Integrated Resource Management: Applying the Concepts of Rico and Chico to Connect Cultural and Natural Resource Management

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Introduction

PRESERVING, PROTECTING, AND PROVIDING UNIQUE RESOURCES is the foundation of the U.S. National Park Service (NPS), as expressed in eloquent, powerful language in the agency's 1916 Organic Act. For the nearly 100 years of the Park Service's existence, the resources entrusted to our care have generally been partitioned into distinct cultural and natural resource groups for the purposes of park management, with contingent effects on overall resource stewardship. We review the roots of this segregation and propose a new approach for integrated resource management as the second century of national park stewardship draws near. This approach is based on the application of three key concepts described in companion articles in this issue: the evolution of structured *decision-process* and *risk-management* procedures for setting and prioritizing resource management objectives (Marcot, this issue), the development of *hierarchical objectives* (Carter and Bennetts, this issue), and application of *assessment points* (Bennetts et al., this issue) to determine our progress at meeting these objectives.

We focus on NPS because it is the organization with which we have the most experience, and the U.S. federal land-management agency that is most directly charged with simultaneously protecting both cultural and natural resources. However, the approach and issues may be extended to other organizations entrusted with similar responsibilities. The views we express are our own; they in no way represent the formal policy or opinion of NPS.

The false dichotomy of natural "vs." cultural resources

National parks are typically categorized as "natural" or "cultural" resource units based on their enabling legislation, the public profile of the park's resources, and the focus of park management on specific resources within the unit. In 1998, the Natural Resource Management and Assessment Program (NR-MAP) formally identified all NPS units judged to have "significant natural resources" and which were, therefore, eligible for participation in several servicewide natural resource science and management programs. Implicit in this approach was that excluded units were (by default) "cultural parks." However, the vast majority of parks contain substantial (even spectacular) natural and cultural resources, and nearly all park management issues involve elements of both (Figure 1).

Classifying park units as either natural or cultural is both intuitively appealing and deceptively simple—until we consider that historic and prehistoric patterns of settlement, resource exploitation, trade, and warfare generally corresponded to the distribution, kind, and extent of particular natural resources. Today, these natural resources usually persist (albeit influenced by past and present human activities) in and around "cultural parks," and are a critical component of park narratives. From the natural resource perspective, advances in paleoecology and ethnobotany provide clear evidence that human activities have had substantial and lasting consequences for "natural" systems for at least the last several thousand years, even in lightly populated regions of the New World (Delcourt and Delcourt 2004), such as the remote landscapes of the western U.S. that contain most of the acreage of the national park system.

There are few universal truths in life, and exceptions to this composite view of natural and cultural resources certainly exist with the 390-unit park system. Units such as Independence National Historical Park or Denali National Park have very focused resource programs that strongly emphasize one category of resource over another for obvious reasons. Yet even for these unusual exceptions, composite resource management issues do occur and, perhaps more importantly, a balanced approach to resource interpretation and education apply. For example, the kind, extent, and distribution of natural resources obviously played a key role in the establishment of Philadelphia, the thirteen American

Figure 1. The vast majority of parks—such as Tonto National Monument—contain both natural and cultural resources, and management issues often involve elements of both. NPS photo.

colonies, and the rebellion that led to the creation of the United States of America. Wouldn't such detail provide for a much richer public understanding of the significance of Independence NHP and the events it commemorates? By the same token, wouldn't explaining the theory of human-caused megafaunal extinction (Barnosky et al. 2004) provide the visitor to Denali with an enhanced appreciation of the park's spectacular contemporary fauna? Would not the park *and* its visitors benefit from a broader understanding of the rapid effects of human-caused climate change through the visible impacts on Denali's major ecosystems?

Roots of the dichotomy in the National Park Service

If park cultural and natural resources are inherently linked (in most cases), why has the NPS failed to effectively integrate resource management efforts throughout the system? The roots of this problem have much to do with agency culture, staffing challenges, competing and superficially divergent professional disciplines, and the broader challenge of effective integration of science and resource management.

