

Cattle and Conservation at Bharatpur: A Case Study in Science and Advocacy

Michael Lewis

For generations of ecologists and park managers throughout the world the destructive nature of livestock grazing on natural systems was so apparent that it never even needed to be discussed. Based on this insight, a ban on livestock grazing was put into practice in US national parks, and written into law in India. At Keoladeo Ghana National Park in Bharatpur, this received wisdom did not have the desired effect of improving the health of the ecosystem. When cattle were banned in 1982, the park's habitat began a slow decline. Through a discussion of debates about grazing in national parks in India in the 1960s, and focusing specifically upon Keoladeo Ghana National Park, this case study challenges the attempt to search for universal conservation truths to be imposed throughout the world. This article does not deny that ecology is a valuable tool for making conservation decisions, but rather claims that the attempt to apply ecological insights as universal conservation truths is highly problematic, fraught with risks, easily politicised and frequently ineffective.

INTRODUCTION

WHEN I SEE a cow, I see culture—or at least a series of associations about what a cow means. Certainly, I see the animal itself, its colour, its size and its condition. But I also give meaning to what I see. The meanings I attach to cows are starkly different than the meanings given to these animals by most Hindus, for whom cattle are sacred, or different still from the meanings associated with cattle by rural Indians—Hindu or Muslim—for whom cattle (as sources of milk if female, as work animals for ploughing or carrying goods to market if male or as sources of dung for cooking fires) are an essential part of their subsistence. It would not

Michael Lewis, History Department, Salisbury University, Salisbury, MD 21801, USA.

be surprising, then, if the way I feel about cattle in national parks was also different from the way a Hindu villager in India might feel about cattle in the neighbouring national park. What would an environmentalist, or an ecologist, make of cattle in an Indian national park, and how much would culture matter?

There are a number of debates about national parks in India—the place of cattle is just one of them. There are debates about people living in national parks. There are debates about people collecting non-timber forest products from national parks, like mushrooms, honey, bamboo or grass for fodder. There are debates about how to draw park boundaries—what size they should be, what they should or should not include. There are debates about how national parks should be managed, and by whom. For this article I would like to consider debates about the place of grazing in Keoladeo Ghana National Park in Bharatpur.¹ These debates have often revolved around how to define ‘natural’ in national parks (i.e., do cattle or people belong?), and this history is illustrative of the danger of assuming that what one group of people assumes is ‘natural’ is universal. In this article I pay particular attention to the way that scientists have attempted to provide answers to questions of park management, and particularly to the question of grazing in Bharatpur. The links between scientific research, culture, politics and conservation policy are complex, and while I do not make any pretence to comprehensiveness, this case study illustrates the dangerous temptation of allowing environmental advocacy to outstrip locally based scientific knowledge.

KEOLADEO GHANA NATIONAL PARK

There are not many wetlands like those at Bharatpur left in northern India. Throughout the world, wetlands have been among the least protected of natural ecosystems (Dugan 1990). There are several good reasons for this. Local populations often perceive wetlands as places of danger. They breed malarial mosquitoes, poisonous snakes and larger dangerous animals (in India, this includes crocodiles, tigers, rhinoceroses and elephants) (Bhandari et al. 1994). One of India’s most famous wetlands, the mangrove swamps of the Sunderbans, averages between 40 and 60 human fatalities a year from tiger attacks. Beyond dangerous wildlife, wetlands are difficult terrain through which to travel, and are prone to such catastrophic inconveniences as flooding. In contrast to their danger when wild, once tamed and drained, wetlands are among the most productive agricultural lands available. The hundreds of millions of people who live in north India are fed by the wheat, rice and sugar cane grown on the former wetlands surrounding the Ganges and its many tributaries. Western style ‘development’ has been, and continues to be, experienced in many parts of the world as attempts to control, regulate and distribute water through damming rivers and draining wetlands.²

The scarcity of wetlands in north India has resulted in a much higher concentration of birds at Bharatpur than would be considered natural in a less-modified, fragmented landscape. But then, very little about the national park is ‘natural’. There are no top predators in the park—a solitary tiger wandered into the park

recently, but it is uncertain how long it will stay, and the last leopard was killed over twenty-five years ago. There is a very limited assortment of non-avian fauna in the park. It does not have a natural ecosystem. More directly, the wetlands now protected in Keoladeo Ghana National Park are not the result of erosion, plate tectonics, or drainage patterns, but rather are the product of dams and dykes constructed on the orders of the Maharaja of Bharatpur in the 1890s.

The Maharaja was not interested in bird conservation for its own sake. On the contrary, he ordered the construction of the wetlands when he had just returned from a trip to Great Britain where he had greatly enjoyed the waterfowl shooting excursions, and he was determined to have a shooting reserve for himself (Ewans 1989: 9). He selected a small pre-existing marsh and expanded and deepened it to make it more attractive for wintering birds and year-round bird residents, using many canals and dykes to regulate the water level. He then crisscrossed the area with walking paths so that hunters could have access throughout the wetland. You can still walk on those paths, some still paved with bricks placed there one hundred years earlier, but now visitors to the national park shoot with cameras, not guns.

The Maharaja was successful beyond his wildest dreams. Bharatpur became famed for its bird hunting, and the Maharaja entertained hundreds of visiting British and Indian dignitaries. Stone plaques in the middle of the national park that remain from earlier, bloodier days, record visitors and their bags—the listings include Lord Curzon (then Viceroy of India—the first of many Viceroys to visit Bharatpur), almost all of the local Maharajas of north India, the Prince of Wales, the crown prince of Germany, and many others. Their daily kills were stupendous, with some hunts reaching above 4,000 birds killed in a single day.

In spite of these hunts, there seemed to be a never-ending supply of birds for Bharatpur. As frequently as ducks were shot from the sky above Bharatpur, wetlands in the rest of north India were being drained and converted to agricultural land, driving birds wintering in those places to the remaining wetlands. Within north India the conversion of wetlands to agricultural land is not a recent process, but it accelerated in the twentieth century and especially after India gained its independence and embarked upon a national push for agricultural self-sufficiency (Schaller 1967: 4–7). In a country of dwindling wetlands, Bharatpur became increasingly unusual as a protected and stable habitat for waterfowl.

