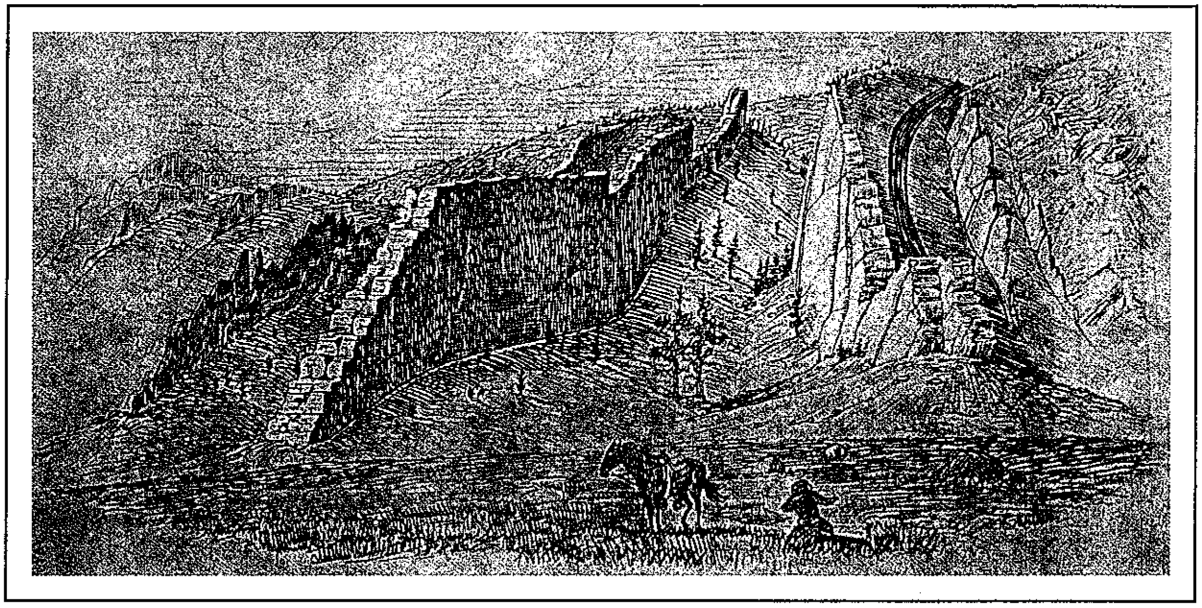
Yellowstone Science

A quarterly publication devoted to the natural and cultural sciences



A Western Spirit of Place
Documenting Diversity
Waste Stream Studies
The Mountain Fox
Fecal Ecosystems

Volume 1 Number 3

Bars of soap from park hotels, gathered for recycling. Jim Peaco/NPS

The Good, the Bad, and the Unglamorous

Environmental historians have chronicled centuries of evolution in our attitudes toward nature. Practically every viewpoint that now exists has existed for centuries, but there has been big changes in balance. For example, a century ago, only a few people would have found anything good to say about wolves; now the wolf is among the most popular (not to say fashionable) of wild animals, star of countless prints, T-shirts, and magazine covers.

Yellowstone exemplifies many of these changes in attitude. For half a century, managers attempted to protect the "good" animal s (elk, deer, bison, and other herbivores) from the "bad" ones (the carnivores, especially wolves, mountain lions, and coyotes). Animals were easy to judge, according to what they ate; ambivalence in bear management over the years must be seen as a consequence of trying to come to terms with an omnivore that could either touch your heart or try to remove it, depending upon the circumstances.

We still haven't achieved an egalitarian perspective on all life forms, of course. It's much easier to fund research on the charismatic megafauna than on the anonymous rodent, but we have progressed, and some of that progress is displayed in this issue.

Michael Foos's study of *Pilobilus* reveals to us a remarkable, near-oddyssean life cycle lost to our sight until now. Our interview with Pete Feigley of the Conservation Data Center shows the extent to which ecological egalitarianism has become a part of the public conscience. And the news item about our garbage habits is as revealing of how Yellowstone Park works as anything else we could publish.

We dearly love a good brown-eyed mammal story (such as Bob Crabtree's), or a good humanist essay (such as Dan Flores's), but all this talk of fecal ecosystems and waste streams keeps us on our toes, and reminds us of how far we have to go. Until we've run articles on diving beetles, biogenesis, lichen, rare and endangered soils, and many other underappreciated aspects of Yellowstone, we haven't begun to strike a real balance.

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On the cover: Devil's Slide, a prominent landmark along the Yellowstone River a few miles north of Yellowstone National Park, as drawn by Henry Elliott, a member of the 1871 U.S. Geological Survey of the Territories under Ferdinand Hayden. Elliott's drawings, now a part of the Yellowstone Park Museum Collection, illustrate the essay by Dan Flores beginning on page 6.

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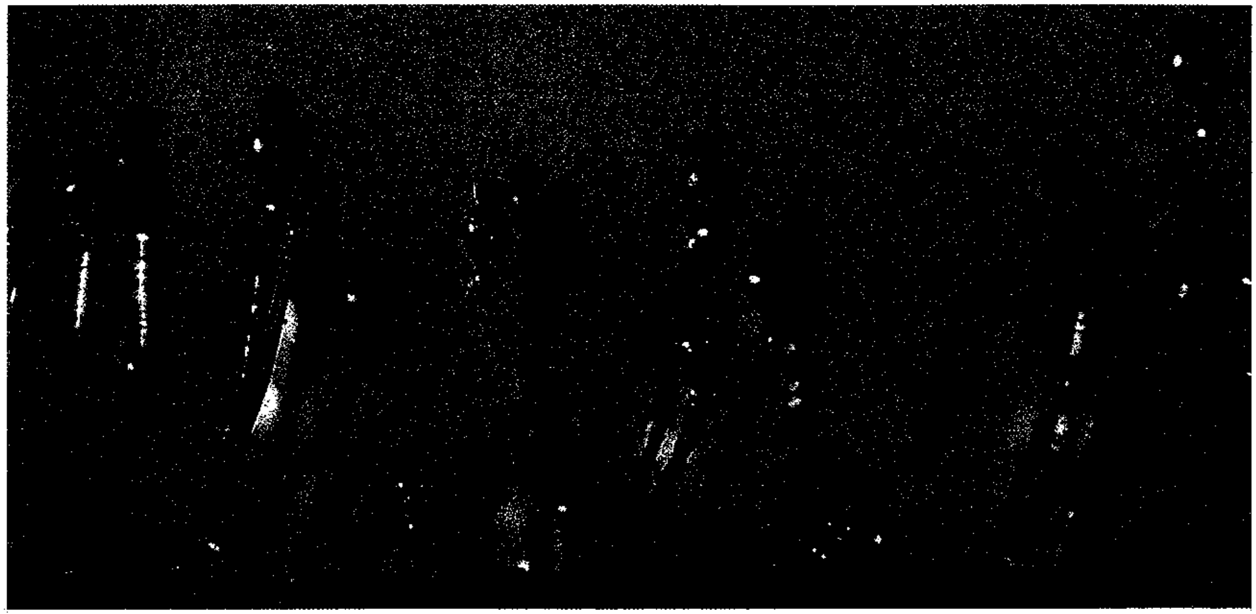
K. Michael Foos



Pilobolus Ecology

Fungal forests, fecal ecosystems, and the wild ride of lungworm larvae

by K. Michael Foos

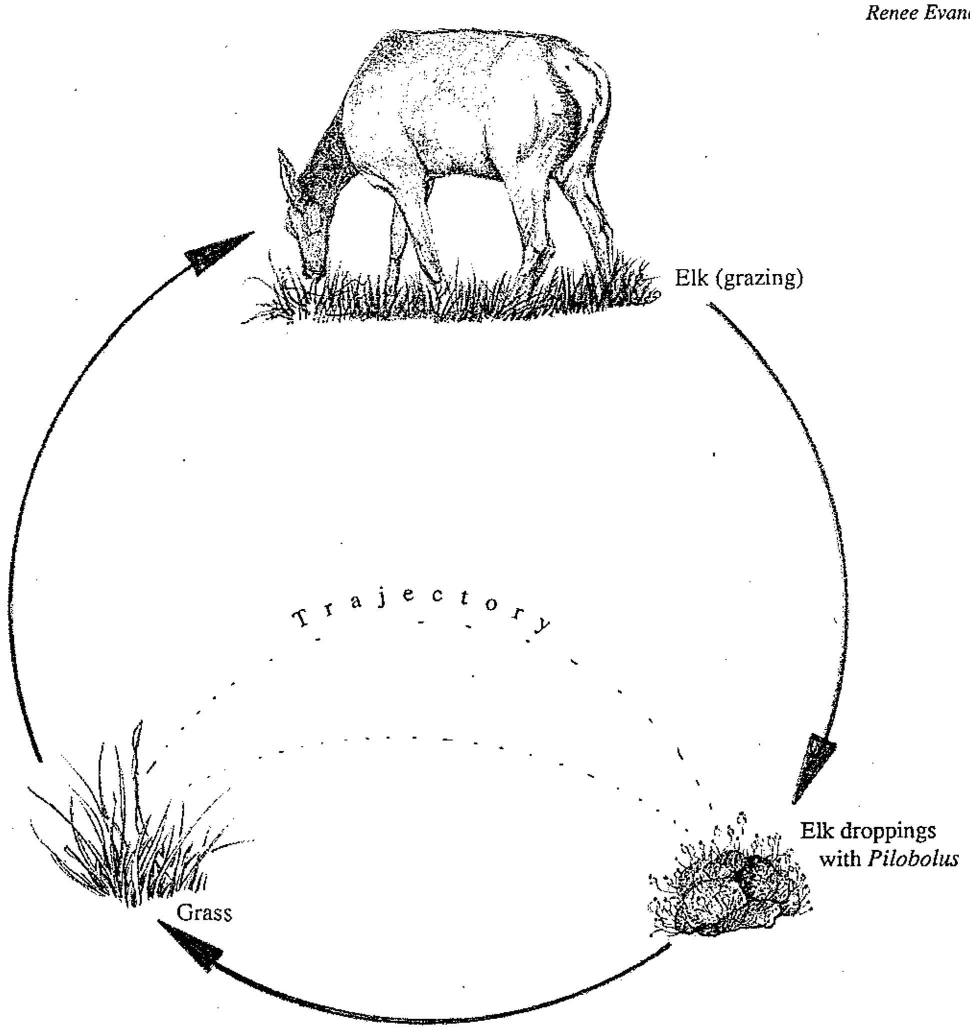
Yellowstone National Park is an area famous for largeness: large landscapes, large geysers, large bears, large buffalo, and large crowds. Even many of the mushrooms are large, some having caps that measure more than eight inches across. But it is also an area of small things. There are small insects, small crystals, and some plants so small they are almost impossible to see.

One of the most intriguing of these small things is a fungus known as *Pilobolus* (pronounced pie•lob•olus). Very few visitors have ever seen it, but its influence on ecological processes in Yellowstone is both powerful and complex. While individual stalks are visible with the naked eye (they range from 1 to 10 mm in height), they are hardly conspicuous. Even when hundreds or thousands of these "sporangiophores" arise close together like a minute forest of glistening trees, they can only be seen by careful examination.

Being small does not mean they are unimportant, however. *Pilobolus* is one genus of many fungi that cause the decomposition of animal wastes, processors of the huge quantities of fecal matter that the park's famous wildlife produce daily. All species of *Pilobolus* grow on droppings from herbivores, and all but one are found exclusively on animal droppings.

Pilobolus is widespread; it has been identified on all continents. In Yellowstone, the fungus is found in forests, meadows, geyser basins, near developed areas, and even in campgrounds. It has been found growing on the droppings of pronghorn, bison, mule deer, elk, bighorn sheep, and moose.