Agency culture. Discipline specialization came relatively late to the National Park Service. Prior to the development of the Resource Careers initiative during the 1980s, resource management was usually a collateral duty for generalist park staff who were engaged in a wide variety of park tasks, from campfire naturalist talks to trail maintenance, fire-fighting to ranger activities. Dedicated resource professional positions were concentrated in very large and high-profile parks, regional support offices, archaeological conservation centers, and university-based Cooperative Park Studies Units. This is in stark contrast to multiple-use land-management agencies such as the U.S. Forest Service and Bureau of Land Management, which had developed (to varying degrees) professional resource management capacity at the onset of agency establishment.

Why would the National Park Service wait decades to make a substantial investment in science and professional resource management at the unit scale, given the agency's challenging mandate and resource-centric mission? Richard West Sellars's (1997) excellent review of NPS natural resource preservation provides numerous explanations; perhaps the most compelling is that there was a commonly held feeling within the Park Service that because the NPS had (1) restricted the kinds and intensity of park use and (2) "fenced out" external human perturbations, science and resource management were largely unnecessary. As detailed by Sellars (1997), this approach was lacking, as perturbations both within and beyond park boundaries have had tremendous impacts on park resources throughout the system. The NPS has recently responded with initiatives to address these problems. New programs such as the Natural Resource Challenge, the Vanishing Treasures Program, Cooperative Ecosystem Studies Units, and Resource Stewardship Strategies seek to improve park management by gathering relevant resource information and improving the direct interface of scientists and managers by placing new science positions out in the field. Not coincidentally, these programs are leading the effort to integrate cultural and natural resources, and to achieve the broader goal of integrating science into overall park management for the benefit of park resources (Soukup, this issue).

Staffing and the divisional structure. With professional specialization came the divisional structure at the park level. Specific functions are currently grouped into hierarchical divisions of specialists, each with a "chief" who answers to the park superintendent. Going by a variety of titles, resource management divisions are commonly dominated by natural resource experts, whereas cultural resources are often lumped in with interpretation or resource protection. Larger parks may contain divisions of both cultural and natural resources (under whatever names); increasingly, many parks are developing integrated resource programs comprising a more-equal mixture of natural and cultural resource experts. While this evolution in divisional structure supports more effective overall resource management, unequal and inadequate staffing levels for resource professionals, and the disjunct nature of the divisional structure, still constrain effective decision-making for complex resource management issues.

"Necessity's mother." "Necessity is the mother of invention" is an often-repeated cliché. Though there are many examples in which this arguably has been the case (e.g., the Manhattan Project), it appears that exactly the opposite is more often true: imaginative inventors create out of inquisitiveness and personal interest rather than serving a specific economic or societal need. Noted ecologist Jared Diamond (1997) terms this phenomenon "necessity's mother," wherein new ideas and technology typically go looking for an application (and where successful application of new technology is itself an accomplishment).

In similar fashion, the identification and prioritization of resource issues at the individual-park scale is often highly influenced by the expertise and interest of the resident staff. For example, if your chief of resources management position is staffed by a vertebrate biologist with a particular interest and experience with bat biology, it is likely that bat research, monitoring, and management will be a major focus of the park. The bat biologist may eventually be succeeded by an archaeologist who shifts the park resource management focus to documentation and preservation of artifacts from a particular period of human occupation—probably a period and culture that she or he knows well, and that attracted that person to the position and park in the first place.

Did the issues or resources change with the position (coincidently), or are personal interests and abilities driving park resource management priorities? Park administrative histories chart the course of which resources are emphasized over time; when compared with an organizational chart of park personnel, they suggest that the latter is often the case. We tend to gravitate towards things we know and like, often oblivious to competing issues with which we are less familiar, or that have not yet been identified. This is not to say that managers have questionable motives, or even consciously move park priorities into line with their own. Rather, when park goals and issues are not clearly articulated, individual expertise and interests ("necessity's mother") can distract and distort holistic resource management.

