inadvertently wandered into the fiction section, and, unwittingly, picked up a novel, and a novel by a writer with an inordinately wild imagination at that. The lives of Edward Drinker Cope and Othniel Charles Marsh can give the reader that sense of having entered a world that is defying the usual rules of plausibility and probability. These fellows were the most famous, and most notorious, paleontologists in nineteenth-century America. Both men were independently wealthy, smart, competent, fiercely protective of their work, and unscrupulous in their pursuit of bones, fossils, and professional standing. Their venomous feud gives us an unforgettable reminder to resist the temptation to romanticize the people of the Western past or exaggerate their virtue and heroism.

Both men were independently wealthy, smart, competent, fiercely protective of their work, and unscrupulous in their pursuit of bones, fossils, and professional standing.

Born into a wealthy and influential Philadelphia Quaker family in 1840, Cope earned a reputation as a naturalist and prodigy at a young age. He lacked the formal scientific education of his rival, but, by 1864, he had secured a position as professor of zoology at Haverford College. In 1870, he joined Ferdinand Hayden's survey, a move that anchored his career as one of the leading paleontologists of his time.

Born in 1831, Cope's rival, Othniel C. Marsh, grew up on a struggling family farm in Lockport, New York. Work on the farm often kept him out of school, and he was at best an average student, showing little interest in the field on which he would eventually leave an indelible mark. In the 1850s, Marsh decided to turn his energies to the study of natural history, and, within a decade, he was appointed the first professor of paleontology at Yale. In the 1860s, Marsh began traveling across the West collecting fossils and building his reputation as a leader in his field. To Cope's dismay, Marsh eventually secured the position of vertebrate paleontologist for the U.S. Geological Survey in 1882.

Fossil footprint on the Dakota Sandstone, Jefferson County, Colorado. *Courtesy of USGS.*

Cope and Marsh met early on in their careers and formed a tenuous friendship that, from the start, set the tone for their future encounters. Reflecting on their first meeting, Marsh wrote of Cope, "[he] called on me and with great frankness confided to me some of the many troubles that even then beset him. . . . My sympathy was aroused, and although I had some doubts of his sanity, I gave him good advice and was willing to be his friend." As one fascinated observer put it, Marsh and Cope's backgrounds "predisposed them to look down, subtly, on each other. The patrician Edward may have considered Marsh not quite a gentleman. The academic Othniel probably regarded Cope as not quite a professional."[14]

Their friendship soured after Marsh visited one of Cope's digs in New Jersey and offered Cope's team money to send him any future finds. Marsh further strained the relationship when he publicly humiliated Cope by pointing out that Cope had mounted the skull of a plesiosaur on the tip of its tail rather than its neck, a mistake that appeared in one of Cope's published reports. For his part, Cope was quick to accuse Marsh of academic fraud. Shortly after the New Jersey visit, Cope complained to the *New York Herald* that "[Marsh] invariably followed my advice and gave me no credit. I found at length that he was using me . . . to furnish him with brains."[15]

Over the next twenty years, the squabbling continued. For nineteenth-century paleontologists, the West offered an unbounded supply of petrified bones. The dry climate and alkaline soil were easier on fossils than the wetter climate and acidic soils of the East. Wind and water eroded the high prairie grasses and cut into the soft rocks of the plains, carving out enormous gullies and exposing fossils that had been buried below the surface for hundreds of millions of years. For Marsh and Cope, the West was a dream come true: a region of bones and fossils that could enrich their personal collections and boost their professional standing.

In their fevered rush to collect, catalog, and report on their findings, the two men bickered incessantly over fossil ownership, spied on one another, bribed one another's teams, and lashed out at each other publicly in newspapers and government reports. Their duel reached its peak in 1877 when two sets of collectors in Colorado found important fossil beds only one hundred miles apart. One set of collectors contacted Cope, and the other contacted Marsh. Caught in the fierce tides of their rivalry, the two sites at Morrison and Cañon City quickly became scenes of sloppy excavations, bribery, theft, and the destruction of valuable specimens as Cope and Marsh each tried to corner the market on the fame and glory of the discoveries.[16]

For all their bickering and back-stabbing, these scientists bequeathed to future generations valuable information about the West's natural environment in the distant past. Working as a scientist today involves defending one's territory, competing for funds, and cultivating one's reputation, but Cope and Marsh set a standard of ratty professional behavior that spares us from comparing our petty, latter-day selves to the Olympians of the past whose virtue and wisdom dwarf our own. No need to waste a moment worrying about that, the examples of Cope and Marsh generously remind us!

"Dakota" hogback at Cañon City, Colorado; valley of "Red Beds" and slopes of Morrison Beds to left, minor hogbacks of Timpas limestone to right, circa 1895. *Courtesy of USGS.*

Federal Agencies and the Ever-Growing Role of Science

Relations between science and policy concerning many issues (e.g., health, energy, natural resources) have been changing worldwide. Public pressure to resolve such complex and often controversial issues has resulted in policymakers and policy implementers seeking better knowledge on which to base their decisions. As a result, scientists have become more actively engaged in the creation and evaluation of policy.[17]

Science has not designed methods for measuring the expanding distribution and force of a hope, but even without an exact method of calibration, it is safe to conclude that the dream of science as a source of neutral and reliable guidance for society has grown exponentially over the last century. And, even as more and more freight has been loaded onto that dream, we await a comparable increase in the cleverness, if not the wisdom, of our strategies for working with scientists and benefiting from their expertise. That situation provides the occasion, the mission, the purpose, and, yes, the dream driving this report.

At the end of the nineteenth century and the beginning of the twentieth, the reforms of the Progressive Era settled the matter: with the creation of the federal natural resource land management agencies, the role of scientific experts in shaping the destiny of the American West (and the hope that their expertise would raise them above politics and allow them to provide steady and solid guidance to voters and office-holders) would become permanent dimensions of national life. The United States Geological Survey was founded in 1879. Congress authorized Forest Reserves in 1891, and the Forest Service was installed in the Department of Agriculture in 1905. Following the designation of Yellowstone National Park in 1872, the National Park Service was called into being in 1916. The Grazing Service originated in 1934, merging with the General Land Office in 1946 to form the Bureau of Land Management. The Soil Conservation Service, now the Natural Resources Conservation Service, came into being in response to the Dust Bowl. The federal Biological Survey originated in 1896, and after a somewhat mobile institutional history, was reconfigured and moved into the U.S. Geological Survey in 1996. The Fish and Wildlife Service is the youngest of these agencies, officially created in 1939, but its roots reach back to U.S. Commission on Fish and Fisheries, established in 1871. For all their differences, these agencies hold in common a great respect for and deference to scientific expertise; at the same time, the conditions under which the agencies must operate have given scientists regular episodes of frustration, occasions of feeling that their scientific judgment was constrained, or even overruled, by considerations of politics.

With all of these institutions and agencies incorporating science into their operations, the federal government has come to rely more and more on the knowledge and expertise of scientists to inform and shape its environmental and natural resource policies. As one close observer notes, "the federal government spends billions of dollars on research aimed at solving or clarifying or providing guidance on environmental and natural resources controversies."[19] A recent example is the $1.8 billion per year approved by Congress for the U.S. Global Climate Change Research Program. The justification for such large expenditures is the hope that objective scientific research will steer policy in the right, rational direction. As

Science and the Origins of Conservation

Samuel P. Hays

"Conservation, above all, was a scientific movement, and its role in history arises from the implications of science and technology in modern society. Conservation leaders sprang from such fields as hydrology, forestry, agrostology, geology, and anthropology. Vigorously active in professional circles in the national capital, these leaders brought the ideals and practices of their crafts into federal resource policies. Loyalty to these professional ideals, not close association with the grass-roots public, set the tone of Theodore Roosevelt's conservation movement. Its essence was rational planning to promote efficient development and use of all natural resources. The idea of efficiency drew these federal scientists from one resource task to another, from specific programs to comprehensive concepts. It molded the policies that they proposed, their administrative techniques, and their relations with Congress and the public. It is from the vantage point of applied science, rather than democratic protest, that one must understand the historic role of the conservation movement.

