a code word for "we have already lost, the question is—how much." Draw a line you can hold and hold it.

Ninth, base all your decisions on the natural values of the system. Whether it be development or management decisions, always remember that for northern and remote areas; there is precious little margin of error for your decisions. Northern and remote areas are closer to absolutes than any other areas I know. One step over the line and they can become nothing more than big giant "ordinary" parks. Remember that you are managing as much a philosophy, an image, an essence, as you are managing the tangible resources that comprise that essence. The reason for the existence of the park and the reason people will come to see it is not what civilization has done, but what it has not done.

Tenth, become a spiritualist. The rewards for managers of northern and remote parks are in heaven.

[Theme paper presented at the 20th Annual Federal and Provincial Parks Conference at Ft. Selkirk, Yukon Territory, Canada.]

Chip Dennerlein, Director, Alaska Division of Parks, State of Alaska [at the time of this address]. Present address is in Anchorage, Alaska.

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The Role of Research in Wilderness

[Keynote address at the Sierra Nevada Wilderness Managers Meeting, 29-30 September 1987. Bass Lake, California]

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In the legislation creating wilderness, Congress has reflected two distinct perspectives: one is the value of wilderness to mankind through its spiritual and aesthetic qualities; the second is wilderness as the conservator of resources likely to be lost elsewhere, including whole ecosystems. Wilderness, in this alternate view, is a vessel containing precious cargo. The history of wilderness legislation reveals increasing understanding on the part of Congress that to be protected, wilderness and its resources must be managed—albeit gently—and that management in turn requires scientific infor-

mation. Finally, other places to learn about naturally functioning ecosystems are simply disappearing: wildernesses will increasingly be turned to a job other places no longer can accomplish.

The aesthetic and spiritual qualities peculiar to wilderness stem largely from the *apparent* absence of human influence. The kinds of intrusions wilderness managers and wilderness users most frequently speak of—fire pits, trail erosion, cut trees, evidence of motorized transport, water contaminated with feces, the presence of too many people—are correctable in a direct fashion as money and politics permit. Ironically, these factors generally have little influence on ecosystem function at levels where they have become intolerable to people. Thus our concern in primarily anthrocentric.

Research for Management of Wilderness

The most significant assaults on the functioning of wilderness ecosystems are typically insidious. They include air and water pollution, alien species of plants and animals (including stock), and introduced diseases. Others are "island effects," operating adjacent to unit boundaries, such as water removal or storage, fire control beyond the boundaries of the unit, or simply ecosystem alternations like agriculture or development that leave the wilderness not large enough on its own account to support some native elements or processes, such as large, mobile mammals and birds, or natural fire. Many of these anthropogenic alternations to wilderness are invisible or subtle to casual observers. Yet to ecologists and others who know the systems intimately, they are disastrous. This biocentric perspective contains another feature: any hope of reversing or mitigating these kinds of systemic changes requires a sophisticated understanding of how the system works, and that requires research.

The bulk of this research for wilderness management is in the form of inventory and monitoring. Detecting variance from natural functioning requires an understanding of what that natural functioning is. Once that underlying picture has been established, and models constructed to explain it, monitoring is necessary—indefinitely—to determine if the system is behaving as predicted. The Forest and Range Renewable Resources Planning Act (RPA) provided an impetus for the Forest Service, in particular, to begin assessing its resources.

The National Park Service incorporated inventory and monitoring into its management policies in 1987. Geographic information systems (GIS) increasingly have offered means of recording, examining, and analyzing resources information in ways far more powerful than traditional one-dimensional tabular files (such as simple counts of trees or grizzly bears). *Distribution* in space offers a second analytical dimension; stacking distributional data about different resources and different environmental factors—comparing, say, the distribution of visitors with the distribution of bighorn sheep, or of high ozone levels with injured yellow pines—provides yet a third dimension of understanding for the manager. New supermicrocomputers with ultra-high resolution color graphics and GIS programs are able to manage and represent vast and detailed information about land areas, permitting levels of understanding or planning never before possible. But first the information must be collected.