The life cycle of *Pilobolus* begins when an herbivore, such as an elk, defecates and fungal spores within the dropping begin to grow. The thallus, or body, of *Pilobolus* is a filamentous network of thousands of hyphae (like tiny roots on a tree) that penetrate throughout the dung. This mass of filaments is much like bread mold, but it is deep



The life cycle of Pilobolus *begins when an animal excretes fecal material with spores. These spores utilize nutrients within the dung while decomposing it. After 4 or 5 days, reproductive structures develop, each topped with a sporangium. Each sporangium is discharged away from the dung pile, where ungulates are more likely to graze. Other organisms, such as lungworm larvae, may be carried with each sporangium. Eventually, a passing elk may consume* Pilobolus *spores (and lungworm larvae), which move through the elk's digestive tract and are eventually excreted to begin the cycle again.*

within the droppings and does not cover its surface until the fungus produces the reproductive structures that begin to rise from the surface of the dropping a few days after it hits the ground.

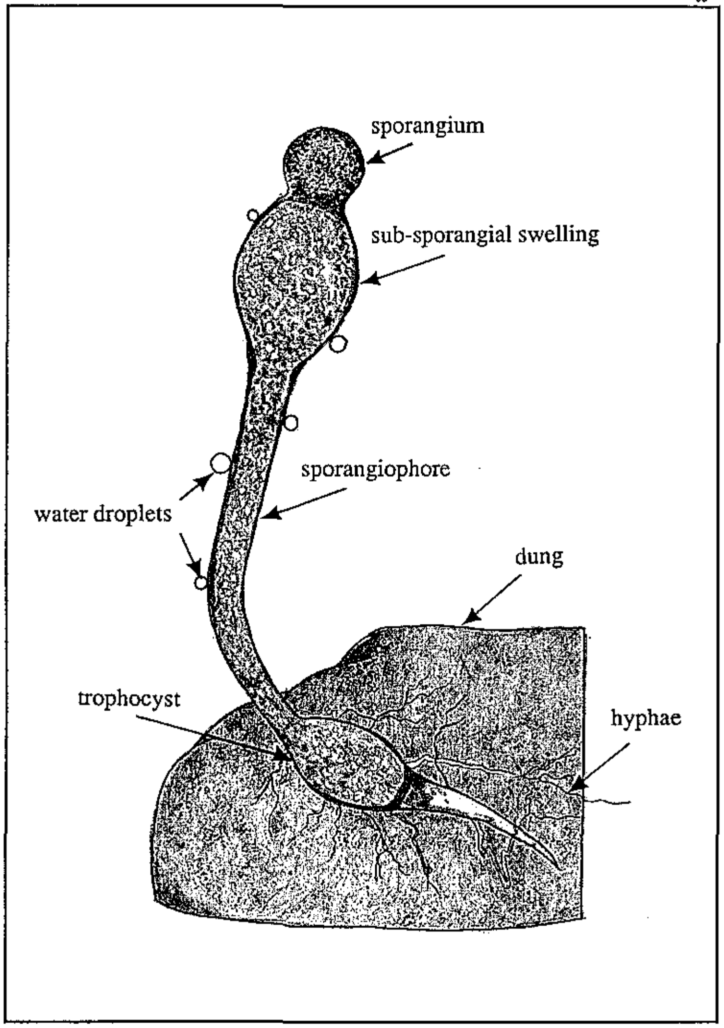
Because herbivores and *Pilobolus* have different nutritional needs, it is possible for both to obtain nutrition from the same forage or browse. First, the animal eats the plant and its digestive tract uses the components it can; then the fungus uses what's left. Elk and the other large grazers are able to use nutrients found in forage, but the fungus cannot. Only when the plant material has undergone the grazer's digestive processes is it in a form that the fungus can benefit from.

The symbiosis between the fungus and the herbivore goes even further than food processing. The dark coloration of animal droppings is important for this fungus. *Pilobolus* grows best at temperatures ranging from 85 to 95° F (29.5 to 35° C), well above the typical ambient temperature in Yellowstone. But when the sun strikes fresh animal droppings, their dark coloration allows them to absorb enough solar energy to produce the heat needed to stimulate *Pilobolus* to grow.

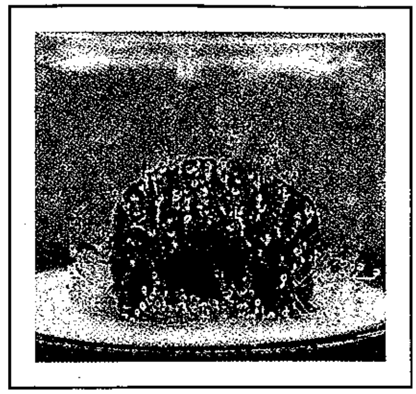
Pilobolus usually grows hyphae for four or five days before the fungal mass is large enough to support reproductive structures. Then, at night, under the appropriate temperature, moisture, and nutritional conditions, just below the surface of the droppings, specialized cells among the hyphae develop into stalks called sporangiophores. Soon these sporangiophores can be seen rising from the surface of the dung like candles on a birthday cake.

In some species of *Pilobolus*, the stalk, or sporangiophore, may be as high as 100 mm (about 4 in.), but species in Yellowstone are rarely more that 10 mm high (still quite large considering that the stalk is made of a single cell). As the stalk reaches its maximum height, a head, or sporangium, develops, con-

Renee Evanoff



K. Michael Foos



Pilobolus *spores grow hyphae throughout the fecal material. Among the hyphae, a specialized cell, called a trophocyst, expands into a single-celled sporangiophore which support a sporangium containing spores. A swelling beneath the sporangium bursts, sending the sticky sporangium as much as 8 feet away.*

taining spores that will eventually produce more *Pilobolus*.

After the sporangium develops at the top of the sporangiophore, the area just below the sporangium swells until it is shaped like a lens. At dawn, sunlight is focused through this swelling onto the growing portion of the sporaniophore, causing uneven growth that aims the sporangium toward the sun. As the sun rises, the sporangiophore follows it across the sky toward its zenith. By mid- to late-morning, the sporangium separates from the rest of the sporangial structure and is violently discharged.

The discharge is caused by increased cell pressure in the portion of the sporangiophore just below the sporangium. When discharged, the sporangium is blown away with a great deal of force, sometimes traveling more than six feet vertically and eight feet horizontally. Because the sporangiophore follows the sun, the head is aimed skyward at the time of discharge.

The sporangia need to be consumed by a passing ungulate in order to complete their life cycle, and this is why the discharge is so important in their life cycle. Grazing animals do not feed in the immediate area of fecal piles, and so *Pilobolus* could not survive unless its spores were able to get beyond that ungrazed area.

Most of the sporangia land on grasses or other foliage that are the primary foods of herbivores; the sporangia are covered with a sticky material, and ahdere to whatever they hit. This shotgun mechanism of spore dispersal ensures that sporangia will be in a good position to be eaten by another herbivore. As the herbivore consumes the plant material and *Pilobolus* together, the spores contained within the sporangium begins the same trip through the animal's digestive tract that has been taken by countless generations of its ancestors.

The highly mobile herbivore also contributes to the dispersal of *Pilobolus*, traveling from site to site as it spreads its fungus-laden droppings across the landscape. By including a trip through an herbivore as a part of its life cycle, *Pilobolus* not only guarantees that its spores are embedded in the very nutrient source they need to grow, but ensures that the spores will be widely distributed.

There is yet another complex relationship in this story, one involving fungus, elk, and a third organism. The third organism is a roundworm, and its presence may help explain a part of a complex disease cycle in Yellowstone.

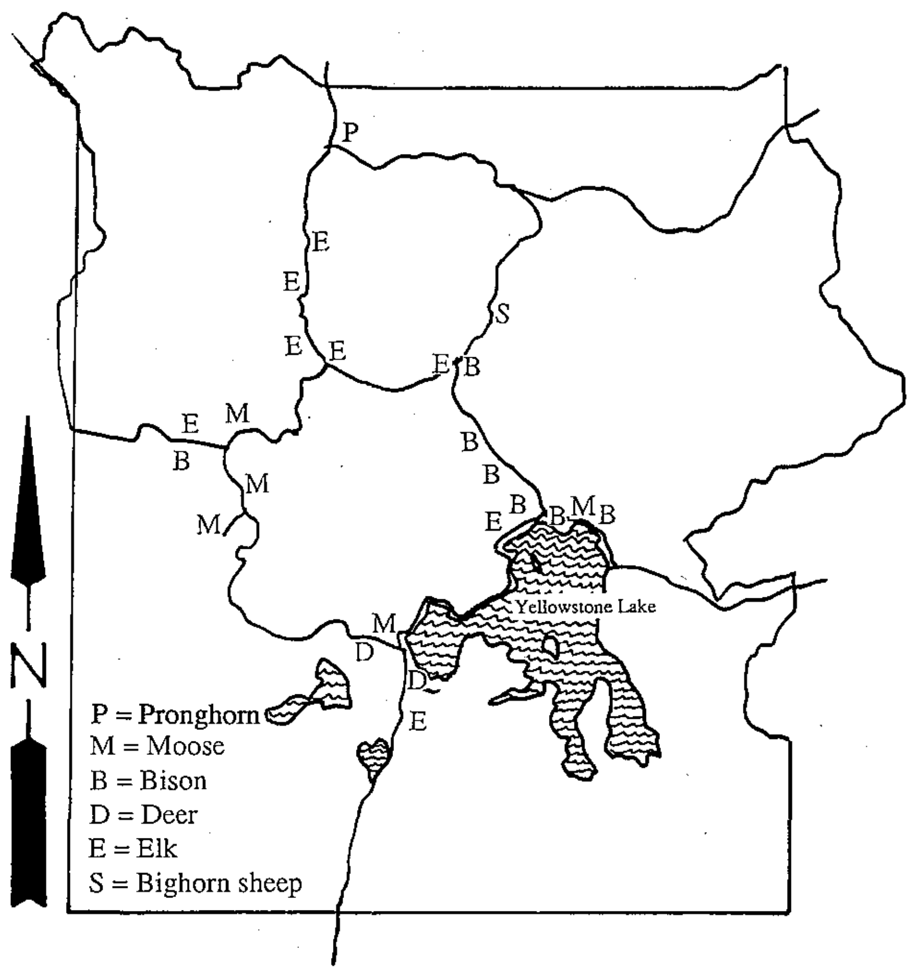
Lungworm disease, sometimes called parasitic bronchitis, is caused by the roundworm, *Dictyocaulus viviparous*. This roundworm has a complex life cycle with several different stages of growth. As the name of the disease implies, adult lungworm inhabit the air passages (lungs, bronchioles, and trachea) of their host, where they lay their eggs. As the elk coughs up these eggs and then swallows them, they begin their passage through the animal's digestive tract along with *Pilobolus*. As the eggs pass through the elk, they develop through two of three larval stages. The third larval stage, known as L3 larvae, is the infective stage and develops in the animal droppings. Under normal environmental conditions, this third larval stage develops in four to six days after leaving the animal—about the same development time as *Pilobolus*.

Also like *Pilobolus*, L3 larvae are attracted to sunlight; they move in a slow writhing motion toward the sun. Considering that these larvae are only about 1/3 mm long and move very slowly, they don't go very far—rarely as much as an inch from where they were dropped with the dung. However, as the larvae move toward light, they will crawl up any developing sporangiophores they come upon. Under a microscope, they weave like miniature cobras as they attempt to climb the tiny stalks of developing sporangiophores.

The environment within the sporangium is very good for L3 larvae; the sporangial wall provides protection from drying and ultraviolet radiation. This means that the larvae are nicely protected until the sporangium is discharged, launching the larvae into flight. Larvae that could normally never move more than a fraction of an inch get a free ride of several feet.

When a sporangium adheres to the foliage it landed on, any larvae in the sporangial mass stick there as well; animals eat the foliage and its two tenants, the sporangia and larvae. The sporangia go about their life cycle as described earlier, and if the grazing animal is susceptible to lungworm disease, the larvae will develop into adults within the lungs and repeat their own cycle again as well.

While we don't know how important *Pilobolus* is in the disease cycle of lungworm disease in elk, its role in the disease cycle of cattle lungworm disease has been described in many studies. From our work in Yellowstone, we have shown that in every specimen examined for both organisms from which L3 larvae have been isolated from elk droppings, at least one isolate of *Pilobolus* is also present. In some cases, all three species of the fungus found in Yellowstone have been isolated from a single elk infected with



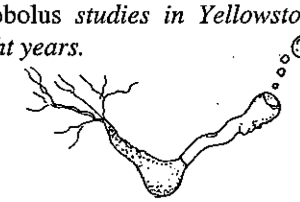
Pilobolus *fungi have been isolated (collected and grown in the laboratory) from many areas of Yellowstone Park. Three* Pilobolus *species have been isolated from fecal material of six different ungulate species.*

Dictyocaulus L3 larvae.