"The new realms of science and technology, appearing to open up unlimited opportunities for human achievement, filled conservation leaders with intense optimism. They emphasized expansion, not retrenchment; possibilities, not limitation."[18]

. . . the dream of science as a source of neutral and reliable guidance for society has grown exponentially over the last century.

Scientists repairing a sediment sampler. *Courtesy of USGS.*

Daniel Sarewitz puts it, "This mental model of how science can contribute to environmental policy-making is consistent with the norms of a culture that places great faith in science and the rationality that science can deliver."[20]

Demonstrating this faith, all of the major federal agencies responsible for managing land and natural resources have declared a commitment to science-based management. Speaking at Mt. Rainier National Park in August of 1999, the Director of the National Park Service, Robert G. Stanton, reaffirmed the critical role of science in shaping Park policy:

> America's National Park System has been described as the greatest set of outdoor classrooms the world has ever seen. But the educational value of those classrooms will be lost if we fail to recognize they are simultaneously the greatest set of natural laboratories. It is the study of nature's boundless variety and unlimited activity that will give us an ever-expanding source of knowledge and information.
>
> The information that we can gather is not idle facts and curious statistics, it is the underlying substance that will allow us to make informed decisions and take informed actions in the Parks and to inspire similar decisions and actions outside the Parks. . . .
>
> We are the stewards of lands and landscapes. We have a responsibility to keep [the Parks as] . . . a living presence for not just one more century, but for many more centuries. It will not be possible without a whole-hearted commitment to science-based management of these great places that have been entrusted to us.[21]

In a similar spirit, the Bureau of Land Management has declared that "effectively managing our nation's public lands requires accurate scientific information," since "the use of the best-available science—along with a consideration of political, social, and economic information—will result in the best-informed decisions."[22] And, of course, the U.S. Geological Survey places science at the center of its mission. The survey "provides reliable scientific information" for these rather ambitious goals: "to describe and understand the earth; minimize loss of life and property from natural disasters; manage water, biological, energy, and mineral resources; and enhance and protect our quality of life."[23]

The USDA Forest Service also features scientific research as a key component of its operations. The agency describes itself as "the largest forestry research organization in the world and the national and international leader in forest conservation."[24] According to the Forest Service, the expertise of physical, biological, and social scientists not only improves the ability of Forest Service managers to do their job, it is "crucial to the agency's capabilities to comply with requirements of key environmental statutes, including the National Forest Management Act, Endangered Species Act, Clean Water Act, and Clean Air Act."[25]

As that list indicates, environmental legislation throughout the second half of the twentieth century considerably upped the stakes for federal agencies and for scientists. Environmental legislation passed in the mid-twentieth century greatly expanded the territory in which officials appealed to scientific research to guide and inform decisions and actions. Whether in controversies over the spotted owl, monitoring of air quality, or preservation and protection of natural features and historic sites, scientists are playing an increasingly important role in shaping policies and directing action. Their testimony and expertise have become a keystone for federal, state, and local agencies as they seek to comply with, administer, and enforce environmental regulations.

In 1970, Congress passed the National Environmental Protection Act (NEPA). The Act "established a national policy to protect the environment, created a Council on Environmental Quality (CEQ), and required that environmental impacts statements (EIS) be prepared for major federal actions having a significant effect on the environment."[26] The EIS process revolutionized environmental oversight of federal agencies, and pushed the agencies to turn more and more to scientific research to support and, at times, defend their actions.

Similarly, the Endangered Species Act, passed in 1973, significantly expanded the role of science in federal operations. The ESA clearly states that listing determinations be made on the basis of "the best scientific and commercial data available."[27] In 1982, Congress amended the act and strengthened the role of scientific research in determining the listing of species as threatened or endangered. The phrase "*solely* on the basis of the best scientific and commercial data available" became the guideline. The addition of the word "solely" clarified the point that scientific research, not economic or nonbiological factors, should determine the listing of a species as threatened or endangered.[28] Economic and social impacts were not entirely excluded from the reckoning. The ESA gives the Secretary of the Interior the authority to review non-biological impacts, but requires that the Secretary weigh them against scientific data in the designation of critical habitat.

As historical examples would lead us to expect, trying to elevate scientific research over economic and social considerations turned out to offer a limited escape from the contentions of politics. In June of 1989, the U.S. Fish and Wildlife Service (FWS) announced its intention to place the spotted owl on the "threatened" list under the Endangered Species Act.[29] The owl, which lives primarily in old-growth forests of the Pacific Northwest, was disappearing as logging reduced its habitat. "Save the Timber Business" groups started in many places in the Pacific Northwest, pleading with the FWS to make the well-being of timber workers a higher priority than the owl. Congress approved $13 million for research and deployed many biologists into the region to study the spotted owl and learn more about its habitat. Their research convinced the FSW to go ahead with its plans to list the spotted owl as an endangered species.[30]

Controversy over the spotted owl offered a prime arena for observing the tensions over science in our times. In one of the best books on the practice of science in the West, journalist William Dietrich described the "new, uncomfortable role" of wildlife biologists, caught off guard when they realized that they could exercise real influence over policy and its economic consequences. Some wildlife biologists, Dietrich reported, confessed that they "used to feel safer—aloof, omniscient, above the fray—when predicting darkly that society was about to send a species into extinction." "The biologists were not used to issuing prescriptions that could cost thousands of wood industry jobs," said Jack Ward Thomas, a biologist who headed the interagency committee that reported on the spotted owl problem and who later became head of the Forest Service. "Scientists would rather just do their thing and print the results in the *Journal of Esoteric Results*. Now they were being thrust center stage." Thomas found this an encouraging trend; "I am pleased science is being built more and more into the decision-making process," he concluded. But the spotted owl controversy was its own telling demonstration of the way in which federal mandates had ended any separation between scientific questions and the political, social, and cultural context in which the scientists did their work.[31]

Environmental legislation passed in the mid-twentieth century greatly expanded the territory in which officials appealed to scientific research to guide and inform decisions and actions.

Northern spotted owl. *Courtesy of the U.S. Fish and Wildlife Service National Image Library.*

On-site research by the University of Colorado's Institute of Arctic and Alpine Research. *Courtesy of CU-Boulder Publications and Creative Services.*

Alternative Expertise

> ***Staying in a region for hundreds or thousands of years builds both individual identity and culture. Understanding places takes time. Stories about places build up, and Indian culture is replete with stories—not usually stories of war, but of how humans, animals, and nature relate.***[32]

. . . naturalists chose to study Indians and their cultures in much the same way they studied the West's flora and fauna, as curiously foreign objects to be sketched, cataloged, and recorded.

Scientists have not been the only people to observe, record, and study the West's natural environment. Through centuries of experience, Native American and Mexican American peoples across the West developed their own inventory of the region's flora, fauna, climate, and geography. Their intimate knowledge of the region proved crucial to the survival and success of the teams of white explorers, naturalists, scientists, artists, journalists, and photographers who set out to "discover" the West's already well-witnessed wonders.