Cultural vs. natural sciences. Perhaps the greatest barrier to the integration of cultural and natural resource management lies in differences in professional training, particularly academic training. Terms and concepts that are unique to one discipline, or have different connotations among disciplines, restrict effective communication between cultural and natural resource practitioners. Academic programs (particularly post-graduate) tend to focus on increasing specialization from a research perspective. Specialization is required as issues become more specific, but comes at the cost of common terms and concepts. Research, in the traditional sense, plays a critical but focused role in park management, as described in the companion papers in this issue. However, the prevailing views of cultural vs. natural science *research* that have developed within and between these disciplines contribute to their separation in a park *management* context.

Anthropology, archaeology, history, and other subdisciplines of cultural resource management are usually identified with the humanities (cultural sciences) or social sciences, whereas natural resources are recognized as earth and life sciences, sometimes with the sneering insinuation that the earth and life sciences are "real" science. This perception of "soft" vs. "hard" sciences is both commonplace and ironic in the context of the earth and life sciences, as these disciplines often receive the same criticism from physicists, chemists, and molecular biologists (Diamond 1997). The scientific method is often linked to the concept of manipulative experimentation under rigorously controlled environments, and in a fashion that can be repeated (Boorstin 1985). As in the cultural and social sciences, opportunities to apply manipulative experiments are much less common (but still important) in the fields of ecology, zoology, geology, hydrology, and climatology, and are usually multi-factor and not entirely free of potential external bias. As a consequence, the earth and life sciences are forced to rely heavily on observation, comparison, and "natural" experiments to complement their meager opportunities for controlled experimentation (Diamond 1997). Therefore, cultural and natural resource disciplines share many of the same limitations and methods, and both share the overall philosophy of the scientific method, if not its ability to rely on manipulative experiments.

Causality, compelling evidence, and adaptive learning. It is paradoxical that the difficulty of employing manipulative experiments and rigorous statistical hypothesis testing has helped to divide cultural and natural resource management, as classical experimentation is typically not possible, desirable, or required to evaluate most park management questions. For example, to determine the potential effects of rodents on the integrity of prehistoric structures, we might experimentally control rodent populations at varying levels at a series of randomly assigned, identical structures while controlling for external influences (not possible), evaluating any structural damage caused by the treatments (not desirable), and reporting our findings with high statistical precision and carefully worded statements of hypothesis rejection or failure to reject (not required).

We do not suggest that experimentation should not be used to evaluate park management questions. For the previous example, a focused-microcosm experiment using caged rodents and simulated structural material could have revealed important insights, such as what environmental conditions might precipitate damage or what barriers might be effective. Instead, we are making the case that direct causal explanations are not required to facilitate effective decision-making, and that our inability to conduct an experiment does not obviate the need to identify, assess, decide, and (if necessary) act upon a resource issue. We must use the tools that are available and appropriate for the issue at hand, rather than just lament the limitations of those tools.

Given that a full experimental approach is often not feasible or desirable in a park management context, an alternative is an adaptive approach to learning (Checkland 1985; Holtz 2006) and management (Williams et al. 2007). Adaptive management is a systematic approach for improving resource management by learning from management outcomes (Williams et al. 2007). Adaptive management incorporates the experimental nature of the traditional scientific method in that each management action can be viewed as an experimental treatment that can be repeated (replicated) over time.

Such an approach is an iterative process that relies on *compelling evidence* from observation, monitoring, comparison, and natural experiments, unambiguous and structured *decision processes*, explicit management *objectives*, and preplanned *assessments* at each iteration. Each of these components draws on the basic philosophy of the scientific method (Boorstin 1985) by applying critical thinking and relevant interdisciplinary information to resource protection issues (Roux et al. 2006).