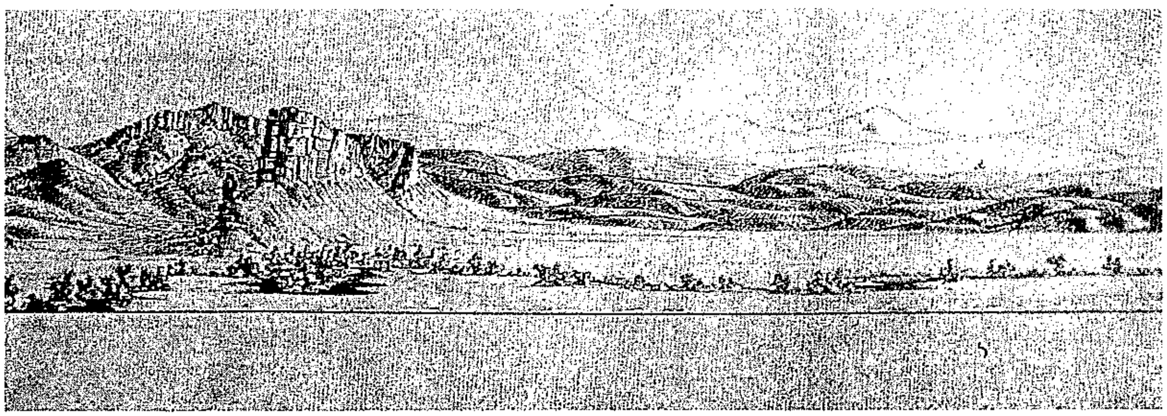
In the 300 years since it was first scientifically described, nine species of *Pilobolus* have been identified. The three of these species isolated in Yellowstone National Park are *Pilobolus crystallinus, P. kleinii,* and *P. roridus.* All three species have been repeatedly isolated from many areas of the park and from droppings of several different herbivores. All three of these species have similar life cycles and appear to have similar impacts on the environment.

For all the local studies of *Pilobolus,* there has never been a systematic study of the geographic distribution of the organism. The current work being done in Yellowstone is part of a systematic study of the biogeographical distribution of *Pilobolus* and the identification and characterization of habitats within which the organism thrives. As we learn more about where it lives and how widely it is distributed, we will be able to identify more clearly its role in the ecosystem and the relative importance in its various activities. While its role in fecal decomposition and in the distribution of lungworm larvae seem to be well described, we do not know what other ecological processes it may participate in during its extraordinary travels.

K. Michael Foos is Professor of Biology and Chairperson of the Natural Science and Mathematics Department at Indiana University East, Richmond, Indiana. He has been conducting Pilobolus *studies in Yellowstone for eight years.*



"Mouth of Beaver Head Canyon," in southwestern Montana, by Henry Elliott, 1871



Spirit of Place and the Value of

by Dan Flores

"The crucial question of the modern world is,
'How are we to become native to this land."
Paul Shepard, in Max Oelschaeger, ed., *The Wilderness Condition*

In recent years it has become clear to researchers, administrators, and the public that most of the scientific and resource-management issues facing Yellowstone National Park are in fact regional issues. Terms such as ecosystem and bioregion are a daily part of current dialogues relating to the park, its care, and its study. All of these dialogues, whether about geothermal resources, ungulate migratory patterns, fire, endangered species, or any other issue, have significant humanities components that may be difficult to quantify but are of great importance.

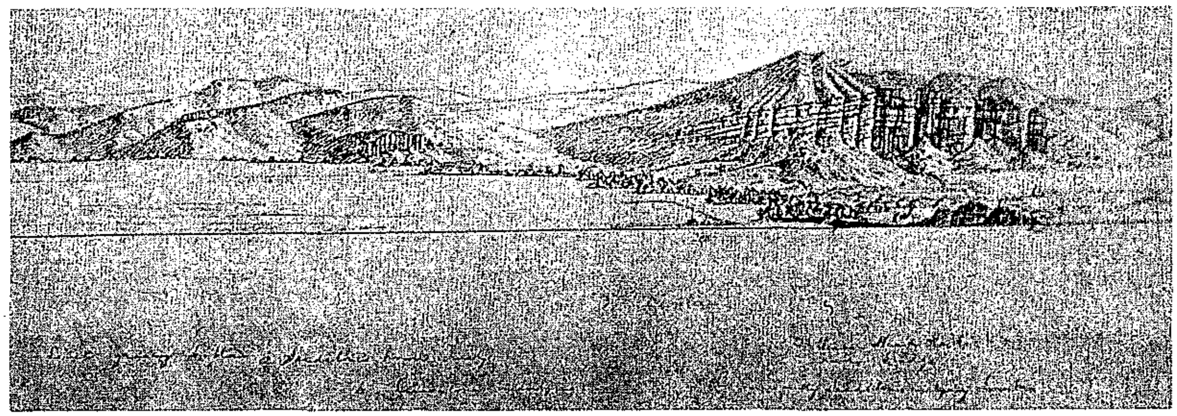
Dan Flores, an environmental historian who has focused on regional cultures and their interactions with ecological systems, presented this paper on December 11, 1992 at the "Humanities and the Greater Yellowstone Ecosystem" workshop at Montana Stste University. It was so well received, and has so many immediate applications to the issues facing Greater Yellowstone, that we persuaded him to allow us to reprint it here. Ed.

I moved to Montana six months ago and find myself, for the third time in my life, engaged in the process of being assimilated into a landscape and a place. As a typically transient American, I have of course actually lived in more than three places in my life. And had I been in Laramie or Sheridan, Wyoming, for more than half a year, or Austin or Sante Fe longer than mere summers (perhaps more significant, had I lived outside rather than in those towns) likely I would know *more* country, bones and soul. As it is, only northwest Louisiana 'round about Shreveport, and the High Plains canyon country south of Amarillo, Texas, have so far claimed me truly and intimately.

In at least one of these places I consciously went native while an adult, so that I was able to observe the process and write a book that was, in effect, the natural history of a spirit of place. As animals whose evolutionary trajectory kept us intimately aware of local and regional landscapes until only the last few symbolic seconds of our species' life, we are still hardwired to experience the sort of landscape energy that undergirds place. This "spirit of place," or "sense of place" as Wallace Stegner would have it, is not an easy phrase to define. And yet I think it is a tangible phenomenon—one that has been noticed and studied for a long time now, and a phenomenon whose investigation may help explain some of the agonizing the modern American West is enduring.

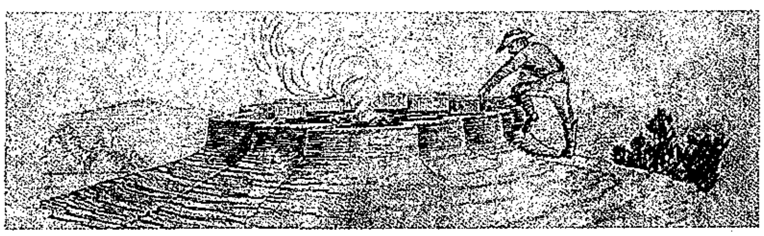
Let me say first what I do *not* mean when I use the phrase "spirit of place." "Spirit" as I am using it here does not refer to supernatural entities or qualities, but rather to essential and activating possibilities, to the vigor or the inspiration that something—in this case "place"—can impart. In the meaning that I am attributing to it here, "place" essentially means "space" (landscape) plus people. Spirit of place, in other words, is grounded in the human interaction with local environments. So investigating spirit of place is an approach for puzzling over the wonderfully diverse ways that women and men

"Beaver Head Rock and Bridge," in southwestern Montana, by Henry Elliott, 1871



Nature in the American West

"Geyser Crater, Upper Basin," now known as Teakettle Spring.



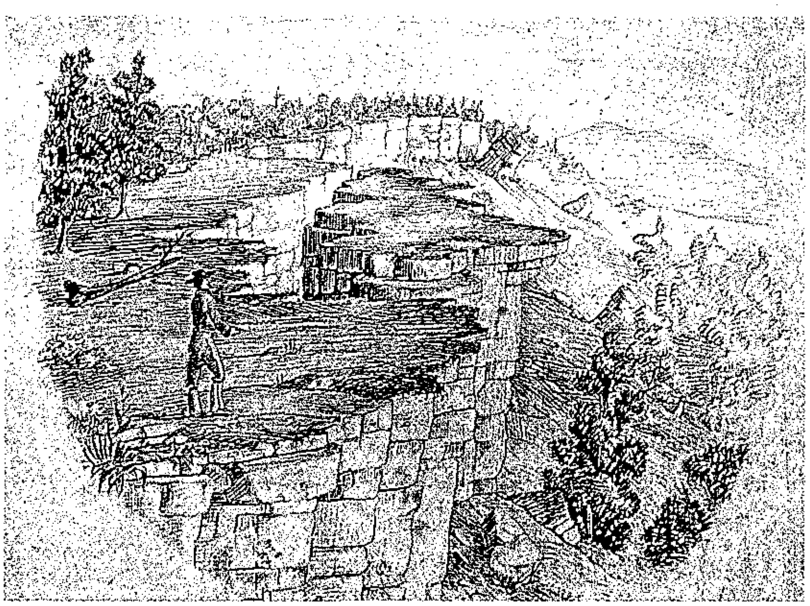
have both lived in and reacted to spaces in the landscape.

In the social sciences the term "place" is in effect a synonym of "region." I would suggest that in a more economics-oriented way, spirit of place has long been studied under the relatively mechanistic hubris of *regionalism*. This kind of regional study is, in fact, an old topic in history. In the early 20th century anthropologists like Clark Wissler and Ellen Semple argued that in pre-Columbian America, Indian cultures had arranged themselves across the continent according to general ecological boundaries (what we would call biomes or ecoregions today), so that in pre-contact North America we had a "Desert Southwest Cultural Region," a "Northeastern Woodland Cultural Region," and so forth. Regionalism (or "sectionalism") once dominated the study of American history. After penning his famous Frontier Thesis in 1893, historian Frederick Jackson Turner spent much of his remaining career on a book called *The Significance of Sections in American History*. In it he further refined thinking about the East, the South, and the West, divvying the West, for example, into four distinctive regions: the Plains, the Rockies, the Deserts, and the Coast. With the continuing spread of the Modern Industrial Age, however, most scholars expected regionalism worldwide to become a casualty of the homogenizing qualities of the global market economy. But like the prognostications of Vanishing American Indians, that prediction seems to have been premature. The emergence of environmentalist bioregionalism and the current fragmentation in Europe indicate just how powerful a force regionalism still is. Two million years of hunting and gathering immersion in place can't be purged from us easily, it would seem!

In its combination of words the phrase "spirit of place" thus refers to a more modern—one might even say more holistic—technique for examining the interaction between humans and slices of nature. Beyond mere local economies, that ought to include more esoteric interactions like art, literature, religion, and environmental adaptions, and how they are influenced by the activating inspirations of particular landscapes.

Let me say now that whether landscapes do or do not actually exude a spirit or energy that human beings actually do sense and react to is not demonstrable by any science I am aware of. Beyond simple, universal ideas about balance and harmony, aesthetics among humans seem primarily derived from culture. Yet until fairly recently in history, most human cultures fashioned themselves around the premise that nature was locally and uniquely enspirited. One example from the American West is that of the Pueblo Indians of northern New Mexico, who built rock "amplifiers" atop the Jemez and Sangre de Cristo mountains to direct the creative energy of the mountains towards their villages. The Pueblos, in other words, entertained no doubts about the energy hologram they occupied.