From the earliest expeditions, white explorers relied on the knowledge and, often, the good will of Indian peoples in the West. For some, Indians proved a godsend in tough times. Indian interpreters opened up lines of communication and smoothed relations among the white explorers and the many Indian tribes of the American West. Indians provided food, shelter, clothing, and companionship to the weary teams of explorers and naturalists sent out on government expeditions to record and study the West. And, more than once, they rescued white travelers who had lost their way in the West's uncharted territory. Reflecting on the role of Indians in the white exploration of the West, William Clark wrote, "Our information is altogether from Indians collected at different times and entitled to some credit."[33]

The Original Experts

"It is not romanticizing Native Americans to say that they have a special relationship with land and nature. Their culture evolved as they lived in specific places and depended on the land. Certainly they used the land and modified the landscape either by hunting, burning, or building irrigation ditches. The quality of the land the Europeans found on their arrival was the result of thousands of years of Indian settlement. American westward expansion was greatly facilitated by Indian expertise in countless facets of forest and prairie living. That the average American is not aware of this legacy, serves as another example of the simplistic and distorted view of our past in traditional education from grade school onwards."[34]

For the better part of the late nineteenth and early twentieth centuries, the federal agencies and the scientific community largely ignored the knowledge and experience of native peoples and failed to take their knowledge of nature seriously. To be fair, naturalists who studied the Indians of the West have left us with detailed descriptions of Indian languages, rituals, and customs, knowledge that might otherwise have been lost in the conquest. But casting Indians as "part of nature" unavoidably dehumanized them, obscuring their humanity with a style of description more appropriate for animals. Indeed, many nineteenth-century and early twentieth-century naturalists chose to study Indians and their cultures in much the same way they studied the West's flora and fauna, as curiously foreign objects to be sketched, cataloged, and recorded. The well-established custom of including collections and displays on Indians in natural history museums exemplifies the common habit of classifying Indian life as a sub-category of nature. In this unsettling framework, individual Indian people became "specimens" for study and display.

Indian people's use of plants for healing calls our attention to their longstanding knowledge of nature. In the American Southwest, traditional medicines represent the confluence of many cultures over centuries of settlement in the region, a potent mixture of Old and New World plants and knowledge that has developed along a track separate from contemporary Euro-American scientific tradition.[35] In recent years, medical researchers, pharmaceutical companies, and a growing number of consumers have been taking note of these traditional folk medicines. Scientific studies have shown that some herbs and treatments, used for centuries by Native Americans and Mexican Americans, are effective in treating common physical ailments. Plant use is key to the Navajo religion, for instance, and tribal members have identified some 450 different wild plants that have therapeutic qualities.

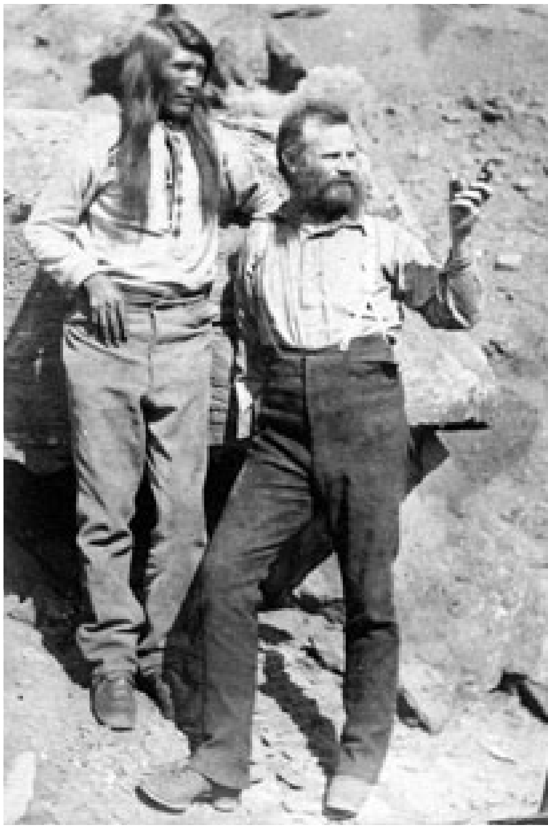
Some of these indigenous plants have recently come up for scientific scrutiny as pharmaceutical companies examine their therapeutic properties.[36]

What these examples point out is that there are many different ways to develop a knowledge of nature. Increasingly, with the rise of "collaborative conservation" (decentralized, negotiated decision-making on environmental issues), officially certified experts, carrying degrees from formally established educational institutions, are finding that yet another new dimension of their work requires them to pay close attention to "local knowledge." As political theorist Daniel Kemmis puts it, "longtime inhabitants of the ecosystems . . . know those ecosystems in a variety of ways, all arising from their years or even generations of having lived with their complexities."[37] Just like the knowledge held by scientists, "local knowledge" can also be romanticized, over-estimated, and given a degree of authority it may not always deserve. But attending to local knowledge, and respecting its holders, is yet another element of the complicated practice of science in the West today.

Local Knowledge

"All forms of knowledge (from science, managers' experience, and indigenous knowledge of citizens) should be given more credibility by scientists and policymakers. . . . When scientists reject such knowledge as invalid or not useful, this is seen as arrogant and has been stated as a major obstacle to developing and maintaining constructive, mutually supportive relations among scientists, policymakers, and stakeholders."[38]

Yucca plant at White Sands National Monument, New Mexico. *Courtesy of the National Park Service.*



John Wesley Powell with guide on the Grand Canyon survey. *Courtesy of Grand Canyon National Park, Museum Collection.*

Making the Most of Science: Complying with the Command to Communicate

> *In the last decade or so, scientists have been delivered a new commandment from on high:* **Thou shalt communicate.**[39]

Professor Jane Bock *(left)*, Department of Biology, University of Colorado at Boulder, speaking at a public forum; Patricia Limerick (*right)*, Center of the American West. *Courtesy of CU-Boulder Publications and Creative Services.*

The situation of environmental scientists in the West today is a dramatic and focused example of a much bigger, worldwide pattern. In every dimension of our lives in the early twenty-first century, the need to enhance and improve communications between scientists and non-scientists registers as a priority. In *Science in Public: Communication, Culture, and Credibility,* two British social scientists have laid out a careful analysis of the widespread discontent with the state of "the public understanding of science." Their summation of the problem shows us how much the concerns of this report are both regionally focused, and worldwide:

> Science often meets the public in times of crisis. Their relationship is conducted fleetingly and acutely through mass media that emphasize emotion in place of what are often rather scarce "facts." And when scientists cannot agree on a solution to a scientific problem, it is not surprising that the public make use of solutions based on moral or emotional considerations in order to get on with their lives. The highly charged environment pushes everyone involved to extreme practical measures and to polarized points of view and often results in a breakdown of both trust and communication between political and scientific authorities and the publics they purport to serve.[40]

In suggesting remedies for this dilemma, Jane Gregory and Steve Miller urge the public to declare, clearly and thoughtfully, what they want from science: "If the public's needs are to be met," they write, "the public must articulate what those needs are." On the other side, "as responsible citizens," scientists "should be prepared to bring out the social implications of their own and their colleagues' work, voicing their optimism and enthusiasm when appropriate and their concerns and reservations when they have them. They are, surely, among the better placed to do this." And, contrary to the stereotype of "scientific facts" as the most settled and unchangeable units of human knowledge, Gregory and Miller remind both scientists and the public that "one of the key features of science is its inherent provisionality. When science is in-the-making, this provisionality is the *essential* feature of scientific knowledge." "It is surely much better," they counsel experts, "for scientists to acknowledge this so that the public and their representatives can make the best use of what information is available, from whatever source."[41]

But what next? How to bring these important, but generalized and abstract, observations down to real-life practice?

To pursue this goal, we will summarize the recommendations of two more commentators, recommendations that move our subject closer to earth, and coincidentally, move "the public" and "science" nearer together.

Coming Back to Earth

The goal of politics is the achievement, through democratic debate, of an operational consensus that enables action. This is a very different goal from that of science, which seeks to expand insight and knowledge about nature through an ongoing process of questioning, hypothesizing, validation, and refutation. . . . Good science is always pushing into the realm of the uncertain and the unknown. . . . Thus, if scientists are doing their job, then 'more research' in the short term is invariably a prescription for raising new questions, problems, and uncertainties—for preventing, not achieving, consensus.[42]

Policy-making is an inherently forward-looking activity, and politicians naturally enlist scientists to provide predictions that can enhance foresight, and thus contribute to policy development. However, in the realm of complex environmental controversies, the capacity of science to provide predictive information that serves the needs of policymakers has yet to be demonstrated.[43]

University of Colorado graduate students unearth a mammoth skull near Golden, Colorado. *Courtesy of CU-Boulder Publications and Creative Services.*

So how to encourage scientists to communicate effectively? And how to help nonscientists arrive at more realistic expectations about what scientists can deliver? How do we bring the viewpoints of scientists on the West's natural resources into a more productive relationship with the concerns of the West's residents, stakeholders, and interest groups? How do we make the most of science?