Finally, we argue that the primary goals of park management (resource protection) and scientific research (reliable knowledge) are substantially different with respect to risk. For park management, we are most concerned with the risk of resource damage or loss from human activities, whereas science is most concerned with the risk of accepting incorrect information into our paradigms of how things work (be they an aquatic ecosystem or the factors that contribute to the emergence of a complex civilization). We use the remainder of this manuscript to illustrate how these ideas might be used to resolve a conflicting cultural and natural resource issue with the overall goal of minimizing the risk of resource loss.

Application of the concepts: Rodents and relics at Casa Grande Ruins National Monument

Casa Grande Ruins National Monument was established in 1892, to protect and commemorate the most-evident remains of an extensive prehistoric Hohokam agricultural complex in what is now central Arizona. The first national monument set aside to protect cultural resources, Casa Grande Ruins contains the spectacular, multi-level “big house” and archaeologically important trash middens and subterranean ruins, many of which have been excavated and investigated before being backfilled to provide some additional protection of these resources. Unfortunately, there was no equivalent method of protection for natural resources as modern agriculture and, eventually, urban development began to fragment the landscape around the ruins (Powell et al. 2006).

Occurring within the floodplain of the Gila River, Casa Grande Ruins once contained lush mesquite bosque (riparian woodland) and xeroriparian vegetation (Clemensen 1992). Frank “Boss” Pinkley was the monument’s custodian (superintendent) for 23 years in the early 20th century, a period that saw the rapid rise of livestock ranching and irrigated row-crop agriculture in the vicinity of the 480-acre monument. Reflecting on the dramatic consequences of these adjacent land uses, Pinkley remarked, in 1924, that the monument would soon be “the only bit of typical desert land in this part of the valley" (Clemensen 1992). Natural resource inventories and interpretive themes were planned and partially implemented (due to funding limitations) as early as the 1930s at this "cultural" monument (Clemensen 1992). When the results of these early efforts are compared with subsequent natural resource investigations, culminating in the vascular plant and vertebrate inventories of 2002, Pinkley's observations do not hold for the present; even the monument's ecosystems have been dramatically altered by land use outside the boundaries (Powell et al. 2006), with implications for both natural and cultural resources.

Burrowing by round-tailed ground squirrels *(Spermophilus tereticaudus)* has resulted in substantial damage to park archaeological resources from the mid-twentieth century to the present (Swann et al. 1994; NPS 1997; Figure 2). As a consequence, concerned park managers have engaged in a sporadic poisoning campaign within the monument for the past 50 years. This effort to curtail a native species that is ubiquitous in the Sonoran Desert (Hoffmeister 1986) has been very controversial, and appears to provide a clear conflict between a cultural resource objective (preserving the ruins) and a natural resource objective (protecting the native biota and ecosystem processes). In the next sections, we will suggest an approach for resolving this conflict at Casa Grande Ruins by applying the concepts presented in this issue.

Figure 2. Burrowing by round-tailed ground squirrels *(Spermophilus tereticaudus)* has caused extensive damage to archaeological sites at Casa Grande Ruins National Monument. Jim Hughes photo.

Developing objectives hierarchies and assessment points for Casa Grande Ruins. The controversy over ground squirrel control at Casa Grande Ruins is less an argument of competing objectives than one of methods. No one argues that the archaeological resources are unimportant or are unaffected by the ground squirrel activity (Swann et al. 1994). Rather, the argument is over the consequences of the methods employed (poisoning ground squirrels and potentially other "non-target" species) and their efficacy at meeting the objective (reducing damage to archaeological resources).

Confounding methods with objectives is a common problem in resource management (Carter and Bennetts, this issue). The park's Integrated Pest Management Plan (NPS 1997) focuses on methods with little discussion of specific objectives, or criteria for knowing if progress is being made toward achieving those objectives. We argue that a clear set of interconnected resource objectives must precede any substantive discussion of methods, and we propose to develop those objectives using an *objectives hierarchy* (Biggs and Rogers 2003; Carter and Bennetts, this issue).