When India achieved independence in 1947, local Maharajas signed agreements with the central government transferring power from their states to the centre. When the Maharaja of Bharatpur negotiated his deed of transfer of power, he made sure that he retained ownership and the ‘exclusive right of shooting in the Ghana [wetland] for himself and his friends’ (Ali 1985: 150). Once the initial heady rush of independence had passed, local people who had been the Maharaja’s former subjects, and demobilised soldiers who had been based near Bharatpur, began to protest his continued privilege in reserving land for his personal pleasure. They argued that this was a clear case of a royal shooting reserve serving no purpose other than the ego-gratification of a former ruler and his friends, and which denied poor landless farmers in surrounding villages land and water. There were

no actual rights among the surrounding villagers to the resources of the wetlands, although local cattle and buffalo were allowed into the reserve on a day-to-day basis for grazing. Bharatpur, local politicians argued in 1950, should be converted to agricultural land for landless labourers, and its canals should stop diverting water from other agricultural areas (Ali 1985: 150; Rangarajan 1996b).

Ali, then head of the Bombay Natural History Society (BNHS), did not see this debate between the Maharaja and his former subjects as centred on questions of the abuse of privilege. He saw Bharatpur as a threatened wetland, one of the last remaining wintering grounds for water birds in north India. His sympathy was not with the poor, but with the birds. In his autobiography he explained the controversy in terms careful to paint the anti-Maharaja forces as motivated by personal politics and as ultimately evil:

The Maharaja's policy of continuing to shoot while denying this privilege to the general public was deeply resented by the powerful anti-Maharaja party of the state, which was prepared to go to great lengths to punish him for alleged misdeeds and injustices in the past. They had whipped up an agitation alleging that he was holding on to the Ghana solely for his selfish pleasure and to entertain influential friends at court in Delhi, and thereby wickedly depriving the poor land-starved ryots [peasants] of good cultivable land and the water they so badly needed for their crops. With the backing of crooked politicians complete physical devastation of the Ghana was plotted (Ali 1985: 150).

Ali wasted no time in protecting the wetlands—he went straight to the top, to his personal friend Jawaharlal Nehru, then Prime Minister of India. 'We apprised him urgently of what was afoot and craved his immediate intervention to stall the vandalism', and Nehru responded to his satisfaction. Nehru had his Minister of Agriculture and Irrigation, Rafi Ahmed Kidwai, check into the charges of land and water deprivation (at that time forestry was included in the Ministry of Agriculture—thus, there was a conflict of interest at the highest level between the two tasks of forest protection and agricultural expansion). The government found that Bharatpur supplied many needs for surrounding poor villagers, including fodder, firewood, berries and thatch grasses, and would be of more use to poor peasants continuing as it was than if it were converted to agricultural land (Rangarajan 1998: 18). On this basis, Bharatpur was 'saved from certain annihilation', in Ali's fervent words (Ali 1985: 150–51).

The Maharaja's shooting reserve had not escaped unscathed from this sequence of events, however, and in 1956 the wetlands were officially turned over to the Rajasthan Forest Department for management and maintenance (Ewans 1989: 10). Bharatpur was saved from agricultural conversion not on the basis of the Maharajas' rights to the land as personal property but on the basis of its biological resources and use value for surrounding villagers. To prevent future conflicts between the local populations and the Maharaja, Bharatpur was turned over to the state. The Maharaja was able to retain hunting rights for another few years,

but only in the non-breeding season, and since 1968 the echoes of gunshots have not sounded across the marshes (Gee 1992: 35).

That is not strictly true—no more shots have been aimed at birds. Bharatpur was declared a national park in August 1981, and so it officially became subject to the 1972 Wildlife (Protection) Act, which required that national parks be areas free of human activities and of livestock. The law made little difference initially. Surrounding villagers had depended upon the vegetation of Bharatpur for decades as fodder and thatch—that was how, after all, the central government had justified not converting the wetlands into agricultural land in the early 1950s—and villagers continued to use Bharatpur for grazing after 1981, in spite of the letter of the law and a large stone wall built around the perimeter of the national park. They would simply enter through the gates, unstopped by the local forest guards. In October 1982, the Indian Board for Wildlife held a meeting in New Delhi, chaired by Prime Minister Indira Gandhi, which addressed the problem of grazing and human pressures in Bharatpur. The Board decided to enforce the rules and completely close the park to grazing, and further, that this decision was to be implemented right away (Rangarajan 1996b). Gunfire returned to Bharatpur following that fateful decision and nine villagers who were trying to enter the park during the resulting protests were killed by the police (Dhawan et al. 1982).

CATTLE AND CONSERVATIONISTS

Cattle and other domesticated livestock inside protected areas have been the *bête noir* (and *bête gris*, and *bête blanc*. . .) of many ecologists, environmentalists and wildlife preservation managers who have worked in India. This has been true in other regions of the world as well—the United States (US) environmentalist John Muir famously referred to sheep in the western US as 'hoofed locusts' throughout his life. Calls to eliminate domestic animals from wildlife sanctuaries are repeated time and again in policy documents, scientific papers, conservationist writings and popular articles. In the 1980s, Kailash Sankhala, first director of Project Tiger and Chief Wildlife Warden of Rajasthan until 1985, wrote, 'Cattle grazing is the major problem that Indian wildlife and the national parks and sanctuaries face today' (Sankhala 1985: 58). The Indian Board for Wildlife, in its recommendations on Wildlife Sanctuaries in 1965, wrote that 'as far as possible grazing of domestic animals in sanctuaries should be prohibited' (Gee 1967: 339). When I spoke with a senior scientist in the BNHS in 1998, I asked if it was reasonable to have pristine core areas in the national parks where people and livestock were excluded. Do the cattle and villagers also have some right to the land? His response: 'Certainly not the cattle. Billions of them. Miserable animals, and they should be. . .'³ He never finished his statement—an aide walked in and we changed topics when we resumed.

George Schaller, a world-famous ecologist who had already written best-selling discussions on the gorilla and the African lion, was more nuanced in his discussion

of cattle in *The Deer and the Tiger*, his landmark book based on his research in India. His first mention of cattle, in his introduction, is harsh: 'A great scourge of India's land is the vast numbers of domestic animals which are undernourished, diseased, and unproductive, yet are permitted to exist for religious reasons' (Schaller 1967: 6–7). At the end of his book, though, he is more moderate. Based on his careful study of the tiger's feeding habits, he concluded that livestock grazing within Kanha National Park helped to sustain an abnormally high density of tigers. Specifically, he claimed that tigers killed enough livestock (cattle and buffalo) in the park each year to completely fill the dietary needs of ten tigers (250 head of livestock). 'From the standpoint of tiger conservation', he wrote, 'it makes no difference whether the prey consists of cattle or wildlife' (Schaller 1967: 328).

