



Protection vs. commercial management: Spatial and temporal analysis of land cover changes in the tropical forests of Central India

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ABSTRACT

Tropical forests worldwide are undergoing rapid changes due to increasing human populations and varied land use practices. In an effort to protect these forests and their species, the number of protected areas has increased exponentially in recent decades. Clearly protected areas play a crucial role in conservation efforts and this strategy has been found to be successful in several studies. However, protected areas are often embedded within a matrix of other land cover types, including non-protected forests, agricultural fields, or urban areas. It is therefore critical for park management to think beyond the borders of their protected areas and work to maintain ecological integrity of the surrounding matrix and the connectivity between protected areas. This study integrates remote sensing, GIS and field observations to examine the effects of different management strategies on land cover changes. As a case study we examine a tiger reserve in Central India which is surrounded by commercially managed forests, representative of many protected areas throughout India. Findings of this study show that while protected areas play an important role in conservation, alternative approaches including favorable management policies could also be effective to extend conservation over larger areas.

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1. Introduction

Human-driven land cover change is considered as the single most important variable affecting ecological systems (Vitousek, 1994) and can significantly change the amount, type and successional state of forests. These changes in forest ecosystems are considered to have global conservation importance since the effects of significant forest-cover loss or within forest modification may include massive soil erosion (Sidle et al., 2006), destabilization of watersheds (Rai and Sharma, 1998), a loss of sustainable forest uses and threats to indigenous people on a regional scale (Samal et al., 2003) and large scale release of atmospheric carbon dioxide through the burning of fossil fuels contributing more to the greenhouse effect (Houghton, 1994). Another alarming aspect of this crisis is the threat to biological diversity (Shukla et al., 1990; Laurance, 1999). Even if the target of 10–12% land protected and reserved across the globe is achieved, up to 50% of tropical species are predicted to go extinct in the next few decades (Soule and Sanjayan, 1998). While the first priority for conservation is still increasing the number of protected areas globally, it is also

important to address issues related to sustainable forest management outside protected areas (Putz et al., 2001).

Parks are believed to protect forest from changes and are established to maintain carbon sinks, protect biodiversity, and to help stabilize global climate (Munroe et al., 2007). Many protected areas in tropical forests have been reported to be successful in slowing the rates of forest loss (Bruner et al., 2001). However, current controversies show skepticism in the effectiveness of parks as management regimes, which is further complicated by the evaluation of the regional impact of parks over time (Ostrom and Nagendra, 2006). Protected areas or parks have witnessed a 500% increase in land over the past three decades (Wittemyer et al., 2008); however, most of them are under severe threat from encroachment, agriculture, ranching, urban development, illegal and legal logging, and collection of non-timber forest products (IUCN, 1999; WWF, 2004). Isolation of ecosystems due to the forest cover decline in the matrix surrounding protected areas is not uncommon in developing countries of Latin America, Asia and Africa (DeFries et al., 2005). Especially in India, where the parks frequently contain forest villages located within or outside the administrative boundary (Nagendra et al., 2006), it might be particularly challenging for the resource managers to maintain a park and its surrounding matrix as a 'whole' ecosystem.

Several studies have challenged the idea that conservation is best served by sustainable timber or forest management (Rice et al., 1997; Bowles et al., 1998) mainly based on the argument that

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conservation can only be served by strict protection (Bowles et al., 1998). However, with high cost for protection, pressures for profitable forest resource extraction and human population growth, sustainable forest management is often the only chance left for maintaining forest cover and biodiversity (Whitmore, 1999). Since forest management practices in many ways depend on the country's developmental stage and politically determined economic incentives (García-Fernández et al., 2008), more smaller-scale case-study type approaches are needed to understand the effect of different management strategies on forest-cover transitions.