An objectives hierarchy is "an exhaustive set of statements, from a general vision statement to statements of specific, technical objectives that provides the framework for achieving and maintaining a set of goals" (Carter and Bennetts, this issue). The general vision statement is an expansive depiction of the optimal state of park resources, free of technical jargon and often drawing on a park's enabling legislation. It might be thought of as the ideal two- or three-sentence response—understandable to the lay public—to the question, "Why is it a park?" (i.e., what is it that makes the place unique or important). Flowing from this general statement of purpose is a series of tiered objectives, each of increasing specificity and narrowing scope, which in composite provide the details that contribute to the general park vision.

The general vision statement for Casa Grande Ruins could be derived from the park's purpose as laid out in its enabling legislation: "[the] protection, preservation and care of the ruins of the ancient buildings and other objects of prehistoric interest thereon..." (Presidential Proclamation no. 1470; 40 Stat. 1818, as cited in Clemensen 1992). By incorporating other mission-defining elements such as the NPS Organic Act, NPS policies, and planning documents, we might craft a final vision statement to read something like this: "The purpose of Casa Grande Ruins National Monument is to preserve the extensive prehistoric remnants of a great Hohokam civilization, to understand the relationships between people and land that led to the rise and decline of this culture, and to relate these stories to park visitors" (Figure 3). Note that this vision statement equates the park's purpose to that of a successful public museum: the park preserves and displays the "artifacts" (cultural and natural resources) of a particular theme (the sophisticated Hohokam culture of the 13–15th centuries), actively researches these artifacts to understand the significance of the theme, and effectively communicates this knowledge to an interested public.

Figure 3. The purpose of Casa Grande Ruins National Monument is not only to preserve the extensive prehistoric remnants of a great Hohokam civilization, but also to understand the relationships between people and land that led to the rise and decline of this culture. NPS photo.

Fine-scale, technical objectives lie at the base of the hierarchy (Biggs and Rogers 2003; Carter and Bennetts, this issue). An example of a fine-scale objective might be, "Maintain the integrity of archaeological middens 'A' such that animal burrows (visible on the surface) do not occur within two (2) meters of the perimeter of the site."

The phrase "burrows do not occur within two (2) meters of the perimeter of the site" is an example of an assessment point (Bennetts et al., this issue), which is critical for linking objectives to something we can measure and interpret. If occurrence of any burrows within 2 meters of the site is an unacceptable level of disturbance, or a perceived point of imminent loss, then we would want to prepare or act before this critical level was reached. To meet this need, we would assign additional assessment points to reflect early degradation of the resource (Carter and Bennetts, this issue), and evaluate the state of the resource when those points were reached. In our example, we might set these additional assessment points at 5 meters, 10 meters, and 15 meters, perhaps with some acceptable density of burrows at the farther distances, based on (hypothetical) values in the professional literature, mandated standards, or expert opinion in any combination. An important caveat is that our monitoring techniques must be able to estimate and detect when an assessment point is reached.

Assessments points do not inherently result in a particular management action. Rather, they trigger a planned evaluation process that may result in management action, reconsideration of existing assessment points, addition of new assessment points, or research into potential mitigation techniques (Bennetts et al., this issue). These evaluations may be informal or very formal and structured, such as using decision-support tools (see below), with the latter being more critical as we approach the unacceptable state. Assessment points are also used to define our desired conditions. For example, if management actions reduced site disturbance (burrows) to 10 meters or farther from the site (again, hypothetical), we might consider the burrowing effects to be negligible, and be able to scale back our management practice (e.g., killing ground squirrels).

Use of structured decision-support tools. The advantage of having very specific objectives and assessment points is that they are clear, unequivocal, and measurable. The disadvantage of using fine-scale objectives is that there must be many of them to adequately encompass the resources and conditions defined in the general vision statement (i.e., the more specific the objectives, the more that you need). As a result, the process can devolve into a list-building exercise. The point of an objectives hierarchy is to identify and develop the most important objectives of a park, not to create a long, unordered list of nice things that someone, somewhere, would like to see at the park. It must be decided which candidate objectives will be added to the hierarchy. Objectives in the hierarchy must also be prioritized, as we can't afford to simultaneously manage for everything with equal effort. Potentially conflicting objectives (such as the ones in the original premise for our example) must also be resolved or compromised upon. Finally, the details of each objective and assessment point need to be agreed upon; for example, is "20% disturbed surface area of midden 'A'" too much? Such decisions cannot be taken lightly if the process is to be successful. *Decision-support tools* that emphasize the risk of resource damage and the feasibility of meeting the objective can help us to meet these challenges (Marcot, this issue).