He was not just interested in tigers, though, and 'from the standpoint of habitat conservation and the maintenance of the park as a sanctuary devoted to the perpetuation of wildlife, the livestock should ideally be eliminated and the wild hoofed animals be permitted to increase' (Schaller 1967: 328–29). Ultimately, therefore, park managers should remove the livestock from within the park. Only then, he concludes his book,

will the park be able to fulfil its unique potential as a living museum and natural laboratory. Above all, Kanha National Park is part of India's cultural heritage, a heritage in many ways more important than the Taj Mahal and the temples of Khajuraho, because, unlike these structures formed by the hands of men, once destroyed it can never be replaced (Schaller 1967: 331).

Schaller was seeking to add the 123 square miles of Kanha National Park to the rolls of living museums—places dedicated to the preservation of earlier times, earlier ways of life, and in the case of his view of a national park, pre-human ecosystems—while thousands of people living in (at that time) and around the park continued to experience their life in the park as very much the present, and its nature as in no way 'pre-human'. This language mirrors that of many Indian environmentalists who speak of the need to preserve 'India's precious natural heritage', or of Indian Project Tiger promotions that attempt to equate India's nature with Indian uniqueness and distinctiveness. This language reinforces a particular vision of the Indian nation, and it does so at the expense of local populations like those who herd the cattle of Kanha.

The American graduate student Juan Spillett wrote by far the most thorough critique of livestock in Indian national parks. Spillett had originally come to India to do his Ph.D. research on ungulates in Kanha National Park but had been forced by his funding sources (at Johns Hopkins University) to change his project to an ecology of wharf rats in Calcutta. The Bombay Natural History Society gave him a temporary respite from the rats—they knew of his presence and background (he had a previous M.S. in Wildlife Biology) and invited him to write a summary of

the state of Indian wildlife preservation for their journal, based on a whirlwind tour of north Indian national parks. In the resulting article entitled 'General Wild Life Conservation Problems in India', Spillett wrote that

India is basically confronted with two major problems. I firmly believe that if these two were brought under control, the numerous other problems which are presently receiving so much attention and publicity, such as the scarcity of food, lack of foreign exchange, poor living standards, and so forth, would eventually resolve themselves. . . . These two problems are: (1) too many people, and (2) too much domestic livestock (Spillett 1966: 617).

This statement directly links poor Indians with cattle as the scourge of India. Spillett follows this astounding claim by comparing livestock grazing to a cancer that quietly destroys an ecosystem, no one noticing until it is too late. India should know better, he claims, for 'primarily due to over-grazing by domestic livestock, India already has the notoriety of having created the largest man-made desert in the world'. As he continues, 'It is a historical fact that more nations have fallen because of land abuse, such as overgrazing by domestic livestock, than by all other factors combined (Spillett 1966: 620).

Such arguments are questionable, but not unusual. Vasant Saberwal has traced debates blaming desertification and erosion on livestock grazing in India. He found that scientists and bureaucrats consistently make the (flawed) assumption that overgrazing causes deserts. In fact, Saberwal asserts, there is not a direct correlation between grazing and desertification in India, and that this sort of mono-causal analysis is misleading (Saberwal 1999). It is a powerful environmental myth, though. We all have seen the photographs of a bare-ribbed cow standing in the midst of a sand dune, plucking the leaves off the only plant in the frame. Such presentations are often more effective in shaping the popular imagination than arguments that global climate change and weather patterns cause deserts, not overgrazing. To this point, grazing has completely destroyed no park in India; conservationists have feared that it will happen for nearly half a century now.

Misidentifying the causes of deserts is a mild sin, at best. Far more severe is making policy recommendations based on those beliefs which result in, literally, human deaths. As Spillett continued in his discussion of livestock grazing in national parks and wildlife sanctuaries,

I am almost invariably told by officials that the problem is realized, but that it is impossible to control grazing by domestic animals in a democracy such as India's. This is faulty reasoning. No government, particularly a democratic one, should permit its people to destroy the nation's most priceless possession—its land. Many feel that in a democracy public property belongs to everyone. But this does not mean that the people are free to destroy the public domain. For example, a public building belongs to everyone just as much as does a

reserved forest or a wild life sanctuary. However, no one is allowed to destroy such buildings or to remove materials from them for private use (Spillett 1966: 618).

Spillett provides here the justification for treating livestock grazing in protected forests as a crime equivalent to the bombings of buildings or theft. He misunderstands the problem of democracy posed by the officials with whom he spoke; he assumes that the officials are claiming that you can't force people to do something like stop grazing. He argues that, like you would shoot a terrorist before he blew up a building, a democratic state would also justify stopping a herder from taking his cattle into a protected area. The problem of democracy in India's national parks, though, is a different one. The vast majority of people living around Indian national parks—and perhaps in the nation as a whole—disagree with park policies prohibiting grazing and human use. They do not see it as a crime, or the herder as a criminal. The people living around parks are not elites, though, and their voices were often muted in conservation debates, more so in the 1960s than now. And arguments such as Spillett's allowed the Indian Board for Wildlife and Indira Gandhi to make the decision to exclude grazing, by force, at Bharatpur. Livestock grazing, after all, was a crime with consequences to the Indian people, they might have stated.

Spillett was not working on his own when he wrote these words. He was a US graduate student writing on behalf of the BNHS, lending his US citizenship and training to their crusade. Obviously, on his whirlwind tour with his BNHS hosts, he saw what they showed him, and they published his article because his views coincided with their own. As the editors of the *JBNHS* had written in their introduction to the volume in which his articles were published,

It is not irrelevant to refer to Spillett's conclusion, that it is not only poaching that is the great threat to the continuance of India's wild life and wild places, but the disastrous effect of over-grazing by domestic livestock all over the country. Understanding a problem clearly is the first requirement toward its solution, and we are grateful to the author of this report for the facts which he has uncovered (Anonymous 1966: 491).

Spillett was not a lone voice in the wilderness, neither was he a ventriloquist's dummy, mouthing words that he did not believe. He was given the platform of the *JBNHS* because the BNHS staff agreed with him and thought that he could further their aims.

