Chapter 12
Adaptive Management of India's Wildlife Sanctuaries

Paul Robbins and Anil K. Chhangani

Abstract This chapter examines India's wildlife sanctuaries as laboratories for understanding the nuanced relationship between science, democracy, and conservation. India's 523 wildlife sanctuaries have been set aside by the Indian Wildlife Act for the purpose of conserving biodiversity and the natural heritage of the county. Amidst social and economic change, these sanctuaries face the threats of urban growth, agricultural encroachment, and exploitation by mining and timber extraction. Even so, these wildlife sanctuaries cannot be considered pristine or characterized by wilderness because they have been recently created and have long been influenced by people. The purpose of this essay is to investigate the Kumbhalgarh Wildlife Sanctuary in Rajasthan in detail to understand the intertwining relationship between new institutions and complex landscapes, thereby providing a scientific opportunity to enhance our understanding of conservation science. A close examination of this sanctuary suggests: (1) ecological transitions in the sanctuary are multidirectional, (2) extensive conservation resources reside outside the sanctuary, and (3) ecological knowledge resources are extensive and untapped. These results suggest an adaptive management approach is paramount, insofar as it would take advantage of the complex dynamics of reserves, as well as the inevitable human impact on the landscape and the considerable ecological knowledge possessed by local communities.

Keywords Wildlife reserve • Human Impact • Ecological knowledge • Kumbhalgarh • Political ecology

P. Robbins (✉)
Nelson Institute of Environmental Studies, University of Wisconsin, Madison, WI, USA
e-mail: director@nelson.wisc.edu

A.K. Chhangani
Department of Environmental Science, Maharaja Ganga Singh University, Bikaner 334001, Rajasthan, India
e-mail: chhanganiak@yahoo.com

A.K. Dutt et al. (eds.), *Spatial Diversity and Dynamics in Resources and Urban Development*, DOI 10.1007/978-94-017-9771-9_12

12.1 Introduction

This chapter argues that India's wildlife sanctuaries—distinct from national parks or other kinds of designated forest areas—present unique opportunities for science, democracy, and conservation to be better intertwined. Based on observations made by Indian colleagues and naturalists in the field of conservation, and especially upon data from the Kumbhalgarh Wildlife Sanctuary in Rajasthan over the past decade, it is clear that these opportunities are predicated on the fact that most sanctuaries are not necessarily pristine areas, but are instead *recently created and long influenced by people*. The opportunities that sanctuaries present, therefore, can only be realized by admitting the following: (1) although they are wild, they are not wildernesses; (2) they can be managed to nurture a range of species, but they cannot be "restored" to an imaginary pristine condition; and (3) they will continue to be influenced by local people and some human activities, no matter what rules and restrictions are implemented for their care. Once the distracting ideals of wilderness, pristinity, and non-humanity are abandoned, possibilities for experimentation, observation, and cooperation abound. Specifically, sanctuaries open the door to (1) the implementation of adaptive management regimes where ongoing earth observation and surveying can be used to set goals and evaluate outcomes in real time; (2) the improved reliance on local, lowest-level foresters and forest guards to help evaluate, monitor, and nurture conservation; and (3) the use of citizen science data collection among local resource users. To make the most of India's sanctuaries, we must treat them as ongoing, in situ socioecological experiments, not miniature national parks.

To begin, it is essential to assert and recognize that *India's wildlife sanctuaries are a vast socioecological science experiment*. India is home to 523 wildlife sanctuaries, areas set aside by the Indian Wildlife Act to conserve the biodiversity and natural heritage of the country, which is faced with challenges of urban growth, agricultural encroachment, and reckless exploitation from industries ranging from mining to timber extraction. Although both parks and sanctuaries are critical parts of the government's extensive efforts to protect wildlife, they differ in many important respects. The characteristics of these conservation spaces, as a result, provide a remarkable opportunity to conduct a national-scale science experiment through the implementation of adaptive management. India's 99 national parks cover 39,000 km^2, but the country's wildlife sanctuaries cover nearly 119,000 km^2 (Table 12.1). At first blush, therefore, it is possible to think of sanctuaries as the leading edge of the country's efforts. However, looks can be deceiving.

Table 12.1 Number and area of India's Wildlife Sanctuaries relative to its National Parks

	Total area (km^2)	Number	Average area (km^2)
National Parks	39,155	99	396
Wildlife Sanctuaries	118,417	523	226

Source: State of the Environment Report 2009. Government of India, Delhi

Significantly, sanctuaries, although more than five times as numerous as parks, are almost half as large on average. This is no accident. Parks have been organized around single key endemic at-risk species with large home ranges and requiring large buffers (e.g., tigers and elephants), but sanctuaries have been adopted opportunistically by carving out available Reserve Forest land that provides habitat to an enormous range of miscellaneous fauna. So too, many of these sanctuary areas are small precisely because they are surrounded by, and embedded within, landscapes that have had long historical human usage as well as intensive development and habitation. If national parks represent Indian conservation's "low-hanging fruit," that is, large areas of land under mostly state control that could be more easily converted into coherent polygons for protection of keystone species, Wildlife Sanctuaries frequently represent ad hoc and interstitial spaces, lands carved on the margins and fringes of human life and industries.