Decision-support tools can incorporate multiple objectives, multiple criteria, uncertainty, and (in some cases) expert opinion (Marcot, this issue). Several decision-support tools have been developed (e.g., analytical hierarchy process, Delphi paneling process, multiple-criteria decision aid, Bayesian belief networks) to address conflict resolution and promote effective decision-making in many fields, including resource management (Marcot et al. 2006). The key features of these approaches are that they (1) seek to reduce personality-driven and "group-think" bias in the decision-making process through structured decision pathways, (2) require *a priori* determinations of multiple criteria with user-defined weighting, (3) address issues of risk (in our example case, resource damage or loss) and feasibility with user-defined standards and probabilities, and (4) effectively incorporate adaptive learning through monitoring and research (Saaty 1990; Holz et al. 2006; MacMillan and Marshall 2006; Marcot et al. 2006; Roux 2006; Marcot, this issue). An implicit advantage to structured decision-support tools is that they require us to document our assumptions, values, and criteria, such that disgruntled participants or external reviewers can track the process from initiation to outcome, even if they do not agree with the outcome. Whereas some managers may fear a loss of control over an issue, or be put off by the apparent complexities of decision-support tools, acceptance of these tools is growing in the resource management community (Marcot, this issue).

By design, adaptive approaches inject the scientific method into the decision-making process. As we have already discussed, cultural and natural resource professionals are familiar and comfortable with the scientific method, and this philosophy can serve as a unifying theme when evaluating resource objectives in a group setting. In this context, the scientific method can be thought of as critical thinking—a curious blend of open-minded, creative brainstorming and enforced cynicism, where a broad array of alternative explanations are weighed against evidence and logic, but no one explanation is wholeheartedly accepted without reservations. This philosophy and the decision-support approaches it evokes allow us to accept uncertainty as being a part of management decisions and to learn and adapt from both research and management outcomes (McDaniels and Gregory 2004). Adaptive learning (Holz et al. 2006) is a powerful tool for evaluating resource objectives and management actions and for making progress on issues that seem intractable; it clearly did not occur in our Casa Grande Ruins example, as the same management actions (principally, poisoning of ground squirrels) were pursued for 50 years without effectively meeting the broadly stated objective.

The progressive addition of new information into the decision-making process through adaptive learning reveals an important truth about the process itself: decision-making is an open-ended, iterative, and dynamic process that will persist as long as the park and the resource protection mandate persist. Adaptive learning allows us to incorporate new information, both from within the park and outside of it, such as management outcomes of new methods, relevant research results, and new policies and laws regarding park resources. The benefits of this adaptive learning process not only guide and improve management decisions, but also inform and refine the actual objectives and assessment points by codifying what is possible and evaluating how effectively resource values were translated into measurable entities.

Concluding the example. So how do these concepts fit our example and serve to integrate cultural and natural resource management in the National Park Service? Consider the likely chain of events that might have transpired if an objectives hierarchy had been developed for Casa Grande Ruins during the early 20th century. We would begin by developing a general vision statement, as described earlier, that clearly emphasized the ancient buildings and other cultural resource elements while still including natural aspects of Casa Grande Ruins, especially as they relate to the Hohokam civilization ("people and land"). The substantial interest in natural resource management and interpretation by early park managers (Clemensen 1992), albeit with few actual funded projects, is evidence that the vision may not be far off.