The BNHS consistently relied upon non-democratic politics to effect environmentalist goals, as when Ali approached Prime Minister Nehru about the Maharaja's threatened shooting grounds. In a 1983 interview for the Indian *Express Magazine*, Ali said,

Years ago when I could have used my friendship with Jawaharlal Nehru to obtain 'favours,' . . . I hesitated, out of the mistaken notion that I should not bother [him], that he probably had enough problems to contend with as it is. How wrong I was. I often think back to this tactical blunder on my part. Anyhow, I certainly shan't repeat the mistake where his daughter, Indira Gandhi, is concerned (Sahgal 1983: 5).

Perhaps the intervening years had obscured Ali's memory of his (and his US collaborator Dillon Ripley's) several appeals to Nehru—about Bharatpur, about the Gir Lions, or for permissions into sensitive areas, among other examples. Or, perhaps he felt that his previous history with Nehru truly was hardly anything, and that he now intended to be even more direct with Gandhi. In any case, Spillett's justification of action based upon an elite conception of the public good was in keeping with the preferred mode of environmental advocacy by the BNHS, and most other international environmental organisations working in the world. The World Wildlife Fund (WWF) very directly claimed that one of its goals was to approach national leaders directly and affect top-down environmental action, as when Prime Minister Indira Gandhi was persuaded by high-level WWF members to support Project Tiger (Denton 1996: 18; Mountfort 1978).

Within a year of Spillett's article for BNHS, there was a flurry of cattle-based activity in the BNHS and the Smithsonian. In 1967, the Government of India established a Parliamentary Committee 'to investigate the implications of a total ban on the slaughter of the cow and its progeny'.⁴ Conservationists in India and throughout the world took note. Zafar Futehally, nephew to Salim Ali, Secretary of the BNHS, and soon to be a leader of WWF, India, wrote an editorial page article for *The Times of India* in which he decried the effect of cattle on the Indian landscape, and he called on international experts: 'In our own sanctuaries in India, as reports by George Schaller and Juan Spillet [sic] show, much harm has been done to wild life and to the habitat in such unique areas as Kanha, Kaziranga, Sariska, and Bharatpur' (Futehally 1967). Futehally was serving as the Indian chair of the International Biological Programme Terrestrial Conservation subgroup, and he moved to get the International Biological Programme (IBP) to fund a study in India on cattle and wild herbivores. He approached the Smithsonian, to check on the availability of PL 480 rupee funds. The Smithsonian was amenable, but would be too slow. The Parliamentary Committee in India needed to submit a report by the end of the year. Although willing to listen to any scientific advice, there was no time for a complete study.⁵

This called for direct political action—so Ripley wrote a letter to Prime Minister Gandhi, asking for her to intervene so that a rupee-funded study could take place (it is worth noting that this whole sequence of events was set in motion by Futehally and the BNHS, not by outside conservationists). Ripley received no response, until finally the US ambassador to India sent a deputy to check with one of Gandhi's assistants. As the ambassador reported to Ripley, 'Haksar readily confirmed that

it had been received, touched briefly on the sensitivity of the subject, and as much as said he thought it better to leave the complexities of the cow problem to the Government of India'.⁶ The ambassador told Ripley not to expect a reply from Gandhi, and further, suggested that in the future Ripley go through the US State Department if he wanted to contact the head of the Indian state. In a gentle rebuke, the ambassador closed by suggesting that Ripley learn what the Indian Government thought were their major problems (as opposed to cattle): 'I am enclosing background memoranda which deal with the two major problems facing India—the modernization of agriculture, and the control of population. I hope you enjoy reading them'.⁷ The files in the Smithsonian Archives usually include attached articles, clippings and memoranda that come with the letters found in those files, no matter how mundane, but those two memoranda are missing. Might Secretary Ripley have thrown them away?

Only two years later, a team of graduate students in ecology completed a preliminary report of a scientific study conducted with PL 480 rupee funds in the Gir Forest (last home of the Asiatic Lion) (Rangarajan 2001). This team was investigating different aspects of the ecology of the Gir Forest. The study as a whole directly considered the role of cattle—domestic and feral—in this ecosystem. It was exactly the sort of specific study that Futehally and Ripley had been pushing for in 1967. One of the students, Paul Joslin, prepared a paper on the lion for the 1969 International Union for the Conservation of Nature (IUCN) meeting to be held in New Delhi—the watershed conference that proved to be so important in the establishment of Project Tiger. I do not have a copy of the IUCN paper, but I did find a copy of the longer report (by his two colleagues Steve Berwick and Peter Jordan) on which the paper was based. The report included the expected information about overgrazing and soil compaction by the cattle, all to the detriment of the forest. But then, the report veered in a direction unforeseen by the BNHS or Smithsonian. First, it indicated that the cattle diet differed from that of the wild ungulates in the forest. Then, it suggested that even if all the cattle and buffalo were removed, it would not lead to a corresponding increase in deer and antelope. As the paper suggested, the wild ancestors of the buffalo and cattle perhaps once lived in this forest, and played a similar role in its ecosystem. If the cattle were gone, the wild ungulates still would not eat the newly available grass. Then the paper concluded this chain of logic: 'removal of livestock will sharply reduce the capacity of the Gir to support lions and other large carnivores'.⁸ The lions depended upon the presence of cattle as food. In the report's conclusion, the young researchers announced, 'current plans to remove all graziers and their livestock and constitute the Gir en toto as a sanctum sanctorum for wildlife, would mean that at most twenty-five percent (the proportion of wildlife in the diet) of the current lion population will remain'.⁹

This did not go over well. Lee Talbot, a Smithsonian official overseeing international ecology projects, quickly wrote Joslin a letter setting him straight. It is worth quoting at length:

I would quite agree that the sudden removal of all domestic stock from the forest would be likely to be detrimental from several standpoints, among them, the increased predation pressure that this might put on the remaining wild ungulates. However, as a long-term objective, it seems most desirable to develop a sanctuary in which the wild ungulates and predators coexist as they did prior to the introduction of the present human uses and livestock. . . . Another dimension of the problem is the India-wide problem of overgrazing by domestic livestock. The Gir does provide an opportunity for meaningful scientific research on this point and recommendations from the Gir which appear to condone overgrazing would be certainly unfortunate. Incidentally, several who have viewed your remarks on the vegetative response [to the] removal of livestock and its effect on the lions, have remarked that they consider you are on pretty shaky ground. I am sure that the authorities in India who have been working hard for the establishment of national parks as well as others who would be at the IUCN meeting and have similar experience from elsewhere would be quite unhappy with the conclusion that can be drawn from a last census of your third paragraph of the discussion, i.e., that the establishment of national parks should be undertaken with caution.¹⁰

This is a remarkable letter. When science did not confirm the conventional wisdom, it was rejected. At the end of the letter, Talbot told the graduate student, 'I am sure it was not your intent to indicate these things . . . however, we do feel it is quite important that you make sure they are not misinterpreted in your presentation at the [IUCN] meetings'.¹¹ Of course it was Joslin's intention to call into question the accepted view of the need to remove the livestock! Talbot was offering Joslin a way out of this snag—after all, Joslin still needed access to Smithsonian funds to do his study, and he could not anger his funding agency—and Joslin was still a graduate student in need of a Ph.D.