The geological scientist and policy commentator, Daniel Sarewitz, asks us literally to return to earth. Adopting a "geological view of nature," Sarewitz suggests, is the first step in the right direction. According to Sarewitz, "misplaced expectations for science derive in part . . . from an overly restrictive view of how science extracts truth from nature." Though many physicists would, no doubt, just as soon be spared the compliment, Sarewitz labels this "overly restrictive" perspective the "physics view."[44] In this view, science generates "predicative hypotheses and theories" through highly controlled experiments that tend to simplify nature. In contrast, a geological view recognizes that nature is "an evolving product of innumerable complex and contingent processes and phenomena" and accepts that "diversity, change, and surprise" figure in the "normal states of affair."[45] The geological perspective, in short, has made its peace with the uncertainty and complexity of nature. In essence, Sarewitz draws a distinction between laboratory science (in which a hypothesis can be sharply outlined; variables isolated and controlled; results tabulated with certainty) and field science (in which experimental conditions can never be ideal; variables can never be properly isolated; and the territory of the inquiry can be instantly compromised with external intrusions and disturbances).

The practice of outdoor science, or the geological perspective on nature, Sarewitz believes, clarifies the role of science in policy-making decisions. The geological perspective would steer policy toward approaches that are adaptive and resilient rather than controlling and rigid. It would put realistic limits on the hope that science can predict and prescribe with certainty. Scientists would still play two important roles in environmental issues: they would identify and diagnose dilemmas needing our attention (they would "alert society to

"Policies are experiments."

potential changes and problems that lie ahead"), and they would observe, monitor, and evaluate the results and outcomes of the policies adopted by governmental agencies (or by private industry, for that matter). In other words, once environmental policies received social and political support and were put into practice, we would recognize those policies for what they are: *experiments*. In the manner of people conducting experiments, we would then observe the results carefully and analytically. Even though we often think of the decision to adopt a policy as the conclusion of a long story of conflict and negotiation, the policy actually begins a new story. "Policies are experiments," Sarewitz declares. And in that framework, "science becomes a tool to help determine if implemented policies are working as intended and if progress is being made toward agreed-upon political goals." Under these terms, both scientists and members of the public would be released from the burden of exaggerated notions of the certainty of scientific prediction. They would also find themselves with fewer opportunities to restage that old and tired play, *Dueling Experts*. Fortunately, governmental agencies have been showing increasing receptivity for this "experimental" approach, under the label "adaptive management."[46]

Rocky Mountain National Park, Colorado. *Courtesy of Rocky Mountain National Park.*

Writing a history of forest management in the Blue Mountains of the interior Northwest, Nancy Langston reached conclusions that match those of Daniel Sarewitz. "Everything managers do," she writes, "is an experiment." Experimentation, she reminds us, "means approaching the world with an open mind; scientists are supposed to treat their own ideas with humility, abandoning hypotheses if the results are not what they expected." In an experiment, we allow "the natural world to shape our ideas, and not just the other way around. There is a kind of give and take, a willingness to be surprised." When we think of the application of a policy as a process of experimentation, "the critical step for management" is "monitoring" the results, and "monitoring" means "people being responsive to what the land is telling them, and being responsible for acting on that knowledge." Langston goes on to remind us that, in monitoring, the territory of science borders up hard on the territory of culture:

> Monitoring is never entirely objective, for it requires an implicit definition of what is healthy and what is not. Before people can decide if an action harms the land, they start out with an idea of what harm means. And that is where cultural conflicts are sharpest. . . . Scientists can predict what kinds of outcomes different kinds of disturbances will have, and what early signs we can look for when monitoring to give us a better chance of reaching those goals. Science, however, cannot define the goals for us.[47]

Sarewitz, Langston, and commentators who share their view have worked to turn a vexing problem into a positive opportunity: with a change in our assumptions and expectations, we can reduce the burden of expectation we place on scientists; we can minimize our frustration and disillusionment when science does not provide us with certain and self-evident solutions; we can anticipate and prepare for our ventures into the border territory where questions of science blend into questions of values and culture. In the relationship among scientists, public officials, and citizens, there is, in the minds of these commentators, very good reason to discard troubling old habits, and equally good reason to embrace more positive new customs.

And now to apply this prescription for habit change to a particular idea and activity of great consequence in Western environmental matters today: restoration.

Dealing with Impairment: Restoration and the Definition of Science's Goals

In its enabling act of 1916, the National Park Service got a complicated mandate. The agency was charged with protecting the Parks "in such manner and by such means as will leave them unimpaired for the enjoyment of future generations."[48] Ask the obvious follow-up question—"What does the word 'unimpaired' mean, and how do we go about applying it to particular places?"—and you have taken a direct trip to the territory where scientific appraisals and cultural values overlap. Other questions immediately appear. If Park resources have become "impaired," is it within human capacity to repair or restore them back to a state of "unimpairment"? If so, *when* were they unimpaired? What past era of better conditions should the agents of repair or restoration select as the goal of their efforts or the measure of their success?

These questions come up in hundreds of decisions affecting the National Parks. Moreover, they crop up in many areas of Western environmental decision-making far beyond the borders of the Parks. An exciting trend of the late twentieth and early twenty-first centuries, the hope for the restoration and repair of disturbed and damaged natural systems engages the attention of many scientists and engineers. The restoration of habitat is crucial for the persistence of wildlife, and a significant group of conservation biologists now devote their efforts to recreating and restoring lost habitat, reintroducing native species of plants and animals, and reducing or eliminating invasive exotics. Chemical reactions between oxygen and rock exposed by mining have produced an increase in acidity in many Western streams and rivers, and scientists all over the West are working to find ways to deal with the problem of acid mine drainage. At the further reaches of restorationist thinking, groups have proposed removing or breeching a number of dams, and thus returning some rivers to a state of natural flow.

Elk traffic jam in Rocky Mountain National Park.
Courtesy of Rocky Mountain National Park.

What past era of better conditions should the agents of repair or restoration select as the goal of their efforts or the measure of their success?

The words that begin with "re-"—restoration, remediation, repair, recover, reclamation, regeneration, rehabilitation, reintroduction—are getting heavy use. In 1999, Secretary of the Interior Bruce Babbitt declared that we were entering "an entirely new era of conservation history, moving beyond preservation or protection toward a deeper, more complex movement, the affirmative act of restoration." After a century or two of "breaking the land," writer William deBuys put it, we are now "trying to repair what was broken." Much of today's activity in resource management, deBuys said, "is a precise reversal of what was done in previous generations."[49]

Such a 180-degree turn in orientation would be guaranteed to produce controversy and contention. Some of the efforts at restoration have set off storms of criticism and dispute. Articulate and audible Western ranchers continue to condemn the reintroduction of wolves to Yellowstone and Grand Teton National Parks, even as wolf-watching has become a major tourist attraction in those locales. The movement to remove dams (the campaign to take out Glen Canyon Dam and restore free flow to the Colorado River gets the lion's share of attention) strikes many traditional Westerners as the height of unreason, a strange and ill-thought-out desire to return to a dreamed-up set of "good old days." The range of opinion on restoration is breathtaking: to some, it is the most potent source of hope at hand; to others, it is a strange and disturbing effort to reverse time and return us to the past.