Research Impacts

While some kinds of inventory and monitoring data can be collected nonintrusively—satellite imagery, topography, or simple personal observation—many other kinds require an impact on the land and the presence of equipment. Stream gauges, air quality samplers, and weather stations are typical visual intrusions. Certain kinds of critical data must be collected destructively, such as toxics loads in animals from blood and fat, tree ring cores to measure growth rates, nutrient levels, and fire scars, or simply the trampling inherent in detailed plot work. Monitoring generally requires repeated measures taken at specified sample plots. Until global positioning systems (GPS) using navigation satellite telemetry for precise determination of locations are economically available, permanent marking of plots will be necessary. Stakes, tags, and flagging will be an unpleasant but necessary adjunct to ecosystem monitoring. Another kind of research intrusion is the transport system necessary for heavy, bulky, or specialized equipment. Pack stock, and often helicopters are necessary to move some materials in and out in a timely fashion. And lastly, some research areas must be closed to some or all public uses during the course of study, either to protect equipment or to avoid compromising the measurements being taken.

In addition to inventory and monitoring, directed studies will always be necessary to provide detailed data about a perceived system perturbance—say the decline of a native species or the appearance of an alien pathogen, and to build models to explain findings and predict the future.

Wilderness as Biosphere Reserve

A second class of research in wilderness is designed to serve not so much the particular land unit, but rather mankind's knowledge of his planet. As the least manipulated and perturbed sites on the continent, American wildernesses often are designated as the core areas of International Biosphere Reserves by UNESCO's Man and the Biosphere Program. These sites provide *control* areas against which the changes we have wrought on the planet can be measured and better understood. The research methods and impacts will be of the same sorts described above, but the benefits are designed to accrue not to the units themselves, but to society in general. Although wilderness managers have traditionally been unsupportive of such externally-driven research, there is an historic inevitability about research designed to benefit human existence.

Wilderness as Outdoor Laboratory

Traditional recreational use of wilderness (as well as grazing and other extractive activities where they are permitted) impose a cost upon wilderness. Trails, signs, and bridges, marring the wild landscape, must be constructed. Pack and saddle stock consume forage and trample meadows. Visitors disturb wildlife, catch fish, pollute water, leave trash, and periodically get lost or injured—requiring helicopter search and rescue. A balanced view, then, must permit scientific research *for its own sake* if the resource costs are commensurate with other kinds of wilderness use. Some kinds of research, for example environmental studies, ecosystem studies, and ecology, use wilderness as a grand untrammeled outdoor laboratory. Much has been learned in recent decades about predator-prey relationships, watershed hydrology, the roles of dead wood in forest systems, naturally functioning fires, natural plant aggregations, background pollutant levels—to name just a few, that could only be conducted in

wilderness settings. Even if these studies offer no direct service to wilderness management (and often they do), and claim no biosphere understanding beyond simply expanding human knowledge, *even if they serve only the scientific community*, they should not *a priori* be considered inappropriate and unwelcome as an activity in wilderness. While the standards of intrusion may justifiably be much stricter than for applied research, this kind of "recreation" is not inherently any less appropriate than backpacking or stock trips. And frequently, a clever manager can seduce scientists conducting research for their own reasons to fill information deficits.

Conclusion

I've described three classes of research that are appropriate in wilderness. While science *per se*, as a system for seeking knowledge, is inherently counterposed to wilderness as the mysterious and unknown place, it cannot be turned away on that basis. Rather, the appropriate standard that managers must apply is whether the benefits that will accrue to wilderness conservation, society in general, and

knowledge (my personal order of priority) by scientific research outweigh the costs imposed on wilderness by those research activities. That means that terribly important research may sometimes be permitted although it significantly compromises wilderness resources. Conversely, even the most fatuous research should be permitted if it imposes no more burden than ordinary recreational activities. It is the