Talbot sent a copy of the letter to David Jenkins, of the British Nature Conservancy. Jenkins wrote Joslin a reassuring letter. As Jenkins said, 'the main point he is making is, of course, that young scientists should devote themselves to their research and not become politicians. With this I wholeheartedly agree'.¹² Jenkins went on to mention, 'I am not really worried about this particular instance since I think that the final rewrite of your paper [completed between the two letters] overcame most of Lee's detailed objections'.¹³ The final version, as presented at the IUCN meeting, conformed to the desires of what Jenkins called 'the ecological politicians'.¹⁴ This is, of course, not how science is supposed to work. If a scientific report is rejected, it should be rejected because of bad science, not objectionable political ramifications.

WHY DID CONSERVATIONISTS FEAR CATTLE?

There are a number of factors that contributed to the bias against livestock among many conservationists. The most obvious of these is the impact of cattle in areas

where they are not native, and have had a damaging impact (as in some places in the American tropics). Cattle are often devastating in rainforest biomes. But why dislike cattle in grasslands? As mentioned above, the argument that Indian cattle cause desertification does not have any evidence to back it up. Cattle also have familiarity working against them—when tourists go to national parks they hope to see unusual or different animals. Unusual is often glossed as ‘wild’. When I was at Corbett National Park, I was thrilled to see a red junglefowl, a beautiful bird, running through the forest. The junglefowl is the direct ancestor of the chicken. In fact, it looks just like a chicken. But it was elusive, it was moving fast, it is listed in the *Book of Indian Birds*, and I was excited.

The divide between a wild animal (and thus to be admired and prized if seen in a national park) and a domesticated one (and thus to be prohibited from destroying the national parks in which they graze) breaks down even further with the water buffalo. When people speak of livestock in India, buffalo are included with cattle. Buffalo are used for milk, for pulling carts (some improbably loaded with fantastic amounts of weight, including concrete and rebar) and for working fields. Buffalo are not sacred, and are thus also eaten in some parts of India (but only after their working days are largely finished). The wild water buffalo is also listed as one of India’s most endangered species, found in only a handful of parks in all of India. The wild water buffalo is almost indistinguishable from a domesticated water buffalo, except that it is larger, with bigger horns and (by reputation) with a nastier temper. Scientists at the Wildlife Institute of India were considering (when I was there in 1998) DNA typing so that they could look for distinguishing genetic markers between domesticated and wild water buffalo. The fear among many environmentalists is that the wild water buffalo is increasingly isolated and surrounded by its domesticated brethren, and is being cross-bred to extinction. Local villagers who live near forests with wild water buffalo will sometimes let their female (domestic) buffalo breed with wild males, in hopes of improving the strength and size of the offspring. And on occasion, a domesticated male might impregnate a wild female, diluting the genetic purity of the hybrid offspring. Of such things—being bred to death—are extinctions made, in this bizarre example.

The most compelling argument against livestock in national parks and other protected areas is not desertification, lack of wildness or its sheer familiarity and lack of excitement to environmentalists. Domesticated livestock are not going to go extinct; many wild animals run exactly that risk because they cannot be domesticated and only exist in non-agricultural, non-settled (‘wild’) landscapes. Given that there are a limited (and diminishing) number of square miles of such wild land left in the world, and that this land can maintain a finite number of animals (domestic or wild), the decision then must be made whether to dedicate that land solely to wild creatures or to allow domesticated livestock to also utilise the resources of that land. Almost unanimously, ecologists and environmentalists argue that wild land must be set aside for wild creatures. As George Schaller argues, tigers can’t tell the difference between wild meat and cattle meat. But the presence of livestock in Kanha National Park lessens the total number of other

herbivores that can survive there. The park has a finite carrying capacity, in ecological terminology. The more water buffalo or cattle there are in the forest, the less endangered barasingha, (swamp deer) the forest can support.

This idea of carrying capacity combines with the lack of enchantment elicited by the familiar and mundane beasts of the world to result in a thoroughgoing prejudice against livestock grazing in national parks. As the Gir study reported, though, removing the cattle might not help the wild ungulates in the forest by opening up more grazing space. The wild animals of Gir, according to that report, eat different plants. So in at least that one ecosystem, the carrying capacity argument appears to be moot. The Gir ecosystem had evolved to the point that livestock use was part of its ‘natural’ workings. Unfortunately, this information reached only a limited audience.

THE BHARATPUR ECOLOGY STUDY

In the late 1970s, the BNHS noticed a slight decline in bird populations in Bharatpur. They could not explain why this was happening. A BNHS staff member, J.C. Daniel, one of Sálím Ali’s recruits from the early days of India’s independence and now the Honorary Secretary of the BNHS, suggested that the BNHS should conduct a ten-year study of all aspects of the Bharatpur ecology, including hydrology, vegetation, fish, mammals and birds. The study was to be almost exclusively observational, recording with as great detail as possible animal populations and resource use, including the vegetational composition of the different regions of the park and fish population dynamics, and how all of these elements seemed to interact. The idea met with widespread approval, and was begun in 1980 with PL 480 funding (the United States Fish and Wildlife Service [USFWS] was the collaborating institution from the US).

The scientists had a decent idea as to why the bird populations were declining. The problem was the cattle. David Challinor, the Assistant Secretary for Science at the Smithsonian, visited Bharatpur in 1980. He was shocked, and after Ripley read his report, Ripley wrote a letter to Ali.