Hayden Survey photo of Old Faithful, Yellowstone National Park, circa 1878. *Courtesy of USGS.*

Science and the National Park Service

As the NPS pursues the goal of "leaving" the Parks "unimpaired," science and scientists become increasingly important. From its founding in 1916 through the first half century of its operations, the NPS focused its energies on expanding opportunities for Park use, encouraging tourism to the Parks, and developing visitor facilities and preserving historic structures within the Parks. These priorities followed logically from the need to secure political support and widespread public commitment to the existence of the Parks. Natural resource management took a back seat to these concerns, and scientific research played only a small role in Park policy. Satisfying the desires of recreational tourists meant accenting "scenery," not "the integrity of each Park's entire natural system." This led to a practice that historian Richard West Sellars calls "'façade' management," or "protecting and enhancing the scenic façade of nature for the public's enjoyment, but with scant scientific knowledge and little concern for biological consequences."[50]

An important figure in Park Service history, George Wright studied forestry at the University of California, Berkeley, before joining the NPS as Assistant Park Naturalist at Yosemite in 1927. While at Yosemite, Wright grew increasingly alarmed over the absence of a scientifically-based wildlife conservation program in the Park. In 1929, he proposed the establishment of a wildlife survey program for the NPS and personally funded the program in its early stages. In his report, known as "Fauna No. 1," Wright provided the first comprehensive evaluation of the NPS's natural resource management policies and proposed a radical departure. Wright recommended that the NPS preserve natural conditions within Park boundaries and work to restore those conditions in areas that had been altered under previous Park policies. He defined natural or pristine conditions as those that existed before the arrival of white settlers, and called on the NPS to rely on scientific research to guide its actions. The findings and recommendations in his initial report encouraged the NPS to undertake its first system-wide research program, aimed at improving its natural resource management policies. Wright also proposed that the NPS develop its own reservoir of scientific expertise with scientists who shared the NPS's underlying philosophy. Wright's innovations lost ground after his untimely death, but he had installed important ideas into the managerial repertoire of the agency.[51]

In 1963, Starker Leopold led a committee that urged the NPS to draw on scientific research to guide its wildlife management programs. "The Leopold Report," historian Richard West Sellars writes, "set the stage for serious tension within the Park Service when it stated flatly that the 'major policy change' recommended was for the Service to 'recognize the enormous complexity of ecologic communities and the diversity of management procedures required to preserve them.' Even more, it urged that scientific research 'form the basis for all management programs' and that 'every phase of management' come under the 'full jurisdiction of biologically trained personnel of the Park Service'—extraordinary challenges to a bureau long focused on accommodating tourism."[52]

In very recent times, the NPS has deepened its commitment to science. In August of 1999, the NPS published a statement, "The Natural Resources Challenge: The National Park Service's Action Plan for Preserving Natural Resources." In this statement, agency leadership called for an expansion of research and inquiry into nature in the Parks. "The lack of information about Park plants, animals, ecosystems, and their interrelationship is profound," the report said. "If we are to protect these resources into the far future, we must know more." The goals of the Natural Resource Challenge deserve our contemplation, since they make such a strong case for the importance of scientific practice in resource management:

1. National Parks are preserved so that this generation and future generations can enjoy, benefit, and learn from them.
2. Management of the National Parks is improved through a greater reliance on scientific knowledge.
3. Techniques are developed and employed that protect the inherent qualities of National Parks and restore natural systems that have been degraded; collaboration with the public and private sectors minimizes degrading influences.
4. Knowledge gained in National Parks through scientific research is promulgated broadly by the National Park Service and others for the benefit of society.[53]

The Natural Resources Challenge makes science and its findings a central feature in NPS management and decision-making, reminding us of how much is at stake in the issues explored in this report.

In the Parks, as elsewhere, projects in restoration raise similar questions, "*What* is the baseline that we are trying to restore? *When* was nature working at its best? *When* was the local ecosystem at its peak?" Since the definition of the "best" natural conditions can take hundreds of different forms, depending upon the criteria used for "best," these are not questions that can deliver us to "hard" and indisputable scientific answers, even though scientists necessarily play an important role in any credible restoration project.

A particular difficulty in answering these questions arises from changes in the paradigm of biology. In the first half of the twentieth century, the ideas of Frederic Clements, at the University of Nebraska, held a central place in the thinking of ecologists. Clements asserted that an ecosystem had a wholeness comparable to that of an organism. An ecosystem, much like an organism going through the stages of life, would start up again after a disturbance, moving from one stage to another as it moved through time. The final stage was the climax stage, in which plants and animals reached a state of equilibrium with the local resources of soil, water, and sunlight. This state would endure until another disturbance, whether natural or human in origin, disrupted the equilibrium and sent the ecosystem back to evolving, once again, through its various stages. The idea of climax ecosystems reaching a state of equilibrium soon moved out into popular thinking, transformed into the idea that nature had a "balance" that it would reliably reach if people stayed out of the picture.[54]

And then a partial paradigm shift occurred. In the opinion of some scholars, the very idea of order in nature lost persuasiveness. As one biologist phrased it, courageously expressing a complicated matter in the sharpest and most striking terms, "Prior to the 1950s nature was simplistic and deterministic; after the 1950s nature became complex, fuzzy edged, and probabilistic."[55] In the 1930s and 1940s, historian Donald Worster states, "ecology was basically a study of equilibrium, harmony, and order." By the 1990s, Worster says, it had "become a study of disturbance, disharmony, and chaos." The emphasis on chaos appeared in many of the natural sciences, not just biology. "Nature, many have begun to believe, is *fundamentally* erratic, discontinuous, and unpredictable," Worster sums up the change in thinking. "It is full of seemingly random events that elude our models of how things are supposed to work. As a result, the unexpected keeps hitting us in the face."[56]

Even though many environmental scientists have stopped well short of embracing a model of such disorder, they have come to recognize a much bigger role for disturbance than Clementsian ecology acknowledged. Remove human presence (quite an undertaking in itself) and ecosystems begin to evolve their way to some kind of equilibrium or stability. But they are unlikely to get very far along in that process before some natural disturbance—fire, windstorm, severe blizzard, flood, drought, volcanic eruption—disrupts the process. The idea of a climax ecosystem may have some standing in theory, but it is unlikely to have much standing in material reality on this changeable and complicated planet.

When biologists changed their models and adopted an idea of ecosystems as unstable, dynamic, and chronically changing, many nonscientists, including a big sector of the membership of environmentalist groups, held onto the idea that ecosystems had once existed in "climax" states of balance, harmony, and equilibrium. And thus, as they pushed for the repair and rehabilitation of ecosystems, restorationists ran head-on into nostalgia for the good old days when nature, before human disturbance, conducted itself with balance and peace.

The human talent for contention has certainly been highlighted in debates over the philosophical premises of restoration. Newcomers to this controversy may be caught by surprise to find that a battle rages between preservationists and restorationists. Some advocates, for whom the preserving of parts of the earth where natural processes are relatively undisturbed is the environmental priority, see danger in restoration. Restoration, they fear, is easily put to use by the enemy. "Once a general policy of restoration is justified, it will be used not only by right-thinking committed environmentalists," writes one critic, "but also by those who wish to continue to degrade and damage natural environments. The degraders and destroyers of natural ecosystems will have a perfect excuse for their activities: they can claim that they can restore the damaged ecosystem to its pre-existing state, or to a state that is functionally equivalent and as valuable as the original."[57] And yet one could as convincingly argue that, since restorationists are the ones who know the true extent and cost of the unintended injuries of ill-planned environmental action, they may well have the

Mountain goats grazing.

Any action that environmental scientists take in the project called "restoration" is almost sure to get them applauded, condemned, questioned, congratulated, and criticized for going too far and for not going far enough.

jump on the rest of us when it comes to advocating sensible caution and foresight in acts of development and extraction.

Most disturbing to the anti-restorationists is the way in which restoration seems to accept—or even embrace—human sovereignty and supremacy. In acts of restoration, human beings explicitly and knowingly make themselves into the designers, managers, and operators of landscapes. To some preservationists, this is, in itself, an act of hubris, with its arrogance giving restoration an intolerable taint. As preservationist Eric Katz states, "The chief ethical point is that if we think restorations are a desirable goal of environmental policy, then we will believe that there are no limits to our power and ambition to develop, degrade, restore, and manage the natural world."[58]

When you return your attention to the conditions of the West today, this whole debate seems strange and otherworldly. One clear outcome of the United States' westward expansion is a great supply of disturbed ground. Look just about anywhere, and you will see examples of erosion, soil exhaustion, pollution and contamination of water and air, extinction of species, and invasion of territory-grabbing exotics. Should we discourage or discount restoration efforts in these afflicted places because restorationists do not go far enough in their renunciation of human power and sovereignty?