In light of this, it is also notable that many sanctuaries (as well as some parks) are, on many occasions, human in genesis, their ecologies the product of the actions of rulers, farmers, and grazers, at least in part. Some of these cases are obvious ones and are internationally famous as a result. The area around the Bharatpur Bird Sanctuary (only recently converted to Keoladeo National Park) was originally flooded by Maharaja Suraj Mal around 1760 to produce hunting habitat. With more than 300 species of birds permanently resident and seasonally migrant to the site, the reserve is unquestionably an anthropogenic wilderness. Other protected areas may not be quite so dramatically artificial, but most of them, especially smaller sanctuaries, bear the marks of human action, species selection, and landscape modification. In sum, it can be observed in general that India's Wildlife Sanctuaries:

1. Opportunistically conserve areas that have a diversity of species
2. Incorporate small, fringe parcels of marginal and interstitial land
3. Have ecological parameters that often emerge directly from human actions on the landscape

These characteristics are not unique to Indian conservation areas; rather, they are part of a global trend. The number of protected areas around the world recognized by the International Union for the Conservation of Nature (IUCN) increased from 27,794 to 102,102 between 1982 and 2003. During the same period, however, the total area under such reserves increased from 8.8 million km^2 to only 18.8 million km^2. Although the number of protected areas has tripled, the average size of a protected area is almost half what it once was (Robbins et al. 2007). These new conservation territories are not only smaller, they are increasingly close to human populations, and are carved from historically settled and heavily used lands (Parks and Harcourt 2002; Zimmerer 2000; Zimmerer and Young 1998). Couple this with the fact that the establishment of a protected area tends to increase human population density in proximity (Wittemyer et al. 2008) and that proximate populations have measurable effects on land cover within conservation sites (Karanth et al. 2006). The problem of India's proliferating sanctuaries can be seen as merely part of a global trend: an exploding conservation mandate facing the diminishing margins of frontier space.

What is unclear, however, is how the large-scale, dramatic imposition of entirely new systems of (frequently draconian and restrictive) rules on human land use will affect areas long influenced by people, close to human habitation, and historically linked to human activity. India's proliferation of protected areas amidst human activity represents, therefore, an *enormous scientific opportunity* to observe the effects of new institutions on complex landscapes. By experimenting with differing rules of use, rigorously monitoring their effects on land cover and on species diversity and structure, India stands to become a world leader for in situ conservation science, for a twenty-first century in which the luxury of pristine wild spaces will be rare around the world. Beyond this, moreover, observation of current sanctuary conditions dictates that the alternative to this sort of intentional experimentation—the naïve expectation that restrictions will produce predictable human behaviors and primitive ecological outcomes—is not substantiated by the facts. Research from Kumbhalgarh Wildlife Sanctuary underlines this basic truth.

12.2 The "Bad News" from Kumbhalgarh Wildlife Sanctuary

The Kumbhalgarh Wildlife Sanctuary is a large protected area well above the national average in size at 610 km^2. Similar to almost all other sanctuaries, however, it is *interstitial*, the product of remnant Forest Department Reserve Forest land in highly marginal uplands in the Aravalli hills. As such, it spans a corridor-shaped diagonal from 73°15′E, 25°00′N to 73°45′E, 25°30′N, flanked on its northwest side by dozens of densely populated small settlements and towns. Although the reserve is lengthy, some 50 km in length, it is as narrow as 8 km in places. The morphology of the reserve is, in this sense, a classic fragment of ad hoc conservation history.

Characterized by vegetation with deciduous forest patches, the reserve is dominated by *Anogeissus pendula* (local: Dhaw), *Boswellia serrata* (local: Salar), *Acacia senegal* (local: Kumbhat), and *Butea monosperma* (local: Palas). This patchy forest cover and steep relief provide habitat for endemic wildlife species including leopard (*Panthera pardus*), hyena (*Hyaena hyaena*), Indian wolf (*Canis lupus*), Hanuman langur (*Semnopithecus entellus*), and nilgai or blue bull (*Boselaphus tragocamelus*) (Chhangani 2000). A large number of migratory waterfowl also annually visit the reserve, bolstering the diversity of its already high avian diversity.

12.2.1 Lesson 1: Kumbhalgarh Is Wild, but It Is Not a Wilderness

As a sanctuary, the reserve has obvious merits. It is biodiverse. It is a breeding site for rare species (e.g., the wolf). Despite some historical inholdings, it is under the historical control of state authorities. But its credentials are also highly suspect, at

least in terms of its status as a wilderness area. The area has been under the extractive control of the Forest Department since the colonial period. The earliest boundary pillars and administrative maps of the forest were probably first created in the wake of the 1887 Forest Survey of Marwar, after which explicit restrictions were phased in over time, subsistence practices were criminalized within forest boundaries, and the cutting of trees and the collection of non-timber forest products was forbidden (Chief Wildlife Warden Kumbhalgarh Wildlife Sanctuary 1996). But just as quickly as such local uses of the forest were banned, large-scale extraction began in earnest. Between 1900 and 1950 industrial forestry was instituted for the extraction of timber for railroad sleepers and the harvesting of *Acacia catechu*, a species now rare in the forest (Robbins 2000). This phase was followed by a period of intensive contract forestry between 1950 and 1972, when private companies leased timber extraction rights across the Reserve. The Reserve was also heavily hunted by colonial officers and local ruling elites over this period, with birds, wild boar, and top predators eliminated in numbers that are hard to estimate. The last tiger was likely shot dead before the early 1960s.