There is also the phenomenon of at-



Drawings accompanying this essay are by Henry Wood Elliot, an artist with the 1871 U.S. Geological Survey of the Territories under Ferdinand V. Hayden. Elliot's art is not as well remembered as that of fellow survey party member Thomas Moran, whose western landscapes became such an important force in defining esthetic attitudes toward these raw western settings, but Elliot did important journeyman work on the expedition, producing dozens of drawings that were at once diagnostic and evocative. The originals are part of the Yellowstone National Park Museum Collection. Elliot's original captions are given, along with commentary.
Left: "Old hot spring. Limestone shelving off by frosts, etc."

tachment to home places, which the geographer Yi-Fu Tuan calls "topophilia." In his book *The Territorial Imperative* of a quarter century ago, Desmond Morris pointed out that territoriality springs from the reptilian brain, the most ancient part of the human mind. And as Diane Ackermann has written more recently in *A Natural History of the Senses*, the evidence is that human evolution is so tied to topography, that our multiple senses continue such rich receptors and our brains such vivid recallers of natural signals, that all humans react emotionally to familiar home places. This emotional attachment occurs on an ascending spectrum of size scales: from hearth to locale, and even to more artificial creations like states and nations.

On the subject of topophilia, I think I would agree with Yi-Fu Tuan on several other scores. Topophilia happens most naturally not in these large creations but in places small enough to be learned well—local landscapes of familiar rocks and soils, the remembered sounds of local birds, the peculiar cycle of local seasons, the cyclically-occurring smells of conifer forests sunned to summer fragrance, or the pungent smell (almost a taste) of valley cottonwoods in the fall. But there are at least three other qualities that make up the kind of interaction with place I have become fascinated with, and that drive the rest of this essay. One is the necessity of sinking roots. "Place is pause," Tuan writes in his book *Space and Place*, an idea all of our modern literary Bioregionalists, from Gary Snyder to Wendell Berry, echo. In the American West, many of our roots are yet shallow, a possible explanation for why so much of what passes for "explanation" of the West is actually myth (think of "the Great American Desert" or "Rain Follows the Plow") imposed by those who scarcely knew the region. Transiency is rare among many peoples around the world, but is a common trait of Americans, engendering a kind of rootlessness that inhibits developing a sense of place. Transiency also inhibits a second element in developing a sense of place, and that is a shared sense of history. Whether it takes the form of mythology, folklore, or historical literature makes no difference. Where history is too short or too diffuse, spirit of place is weak, still much in flux.

But it is the role that value systems play as a kind of human template in spirit of place that is most interesting of all.

When they have studied what I am calling spirit of place, historians have done so primarily by studying modes of production, using theoretical constructs like environmental determinism or possibilism to explain how particular economies emerge in particular places. Or, they have utilized systems theory or central place theory when they have wanted to demonstrate how places are influenced by outside forces. Yet, as I've said, our reactions to landscape have not just been economic. They have also been aesthetic, creative, mythic, and entirely sensual. They have led to indigenous art, such as the painting and folk art traditions of the modern Southwest or the literary renaissance of the Northern Rockies, that express spirit of place symbolically and metaphorically. Yet even in these artistic responses—perhaps more especially in these responses—spirit of place occurs within the context of history and cultural evolution.

Let me say that in another way so that no one gets the impression that I am advocating a kind of environmental determinism. Despite our "hard-wired" biology, human perceptions and the values we place on nature are so culturally driven that we ought not to believe that certain environments exert an irresistible pull of one kind or another. Think of the diverse lifestyles on the Great Plains across the past 12,000 years. All those cultures were reacting to the same *space*, yet they created different *places*. Even in the life of a single culture, spirit of place changes over time. The phenomenon is dynamic, not static.

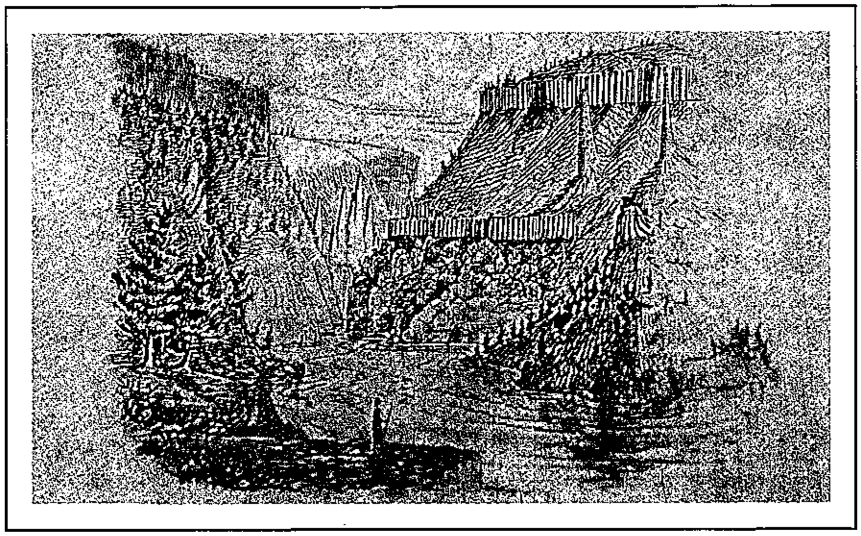
So in this tour of how spirit of place

operates, we have to consider the culturally inherited value systems (the human "software") that have to do with how humans perceive nature. Spirit of place of one kind or another no doubt exists everywhere humans have paused long enough to feel a topographic pull, but the shape and feel and taste of it will be very different from one society to the next. The upper stretches of the Ruby River or the Clark Fork in Montana no doubt fostered a kind of emerging spirit of place in the early years of Bannack or Butte—but it was a very different one from the spirit of place the New Mexican Pueblos felt in the valley of the Rio Grande, or the Mountain Crows experienced in their Absaroka homeland, or the 400 year-old Hispanic culture feels about the Southwest.

If the modern American West can be understood to function as a region with its own diverse spirits of place, then it might be useful to try to define what values of human thought have helped create our contemporary places in the West. When we speak today of "nature," "wilderness," even "ecosystems" or "sacred places," are we speaking of abstract realities or of agreed upon fictions springing from particular value systems? And what does it mean for the West as place when one set of values confronts another, perhaps newly emergent set?

Perhaps what distinguishes Euroamerican thought about nature most has been the two-thousand year perception in Western Europe of nature as a storehouse of natural resources, a storehouse that stands independent from humans, and which was specifically created for our use. This anthropocentric idea, as a host of writers have demonstrated—perhaps most accessibly Clarence Glacken in *Traces on the Rhodian Shore*, Max Oelschlaeger in *The Idea of Wilderness*, and Clive Ponting in his recent *A Green History of the World*—can be traced to a succession of rachet-like changes in the evolution of human societies beginning as far back as the Neolithic Revolution of 10,000 years ago. This abandonment of the green and leisurely world of gathering/hunting for the much harder work of agriculture and the settled life of villages and towns set in motion an initial separation of humans from wild animals, wild plants, and an intensive knowledge of local bioregions. In the literature of many modern writers, this constituted the true "fall" of humanity, cast symbolically in the Bible as the expulsion from the Garden.

The continuing development of Western ideas and values proceeded (this is a shorthand version) with the Greek idea of the existence of a human soul that is separate from the worldly realm; the Judaic idea that since humans were the only life form made in the image of God, only they possessed souls; and the Christian exorcism of the pagan *genii locii* (local spirits) from the world, a step that desacralized nature and made its conquest possible. Then came the secularization of the great mysteries of nature via the Scientific Revolution and an empirical method that initiated a general investigation of the natural laws. The Western Age of Reason (17th century) and The Enlightenment (18th century) furthered the machine metaphor for nature with Rene Descartes' model of animals as mere machines lacking either souls or consciousness, and Descartes' methodology of examining the world scientifically by starting with the known and proceeding from there. Because nature has proven so very complex, Descartes' reductionist method has tended to fragment knowledge, to divide nature into pieces for study, so that the overall tendency of science has been to lose sight of the whole.



"Basaltic columns resting upon pebbly conglomerates and granites, canyon below mouth of Tower Creek." This is the area near present Calcite Springs Overlook along the Yellowstone River.

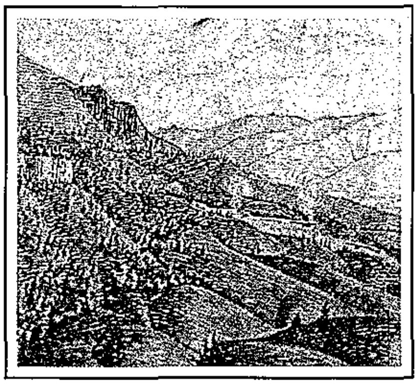
The emergence of individualism and capitalism, both linked to what the historian Walter Prescott Webb called "The Great Frontier"—the European conquest of the world and its incorporation into the global market economy—was the next step in the development of the Western conception of nature. In effect, Adam Smith saw to it that individual greed in the interest of the community good became a dominant Western value. Thus, by the 19th century, when the American West was being overrun by Euroamericans and the outlines of our present land-use system for the West were being drawn, the progression of ideas and values peculiar to the dominant Euroamerican culture began to interact with the landscape energy emanating from the Great Plains, the Rocky Mountains, the Western deserts. The result was the skeleton of spirit of place in the modern West.

This skeletal framework included, we might have to admit, some pretty peculiar ideas. Euroamericans did not apprehend, or would not admit, that the continent they wrested from the native peoples was in fact a human-shaped one. We know better today. We know, for example, that at least 12,000 years of human interaction had profoundly shaped the ecology of North America —from Paleolithic involvement in the massive ecological simplification that saw some 32 genera of large animals go extinct around 10,000 years ago (and that left our modern keystone species in place in the West), to the use of fire and other land-use modification strategies by 300 generations of Indian peoples. And yet, powerful European ideas like "Virgin America" and "Wilderness" profoundly shaped the way Americans looked at the natural world.

But by the middle of the last century Euroamericans were being shaped by some new values and ideas. The most important of them was the Romantic backlash against the Age of Reason. The Romantic Movement, begun a century earlier in Europe and influencing Americans only after about 1825, stressed intuition and emotion, which could be experienced in a transcendant way in nature as nowhere else. Mountains, regarded as chaotic warts on the landscape by Europeans during the Middle Ages, now could be and were appreciated aesthetically.

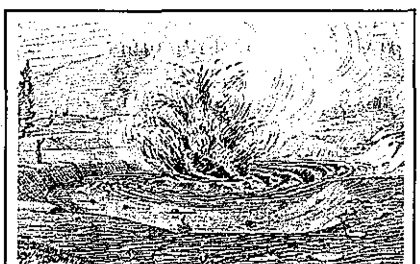
Americans also were influenced by their sense of cultural inferiority with respect to Europe, and that—coupled with aesthetic appreciation and a growing perception that there were lands in the West that were economically marginal—led to American leadership in the creation of national parks. In creating national parks, what Americans were most interested in, perhaps all the way through the early 1930s, was preserving monumental landscapes that demonstrated to the world that America was a morally superior nation because it occupied a larger-than-life, aesthetically superior continent. The implication was that a superior culture—great music, art, literature, and architecture—would emanate from such surroundings. Since monumentalism had little to do with ecology, we got artificial, linear boundaries for our parks. On the other hand, in a society where nature had become secularized, the great early national parks like Yellowstone and Yosemite began to function—and still do—as the great sacred places of American culture.

Here on the cusp of the 21st century we are still hauling all of this human baggage—a very long baggage train



"Hot springs on Gardner's River (Seen from mountains at Forks of Gardiner River)," shows the Mammoth Hot Springs area from above the mouth of Lava Creek.

extending 10,000 years and farther into the past—that we have internalized both culturally and individually, and that we are towing along with us like a brontosaurus tail. Our current struggles over relatively new ideas like Greater Yellowstone or Northern Continental Divide ecosystem protection, biodiversity, and biocentrism, have much to do with disjunctions between these internalized values and newer ones that represent a further maturing of Western spirit of place. The result has been an increasingly contentious society in the West lately. Think of it this way: Contentiousness in the modern West centers around such jarring collisions as managing for new values like ecosystem protection or natural fires, parks that were created and set in motion by older, 19th century values. Or asserting ideas like the innate rights of all life, the advantages of biodiversity, or the spiritual value of wilderness, in a cultural milieu still dominated by unquestioning acceptance of traditional anthropocentric or cost-benefit models. Or recognizing how profoundly humans



"Mud Geyser Yellowstone River, July 27th, 1871."

have occupied and shaped this continent, while managing a wilderness system based on the ancient Western ideas that humans exist apart from nature and that America was a virgin land.