He was horrified by the developments there saying that there seems to be some frightful bounder who is currently running the preserve who has never completed the surrounding perimeter wall, and consequently allows quantities of cattle, buffalo, etc. to run all over the preserve mixing among the few Nilgi [sic] and Black Buck that are there. The cumulative effect of invasion by cattle has been to break down the bunds trampling them beyond recognition in some cases and allowing the water to escape totally.¹⁵

The Government of India had planned to erect a stone wall to keep out cattle since 1976, when Prime Minister Gandhi visited the refuge and suggested that it was needed.¹⁶ The BNHS, and other conservationists in India as well as the US, decided to advocate the declaration of Bharatpur as a national park, not just a bird

sanctuary. National parks, according to the 1972 Wildlife (Protection) Act, were required to be free of cattle and people. Bharatpur was declared a national park in 1981, and as indicated above, in 1982 the Government of Rajasthan (at the insistence of Gandhi herself) enforced the ban, and nine people were killed trying to enter the park in the resulting riots.¹⁷ The Bharatpur ecology study by the BNHS, begun in 1980, was thus fortuitously positioned to compare the park's ecology before and after its change in status, and before and after the grazing ban.

By 1986, the Indian conservation community had begun to whisper that surprising results were coming out of Bharatpur. A mid-study report had indicated that bird diversity in Bharatpur was dropping since the ban on grazing and fodder collection had taken effect (Vijayan 1987). When the final report on the BNHS project came out in 1991, it was official. A few weed species were taking over the Bharatpur wetlands, reducing the fish populations, which was also reducing bird populations and nesting. The canals were clogged, the marshes were filling up with weeds and the grass in the grasslands proved to be dangerously productive—there had been a series of out of control wildfires which had not been conducive to dry-land bird nesting, and the birds had nowhere else to go. The vegetation of Bharatpur was more fecund than any scientist had anticipated, and in the absence of intense use, a few 'weedy' plants (both fast-growing native species, and introduced species such as *Paspalum* and the water hyacinth) were destroying the park as an open wetland habitat so well suited for birds. The wild ungulates in the park (nilgai, chital, blackbuck, and sambar) were not eating these weeds. In one of the truest surprise endings ever found in a scientific document, the BNHS, the strongest advocates for the notification of the wetlands as a national park and the ban of grazing from Bharatpur, concluded that 'the only ecologically viable alternative [to the weed takeover] is to set the primary consumers (buffalo) back into the system' (Vijayan 1991: 18). To fail to do so, the report argued, would result in a continuing decline in Bharatpur's bird population, both in numbers of species found, and in total numbers of birds.

The final report explained that hands-off management of wild areas would not work in Bharatpur. 'In the case of most wetlands in this country, man's interaction with them has become almost inseparable and hence, man has to actively manage them' (Vijayan 1991: 1). The only problem was that hands-off, or 'natural' management had been the international environmental standard when India's Wildlife (Protection) Act had been written and passed in 1972, and was thus written into the law. Natural management—the strict elimination of any human 'interference' with the 'natural' workings of a nature reserve—means letting fires burn uncontrolled, and letting animals starve to death if their populations become too large. Advocates of natural management believed that eventually such a management style would allow the nature reserve to re-establish historically normal populations and vegetational communities.

In the late 1960s, many US environmentalists were convinced this was the best management style for a national park—it would allow nature to act naturally. In the US, the 1916 Act establishing the National Park Service had been passed

within the context of dramatic overhunting of game species such as the American bison, and its overriding concern was 'one of saving resources from the rapaciousness of private commercial interests' (Budiansky 1995: 142). The act was thus open-ended as to precise policy, but adamantly oriented towards preservation, not management. In 1969, the managers of Yellowstone National Park, the flagship of the US park system, decided to begin a new management style of complete non-interference—natural management (Reed 1974: 40). This policy was justified both by the original 1916 Act, and also by scientific ideas such as 'ecological homeostasis' (Budiansky 1995: 131–55).¹⁸ In truth, this was a warmed-over version of Frederic Clement's old (and discredited) climax theory of vegetational succession, applied to an entire ecosystem—if we remove any human disturbance, the balance of nature will assert itself and the ecosystem will reach a homeostatic climax state. This policy quickly became an unofficial norm throughout the US park system.

The US National Park system has served as a model for the establishment of national parks throughout the world. Yellowstone National Park was the world's first national park, established in 1872. Parks such as Yellowstone were the model for IUCN's international standards for national parks and other forms of nature reserves, codified in 1960. In 1962, the 'First World Conference on National Parks' was held in Seattle, sponsored by the US National Park Service, the IUCN, UNESCO and FAO. There were 145 international delegates, and 117 from the US (who, though the panels were often international, dominated many of the 'commentator' and 'summary' positions, as well as provided the Keynote address) (Adams 1962: xxxii). The stated purpose of the meeting was to 'establish a more effective international understanding and to encourage the national park movement on a worldwide basis' (Adams 1962: xxxii). Ten years later there was a second such meeting, held at Yellowstone National Park in honour of its centennial. Again, the purpose of this conference was to spread the national park gospel, and this time, the gospel included Yellowstone's new policy of 'natural regulation' (Harroy 1974: 24–32; Reed 1974: 40).¹⁹

When India's Wildlife (Protection) Act was passed, just a few months after this 1972 conference (a conference attended by the author of the Act, M.K. Ranjitsinh), it wrote into Indian law the current US national park model, exemplified by Yellowstone since 1969 and explicitly advocated at the 1972 conference, of natural, hands-off management. To see national parks in India as solely based on US models is of course too simple. Ranjitsinh was from a royal family in Gujarat, and many of the Indian maharajas had been maintaining private hunting reserves for decades—this gave them experience in managing wildlife. Ranjitsinh points to these roots when he talks about the law he did so much to write and see implemented (Ranjitsinh 1997). Similarly, British forest and wildlife reserves had been established in the late 1800s (Rangarajan 1996a). These earlier Indian models made it easier to accept the validity of the US model of national parks (Saberwal et al. 2000). In any case, within months of a conference in which people from around the world celebrated the 100th anniversary of the US national park system, and

speaker after speaker spoke of spreading it through the world, India implemented a national park system that contained the key provisions of no people, no cattle and natural management.

In the intervening years since 1972, natural management has proven questionable at best in US parks such as Yellowstone, leading to a firestorm of criticism. The elk population, without traditional predators such as wolves, is out of control and the elk are decimating the aspen and willow stands in the park (Kay 1990). Though wolves have been reintroduced to the park, there are not yet enough of them to control the elk population. In addition to the elk, in the summer of 1988 forest fires burned 45 per cent of Yellowstone National Park, feeding on nearly a century of dry timber that had never been burned due to an earlier fire-suppression policy (Budiansky 1995: 141).