For three quarters of a century, therefore, the ecological structure, vegetation profile and density, and diversity profile of the forest were undoubtedly permanently altered. The establishment of the Wildlife Sanctuary in 1972 did not occur in a wilderness, or a place "untrammeled by man." The contemporary legacy of this extractive activity is difficult to evaluate without baseline data, which exist for very few if any of India's hundreds of sanctuaries, but Kumbhalgarh is not a wilderness. Similarly, we suggest, most of India's sanctuaries lack conditions close to anything that can be described as wilderness. These sanctuaries, therefore, must be managed without the luxury of any such assumption.

12.2.2 Lesson 2: Pristinity Is Impossible

Ideally, a wilderness management regime would seek to remove human impacts from the forest in their entirety and so allow the restoration of the landscape to a "pre-human" state, whatever that might be. There are several aspects about the current ecosystem status of Kumbhalgarh, however, that make that extremely unlikely. First among these is the absence of the historic top predator of the system. The absence of tigers from the forest means that, as a result of concomitant changes in top controls in the trophic system, nothing resembling pre-human conditions is likely to be achieved even if all human impacts were removed from the forest. By removing the "top cat," many prey species have come to thrive, possibly in populations that exceed in density those that existed before the elimination of tigers. Populations of langur monkeys, for example, and of Indian blue bulls are large and on the rise. More interesting, the absence of the apex predator has opened the habitat to the successful rise and persistence of second-tier predators, most notably the leopard and the Indian wolf, which have become keystone species for the reserve and central conservation concerns in the Sanctuary's management plan (Robbins et al. 2009).

Second, the likelihood of simple return to a prior state is drawn more dramatically into question by the ecological restructuring of the forest system resulting from invasive plant species. At Kumbhalgarh, the two central invasive species problems are *Prosopis juliflora* (known locally as Angrezi babul, Vilayati babul, and Sarkari babul) and *Lantana camera*. Both are found dominating many sections of the reserve and have expanded in coverage, especially in the past 15 years. Although the introduction of the species was anthropogenic (both were brought into the region by direct and intentional introductions by the Rajasthan Forest Department), it is extremely unlikely that a reduction of human activity in the sanctuary will lessen the rate and trajectory of their increase.

There are multiple vectors for seed dispersal among wild animal species present in the reserve, most notably with langur scat showing significant numbers of *Lantana* seeds and nilgai scat being a major source of *P. juliflora* seed distribution and reproduction. It is possible that other disturbance forces might lessen or curb the expansion of these invasives. It is not clear, for example, how the forest responds to fire events, and whether these would favor native species recovery or rather exacerbate invasives. It is also unclear the degree to which direct human removal of invasives from blocks or sections of the forest might retard their continued expansion. Each such intervention, however, would have to be considered an anthropogenic disturbance and highly experimental.

These changes and outcomes that make a restoration of pristinity impossible are not necessarily "bad" ones, especially if the conservation of wolves, panthers, nilgai, and langur monkeys, for example, is an important management goal. They merely draw into question the concept that removing human influences will lead to a creation of pristine environmental conditions at Kumbhalgarh. We suggest that for many. if not all, of India's sanctuaries, comparable arguments could be sustained.

12.2.3 Lesson 3: Human Impacts Are Ongoing and Difficult to Curb

Any plan to manage India's sanctuaries as wildernesses also confronts the very real fact that removing human influences and land uses from the forest has proven extremely difficult. Forest officers, in cooperation with state authorities and Central Government agents, have done a fairly good job of retarding the most destructive, widespread, large-scale activities in sanctuaries, including large-scale commercial forestry, most notably, as well as mining. More intractable have been the daily household extraction practices including grass and leaf collection, fuelwood harvesting, and grazing.

Kumbhalgarh is emblematic in this regard. A household survey of forest uses showed enormous and wide-scale use of forest products by residents of villages and towns adjacent to the reserve, *despite a total ban* on all such extractive activities, as of 2002. These are summarized, stratified by caste, in Table 12.2.