I began by speaking of spirit of place because it embodies so clearly human values engaged in a dialectic with the land. The defining essence of spirit of place is not just that it occurs on a bioregional level, or that humans ought to stay put and sink roots, or even that sense of place requires a shared awareness of history to flower fully. The most important thing about spirit of place is that cultural values and human imagination determine it as much as landscape does—and that it exemplifies history's greatest lesson: everything is always changing.

As scientists have been so willing to point out, history's great flaw is that it is explanatory, but not predictive. Yet something, obviously, is happening in many parts of the West as we eye the 21st century. What Thomas Kuhn a quarter century ago referred to as a "paradigm shift"—a base change in values that occurs when sufficient anomalies crack open a long-accepted worldview—seems to have found fertile soil in many areas of the public lands West. The resulting tension between the past and the emerging future, between the old, internalized values and the new environmentalist ones, is manifest not merely in hoarse debate but in what I think may be more predictive venues, art and literature particularly, that have long sensed an impending sea change.

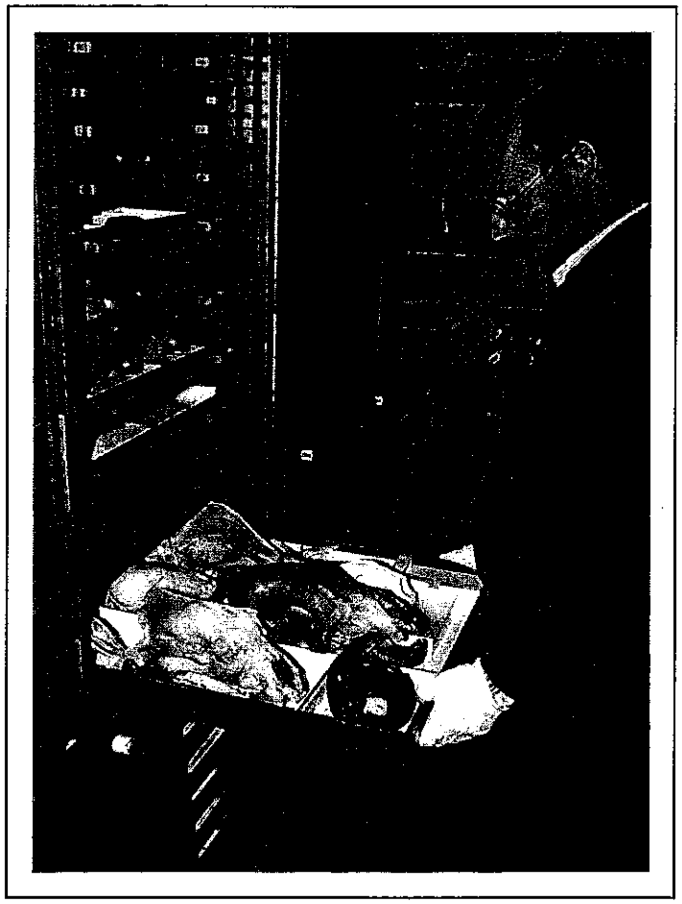
Perhaps what it all means is that after taking a hard look at ourselves and the places we've created in the vast, stunning, sunlit spaces of the American West, we are starting to assimilate, starting at last to go native. Through a shift in Western spirit of place, the most haunting landscapes on the continent may be finding a new voice.

Dan Flores holds the Hammond Chair in Western History at the University of Montana in Missoula. His most recent book is Caprock Canyonlands: Journeys into the Heart of the Southern Plains *(University of Texas Press).*

Yellowstone Science Interview:
Pete Feigley

The Greater Yellowstone Conservation Data Center

NPS /Jim Peaco



Project coordinator/zoologist Pete Feigley and a staff botanist will initially use museum specimens and herbaria to gather data for the heritage program.

A new player on the greater Yellowstone conservation scene is the Greater Yellowstone Conservation Data Center, a Natural Heritage Program funded by the Nature Conservancy with logistical support from the National Park Service. This new initiative aims to inventory and monitor a wide variety of species in greater Yellowstone, in order to improve understanding of the status and trends in ecosystem health. We spoke with project coordinator Pete Feigley, in his office at Mammoth Hot Springs, in March of 1993, about this important new venture. Ed.

YS Many people are familiar with The Nature Conservancy (TNC), but just for background, what are your goals?

PF TNC is committed to preserving natural diversity by protecting lands and waters that support representative samples of biodiversity. TNC was a spinoff of the Ecological Society back in the 1940s. It has been extremely effective, possibly the most effective environmental organization in the world, not only in purchasing conservation land, but also in working with landowners and agencies to adopt land management practices that are less intrusive on natural communities.

YS How did the heritage program come about?

PF The Natural Heritage Program was started back in 1974. Now it has progressed to where all 50 states, as well as 13 Latin American countries, have heritage programs. As TNC conserved lands and grew, its managers needed a method for inventorying plants and animals, and prioritizing critical areas.

The heritage program developed a standardized methodology for inventory and assessment that can be used anywhere in the world and can be combined into a common database. Instead of inventorying and classifying places only, the heritage programs inventory and classify elements of diversity.

Because TNC works on a continental, and even global level, the data must be organized in a consistent and objective manner. Therefore, the backbone of the heritage program is the database, the Biological and Conservation Data System (BCD).

YS How does the BCD work?

PF TNC developed computer software specifically for the Natural Heritage program to maintain consistency in data necessary for conservation. The fundamental unit of the BCD is an "element," which is an animal or plant species, or a community type. These are readily identifiable elements of biological diversity. Elements are the actual entities—species or communities—that contribute to the biological diversity of the greater Yellowstone area (GYA).

Besides the element database, there is the "element occurrence database. " Element occurrences are geographical locations where an element is present. It represents sustainable habitat, and consequently it's the fundamental unit that drives all protection of the species from a TNC standpoint.

YS Can you give me an example of an element occurrence?

PF Locations of plant populations or nesting territories of bald eagle are examples of element occurrences. In Grand Teton National Park, a graduate student was studying harlequin ducks, and though the nests were very difficult to find, he knew the ducks nested in a specific streamsite area and used a particular drainage for nesting and rearing chicks. The heritage program does not require the exact locations of each nest. Instead, the riparian area where the ducks nest is the element occurrence. That's the area you can manage for protecting the ducks—the nesting habitat. Another element occurrence might be the brood-rearing habitat, which may be on Jackson Lake. Each occurrence is a mappable and manageable area, and vital to the survival of the plant or animal.

YS What other information is in the BCD?

PF Elements and element occurrences are just a few of the databases that go into the BCD. Associated with each elemental occurrence is the source of the data, whether it came from your field notes, a graduate thesis, or a journal article. Global and state ranks or the status of each species are included. Some species may be common locally, but rare globally.

The BCD also includes extensive information on land ownership and current management practices. The heritage programs continuously monitor and update these databases, because the database must be as dynamic as the ecosystem it covers.

YS How does the Greater Yellowstone Conservation Data Center (GYCDC) fit into the picture?

PF Most heritage programs limit their area of concern to their respective state. The GYCDC is one of the few heritage programs that is a regional project. Our purpose is to look at an area that spans the boundaries of three states. TNC Field Offices of Idaho, Montana, and Wyoming are co-funding this project to get us started. The goal is to establish the GYCDC with TNC support, but eventually fund the program with federal, state, and private support just like other heritage programs.

YS So now that the GYCDC is established, where do you start?

PF First we develop an inventory of what is rare, threatened, and endangered as well as other species that may be common but suffer from some form of endangerment—whether it's isolation, habitat fragmentation, or whatever. To do this, we will coordinate all information from the three state heritage programs that falls within the boundaries of the GYA. Our sources of information will be museums, herbaria, and any other identified items that have been collected in the past. We will use this information to identify locations where we can look for existing populations of plants or mammals.

YS Will you actually go out into the field to conduct surveys?

PF Yes, that's a standard heritage program protocol. In fact, as the program matures and we get our list prioritized for species to monitor, we will continually identify areas where there are holes in the data set. Plant and animal surveys and monitoring are an integral part of the heritage program.

YS How small a critter would you try to keep track of? Diatoms in Yellowstone Lake are considered extremely vital to the well-being of the ecosystem.

PF They're also extremely sensitive to climate perturbations. Something like that, particularly if it's a rare species or an integral part of lake ecosystems, would eventually be something we may track.

YS What would you recommend to a researcher interested in collecting data so that it's compatible with the heritage program? How do they start?

PF If they're not familiar with the heritage program database, it would be useful for them to contact us to understand the information and format we're interested in. We could also provide field data forms for gathering information in a natural heritage format. As the program matures, the heritage program can provide information for the researcher or manager, as well.

YS So what are the potential uses of the heritage database?

PF The heritage program database is typically accessed by a variety of people, from scientists researching a particular organism or community, to agencies considering management or development actions. Whether it's a state transportation department proposing roads, or the Army Corp of Engineers working on a flood control project, they would probably access heritage information on distribution of species for the areas they were working in. If development is slated for a particular area, information is made available to protect sensitive areas or to support mitigation.

YS What do you consider the most exciting thing about this program?

PF I think the most exciting thing is the overall objective of coordinated management of the GYA. That, and the fact that the heritage program database is going to gather information for the conservation of biodiversity for the whole area. The GYA consists of two national parks, the John D. Rockefeller Parkway, seven national forests in three regions of the Forest Service, Bureau of Land Management lands, U.S. Fish and Wildlife Service refuges; and then on top of that there are the private holdings.

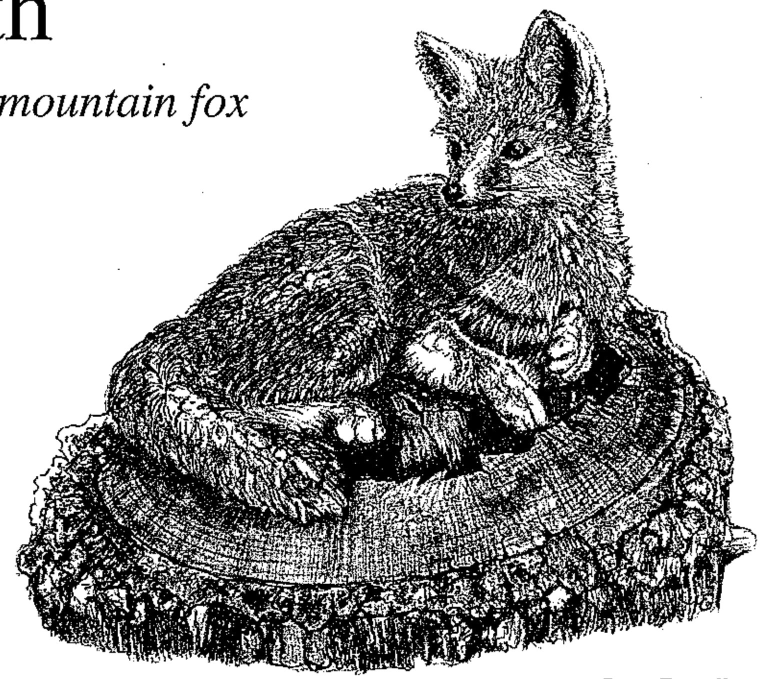
The overall coordinated management of this area requires input from the private sector as well as federal and state agencies, so it's an extremely complex system. To me that's the most fascinating aspect: the heritage program is here to have a positive influence on how the area can be managed.

For more information on the GYCDC, contact Pete Feigley, Greater Yellowstone Conservation Data Center, P.O. Box 168, Yellowstone National Park, WY 82190 (1-307-344-2157).

Gray Ghost of the Beartooth

On the taxonomic trail of the mountain fox

by Robert Crabtree



Renee Evanoff

Zero wind and clear skies at sunrise hasten the take-off of an aerial wildlife survey. Both pilot and biologist prepare themselves for a morning flight over the largest contiguous area of alpine tundra in the lower 48 states—the remote and desolate Beartooth Plateau. The low-angle sunrise backlights a grayish dog-like creature loping across an alpine meadow, not of grass but deep snow.

It is mid-January at 10,500 feet, just outside the northeast corner of Yellowstone National Park, and the creature is a fox. In areas uninhabited by coyotes during winter, Cooke City residents as well as wildlife biologists note the occurrence of these mostly gray and occasionally reddish foxes in high-elevation areas.