The BNHS study of Bharatpur indicated that the natural management policy was similarly problematic for that park, but the miniscule Bharatpur could ill afford the problems that the larger Yellowstone could more easily survive. As the BNHS found, 'natural' management at Bharatpur resulted in a park dominated by a few weedy species. What the BNHS and the Government of India wanted from Bharatpur, their idea of 'natural', was in fact an avian-oriented ecosystem dependent upon livestock grazing and human fodder and thatch collection. Bharatpur had never been a natural ecosystem—it had been created for duck hunting after all—and thinking that it would thrive without human management was simply wrong. If Bharatpur were to continue as one of the world's premier sites for avian biodiversity, it would have to be actively managed towards that goal.

The BNHS, since 1991, has been asking the park managers from the forest department to please let the buffalo back into the park. Late one evening, Shruti Sharma, the Forest Officer in charge of Keoladeo Ghana National Park in 1997, made the time to speak with me in her home. She explained,

The BNHS (specifically Salim Ali) had approached the government to push the establishment of Keoladeo as a national park. They wanted to end grazing and cutting in the park. After the park was established, and the BNHS conducted their ten-year study, they decided that the lack of grazing was hurting many elements of the avian habitat. They therefore began to advocate allowing cattle [meaning both cows and buffalo] in the park. They have suggested that 2–3,000 buffalo could be sustained in the park. Around my park I have 40,000 buffaloes. Whose should I allow in? And before I allow the buffalo in I have to change the Wildlife (Protection) Act.²⁰

As it is, there are feral and non-feral livestock in the park (as I had witnessed). Forest department staff periodically tries to remove the cattle from the park. It is not politically expedient to kill the cattle, so they are removed some distance from the park and released (where many eventually die of starvation anyway, and others are claimed by their owners). Many of the feral cattle in the park die after each monsoon of hoof and mouth disease, and the park staff have even tried

sterilisation of cattle in the park. Ultimately, Sharma admitted, it is a rather hopeless battle. Even if all of the cattle currently in the park were removed, villagers periodically break holes in the walls and let cattle into the park.

Even with imperfect enforcement, there are far fewer livestock in the park than there would be if the ban was lifted, and far fewer than if the BNHS could manage the park according to their recommendations. Local forest officials like Sharma are in a bind—she admits that perhaps 300–400 buffalo would be invaluable in clearing out canals of weeds. She is in a politically vulnerable position, though. If she began to hold lotteries to allow buffalo to come into the park, she would be attacked by locals for not allowing more buffalo into the park, or for exhibiting bias in the selection process, and she would be attacked by environmentalists and government officials for breaking the Wildlife (Protection) Act which had been such a battle, literally, to begin to enforce in the first place. As she said, until the law is changed, she will not change the park policy.

The Forest Department did make one compromise following the release of the BNHS study. On the basis of the unmanageable fires that had devastated much of the park's grasslands, the forest department decided to allow villagers to collect fodder in the park. Villagers pay a fee and get a cutting license. They are then allowed to cut any grasses in the dry sections of the park. This policy has been in effect since 1991. While I was at Bharatpur, I saw a constant stream of villagers with headloads of grass leaving the park. In the US, grassland management relies upon frequent controlled burns that are managed so that they do not burn too hot or out of control (in New Mexico in the summer of 2000 this policy failed, as several fires did get out of control). When I asked Sharma if this had been considered at Bharatpur, she replied, 'American parks can afford to burn grass. Indian parks cannot. We have to have a park which is human managed'. To burn grass at Bharatpur would be a colossal waste of a resource which local villagers can use to feed their livestock, make into thatch for their roofs, turn into baskets, and any number of other uses. This need to manage Bharatpur in such a way so that valuable forest resources are not wasted influences the options for clearing out the weeds as well. One US scientist, Craig Davis, has suggested that water levels in the canals should be managed to mimic quick monsoonal floods, thereby drowning the weeds. Some BNHS staff members have suggested that perhaps more wild herbivores could be introduced to the park (more nilgai and sambar) to eat more of the weeds—if they even *would* eat the weeds. Neither of these options has been judged particularly plausible by the forest department, and advocates for the local villagers argue that such complex solutions are not needed and would be wasteful compared to simply importing buffalo.

The BNHS Bharatpur study has never been published in a scientific journal. Copies of the final summary report have been bound and distributed widely throughout India, but informally. Even without publication, this study and its shocking determination that the banning of livestock hurt the health of the national park is one of the best-known research projects in India among ecologists and

environmentalists. Many environmentalists accept the BNHS findings for Bharatpur, but still maintain that larger parks that are not so artificial would benefit from a ban on grazing. It seems that more studies should be done—were the graduate students at Gir correct in their assessment? If so, that would support the implications of the Bharatpur study. Defenders of natural management in the US argue that the management idea is good, but Yellowstone is not quite large enough either (Budiansky 1995: 152–53). Yellowstone is a huge park. Conversely, many pro-people advocates who work with villagers in India claim that the Bharatpur findings apply to all grazing and fodder collection in all national parks. All Indian ecosystems, they maintain, have evolved within the context of (sometimes, heavy) human use. This sort of universal statement seems as dangerous as its opposite. This debate is by no means finished, and researchers are working on similar questions throughout India.²¹ We can hope that they will do as well as the scientists of Bharatpur—to the credit of the BNHS, these scientists were not ideologues, and when their data did not conform to their expectations, they did not ignore the data, but they instead changed their opinions.

CONCLUSION

The BNHS study at Bharatpur showed that nature reserve management decisions in this park had been predicated upon assumptions that had never been tested. Such assumptions often are based upon inadequately tested theories derived from ecological insights that seem so apparently true that scientists and managers assume further testing is not needed. For generations of ecologists and park managers, in the US and in India, the destructive nature of livestock grazing was so apparent that it never even needed to be discussed. This insight was put into practice in US national parks, and written into law in India. At Bharatpur, this received wisdom was shown to be wrong. The true tragedy is that this lesson was not free—its cost was paid in blood by villagers killed in the interests of a policy that ended up being harmful to the very nature that the national park strove to protect. And now, the managers of Bharatpur are saddled with a law based upon an inadequate ecological understanding of how ecosystems in India should be managed.