Table 12.2 Proportion of members of caste groups participating in specific forest uses (by percent)

	Ever collect firewood in forest	Collect firewood only in forest	Ever collect timber in forest	Ever graze CB in forest	Ever graze SG in forest	Ever collect palas in forest	Ever collect Dhav in Forest
Total ($n=708$ households)	70.1 %	48.4 %	52.0 %	48.7 %	40.3 %	25.0 %	19.0 %
Rajput ($n=71$, 10 % of all households)	70.4 %	53.5 %	29.6 %	70.4 %	7.0 %	15.5 %	2.8 %
Scheduled tribes ($n=86$, 12.1 %)	72.1 %	53.4 %	67.4 %	46.5 %	48.8 %	24.4 %	30.2 %
Scheduled caste ($n=141$, 19.9 %)	64.5 %	40.4 %	41.8 %	46.1 %	26.2 %	9.9 %	7.8 %
Jat ($n=54$, 7.6 %)	61.1 %	48.1 %	63.0 %	74.1 %	0.0 %	70.4 %	5.6 %
Rabari (n = 230, 32.5 %)	71.7 %	50.7 %	70.0 %	40.4 %	81.3 %	32.6 %	40.0 %
Brahman ($n=31$, 4.4 %)	64.5 %	38.7 %	16.1 %	48.4 %	9.7 %	22.6 %	3.2 %
Mali (n = 23, 3.2 %)	47.8 %	39.1 %	34.8 %	47.8 %	13.0 %	30.4 %	0.0 %
Vaishya ($n=21$, 3.0 %)	50.0 %	9.5 %	0.0 %	4.8 %	0.0 %	0.0 %	0.0 %
Muslim ($n=16$, 2.3 %)	62.5 %	25.0 %	25.0 %	25.0 %	18.8 %	0.0 %	0.0 %
Kumhar ($n=35$, 4.9 %)	42.9 %	25.7 %	34.3 %	71.4 %	14.3 %	11.4 %	0.0 %

Source: Robbins et al. (2007)
Respondents were allowed to provide more than one type of forest use; percentages may add to more than 100 % across caste rows. CB = Cattle/Buffalo; SG = Sheep/Goats

Notably, a significant proportion of households rely on the forest as an important basis for household maintenance and many use the forest exclusively for sources such as firewood and grazing. This study further demonstrates that the presence or absence of offsetting resources (village common grazing land, most notably) had no influence on whether households utilized the forest. The clear conclusion is that small-scale but widespread use of the reserve is pervasive and persistent, despite national and regional efforts to halt such activities. It is likely that such activities have had a negative effect on some forest canopy. Time-series analysis of satellite images of the forest suggest some loss in forest canopy, as summarized in Fig. 12.1.

What we do *not* know is the degree to which such activities and land cover changes are damaging to wildlife habitat and, if so, for which species. Given the wide range of adaptations and landscape ecologies of the diverse animal and avian species of the forest, this remains a point only for speculation. We further suggest that this situation, of ongoing human forest use in sanctuaries, is ubiquitous in the sanctuary system, and that it has proven difficult to control. We also suggest that the actual effects of this human activity remain poorly understood.

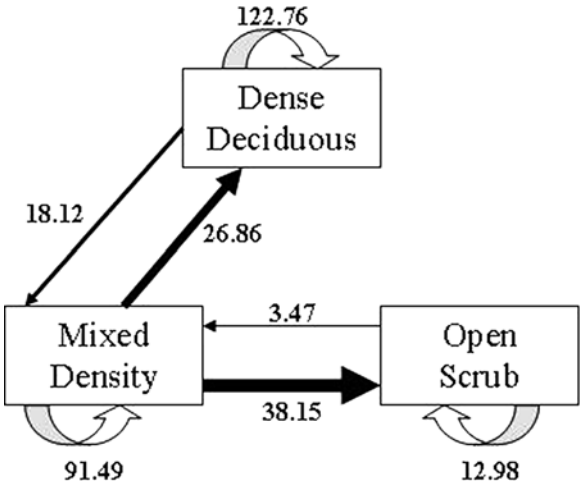

Fig. 12.1 Change in forest cover at Kumbhalgarh Wildlife Sanctuary between 1986 and 1999. (From Robbins 2000)

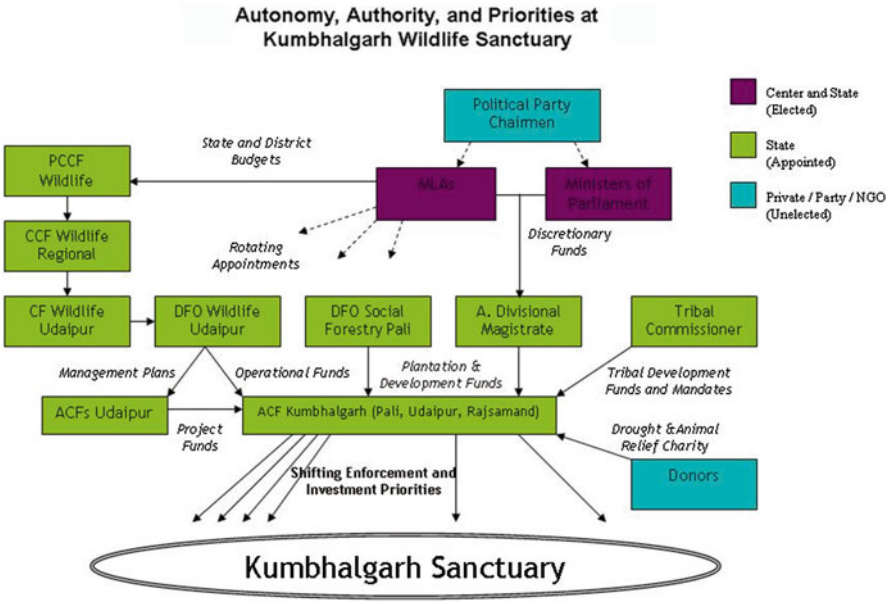

Fig. 12.2 Simplified diagram of enforcement authority at Kumbhalgarh Wildlife Sanctuary, stressing the lack of autonomy of lowest level personnel and the most local managers and observers