One ponders where this creature comes from and how it survives the harsh environment. Its presence here is even more puzzling when one realizes that this animal is considered a North American red fox—the same species as the foxes of lowland Iowa corn fields. But which subspecies is this high elevation fox? The answer to these questions lie, in part, with its surprising taxonomy and evolutionary history, or does it?

Distribution and Zoogeography

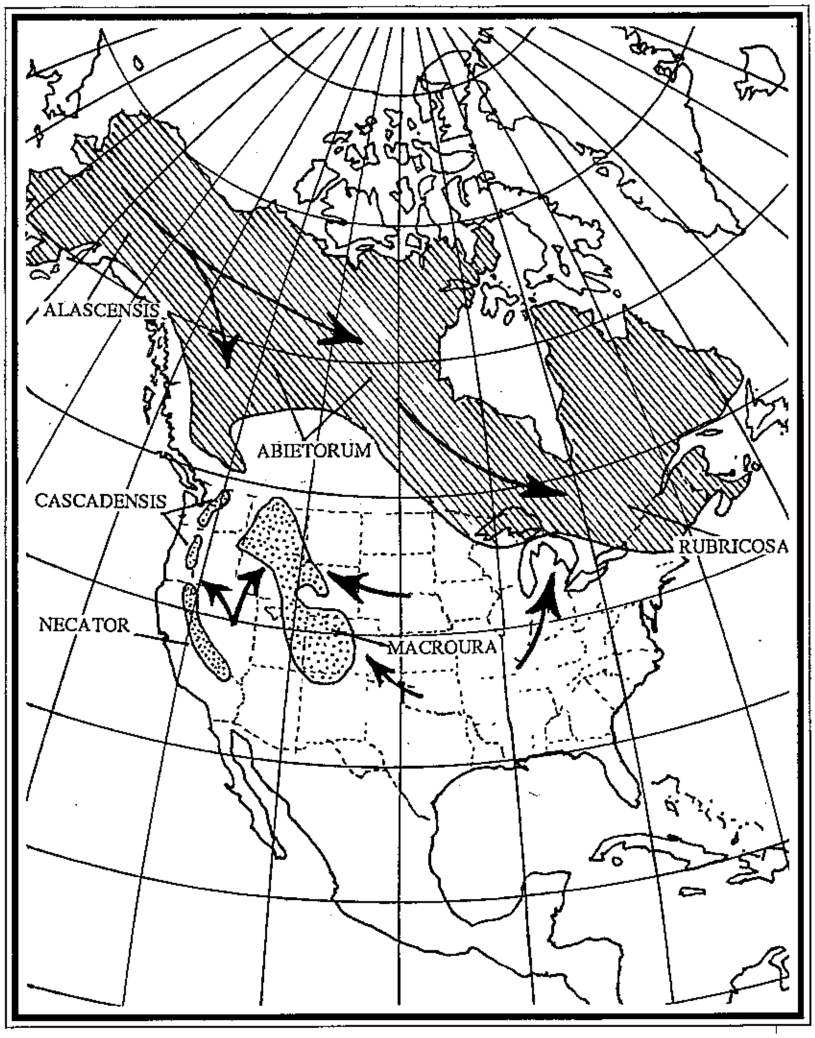
In 1900, C.H. Merriam classified the high-elevation fox of the central Rocky Mountains as a seperate species. Since then, however, all forms of North American and Eurasian red foxes have been lumped into one species, *Vulpes vulpes*, with 9 subspecies.

Three of these nine subspecies form a group collectively known as the "mountain fox." Because of the remoteness of its preferred habitat, its historically low population numbers, and its fear of human contact, this fox is rarely encountered; so little is known about it. It is restricted to high-elevation montane and alpine habitats of the Cascades (*V. v. canadensis*), the Sierras (*V. v. necator*), and the central Rocky Mountains (*V. v. macroura*), and is not predictably present even in those areas.

The oldest known North American red fox fossils are from central Alaska, and date from the Illinoian glaciation of the Pleistocene (160-130,000 years ago). These and other records indicate that red foxes originally colonized North America from Asia before the last glacial period by way of the Beringian land bridge. Red fox began to move south during the prevailing Sangamon interglacial period, and, with the onset of the Wisconsin glaciation (70-12,000 years ago), red foxes became divided by a continental ice sheet that created two refugial metapopulations: one in the Beringian area near Alaska, and the other along the unglaciated southern edge of the ice sheet.

With the retreat of the continental ice sheet, it is presumed that red foxes recolonized North America from these two refugial metapopulations. This resulted in a distribution of red fox in North America prior to European settlement that was limited to essentially two regions: the tundra and boreal forests of Canada and Alaska, and the alpine and subalpine meadows and parkland in the western mountains.

The archeological record also indicates that the indigenous red fox of North America did not exist over most of what is now the United States. Most



A theoretical distribution of the indigenous red fox in North America during the Holocene period. The subspecies, V. v. abietorum, *originated from a post-glacial northern population. The three mountain fox subspecies,* V. v. cascadensis, V. v. necator, *and* V. v. macroura, *originated from a southern refugial population as the glaciers receded. Theories suggest the fox of the Beartooth Mountains could originate from either population.*

people are surprised to learn that the current distribution of red fox in the United States is mostly the result of introduced European red foxes since the mid-1700s, supplemented by more recent fur-farm releases.

But the current distribution of the indigenous red fox did not happen simply. At the height of the Wisconsin glaciation, the distribution of red fox and their preferred habitat types included broad areas of what is now the continental United States. In the mid-West and East there was a continuous, narrow belt of tundra bordering the southern edge of glacial ice. South of this zone were wider bands of boreal forest. A similar pattern existed in the West, but was complicated by the climatic modifications of the high mountain ranges.

With the disappearance of subarctic and cool-temperate conditions, the ice sheets retreated and the preferred habitats and prey species of the red fox moved north. In the West, the subalpine and montane condtions persisted and created favorable habitats in the Sierra, Cascade and Rocky mountain ranges. Thus, the current mountain fox of the Yellowstone region may be a pure remnant of the once southern refugial population of the Wisconsin glaciation.

Still, no one is sure as to the exact origin of the mountain fox of the Beartooth Plateau. During the last few thousand years or more of the Wisconsin glaciation, the continental ice sheet was split by what is called an ice-free corridor. This corridor extended from Beringia south through Canada and down the Rocky Mountain eastern front to the Beartooth-Absaroka Wilderness area. Red fox from the northern refugium could have dispersed south much faster than was previously thought.

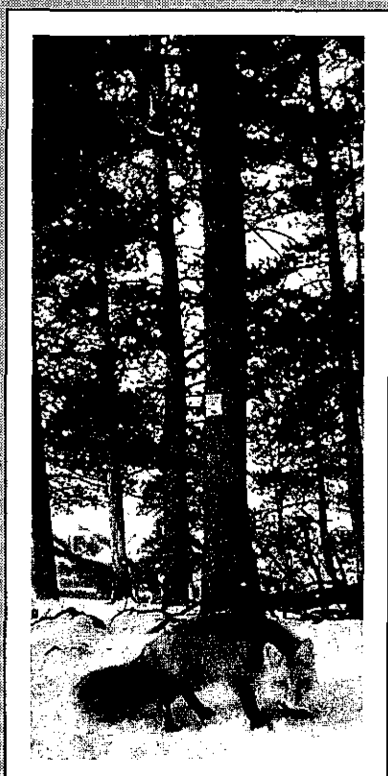
So although the mountain fox of the Beartooth Plateau appears within the presumed range of *V. v. macroura*, which live as far south as the Colorado Rocky Mountains, it may be more closely related to the red fox of the northern boreal forest (*V. v. abietorum*).

This, combined with other habitat differences and geographic insularity and distance, leaves the door open for further speculation.

The Sierra and Cascade Cousins

The three subspecies of "mountain fox" are morphologically and ecologically distinct from the red foxes of the northern boreal regions, and also from the red foxes of the central and eastern United States, which are almost certainly introduced. The Cascade red fox is described in an excellent Ph.D. dissertation by Keith Aubry, currently with the U.S. Forest Service. Extremely little is known about the Sierra red fox, and next to nothing is known about the Rocky Mountain red fox. At this point, our only hope of information and understanding of the mountain fox of the Beartooth region is through comparison with its other two mountain cousins.

Historical records of the Sierra subspecies, *V. v. necator*, indicate it originally lived primarily above 7,000 feet ranging from Mt. Shasta to the southern end of the Sierra Nevada mountains. Since early this century an apparent decline has occurred. The last decade has produced only a few sightings, with the last verified sighting being a photograph taken near Tioga Pass Resort at the east entrance to Yosemite National Park a few years ago. The State of California has classified the Sierra red



Fox Photography

Thanks to a cooperative study by the National Park Service, Earthwatch, and BioSystems Analysis Inc., a series of remote camera stations in and near the northeast corner of Yellowstone Park have yielded many photographs of the local mountain fox. In this study, Robert Crabtree and Park Service biologists Sue Consolo Murphy and Mary Harter experimented with various methods to monitor small and mid-sized carnivore distribution. These images were taken early in 1993 by tree-mounted cameras. The shutter was triggered by the animals when they broke a photoelectric beam. The larger mammal in the photo to the right is author Bob Crabtree, testing the strength of the cord to which a bait will be attached.

fox as "threatened". A status report issued in 1987 states that "the most recent summary of information on the Sierra red fox indicates a small, possibly declining population" and, "the virtual absence of data upon which to base management planning is in itself a threat to the population."

Cascade mountain foxes were found to be restricted to the subalpine meadows and parklands near the Cascade Crest and some in the high-elevation open forests of the eastern Cascade slope. Although there is a suspected overall decline this century, records reveal no significant changes in distribution since 1970. Aubry also concluded that the Cascade fox has been unable to expand distribution due to its ancestry; it is specially adapted to climatically cold, high-elevation habitats, and does not migrate to lower elevations in the winter. Food items include primarily pocket gophers, voles, snowshoe hare, birds, insects, and carrion.

In addition, Aubry presented substantial evidence that the Cascade mountain fox and the introduced lowland red fox in Washington are discrete biological entities. For example, striking differences were found between the helminth-fauna (parasites) of 13 Cascade and 14 lowland red foxes examined.

What does all this mean for the mountain foxes of the Yellowstone area? Direct extrapolation from the Sierra and Cascade cousins to the Beartooth is suspect, but several strong possibilities exist.

It is possible that the Beartooth red fox is genetically isolated from the lowland red fox. It is not probable that a lowland red fox would disperse up onto the Beartooth Plateau. Second, populations of Rocky Mountain red fox have probably declined, and even in earlier times they probably existed as a low density, isolated complex of populations. The Rocky Mountain red fox is non-migratory and is probably restricted to alpine tundra, subalpine meadows and parklands, and montane habitats similar to those favored by their cousins in the Cascades and Sierras.

Studying the Yellowstone Mountain Fox

Reviews of early accounts of the park area, and of the sightings records kept at Mammoth Hot Springs, indicate that foxes were probably more common prior to 1880 than at present. Although most animals sighted have a reddish to creamy coat color, there are consistent sightings of a gray-phase red fox. Based on reports, sightings, and interviews with local residents in and around Cooke City, the gray phase is most common and, the incidence of a permanent gray phase increases with elevation. Besides occasional sightings of the typical auburn-colored red fox in a variety of areas in Yellowstone National Park, sightings have also been reported on and around Mount Washburn (10,000 feet).

After hearing of sightings on and around the Beartooth Plateau, I became curious about them, primarily due to an experience I had with a Cascade mountain fox twelve years ago. While live-trapping lynx for a research project in the North Cascades in March of 1981, I was totally surprised to capture an old vixen red fox at nearly 8,000 feet, in five feet of snow.

Eleven years later, I decided to investigate a reported sighting around the Island Lake area near Beartooth Pass in August of 1992. I observed several tracks and scats of a canid the size of a red fox, and actually found a den on a grassy slope above Claw Lake. The den area was scattered with old bones and several marmot skulls, presumably large packages of prey brought back to the den to feed fast-growing fox pups.