What this Indian history of Bharatpur challenges is not just the validity of natural management, but also the entire attempt to propose a universal scientific model of conservation throughout the world. An international model of conservation assumes that there is one best way to save and preserve nature. Most ecologists—most scientists—look for universal, not just local truths. When the results of an ecological study are applied to international conservation decisions, environmentalists run the risk of imposing models developed for one area, and with one set of values, upon another area and culture, which might then experience the model as a straitjacket. And make no mistake: over the past fifty years, there have been several attempts at creating an international model for conservation, often based upon the same ideas discussed in this article, and there are several international organisations still dedicated to some form of its spread.²² I say this

not as someone opposed to the preservation of the various wild species and wild places of the globe. I want Bharatpur's birds to flourish. The best argument against international ecological advocacy based not on local case studies but on theoretical knowledge, or on the attempt to impose universal conservation models, is that it often has not worked. A peopleless, cattleless park did not help Bharatpur's birds. That is what we might learn from this case study: the futility of imposing one vision of how to save nature across the globe, no matter how dire the environmental crisis seems to be.

Notes

1. As do many of my sources, I will use 'Bharatpur' to stand not for the city, but for the wetlands of the national park. I would like to thank the many people who have commented upon earlier drafts of this work. Particularly helpful were the comments of Mahesh Rangarajan, the participants in the 2002 Cornell Workshop on 'Landscapes and Genomes in South Asia', and the anonymous reviewers, who offered many substantive comments, many of which I used here. All errors in judgement or fact, of course, are my own.
2. This has been especially true in the United States. States such as Iowa and California have converted over 95 per cent of their wetlands into agricultural land.
3. Interview at the BNHS House, Mumbai, 8 February 1998. This interviewee has asked to remain anonymous—the signed transcript is on file with the author.
4. Letter from B.R. Seshachar to A.K. Sarkar, 22 October 1967, Record Unit 271. Ecology Program, Office of Environmental Sciences, 1965–73. Box 14, Folder 1, Smithsonian Institution Archives.
5. Letter from B.R. Seshachar to Zafar Futehally, 24 October 1967, Record Unit 271. Ecology Program, Office of Environmental Sciences, 1965–73. Box 14, Folder 1, Smithsonian Institution Archives.
6. Letter from Chester Bowles to S. Dillon Ripley, 7 November 1967, Record Unit 271. Ecology Program, Office of Environmental Sciences, 1965–73. Box 14, Folder 1, Smithsonian Institution Archives.
7. Letter from Chester Bowles to S. Dillon Ripley, 7 November 1967, Record Unit 271. Ecology Program, Office of Environmental Sciences, 1965–73. Box 14, Folder 1, Smithsonian Institution Archives.
8. Stephen Berwick and Peter Jordan, 'Conservation of a Natural Ecosystem in the Gir Forest, India,' unpublished report, Record Unit 274. Office of International Programs, 1964–76. Box 9, Folder 7, Smithsonian Institution Archives.
9. Stephen Berwick and Peter Jordan, 'Conservation of a Natural Ecosystem in the Gir Forest, India,' unpublished report, Record Unit 274. Office of International Programs, 1964–76. Box 9, Folder 7, Smithsonian Institution Archives.
10. Letter from Lee Talbot to Paul Joslin, 11 November 1969, Record Unit 271. Ecology Program, Office of Environmental Sciences, 1965–73. Box 14, Folder 4, Smithsonian Institution Archives.
11. Letter from Lee Talbot to Paul Joslin, 11 November 1969, Record Unit 271. Ecology Program, Office of Environmental Sciences, 1965–73. Box 14, Folder 4, Smithsonian Institution Archives.
12. Letter from David Jenkins to Paul Joslin, 8 December 1969, Record Unit 271. Ecology Program, Office of Environmental Sciences, 1965–73. Box 14, Folder 4, Smithsonian Institution Archives.
13. Letter from David Jenkins to Paul Joslin, 8 December 1969, Record Unit 271. Ecology Program, Office of Environmental Sciences, 1965–73. Box 14, Folder 4, Smithsonian Institution Archives.
14. Letter from David Jenkins to Paul Joslin, 8 December 1969, Record Unit 271. Ecology Program, Office of Environmental Sciences, 1965–73. Box 14, Folder 4, Smithsonian Institution Archives.

15. Letter from S. Dillon Ripley to Sálím Ali, 11 February 1980, Record Unit 7008. S. Dillon Ripley Papers, 1913–93 and undated, with related materials from 1807, 1871–91. Accession 92–063, Box 1, Smithsonian Institution Archives.
16. N.D. Jayal, 'Note on a Tour of Keoladeo Ghana Bird Sanctuary at Bharatpur,' unpublished report, July 1976, Record Unit 254. The Assistant Secretary for Science, 1963–78. Box 24, Folder 3, Smithsonian Institution Archives.
17. Ripley and Ali corresponded about the event—they were concerned that the ban on cattle had been poorly implemented. Ripley had written a draft letter to Gandhi urging her to hold firm on the ban—Ali suggested he not mail it. Letter from S. Dillon Ripley to Salim Ali, 6 December 1982 and Letter from Salim Ali to S. Dillon Ripley, 16 December 1982, Record Unit 7008. S. Dillon Ripley Papers, 1913–93 and undated, with related materials from 1807, 1871–91. Accession 92–063, Box 1, Smithsonian Institution Archives.
18. Budiansky offers a spirited critique of this move, and also documents in detail the political machinations which resulted in this policy, including thousands of letters from school children decrying the 'culling' of elk, and protests from big-game hunters in Montana who needed animal overpopulation in Yellowstone to supply them with animals to hunt in bordering lands when the animals wandered out of the park.
19. Harroy, of Belgium, makes an explicit claim for the US National Park System as a global model.
20. Interview with Shruti Sharma, 28 December 1997.
21. One place where this is occurring is the Valley of Flowers National Park. The centrepiece of this national park is a valley meadow of astonishing floral diversity. Traditionally, high Himalayan meadows served as summer grazing areas for nomadic herders. Researchers from the Wildlife Institute of India (WII) claim that banning herding is helping the park; researchers from Delhi University claim that grazing has helped to control a pesky weed that would otherwise have taken over the valley much earlier (informal interviews with researchers at Delhi University and the WII, February 1998, and April 1998).
22. These include various national branches of the WWF, Conservation International, the IUCN, and others. For a more detailed discussion of these themes, see forthcoming: Michael Lewis, *Inventing Global Ecology* (Delhi: Orient Longman).

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