12.2.4 Lesson 4: Little Room to Adapt or Change Rules and Few Resources to Monitor Impacts

Given the ongoing changes in sanctuary conditions (e.g., invasive species, human uses, canopy transformations) and the complexity of its management regime, observation of the situation at Kumbhalgarh has underlined one further problem in management: the degree to which sanctuary managers have discretionary authority to adapt to changes, write new rules, and experiment with new techniques or activities (i.e., plantation or controlled use of fire). Between 1986 and 2009, the only major policy/management changes that have occurred at Kumbhalgarh have been increasing stringency in the rules against human forest use. These rules have largely been mandated from the district and divisional levels, and also from the Central Empowered Committee of the supreme court, rather from the level of the Wildlife Wardens, range officer, or foresters observing changes in habitat, cover, and animal populations locally. Figure 12.2, which summarizes the structure of decision making and flow of authority over Kumbhalgarh, in a highly simplified way, stresses the lack of autonomy and authority possessed by the most local level of wildlife managers.

This lack of autonomy means (1) that the ability to adapt or change rules or strategies in the face of ongoing change is limited, and (2) that the possibility to transmit learning or observation up the chain of control is impaired. We would further suggest that such a situation is in no way unique to Kumbhalgarh, but instead is typical of the structure surrounding all sanctuaries.

To summarize, observations of the situation at Kumbhalgarh stress that sanctuaries are not wildernesses in any real sense, that their restoration to pristine conditions is unlikely, that human use is ongoing, and that adaptive autonomy of foresters is limited. These points would all seem like "bad news" from the point of view of wildlife management.

12.3 The *Good News* from Kumbhalgarh Wildlife Sanctuary

Yet the situation at Kumbhalgarh shows remarkable and surprising conservation successes, and the potential for many more such successes through experimental and open-ended and adaptive management. Specifically, under close observation: (1) ecological change at the reserve has proven to be multidirectional, (2) the knowledge resources of local people and foresters have proven to be extremely rich, if untapped, (3) many of the conservation resources for wildlife have been demonstrated to be extensive, but that these frequently lie outside the sanctuary boundaries, and therefore success is possible.

12.3.1 Ecologies Are Multidirectional

Although it is true that heavy extractive uses of the forest at Kumbhalgarh have resulted in deleterious land cover change as described previously, it is also the case that surprising increases in forest cover can be observed. Figure 12.1 shows, for example, that change in forest density is bidirectional. Although there has been forest clearance, a significant proportion of forest cover has actually increased, especially succession of mixed-density forest to closed canopy. Further examination of the spatiality of the change suggests that both sites of forest increase and decrease occur in areas proximate to human populations. In a period of ongoing and heavy forest use, this raises a number of questions. Where precisely is forest cover increasing? What are the landscape-scale changes in forest pattern and structure? What impact does forest cover increase have on the conservation mission? The key general insight, however, is that sanctuaries can change in multiple directions. They may not be liable to recovering pristinity, therefore, but may be able to transform, even under human use, into viable and sustainable habitat.

Similarly, although decline of key species has been noted at Kumbhalgarh, many fauna have thrived under these recent transformations. Table 12.3 summarizes wildlife population change data for the sanctuary between 1991 and 2005. Some species of concern have clearly experienced precipitous declines, with implications for the sustainability of the sanctuary as a whole, especially including wolves, jungle fowl, and wildcats.

Remarkably, however, a number of other species are thriving in precisely this turbulent and dynamic environment, especially including the sloth bear and leopards, but also the elusive sambar deer. It is certainly the case that interpreting so short a data time series for a complex ecology is difficult. Species experiencing short-term declines may recover dramatically and vice versa, following classic

Table 12.3 Selected wildlife population change trends between 1991 and 2005 at Kumbhalgarh Wildlife Sanctuary

Species		1991	2005	Δ
Langur	*Presbytis entellus*	3,071	4,894	59 %
Sloth bear	*Melwasus ursinus*	105	162	54 %
Blue bull	*Boselaphus tragocamelus*	604	931	54 %
Leopard	*Panthera pardus*	54	82	52 %
Sambar	*Cervas unicolor*	88	122	39 %
Jackal	*Canis aureas*	312	300	–4 %
Hyena	*Hyaena hyeana*	125	119	–5 %
Mongoose	*Herpestes smithi*	162	149	–8 %
Wildcat	*Felis chaus*	76	65	–14 %
Grey jungle fowl	*Gallus sonneralii*	629	430	–32 %
Wolf	*Canis lupus*	85	47	–45 %