While live-trapping coyotes during the past three years as part of a research project in the Blacktail Plateau and Lamar Valley areas of Yellowstone Park, researchers have captured and released two red foxes. In addition, they reported an apparent increase in red fox in the Lamar Valley area. The first two winters, we recorded only a few sightings each winter, but the third winter (1991-1992) we saw one of several different individual red foxes once every week or so.

This last winter (1992-1993), up to six different foxes were sighted nearly every day. These captures and observations were around 6,000 to 7,000 feet in elevation, which is lower than expected for a Rocky Mountain red fox. Could it be that the lowland red fox has extended its range up the Yellowstone River drainage and formed a zone of interbreeding with the Rocky Mountain red fox, or is this animal something altogether different?

This past winter (1992-1993), Sue Consolo Murphy and Mary Harter (National Park Service researchers in Yellowstone) and I undertook an extensive winter survey of medium-sized mammalian carnivores. In January and February, research teams skied transects to observe and record tracks left in the snow. We also placed out infrared-triggered cameras and hair-snag devices. The effort was quite fruitful, and we recorded numerous tracks of various species, including many coyotes and marten, several bobcats, three wolverine, four mountain lions, and presumably one fisher.

Based on visual sightings and photographs of uniquely marked red fox, we were able to identify at least twelve different individual red foxes from Geode Creek to Republic Creek near Cooke City. Several of the foxes were a creamy, bleached red, and one was a ghostly gray phase adult at Amphitheater Creek.

Again, while pondering the origin and current status of the Beartooth fox one is somewhat relieved that there is a new technique on the scientific market which could greatly increase our understanding of these mysterious creatures. It is DNA fingerprinting, which has the potential to give us additional insights into the true origins and uniqueness of the red fox in the Beartooth. This technique requires a blood or tissue sample, and is relatively inexpensive. In addition, any additional sightings or research of any kind would be a valuable contribution to our understanding of a truly unique ecosystem.

You can help us understand our region's mountain fox. Any sightings should be reported to the Yellowstone Center for Resources, Post Office Box 168, Yellowstone National Park, Wyoming 82190 (307-344-2233). The information that this paper is based on is available from me at P.O. Box 6640, Bozeman, Montana 59771.

Robert Crabtree, an adjunct professor of Biology at Montana State University, Bozeman, has been studying Yellowstone canids for several years. He is the Executive Director of the Yellowstone Project, which conducts volunteer-supported field research in the greater Yellowstone ecosystem.

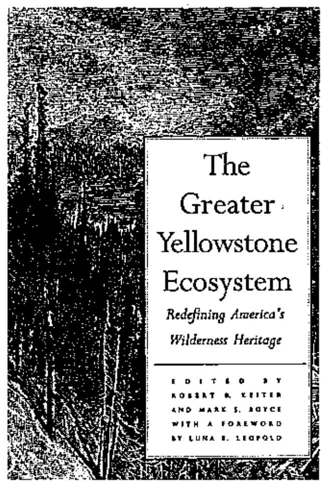
Jim Peaco/NPS

Book Review

The Greater Yellowstone Ecosystem: Redefining America's Wilderness Heritage. Robert B. Keiter and Mark S. Boyce, editors.
New Haven, Yale University Press, 1991. xiv + 428 pages; $45.00.

Stretching across millions of acres in Wyoming, Montana, and Idaho, the greater Yellowstone area is renowned for its vast, wild beauty and for the diversity and abundance of its resources. The region embraces two national parks, including the world's first such reserve, three federal wildlife refuges, portions of six national forests, and the Wind River Indian Reservation, as well as substantial tracts of state and private land. Greater Yellowstone is extraordinary for many reasons, not the least of which is that for more than a century it has served as a crucible for changing attitudes about nature and natural resources policy. Today, the greater Yellowstone area is the testing ground (some would say battleground) for a new approach to resource management, the goal of which is to maintain natural ecological processes with minimal human interference. The emergence of ecological-process management and the controversies it has sparked are the subject of *The Greater Yellowstone Ecosystem: Redefining America's Wilderness Heritage*, a collection of twenty-four essays originally presented at a 1989 symposium in Laramie, Wyoming.

The concept of ecosystem management originated in the early 1960s amidst a growing public concern about the environment. Fueled by the popularization of ecology as science and philosophy, the burgeoning environmental movement prompted a wide-ranging reevaluation of federal resource policies, including those affecting the national parks. In 1963, a federally commissioned study of park wildlife recommended a dramatic departure from traditional management practices. The Leopold Report suggested that instead of focusing on individual species, managers should think of all park features as interconnected. The goal of



management, the report urged, ought to be the preservation (or, where needed, the restoration) of natural ecological processes.

Yellowstone National Park was among the first reserves to try out the new approach, beginning with a policy of weaning bears from food begged along roadsides and consumed at garbage-dump spectacles. In the late 1960s and early 1970s, Yellowstone instituted other aspects of what came to be called natural regulation, most notably the let-burn fire policy and an end to periodic reductions of the elk herds.

Over the years, Yellowstone's natural regulation experiment has encountered many obstacles, none more perplexing than the fact that ecological relationships often extend far beyond the park's boundaries onto lands where very different management imperatives prevail. From this realization came the idea of a greater Yellowstone ecosystem. During the 1980s, the National Park Service and U.S. Forest Service began to explore ways in which to manage ecological processes across the region's jurisdictional boundaries.

In *The Greater Yellowstone Ecosystem*, scientists, legal scholars, and economists consider the ongoing debate over extending natural regulation or some version of it to the multi-jurisdictional greater Yellowstone area. Their purpose is two-fold: to critically examine the theoretical basis for ecosystem-process management and to chart out some of the scientific, legal, economic, and political constraints on implementing new management strategies.

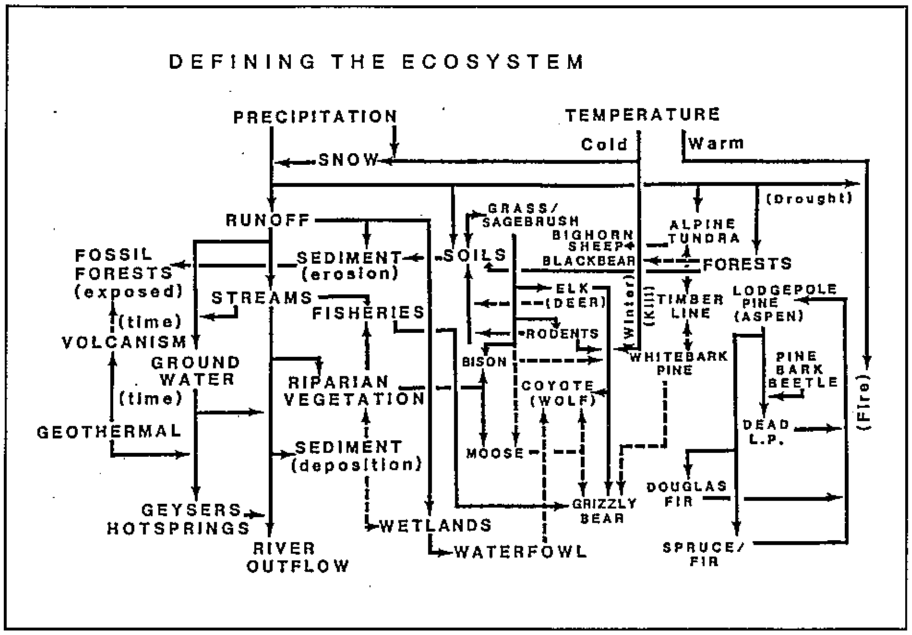
The volume begins with a somewhat disjointed set of essays intended to provide background information for the more detailed discussions in later chapters. Readers may find co-editor Robert B. Keiter's introductory essay most useful in describing the existing management practices in the region and how they have come into conflict.

More interesting by far are the three sets of topical essays that constitute the bulk of *The Greater Yellowstone Ecosystem.* These address the most controversial aspects of natural regulation in Yellowstone: fire policy, management of the northern range, and the proposed reintroduction of wolves. Non-specialists may find the technical jargon in which some of the essays are encrusted a bit intimidating, but with a little patience even the general reader will come away with a better appreciation for how new research in landscape ecology, conservation biology, paleoecology, and other fields is helping managers better understand the complex relationships that characterize the region.

The Greater Yellowstone Ecosystem concludes with an essay by the editors that nicely summarizes the difficulties confronting resource managers as they seek to devise coordinated, ecosystem-wide policies. These difficulties are substantial, indeed. Ecosystem-process management, which proposes to redefine how the region's resources are valued and used, calls into question customary ways of thinking about nature and society.

To get a sense of how profound this proposed transformation is, consider one simple question: where is the greater Yellowstone ecosystem? Despite a recent proliferation of maps purporting to show the greater Yellowstone (including one that appears as frontpiece to this volume), no one has yet to offer a definitive description of the region. The greater Yellowstone, it seems, is lost in space.

The reason this is so reveals one of the many conceptual conundrums inherent in the idea of ecosystem management. It is difficult to locate the greater Yellowstone geographically because an



The complexity of a large ecosystem almost defies comprehensive portrayal. This figure, from Duncan Patten's "Defining the Greater Yellowstone Ecosystem," Chapter 2 in the Keiter-Boyce book, is entitled" A conceptual model of the flows and interactions among many of the major components of the Greater Yellowstone Ecosystem."

ecosystem is a process not a place. An ecosystem, as Duncan T. Patten points out in his essay entitled, "Defining the Greater Yellowstone Ecosystem," is a set of processes whose coherence is relational more than spatial. Greater Yellowstone "has no definite boundaries," Patten says, "and yet it is bound by its ecological unity or cohesiveness" (p. 19). Just how mind-boggling this conceptual shift from place to process can be is illustrated by the "model of . . flows and interactions" that accompanies Patten's essay (p. 23). Contrast this chart to the reassuringly Romantic woodcut of Pumice Point by Thomas Moran on the title page or the tidy, bureaucratic map on p. xviii. Moran's sketch and the map seem familiar, comprehensible—we are accustomed to visualizing the natural world in these essentially spatial forms.

Ecological processes, on the other hand, are not easily visualized and what we cannot imagine, we find difficult to cherish. As John Varley and Paul Schullery note in their essay on the 1988 fires, support for ecosystem management will come only as the public is educated "to the aesthetics and language of natural process" (p. 118). That task is made all the more difficult because it requires people to visualize nature in a new way.

The emphasis on ecosystems as integrated, coherent processes has implications for the way nature is used as well as envisioned. In a perceptive essay entitled, "Ecosystems and Property Rights in Greater Yellowstone," Joseph L. Sax notes that Euroamericans traditionally have fragmented nature, separating out the parts of natural systems and giving owners property rights to the various pieces. This "enclosure and exclusion" helped transform America "into an agricultural (and later industrial) economy" (p. 77). In short, the imperatives of a market economy demanded a disassociated nature. Resource laws (and the institutions created to implement them) have served the purpose of destroying "functioning biological systems" (p. 77).

However regrettable that process may now seem to some people, no one can deny its integral role in constructing an economic and social system that the vast majority of Americans have supported for over two centuries. Because ecosystem management proposes to put the pieces back together, to treat nature as a whole rather than as an assemblage of exploitable parts, it implies a radical challenge to the prevailing capitalist system.

Although few advocates of natural regulation openly champion a wholesale renovation of American capitalism (indeed, most seem unwilling even to acknowledge the full portent of their particular envisioning of nature), it is precisely this implicit challenge that prompts the most virulent opposition to ecosystem management. See, for example, the essay by Karen J. Budd, which studiously avoids addressing the issue of ecosystem management at a conceptual level, favoring instead a reductionist insistence on maintaining the separate institutional mandates in which the American system of fragmented nature is embodied. Clearly, what is at stake in the debate over ecosystem management are conflicting value systems, rooted in very different ways of perceiving nature. "At the heart of the conflict," Keiter and Boyce observe, "is the question of the appropriate relationship between people and the natural environment" (p. 402).