We have put our readers through this complicated tale in order to provide an instructive example of what it means to say, "We cannot separate cultural values from scientific practice." Any action that environmental scientists take in the project called "restoration" is almost sure to get them applauded, condemned, questioned, congratulated, and criticized for going too far and for not going far enough. As to what scientists might do when greeted with this varying response, the best advice might be this: Recognize that you are actors in an important historical era. Get a nice notebook, keep a journal, and record all these fevered responses to your work. Historians of the future will be grateful. Now, whether you are attacked or celebrated, you have the consolation of knowing that you have become historically significant and the even greater consolation of knowing that you're the one keeping the records.

Photo of dam in Rocky Mountain National Park. *Courtesy of Rocky Mountain National Park.*

A Talent for Warning

In Daniel Sarewitz's earlier recommendation, scientists got the important assignment of warning society about environmental problems that require attention and concern. We turn now to three examples, spaced over a period of two centuries, showing naturalists or scientists in action, taking on this assignment and giving society a good and forceful warning. For all the enormous differences in their historical settings, our three exemplary figures dealt with the same subject—the aridity of the interior West.

Warning #1

Edwin James was a physician and naturalist who joined Major Stephen Long's expedition to the Great Plains and Rocky Mountains in 1819–20. During the expedition, James collected and identified hundreds of native plants and mapped the region's geological features. Today, James's contributions in the fields of botany and geology have faded from view, save for the few plants and geographic features that carry his name, but his role in shaping the popular image of the West as an arid, inhospitable land marks his abiding legacy. On his map of the Long expedition, James labeled the region east of the Rocky Mountains the "Great American Desert," the term that Long had coined to describe the land. In the decades that followed, the West-as-desert image drew considerable criticism from boosters, politicians, land speculators, railroad promoters, and newspaper editors who championed an "equal and opposite" image of the West as the "garden spot of the world" that would "bloom like a rose" from the exertions of settlers. Since Long's and James's view of the interior West as an uninhabitable and barren land did little to deter rapid settlement and the spread of agriculture in the region, it might have seemed logical, in the short run, to dismiss their warning as exaggerated. Nearly two centuries later, episodes of drought, as well as heated debates over population growth and water allocation, remind us that James's warnings about the "Great American Desert" carry long-range meaning with which we still struggle.[59]

Great Sand Dunes National Monument, New Mexico. *Courtesy of the National Park Service.*

Warning #2

History records some magnetizing moments when naturalists and scientists spoke out with considerable force, setting forth the social and political meaning of their findings. While John Wesley Powell unmistakably enjoyed outdoor adventure, he was also a thorough utilitarian, not exactly "St. Powell of the Environmentalists," as he has sometimes been portrayed. Still, he certainly had a fine moment when he spoke to the Irrigation Congress in Los Angeles in 1893.[60] The Irrigation Congress members thought of Powell as their founding father; they expected him to cheer for the cause of irrigating the West. But Powell caught them by surprise. "When all the rivers are used," he said to the increasingly crestfallen Congress members, "when all the creeks in the ravines, when all the brooks, when all the springs are used, when all the reservoirs along the streams are used, when all the canyon waters are taken up, when all the artesian waters are taken up, when all the wells are sunk or dug that can be dug in this arid region, there is still not enough water to irrigate all this arid region." "What matters it whether I am popular or unpopular?" he declared. "I tell you, gentlemen, you are piling up a heritage of conflict and litigation over water rights, for there is not sufficient water to supply these lands."[61]

"When all the rivers are used, . . . when all the creeks in the ravines, when all the brooks, when all the springs are used, when all the reservoirs along the streams are used, when all the canyon waters are taken up, when all the artesian waters are taken up, when all the wells are sunk or dug that can be dug in this arid region, there is still not enough water to irrigate all this arid region."

Contemplating this moment makes one wonder if it would not be in our interests to license environmental scientists to speak very directly, even sharply to us, if they think we are getting ourselves into a pickle. It is common for policy specialists to caution scientists against confusing their values with their science. That is generally excellent advice, but it is also advice that discourages the reoccurrence of occasions like Powell's warning to the Irrigation Congress. Instead of having scientists defiantly proclaiming, "What matters it whether I am popular or un-

Irrigation ditch constructed by Mormon pioneers, Moenkopi Canyon, Coconino County, Arizona, 1909. *Courtesy of USGS.*

popular!" and then riling us up with their heart-felt, data-based message, we will yawn while scientists say to us, "I have worked hard to separate my values from my findings; here are graphs and charts that present my data; it is up to you to figure out what, if anything, they might mean to society." The meeting of the Irrigation Congress in 1893 gives us an example of a scientist declaring his indifference to popularity and speaking truthfully and uncomfortably. Should we encourage today's scientists to do more of that? Or would we only be setting them up for trouble?

Warning #3

For our last episode in warning, we turn to the publication, in 2003, of a collection of articles, *Western Water Resources and Climate Variability*. The editor of the volume, the limnologist William M. Lewis, Jr., is a veteran of multiple occasions of presenting his scientific findings in complicated social and political situations. In 1999, he convened a group to explore the role of climate in shaping water supply and society's methods of managing water. As his example shows, in the West of the twenty-first century, the project of warning society has become much more complicated. Lewis's assessment of the relationship of Western American society to its water supply has to address matters of climate that extend far beyond any regional borders. To reflect on the arrangements of Western water, he had to convene specialists across a spectrum from climatology to hydrology, dendrochology to geography, along with legal scholars and professional water managers. While Lewis's team does put forward hopeful news about human capacity to predict the linkages between climate variability and water supply, much of the message of warning now involves a recognition of uncertainty: "The manager can never rest assured that today's management will be adequate tomorrow," Lewis writes. "Water in the West, although under intensive development for more than a century, is far from being a settled matter."[62]

In the early nineteenth century, Edwin James looked at the interior West and warned that the interior West would be a sparsely populated region, with human settlement sternly limited by aridity. In the late nineteenth century, John Wesley Powell looked at the interior West and saw a region more and more taken up with conflict and litigation as people refused to see aridity as a limitation. In the early twenty-first century, William Lewis tells us that both James and Powell did, in a sense, have it right, and the problem of limited water supply is now much complicated by the increase in human population and the proliferation of ardently held positions on the proper use of water. Lewis warns us that even if improvements in the prediction of climate give us a better estimate of future water supplies, still, modeling shows "a surprising diversity" of "hydrologic responses across the West to climate change." Lewis, in other words, reminds us of the complexity and contingency visible everywhere in environmental society, and he warns us against over-confidence, a message that is not a world apart from the warnings given by his predecessors in the business.