Δ refers to change (in %) in the table between 1991 and 2005

Lotka–Volterra long-wave interactions between predators and prey (Lotka 1925). Preliminary evidence suggests, however, that many of these trends are real, and the result of adaptation of species to changing conditions. Langur monkeys (which provide a key prey base for leopards), for example, have adapted to invasive species, especially *Lantana camera*, for new and expanding forage resources. Leopards have come to prey extensively on local livestock so as to maintain strong reproductive populations. These results suggest much the same implications as those for land cover. The ecology of Kumbhalgarh is going through an ongoing transformation that makes it unlikely to ever recover to pristine wilderness conditions. This caveat does not rule out in any way, however, the possibility of species-specific successes and successful conservation. What we do not know, however, is which, if any, of the anthropogenic impacts on the forest (e.g., grazing, tree clearance, grass harvesting) have come to favor which species, and why. In the absence of experimental monitoring of these impacts and direct intervention into the sanctuaries rules of access and use, these questions will remain unanswered.

12.3.2 Extensive Conservation Resources Lie Outside the Sanctuary

It is also increasingly clear that the conservation successes observed at Kumbhalgarh are not independent from human land uses and actions outside the reserve. Specifically, cropping and livestock raising unquestionably provide subsidies for conservation efforts, supporting both predatory and grazing species in the reserve.

Results from Chhangani's recent village survey (2008) reveal that approximately 75 % of households report experiencing crop raids by wild animals from the reserve, 50 % of these reporting nightly raids during the cropping season. Of these, 98.5 % report blue bull raids, 47.4 % wild boar raids, and 14.9 % raids by langur monkeys. Notably, at least two of these species are species thriving in the reserve. Although it is true that increased wildlife populations unquestionably lead to crop raiding, the reverse is also clear: agricultural resources are important to the conservation success of these species.

Much the same can be said of predatory animal activities. Of the households, 37 % report livestock loss to predators, with averages as high as 3.9 animals reported lost per month per household with large herds (local herd sizes can exceed 300 sheep and goats). Aggregating this effect over the study region, this represents losses of dozens or hundreds of animals per month, and must therefore be considered a substantial proportion of food resources for the current 129 wild predators in the reserve. Notably, 79 % of these losses were reported by herders admitting that their herds experienced this predation while grazing (illegally) within the sanctuary. Because these illegal losses cannot be remunerated, herders simply consider this an overhead operating expense, a kind of tax paid to conservation activities in exchange for grazing resources in the reserve.

Table 12.4 Species conservation success and nuisance status

Mammals of conservation concern	Households reporting nuisance (%)	Species population change 1991–2005	Species population trend 1991–2005 (% of 1991)
Blue bull	73.34	327	54.14 %
Wild boar	35.96	–408	–64.66 %
Leopard	26.79	28	51.85 %
Hyena	26.37	–6	–4.80 %
Sloth bear	23.69	57	54.29 %
Jackal	20.73	–12	–3.85 %
Langur	18.19	1,823	59.36 %
Wolf	08.46	–38	–44.71 %
Four-horned antelope	00.00	–105	–49.76 %
Chinkara gazelle	00.00	–27	–72.97 %

Source: Chhangani et al. (2008)

Table 12.4 summarizes the relationship between conservation successes and nuisance status for key species of concern. Clearly there is a positive relationship overall between the ability of animals to access important resources from outside the reserve and their ability to thrive and so meet the conservation goals of the reserve.

Nor is any of this unique to Kumbhalgarh. The great success of the aforementioned Bharatpur Reserve, which notably attracts hundreds of species of migrant birds annually, is precisely a result of the fact that its wetland marshes are surrounded by grain fields rich in forage resources and nest thatching. The success of many such reserve "islands" is likely linked to their surroundings. This likelihood is reinforced by the findings of Jai Ranganathan and colleagues (2008), who have established that avian diversity in production-oriented forests associated with betel nut production is equal to or higher than that of nearby conservation forests. That there is some interaction between these "natural" and "artificial" landscapes in the conservation of species in difficult to doubt. Thus, the good news from Kumbhalgarh, applicable to other sanctuaries in India, is that conservation success can be as much *aided* as thwarted by humanized resources and activities in the areas surrounding reserves.

12.3.3 Ecological Knowledge Resources Are Extensive but Untapped

Equally good news from Kumbhalgarh is the increasing evidence that local producers and local foresters have extensive ecological knowledge of forest conditions. A great deal of attention is paid (around the world and in the United States as much as in India, it should be noted) to the ecological knowledge of local people. Surveys of local people suggest that producers who use forest resources can identify dozens

of species, can enumerate the interactions between human and climate impacts and species distribution (Robbins 2000), and can identify the range and habits of most local fauna. They know where panthers, sloth bear, and wolves predominate and can track their observations and encounters over time. Although this knowledge is occasionally brought to bear on individual management challenges (for example, finding a nuisance predator preying on village sheep), there is currently no formal way for local information about plants and animals to be used in the design of rules or the execution of conservation activities.