Anyone concerned about our society's on-going re-evaluation of the human/nature relationship or the controversies that continue to swirl around the greater Yellowstone area, will find this collection of essays informative and provocative. The contributors, for the most part supporters of ecosystem-process management, articulate their positions thoughtfully and with a minimum of stridency. Throughout, all are mindful of the constraints on any management approach—limitations imposed, on the one hand, by a still-evolving scientific understanding of the region and, on the other, by the desire of a democratic society for policies that "reflect widely shared values" (p. 190). *The Greater Yellowstone Ecosystem* offers no clear solutions to the pressing issues now facing managers, but it does succeed admirably in raising the level of discourse on a subject of great importance to all Americans.

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Reorganization News: The Yellowstone Center for Resources created

At a series of staff meetings in early March, Yellowstone Superintendent Robert Barbee unveiled the new structure of research and resource management for Yellowstone National Park.

As mentioned in our last issue, the current Division of Research will be dissolved. Secretary of the Interior Bruce Babbit's plan to create a National Biological Survey (NBS), composed of scientists from several agencies, is still in too early a stage of planning at press time for us to know precisely how it will affect Yellowstone's scientific team, though it is assumed that National Park Service research-grade scientists will become part of the NBS. Until the NBS is fully constituted (see next article) park service researchers are temporarily organized as a Yellowstone Park Branch of Science, with Yellowstone wildlife ecologist Peter Gogan serving as leader.

The resource management staff, formerly under the Chief Ranger, will for the most part be reassigned to a newly created Yellowstone Center for Resources. All other personnel in the old Research Division will also be reassigned to the Center.

The primary goal of the new Center will be to provide a fresh emphasis on park resources and to elevate resource management to a level equal with other division-level park operations. John Varley will assume the title of Director of the Center, which, in addition to the temporary Branch of Science mentioned above, will have five branches: natural resources, cultural resources, strategic planning, advanced resource technology, and professional services.

The Natural Resource Branch will continue much as it has in the past, directing and coordinating numerous resource-management functions in cooperation with rangers, maintenance, and other personnel. Stu Coleman will serve as chief of this branch.

The Center draws together for the first time in Yellowstone history all cultural-resource management functions, which were previously located in several different divisions. The park's historian and curator and their staffs, as well as the library, archives, and museum collections, will move from Interpretive Division supervision to the Cultural Resources Branch, and the park's cultural resource management specialist will move from the Planning Office. Paul Schullery will serve as acting branch chief during the transition, and a full-time branch chief position will be advertised in the future.

The Planning Office, which was most closely aligned with the Park Superintendent's Office, will become the Strategic Planning Branch. This branch will be responsible for preparation of a great variety of compliance and planning documents, including environmental assessments and impact statements. John Sacklin will continue his role as chief of this operation.

The Branch of Advanced Resource Technology, which has already generated an in-house acronym (BART), will bring together several large-scale information systems, such as GIS, elements of the new Conservation Data Center, cumulative effects models, and related monitoring systems and databases. Henry Shovic, whom the park has long shared with Gallatin National Forest, will serve as chief of this branch.

The Professional Services Branch, supervised by Wayne Brewster, will continue other operations, including the publications program that currently produces *Yellowstone Science*, various public education programs, liasion with visiting researchers (permits will be handled through the Center), and other support and administrative functions.

There should be no significant changes in how Yellowstone's many visiting researchers deal with the park, except that it is the expressed goal of the Center to further facilitate coordination between researchers, resource managers, and other park staff.

National Biological Survey Announced

On April 26, Secretary of the Interior Bruce Babbit announced a complete reorganization of biological research conducted by the Department of the Interior. The goal is to coordinate all biological research in the Department under one agency, a newly created National Biological Survey (NBS).

Babbit said that "the Survey will not incorporate regulatory or resource management responsibilities. Its function will be to provide information for resource managers. The resource managers will retain responsibility for management decisions, and the decisions confronting them will largely shape the agenda of the NBS." Less formally, Babbit has said he wants to avoid "train wrecks" like the spotted owl controversy, in which he believes scientific disagreements between agencies heightened, rather than decreased, the problem of resolving complex management issues.

As of October 1, 1993, the NBS will consolidate about 1,600 scientists and support personnel from several agencies into the new agency. Until then, the details of this complicated restructuring will continue to evolve.

The NBS reorganization will be based in part on a distinction between "pure" and applied science. An Interior Department fact sheet released on April 26 summarized the distinction this way. "...most scientists involved in applying the results of biological science will remain with their bureaus. For example, there are about 4,500 Fish and Wildlife Service employees classified as biologist; and of that total, about 950 will be transferred to NBS. Researchers moving to NBS are involved in formation and testing of hypotheses, the study of population dynamics, physiology, behavior, ecology, habitats, biodiversity, and ecosystem processes and functions; and national inventories or those of national significance."

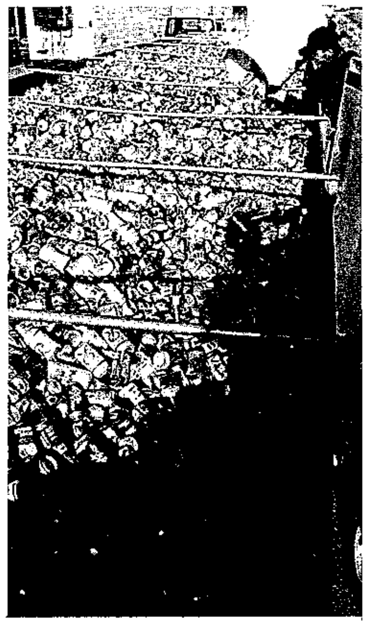
The NBS has many potential implications for Yellowstone and its science program, and we will keep you apprised of developments in future issues.

Noncharismatic Research: The Yellowstone Waste Stream

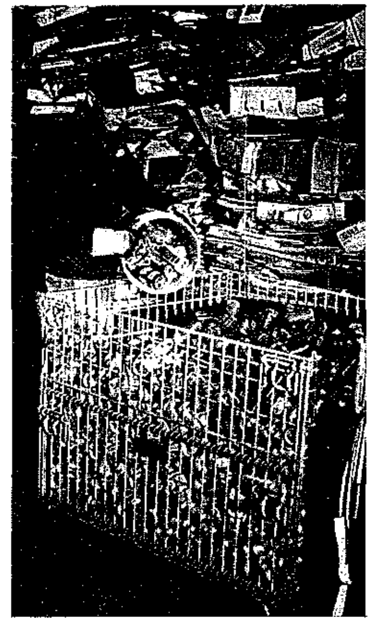
Traditionally, research in Yellowstone has focused on the natural and physical sciences, with glamorous subjects such as bears and geothermal issues getting most of the public attention. But a growing number of historical and sociological studies are changing that balance, often to the good of the park. A recent project investigated a mundane but important element of human pressure on the Yellowstone ecosystem, the solid waste produced by the park's human inhabitants.

As a gift to the park, and to celebrate 75 years as the park's sole gasoline concessioner, Conoco conducted a comprehensive study to address waste recycling in Yellowstone National Park. This study identifies the components of park waste, reviews existing waste collection and recycling practices, predicts what is available for recycling, and recommends a recycling program. The comprehensive review was titled "Yellowstone National Park Recycling Optimization Study." Supporting organizations included Du Pont (parent corporation for Conoco), James River Corp., National Park Service (NPS), Hamilton Stores, TW Recreational Services (TWRS), Yellowstone Park Service Stations (YPSS), and Richard Gamble and Associates.

The study provides a boost for current recycling programs, but is also interesting for what it tells us about what we throw away. Gamble and Associates, a consulting firm specializing in waste management, characterized components of the park's "waste stream" by sorting, characterizing, weighing, and recording 15,574 pounds of waste from various locations in the park. This represented almost a week of Yellowstone waste.



Jim Peaco/NPS



Aluminum cans are currently recycled by the truckload, but are only a fraction of the total recycled waste.

In 1991, NPS hauled an estimated 4,732,620 pounds of waste for incineration. The breakdown of the park's waste stream included: 40.1% food, 24.6% paper, 8.8% glass, 7.1% plastic, 5.2% metal, and the rest in miscellaneous items.

The recycling team also conducted a "waste audit" to identify sources of recyclable waste. The recycling team obtained 1991 computerized purchasing reports by location from TW Services, weighed recyclable packaging materials from items located throughout the facilities, and multiplied individual rates by total materials purchased to yield total available recyclable packaging materials. Of a total of 141,402 pounds of packaging materials, 61% was glass, 14% tin, 12% HDPE (plastic jars, bottles, etc.), 5% aluminum, 4% milk cartons, and 4% polystyrene.

In 1991, Hamilton Stores, TWRS, NPS, and YPSS recycled 204 tons, more than half of which was corrugated paper. In 1992, they raised the total to 303 tons.

The study targeted several opportunities for Yellowstone to recycle a larger quantity and a higher quality of recyclables. First, develop a single unified, coordinated recycling program for all parties, both concessioner and NPS. Second, use a Material Reclamation Facility (MRF) to receive, sort, store, and coordinate transportation for all recyclables. Operation of the MRF should be coordinated by the NPS, because they currently handle waste removal throughout the park, but concessioners could assist. Another option is to contract the MRF operations to an end-market recycler. Third, install color-coded "Recyclables Only" containers alongside trash containers throughout the park.

The study contained a number of other recommendations, including a visitor and staff education program, reusable tableware in concessioner food services, two-sided office copying paper, reusable shipping containers, and preferential purchase of recycled materials.

Conoco has also committed to "backhauling" YPSS's motor oil bottles from YNP to a recycler in St. Louis, Missouri, based on market availability. This single change will result in an estimated 1,944 pounds of plastic being recycled into items such as picnic tables, benches, fencing, and sign posts.

Archeology Symposium Rescheduled

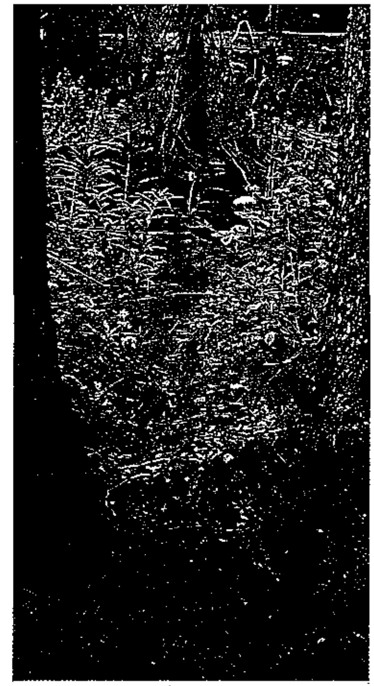
The greater Yellowstone archeology symposium, announced in our last issue as occurring in St. Louis during the annual meeting of the Society of American Archeology, has been rescheduled. The symposium will occur during the First Biennial Rocky Mountain Anthropology Conference in Jackson, Wyoming, on October 1-2, 1993. Participants will present a series of papers on the prehistoric environment and human occupation of greater Yellowstone. This multidisciplinary approach will provide an important overview of how prehistoric groups have adapted to a changing environment since the time of glacial retreat.

Kenneth Cannon, archeologist with the National Park Service's Midwest Archeological Center in Lincoln, Nebraska, notified us of the new date for the meeting, observing that, "We're very excited about the prospects for this conference and the symposium, because it provides a forum for presenting the results of recent anthropological research in the Rocky Mountains, an area that has been in the past delegated a marginal role to the rest of North American prehistory."

Clover Mist Fire Tour to Precede Conference

The Society of American Foresters and the U.S.D.A. Forest Service will host a tour on Saturday, September 18, 1993, the day before the beginning of Yellowstone's fire conference. All those planning to attend the conference are invited to attend. Participants will tour the 1988 Clover Mist Fire area east of the park, and will focus on forest management responses to the fire's effects. Starting from Cody, Wyoming, and traveling through the scenic Sunlight Basin and Clarks Fork Canyon areas, the day-long outing will provide an opportunity to view vegetation response after five years, to discuss environmental effects of the fire, and to learn about management efforts, such as salvage logging and planting.

Renee Evanoff



This is an exceptional opportunity for firsthand exposure to the effects of the 1988 fires outside of Yellowstone National Park in the company of the professionals who monitor and manage these lands.

If you are interested in participating, or desire more information about this tour, contact Joe Vessels, 409 Bluebell Lane, Worland, Wyoming 82401 (1-307-347-9871).