Balanced rocks on south wall of Park Avenue, Arches National Park, Utah. *Photo courtesy of USGS.*

Effort in the Right Direction

In 2003, Jill Baron, an ecosystem ecologist with the U.S. Geological Survey, assembled the work of a diverse group of scientists into a book called *Rocky Mountain Futures: An Ecological Perspective*. The book, she wrote, was "an attempt to look objectively at the cumulative ecological effects of human activity in the Rocky Mountain region." The writers ranged in topic from the environmental history of the Rockies in the last 20,000 years to the most recent boom in second homes and tourism in rural areas, from the effects of the exclusion of fire in forests to recent efforts at collaborative decision-making in conservation. These scientists are making a good-faith effort to draw, from their expertise, an assessment of regional environmental conditions, in the hope that this assessment can provide the foundation for well-informed decision-making and action-taking. Jill Baron does not evade the complexity of the challenge:

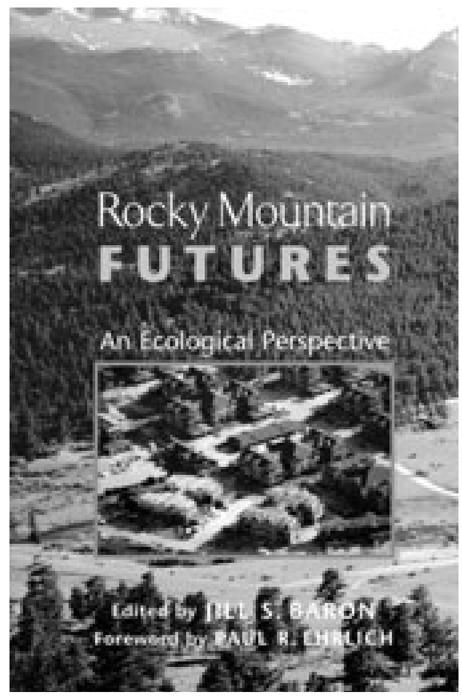
> There are two options in considering the future of the Rocky Mountain region: begin the very difficult task of planning and working toward an environmental future we as a society want, or ignore the trends described in this book and face the future that will be happen by default, to the detriment of Rocky Mountain ecosystems. Although the first option may seem almost insurmountably difficult, the second one is unacceptable.

The book concludes with an expression of faith in the benefits that come with knowledge. If scientists research, quantify, and report to us on the state of nature today, the authors hope, they will tell us what we need to know to make wise choices for the future. As Jill Baron writes, "we know the effects of our past activities on Rocky Mountain ecosystems—let us allow them to guide our planning for the future."[63]

Is that a proposition verified in reality? Can knowledge of the past offer us sound and practical guidance for our actions in the future? Observing the hopes and goals of the authors of *Rocky Mountain Futures* returns us to the dream we wrote of at the start of this report. In *Rocky Mountain Futures*, environmental scientists of great good will and the best of intentions came together to share their expertise with an audience of residents of the region. Will the residents recognize this act of good will? If Westerners read this book, will the quality of their thinking—about the future of the places they live—be deepened and improved?

It is our hope to use the publication of *Rocky Mountain Futures* as an experiment in itself: we urge you to get the book, read it, and let us know what you think. Does its presentation of scientific findings leave you feeling like a better informed, better oriented Western citizen? If not, why not? What strategies would increase the effectiveness of scientists in communicating with the public? As Jane Gregory and Steve Miller put it, "If the public's needs are to be met, the public must articulate what those needs are." Here's your chance to give it a try.

". . . we know the effects of our past activities on Rocky Mountain ecosystems—let us allow them to guide our planning for the future."



Rocky Mountain Futures: An Ecological Perspective, **edited by Jill Baron (Washington, D.C.: Island Press, 2003)**

A Western Experiment: Remodeling Our Relationship with Scientists

The West, historian William Goetzmann wrote, presented itself to scientists as "a vast natural laboratory." In those terms, the West volunteers itself as the site for a great experiment, and that is exactly what we propose. First, we will list the attitudes, assumptions, and habits of mind that have, generally, governed public behavior toward scientists in the last century. We will then declare that century to be an experiment of great interest, but one coming close to closure. Second, we will offer a list, reconfiguring those attitudes, assumptions, and habits of mind, and proposing that we dedicate the next century of Western life to an experiment in which we deploy this reconfigured approach. We will presume on the kindness and attention of the Westerners of the future, in asking them to monitor the results of this unusual venture in the experimental method.

Attitudes Already Deployed and Tested in the Twentieth Century's Experiment

1. **Good scientists differ from normal human beings; if their lives as scientists touch their lives as citizens, their research will be compromised.**
2. **Good scientists should be able to provide us with firm and settled answers to questions about how nature operates and how human action affects those operations.**
3. **By examining data from the past and present, good scientists should be able to predict the future.**
4. **Good scientists can do good research under whatever circumstances they are handed; if they are given a unit of land with very arbitrary natural borders (say, a National Park or a National Forest), they should exert extra intelligence and cleverness to design appropriate experiments and come up with answers and recommendations that will not sacrifice any comprehensiveness or force to the constraints of a truncated case study.**
5. **Good scientists will reveal natural laws and universal patterns, so that we will end up with a supply of solutions we can apply to many different places and situations.**
6. **Scientists working in the West come from elsewhere, and thus locals will always have reason to distrust them as outsiders.**

Tested in Western life in semi-controlled circumstances over the last century, these assumptions have yielded an extraordinarily interesting and instructive story, with the activities of scientists woven into the most important patterns of regional history. And yet it would be hard to argue that this experiment has produced the best possible results in the cause of "making the most of science and scientists."

So, for the next century, let's change the experiment.

This time, let's try putting into practice some new habits of mind and see what results they produce.

Attitudes to Deploy and Test in the Next Century's Experiment

❶ **Accept the fact that scientists are human beings.**

Scientists have enthusiasms and aversions; they operate knowledgeably in a world of cultural values and meanings. The fact that the lives of scientists have inner, subjective dimensions does not discredit them or their findings. Humans have well-established capacities to examine data and reach—and report—a conclusion that goes against their preferences and even their convictions. Rather than discrediting scientists, a recognition of their humanity frees them of the stereotype of being unfeeling pursuers of data. We already have enough computers and automated equipment in our lives; there is no need to ask scientists to refashion themselves into mechanical, soulless beings. Instead, it is time, in the words of one science administrator, to "restore soul to science."[64]

❷ **Recognize that there is a significant factor of uncertainty in nearly every scientific conclusion.**

The hope that scientists can provide us with firmly settled answers that will last for the ages has been the source of much mischief. Ecosystems are enormously complicated sites of study; they are networks of relationships in which many entities change and transform each other. The direction of scientific discovery in this last century has led steadily toward findings of complexity, which is not the destination that most politicians or advocates prefer. The path of wisdom for Westerners is to recognize the solidity and meaning provided by scientific study, while keeping expectations for full and final certainty at an appropriately realistic level. And, in many situations, we must face the fact that if we wait for studies to be completed and certified beyond any imaginable question or challenge, the moment for useful decision-making will be long gone.

❸ **Face the fact: human beings have many talents, and predicting the future is not one of them.**

Forecasting the future is not an easy matter for mortals, no matter how accomplished those mortals may be in the experimental method or how firmly they base their predictions on solid data sets drawn from the past and the present. Asking scientists to predict what will happen, if we take one course of action or another, may be the toughest assignment we give anyone in society. There is much to recommend in the adoption of the "least regrets" strategy, by which we make our peace with the unknowability of the future and try to choose the actions that will be least likely to deliver us to outcomes we will regret.[65]

❹ **Reduce expectations of precision and certainty in scientific results, in proportion to the "truncatedness" of the unit of study.**

With their arbitrary borders, the public lands by their very nature offer a daunting challenge to scientists. These units are fragments of what were larger ecosystems. Working with these truncated units, with borders so easily crossed by air, water, animals, and plant seeds, places a strain on ecological science that should make us all the more tolerant of scientific uncertainty and incompleteness of findings.

❺ **Give up on the hope for a "one size fits all" strategy of land management, and accept the reality of local variation.**

Impatient citizens may feel, sometimes, like saying to scientists, "For heaven's sake, you have been working on this region for the better part of two centuries; haven't you figured it out yet?!" But each place presents its own complicated set of relationships; in a matter like the frequency of fire, areas near to each other may still undergo very different fire regimes. Plus, human activity keeps changing the situations under study, and thus the work of science is ongoing, a constant process of taking in new information and trying to mesh it with prior conditions.

Citizen Scientists

An important step in putting Habit of Mind #1 into experimental practice would be designing a ritual of communication, by which (Stage One) scientists can present the results of their research, and then (Stage Two) they can shift gears and tell us the meaning that they themselves find in those results, as well as the actions that they would like to see adopted in response to their findings. This could be signaled with the statement, "I shall now exercise my constitutional rights to speak as a citizen and a resident of the West," or perhaps with a flourish—shutting off the PowerPoint, putting down the microphone, stepping away from the podium, and standing before the audience as an appealing human being, momentarily without "tech support." With this clear distinction—between the Scientist and the Citizen—visible, acknowledged, and recognized, it will be harder for partisans to dismiss the results in Stage One as the doubtful product of the preferences communicated in Stage Two.