Much the same can be said of forester knowledge. Most of the foresters at Kumbhalgarh have been in their posts for more than 20 years. Their amassed collective knowledge of plant and animals species has, unsurprisingly, proven enormous. And yet, as for that of local people, the foresters' knowledge goes largely untapped. When researchers from the School of Desert Sciences conducted a training of foresters to collect botanical information at sites throughout the forest in 2006, foresters demonstrated knowledge of almost all tree, shrub, and grass species in the forest and the favorability of specific floral configurations for habitats of birds and mammals. At the conclusion of the exercise, however, foresters noted that this was the first "actual forestry" they had been called upon to do for many years. As the previous generation of foresters continues to age, moreover, it is entirely unclear that the next generation of practitioners, although well trained in geographic information science and other critical skills, will possess anything close to the contextual ecological knowledge required for success of the Sanctuary's mission. Nor is it clear how current institutional configuration might take advantage of that knowledge, assuming they had it.

In sum, Kumbhalgarh is a reserve that is deeply humanized and impossible to restore to a pristine state, but it is also one where conservation successes are ongoing, where resources exist both inside and outside the forest to conserve critical species, and where local people and foresters possess extensive knowledge. What form of management might take advantage of the inevitable dynamics of the reserve, the extensive reality of human impact, and the intellectual and knowledge base possessed within local communities and the forest department itself?

12.4 Adaptive Management: A Modest Proposal

The answer must be adaptive management. Adaptive management (following Holling 1978) is here understood as a management regime that proceeds based on the assumption that the way the managed system operates is *poorly understood and unpredictable*. Such an assumption, as we have demonstrated here, definitely applies to Kumbhalgarh and probably applies to almost all reserve areas. With that in mind, management decisions are made to intentionally provoke experimental conditions. By simultaneously implementing varied policy treatments and then comparing their results, it is possible to test hypotheses about the behavior of complex systems, even while managing them for desired outcomes.

> Experimentation in this sense goes beyond management through trial and error and casual observation; it is structured and theoretically driven, designed to elicit specific responses from systems under study such that new knowledge can be incorporated systematically into future treatments…. The approach also recognizes that managed systems present moving targets influenced largely by human drivers and, therefore, explicitly incorporate these human factors into management experiments. (Arvai et al. 2006, p. 218)

When applied to Kumbhalgarh, and by implication to all Sanctuaries in India, what this would entail is (1) the *freedom* to adapt and invent new conservation rules, (2) the *opportunity* to directly intervene in environmental systems, (3) the *necessity* of democratic and scientific monitoring, and (4) the *obligation* to change rules to create new outcomes.

12.4.1 The Freedom to Adapt and Invent New Rules

Because India's wildlife sanctuaries are by their nature experimental, there is no reason to believe that any given, centrally determined rule system (e.g., one that disallows grazing, no matter what, everywhere, all the time) will always help to achieve conservation goals, under all circumstances. As a result, it is essential to deliberately design experimental interventions in reserve rules, *based on what we want to know* (e.g., how do grazed areas actually differ from ungrazed ones?). The development of these rules would necessitate allowing responsible regional and local authorities, in consultation with appropriate experts from the Indian Wildlife Institute, for example, the freedom to invent management rules that may differ from those of other reserves, and that may be uneven across a single reserve, as where part of a reserve may be subjected to a treatment, such as allowing grazing, deliberate burning, or plantation of a specific species, and other parts of the reserve kept as untreated controls.

12.4.2 The Opportunity to Intervene

These rules must then lead to deliberate human actions that follow from the designed rules. For conservation, the list of interventions is lengthy, but some areas or subareas would have to have grazers removed under full enclosure but others would allow them access, for example. Some areas might be subject to plantation while others to deliberate species removal (of exotics, for example). Fire might be applied in some areas and withheld elsewhere. Culling of species might take place, or reintroduction. By admitting that human actions in part craft the landscapes of conservation, no single management technique should, a priori, be eliminated from consideration as a tool for any given reserve.

12.4.2.1 The Necessity of Democratic and Scientific Monitoring

None of these interventions makes any sense if the outcomes are not monitored. To know whether a specific practice has a significant result requires conditions to be observed before, during, and after new rules are implemented. Such monitoring, across more than 500 reserves, would be too resource demanding. Fortunately, available resources are more extensive than previously recognized.

In the first place, the power of remotely sensed data, both from India's own impressive satellite systems as well as those of other international consortia (e.g., SPOT Image), allows regular, controlled, monitoring opportunities, at least of land cover change in Reserves. By better coordinating the monitoring activities of the Indian Space Agency with local reserve manager needs, more deliberate efforts can be made to test specific hypotheses. Remotely sensed data are, by their nature, limited in resolution and their ability to discern relevant objects. Wildlife themselves, along with specific distributions of floral resources and habitat conditions, will necessarily require monitoring at a finer scale. Here, the vast and totally untapped knowledge of local people and foresters might be brought to bear.

In terms of forestry, the role of local foresters and cattle guards in recording and monitoring environmental conditions has been extremely limited, and on the decrease in the period since forests set aside for economic production have been transitioned to sanctuary status. For adaptive management to work, the lowest level foresters would need to be empowered to collect data (e.g., scat, pugmarks, etc.) not only during the periodic census that now constitute the forest mandate, but on a rolling and deliberate experimental basis, precisely to sample the forest to discern meaningful differences or changes where new rules have been implemented.