As each tier of the objectives hierarchy was developed, we would eventually end up with many fine-scale resource objectives related directly to cultural resources, such as the earlier example: "Maintain the integrity of archaeological midden 'A' such that no more than 20% of the surface area of the site contains active animal burrows." Fine-scale natural resource objectives would also be developed through the objectives hierarchy, though they would probably be less numerous and less emphasized than cultural resource objectives. Natural resource objectives might directly address round-tailed ground squirrels (e.g., "Maintain round-tailed ground squirrel populations with 25% of their documented population size in relatively undisturbed areas") or, more likely, address them indirectly through objectives that focused on more holistic issues of ecosystem structure and process (e.g., "Sustain near-surface vegetative cover over 65% of the park area" or "Preserve raptor populations on the park to within 30% relative abundance of reference conditions").

As assessment points were reached first for the relevant natural resource objectives, then the relevant cultural resource objectives, the structured decision-support evaluations would focus effort on mitigating or reversing the undesirable trends for both kinds of objectives. Through the adaptive-learning process, we would refine our objectives, try new approaches and methods, and eventually realize the convergence between our cultural resource problem and our natural resource issue.

If such a focused integration of science and management had occurred following the establishment of the park, then Boss Pinkley's famous forecast of 1924 might have instead been something like, "Casa Grande Ruins will soon be the only typical desert land in this part of the valley, and our science and management efforts provide clear evidence that even the monument's ecosystems are in peril. If we do not act to protect our natural systems, even the Big House ruins themselves might be in jeopardy." Perhaps such a statement, backed by the compelling evidence provided by this approach, could have rallied political support for a park expansion on a scale commensurate with the ecological processes in question. Failing that, this process could provide guidance for best management practices to maintain at least a key subset of the native ecological processes, accepting that the ecological remnants of past systems would mirror the diminished ruins themselves. Finally, the process could at least focus management effort on the successful achievement of the original concern: effective damage control for the most critical cultural resources.

Although the issue at Casa Grande Ruins is real, the application of these processes is hypothetical. However, we have proxy information that provides insights into the causes of the problems and testifies to the interconnected character of cultural and natural resource management. As described, the natural systems of Casa Grande Ruins have suffered tremendous impacts during the past century, as documented by the dramatic differences between the resources observed in the early 20th century and the present (Powell et al. 2006). These data further illustrate a natural system that is extensively modified and now dominated by the land uses surrounding the park. Many of the key predator species and their requisite habitat are now absent or greatly reduced within the park (Powell et al. 2006). Round-tailed ground squirrels have been observed extensively utilizing the surrounding farm fields for foraging while using the park (free of plowing) as "home base," developing a high density of burrows to support their nesting activities (Karen Monroe, pers. comm.). Synthesizing this information in an ecological context, Swann et al. (1994) made a persuasive case against poisoning squirrels to protect ruins, based on their habitat needs. Essentially, Swann et al. (1994) urged the park to protect the habitat and promote ecological processes (e.g., predator–prey relationships) instead of pursuing the hopeless task of treating the symptoms (i.e., rodent overpopulation). We argue that this important conclusion would have been reached much earlier (when the odds of success were greater) if an integrated approach to resource management, based on the concepts presented, had been employed long before the present.

Conclusion

As we approach a new century of National Park Service stewardship, it is vital that we reassess our approaches to managing and protecting the resources entrusted to our care. Our agency tends to view cultural and natural resources and their management in a divided context due to agency culture, history, and perceived differences between the cultural and natural sciences. We argue that this divided view is incorrect, as all parks have, at their essence, a key theme or narrative (i.e., why they're parks) that includes an interlocking mix of cultural and natural resources. The result is that resource protection issues fall along a continuum from purely natural resources to purely cultural resources, with the vast majority falling between the extremes. The example from Casa Grande Ruins illustrates this interdependence; rather than one category of resources impairing the other, as the controversy has been historically framed, the reality is that the extreme impairment of the natural biota and ecosystem processes (i.e., a system "out of balance") has had negative consequences for cultural resources.