❻ Welcome—or least acknowledge—scientists as neighbors and fellow Westerners.

Before the twentieth century, the scientists who studied the West came from other places. There was good reason to think of them as outsiders who did not know much about local communities. Over the last century, this arrangement has been much transformed. People born and raised in the West have become credentialed scientists; others have moved to the West from elsewhere and then settled down as committed residents of the region. It is particularly notable that many federal employees managing the West's natural resources have as good a claim to be "legitimate" Westerners as the people who sometimes denounce them as outside meddlers. It is time to recognize that the stereotype of the "scientist as outsider" has lost a lot of its factual accuracy, and many environmental scientists are permanent, loyal regional residents. Dismissing them as outsiders and intruders is a form of condemnation that has outlived its shelf life.

It seems worth a try. We persuade Westerners to shift over to this second set of mental habits. We let the experiment run for a century. We leave an abundant set of records of the effects and results. We make arrangements for a group of Westerners in 2103 to review these records and assess the outcome. Even though we have taken a very firm stance against the mistaken idea that humans can predict the future, we are still very tempted to say this: the results of the second century's experiment are going to be better than the results of the first.

Sunshine Peak, Colorado.

Not Exactly the Ancestor We Would Have Asked for, but for Better or Worse, the One We Got: Ferdinand Hayden and the Image of the West

Expressing enthusiasm for nature, exploiting the growing taste for popular science and scenery, and undertaking serious research on natural history—these approaches underlay Hayden's work in Yellowstone and, in his mind, always blended together.[66]

During Hayden's time, scholars began to specialize in their studies of the sciences. They divided natural history into botany, biology, zoology, for example, and they subdivided each of these into smaller pieces. Hayden preferred the older, unified approach. For him, splitting disciplines into topical specialties actually created separate subjects, separate realities, but destroyed the seamless fabric [of nature]. To Hayden, the reality of nature was a totality, a wholeness. . . .[67]

Ferdinand Hayden. *Courtesy of USGS.*

The work of naturalists and scientists from the past continues to set the terms for today's debates over the West's natural resources. Naturalists and scientists in the nineteenth century played a key role in shaping the image of the West. They were keen and acute observers; many of them were good writers; they had the magnetism carried by people who love their work; they built a consequential partnership with artists and photographers. Public funding offered the incentive that made skill in communication into one of the prerequisites of becoming an accomplished scientist.

Moreover, their lives provide parables that offer us a kind of language, or vocabulary of examples, for our discussions of the role of science in our own lives. These individual lives give us points of reference to hold in our minds as we think about the practice of science today. And yet the scientists of the past were extremely complicated people, and sometimes troubled and unpleasant people. Perhaps the most telling example of all is the life of Ferdinand Hayden, at one time one of the best known naturalists in the United States.

Hayden Survey, 1873. Left to right: Hayden, Stevenson, Holman, Jones, Gardner, Whitney, and Holmes. *Courtesy of USGS.*

From an impoverished and difficult childhood, Hayden went on to attend Oberlin College; like many other naturalists of his era, he also trained as a physician. A gifted networker and lobbyist (he "pleaded, fawned, flattered, pestered, and badgered until he got what he wanted," as his biographer, Mike Foster, writes), Hayden soon caught on to the wisdom of securing government sponsorship for his scientific enthusiasms. After expeditions up the Missouri River and to various locations on the Plains, Hayden was able to use a survey of Nebraska in 1867 as the foundation for a continuous sequence of government-sponsored expeditions. "Hayden did his job so well and made such effective use of publicity," Foster says, "that more than anyone else, he drew attention to the importance of Western surveying." With his survey achieving considerably higher visibility than Clarence King's or John Wesley Powell's, Hayden "could

Members of the 1870 Hayden Survey, Red Buttes, Wyoming. Standing left to right: John "Potato John" Raymond and "Val," cooks; Sanford R. Gifford, landscape painter; Henry W. Elliott, artist; James Stevenson, assistant; H. D. Schmidt, naturalist; E. Campbell Carrington, zoologist; L. A. Bartlett, general assistant; William Henry Jackson, photographer. Sitting left to right: C. S. Turnbull, secretary; J. H. Beaman, meteorologist; Ferdinand V. Hayden, geologist in charge; Cyrus Thomas, agriculturist; Raphael, hunter; A. L. Ford, mineralogist. *Courtesy of USGS.*

Hayden Survey of 1874. W. H. Jackson photo of cascades at the foot of Round Top Mountain, Rocky Mountain National Park. *Courtesy of USGS.*

scarcely keep up with requests for his works from countless individuals: congressmen, Western governors, state officers, federal officials, land offices, county assessors, state geological surveys, teachers and professors, amateur naturalists and ethnologists, doctors, railroad agents, land agents, miners, travelers, farmers, ranchers, army officers, Indian agents and commissioners, authors, a variety of businessmen and lawyers, and a host of foreign governments, societies, and individuals." Careful to include artists and photographers on his teams, Hayden played a key role in bringing the Yellowstone country to popular attention and in generating enthusiasm for the creation of the first National Park.[68]

Ferdinand Hayden was an unmistakably troubled soul; writing his biography, Mike Foster says, was an occasion of "confronting the demons that inhabit another's soul." Hayden was a "self-absorbed man, often an insensitive friend, and always an aggressive adversary, who could employ devious tactics of his own;" he lied about his childhood; he committed a blatant act of plagiarism in the composition of one report; he led an unstable early life and died at age fifty-nine from advanced syphilis. In 1879, in the fight over who would become the founding director of the United States Geological Survey, flaws unique to Hayden's personality intersected with the general factionalization and divisiveness of the American scientific community, and he lost out to the better positioned Clarence King.[69]

But Foster insists that these troubles cannot obstruct our recognition of Hayden's achievements and impact. Hayden "embraced the entire province of natural history as his own" and "established himself as the most formidable collector of rocks, fossils, and natural history specimens in America." "Always keen to expand the public's appreciation of science," Foster writes, "Hayden saw to it that his reports were written in a popular language," and "a diverse readership eagerly awaited these annual updates of his explorations." His writings "directly affected" how the West "came to be understood in the popular mind." In describing the West, Hayden "emphasized those qualities that can be captured in a picture: color, space, light, perspective, scale—visual qualities." With this visual accent on grandeur, "Hayden's particular interpretation of the West continues to the present day, as witnessed by the endless flood of coffee-table books, prints, and calendars." Although scorned as a popularizer, Hayden could also be seen as "a sincere idealist who believed the public could understand science if offered facts in an attractive context."[70]

Before we usher Hayden and his contentious colleagues off to the status of outmoded relics, we should note how successfully they avoided the two failings we sometimes lament in contemporary scientists: the inability or unwillingness to communicate with the public, and the inability or unwillingness to think about nature as a whole. The prominent scientists of the late nineteenth century made communicating with politicians and public audiences into a professional priority. And they were indefatigable in their efforts to assemble parts into whole, to see and describe the big picture of nature. It would be difficult to label those aspects of their lives as "outmoded" and "antiquated." In their full human complexity, the nineteenth-century scientists retain their relevance, even as they cure us of nostalgia and leave us prepared and positioned to make the most of the scientists among us today.

Readings

Primary Sources

Observations of the natural world gave interest and appeal to the writings of nineteenth-century explorers. Reading those reports today offers its own satisfying form of vicarious adventure. Just as important, comparing then and now—the role of the naturalist in the nineteenth century; the role of the scientist in our time—offers its own invigorating exercise for the mind. Readers who take up the suggestions here are guaranteed both a good time and the occasion for worthwhile reflections on the role of the scientist in Western life.

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