But even full forester participation would likely be unequal to the data challenges of an adaptive regime. Citizen science, where monitoring, reporting, and accounting for local species is performed by the people themselves (Irwin 1995), is the only viable model for decentralized experimental sanctuary design and management. The incentive for participation in such activities, especially on the part of local producers, is necessarily their inclusion in the decision-making process and rule crafting, the forwarding of actual researchable questions, the allowance of their uses of sanctuary areas under certain regime conditions, and/or their share in any remunerative benefits of conservation. More than participatory management, therefore, there is a need for *participatory science*.

12.4.3 The Obligation to Adapt

Finally, any effort at adaptive sanctuary management requires that once an outcome has been observed for better or for worse or, whenever a change in conditions occurs for reasons exogenous to management plans (as a result of climate stress, for example, or catastrophic events), it is necessary to change the management rules. The challenge that such an approach represents is profound, because it requires a

reorientation of thinking within management bureaucracies. Managers must be allowed to consider new conditions and imagine different outcomes. In so doing, they can then begin the consultative process of designing changes to existing rules, precisely to test new ideas about how the managed system works. By allowing change, new techniques must be allowed for conservation on a continuous basis, so that managers can be made ready to prepare for contingency and empowered to make substantive and desirable changes.

12.5 Conclusion

The barriers to such a change in mental outlook within sanctuary management in India are precisely those that opened this essay, however. Assuming that wildlife sanctuaries are wildernesses, that they can be conserved back to a pristine state, and that human impacts can be fully disallowed in conservation areas, makes it literally impossible to even imagine adaptive governance. It further imposes an undemocratic and necessarily unscientific attitude toward wildlife governance, excluding the possibility that wildlife scientists, foresters, and local people might pursue answerable questions to preserve wildlife, precisely by sharing the forest. As we have tried to demonstrate here, these assumptions are empirically unsustainable and politically dangerous. They are bad for panthers and for people. By jettisoning these impediments for India's sanctuaries, the country can lead the way internationally, through its ongoing experiment to save the country's treasured wild heritage.

References

Arvai J, Bridge G, Dolsak N, Franzese R, Koontz T, Luginbuhl A, Robbins P, Richards K, Korfmacher KS, Sohngen B, Tansey J, Thompson A (2006) Adaptive management of the global climate problem: bridging the gap between climate research and climate policy. Clim Change 78(1):217–225

Chhangani AK (2000) Ecobehavioural diversity of langurs (*Presbytes entellus*) living in different ecosystems. Unpublished Ph.D. thesis. J. N.V. University, Jodhpur

Chhangani AK, Robbins P, Mohnot SM (2008) Crop raiding and livestock predation at Kumbhalgarh Wildlife Sanctuary, Rajasthan, India. Hum Dimens Wildl 13(5):305–316

Chief Wildlife Warden Kumbhalgarh Wildlife Sanctuary (1996) Management plan: Kumbhalgarh Wildlife Sanctuary 1996–1997 to 2000–2001. Rajasthan Forest Service, Udaipur

Holling CS (1978) Adaptive environmental assessment and management. Wiley, New York

Irwin A (1995) Citizen science: a study of people, expertise, and sustainable development. Routledge, New York

Karanth KK, Curran LM, Reuning-Scherer JD (2006) Village size and forest disturbance in Bhadra Wildlife Sanctuary, Western Ghats, India. Biol Conserv 128:147–157

Lotka AJ (1925) Elements of physical biology. Williams & Wilkins, Baltimore

Parks SA, Harcourt AH (2002) Reserve size, local human density, and mammalian extinctions in U.S. protected areas. Conserv Biol 16:800–808

Ranganathan J, Daniels RJR, Chandran MDS, Ehrlich PR, Daily GC (2008) Sustaining biodiversity in ancient tropical countryside. Proc Natl Acad Sci U S A 105(46):17852–17854
Robbins P (2000) The practical politics of knowing: state environmental knowledge and local political economy. Econ Geogr 76(2):126–144
Robbins P, Chhangani AK, Rice J, Trigosa E, Mohnot SM (2007) Enforcement authority and vegetation change at Kumbhalgarh Wildlife Sanctuary, Rajasthan, India. Environ Manag 40(3):365–378
Robbins P, McSweeney K, Chhangani AK, Rice JL (2009) Conservation as it is: illicit resource use in a wildlife reserve in India. Hum Ecol 37(5):559–575
Wittemyer G, Elsen P, Bean WTA, Burton CO, Brashares JS (2008) Accelerated human population growth at protected area edges. Science 321(5885):123–126
Zimmerer KS (2000) The reworking of conservation geographies: nonequilibrium landscapes and nature-society hybrids. Ann Assoc Am Geogr 90(2):356–369
Zimmerer KS, Young KR (1998) Nature's geography: new lessons for conservation in developing countries. University of Wisconsin Press, Madison