By examining resource issues in a larger context, we realize that there is an interconnectedness that demands a re-examination of our decision-making processes. The use of decision-support tools in conjunction with objectives hierarchies makes use of structured decision processes, risk management approaches, and assessment points, and leads to an adaptive-learning process that better informs our methodology and will allow us to enter a new era of more effective resource protection and management. Integrating science into park management is a crucial step toward effective resource protection and interpretation, and it begins with an holistic approach to cultural and natural resource management.

References

Barnosky, A.D., P.L. Koch, R.S. Feranec, S.L. Wing, and A.B. Shabel. 2004. Assessing the causes of Late Pleistocene extinctions on the continents. *Science* 306:5693, 70–75.

Biggs, H.C., and K.H. Rogers. 2003. An adaptive system to link science, monitoring, and management in practice. In *The Kruger Experience: Ecology and Management of Savanna Heterogeneity*. J.T. du Toit, K.H. Rogers, and H.C. Biggs, eds. Washington, D.C.: Island Press, 59–80.

Boorstin, D.J. 1985. *The Discoverers: A History of Man's Search to Know His World and Himself.* New York: Vintage Books.

Checkland, P. 1985. From optimizing to learning: A development of systems thinking for the 1990s. *The Journal of the Operational Research Society* 36, 757–767.

Clemensen, A.B. 1992. *Casa Grande Ruins National Monument, Arizona: A Centennial History of the First Prehistoric Preserve, 1892–1992.* Washington, D.C.: National Park Service. On-line at www.nps.gov/archive/cagr/adhi/adhit.htm.

Delcourt, P.A., and H.R. Delcourt. 2004. *Prehistoric Native Americans and Ecological Change: Human Ecosystems in Eastern North America Since the Pleistocene.* Cambridge, U.K.: Cambridge University Press.

Diamond, J. 1997. *Guns, Germs, and Steel: The Fates of Human Societies.* New York: W.W. Norton.

Hoffmeister, D.F. 1986. *Mammals of Arizona.* Tucson: University of Arizona Press.

Holz, L., G. Kuczera, and J. Kalma. 2006. Multiple criteria decisionmaking: Facilitating a learning environment. *Journal of Environmental Planning and Management* 49, 455–470.

McDaniels, T.L., and R. Gregory. 2004. Learning as an objective within a structured risk management decision process. *Environmental Science & Technology* 38:7, 1921–1926.

National Park Service. 1997. *Integrated Pest Management Plan for Casa Grande Ruins National Monument.* Washington D.C.: National Park Service.

Powell, B.F., E.W. Albrecht, C.A. Schmidt, W.L. Halvorson, P. Anning, and K. Docherty. 2006. *Vascular Plant and Vertebrate Inventory of Casa Grande Ruins National Monument.* Open File Report no. 2005-11851.Tucson, Ariz.: U.S. Geological Survey Sonoran Desert Research Station,

Roux, D.J., K.H. Rogers, H.C. Biggs, P.J. Ashton, and A. Sergeant. 2006. Bridging the science–management divide: Moving from unidirectional knowledge transfer to knowledge interfacing and sharing. *Ecology and Society* 11:1, 4. On-line at www.ecologyandsociety.org/vol11/iss1/art4/.

Saaty, T.L. 1990. How to make a decision: The analytical hierarchy process. *European Journal of Operational Research* 48, 9–26.

Sellars, R.W. 1997. *Preserving Nature in the National Parks: A History.* New Haven, Conn.: Yale University Press.

Swann, D.E., W.W. Shaw, and C.R. Schwalbe. 1994. Assessment of animal damages to archaeological resources at Casa Grande Ruins National Monument. Final Report to Southern Arizona Group, U.S. Department of the Interior, National Park Service, Phoenix, Arizona, USA.

Williams, B.K., R.C. Szaro, and C.D. Shapiro. 2007. *Adaptive Management: The U.S. Department of the Interior Technical Guide.* Washington, D.C.: U.S. Department of the Interior Adaptive Management Working Group.

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