Tropical dry forests, even though more threatened and less protected than tropical moist forests (Murphy and Lugo, 1986; Janzen, 1988), are particularly under-studied in India (Sagar and Singh, 2004). Dry forests have often been preferred by humans due to their fertile soils (more suitable for agriculture) and more favorable climate for livestock (Murphy and Lugo, 1986). They have also been subjected to unsustainable forest resource extraction pressures (Bullock et al., 1995) to support high human population densities. Resource managers are often confronted with the daunting task of managing natural resources sustainably while meeting the needs of the human population. This can be a specific problem in developing countries (Gadgil, 1991; Rodgers, 1991), e.g. India, where approximately 50 million people depend directly on forests for their livelihoods (Hegde et al., 1996), and where substantial loss of forest area might result from continued grazing, fuelwood collection and non-timber forest product extraction (Kothari et al., 1989). More studies involving long-term monitoring of tropical dry ecosystems are thus required to develop effective forest management policies (Kumar and Shahabuddin, 2005).

This study contributes to the land change science and conservation literature by examining the effects of different management strategies on land cover changes, within and outside Pench Tiger Reserve (PTR), Maharashtra in Central India, using a host of spatial data, GIS tools, and field observations. Among different forest management practices within India (such as commercial timber extraction, participatory management, and community-based management) the present study deals with two opposing strategies—strict protection and commercial extraction. While we expect to see different forest cover change trajectories resulting from different management practices, a balance should be maintained between forest covers within and outside the park to avoid isolation. PTR, Maharashtra was chosen for this study as it is one of the reserves in the Indian subcontinent which could potentially host a large tiger population (Ranganathan et al., 2008); thus maintaining the forest cover and ecological health of the park and its surrounding matrix can contribute to the local chapter of the global tiger conservation effort. This study uses both discrete land cover maps and continuous Normalized Difference Vegetation Index (NDVI) data sets for a spatial and temporal land cover change analysis, specifically asking the following questions:

1. Does exclusionary management of PTR, Maharashtra result in the conservation of forest cover and/or regeneration of forest cover?
2. Do the spatial and temporal land cover trajectories vary in areas of commercial extraction outside the park boundaries from those found within the park?
3. Are the changes shown by land cover change trajectories also supported by the changes in NDVI values, reflecting vegetation productivity?

2. Indian forestry—policies and practices

Pre- and post-independence forest management practices in India have been mostly guided by national-level policies (Bhat et

al., 2001). Forest categories such as “Reserved Forest” (RF) and “Protected Forest” (PF) were first introduced during British rule (Forest Protection Act, 1927), and were retained by the Government of India after independence (post-1947). Presently, RF enjoys higher degree of protection than PF, since no hunting, and/or grazing are allowed in the former except under specific orders. Continued conservation efforts have led to pockets of RF (often upgraded to national parks and wildlife sanctuary) embedded within a PF matrix. Besides different management strategies, other factors including frequent relocation of forest villages outside protected areas, national-level emphasis on agricultural expansion, and industrial activities (such as road network development, hydro-electric projects) contributed to post-independence forest degradation (Bhat et al., 2001; Nagendra et al., 2006).

The focus of colonial-period policies was to extract commercial timber under several “working circles” (which is an area allocated to timber extraction under a “working plan” and which has a 30-year extraction cycle), which is still being practiced in non-reserve forests. Post-independence priority changes of the Indian government introduced need-based forest management where vast areas of forest were cleared and selectively cut (Pandey, 1992; Prasad, 2000) to supply timber for farm-building construction, industry, and hydro-electric projects. However, continued forest loss set off an alarm and various plantation programs were implemented (1980 onwards) to increase forested areas, although most resulted in failure (Pandey, 1992). In 1988 the forest policy was revised (MoEF, 1988) with priority given to forest and biodiversity conservation rather than financial benefits from forests and acknowledging the need of community participation in the co-management of degraded forest. As a result of this amendment, the post-1988 period witnessed a complete ban on tree felling within any national park contrary to the usual practice of controlled timber extraction through working circles within national parks. In the following two decades several other changes in government policies have continued to identify the importance of community involvement in conservation, such as the National Afforestation and Eco-development Board (NAEB) set up in 1992, participatory management programs such as “Joint Forest Management” (JFM) and “Village Eco-development” (VED), the World Bank funded India Eco-development Project (1996–2001) and the Wildlife Amendment Act (2002). While it is particularly difficult to find one ‘optimal’ management regime in the tropics (Pearce et al., 2003), comparative analyses of different regimes might be an effective tool to find regional solutions.

3. Methods

3.1. Study area

PTR is situated in the Nagpur district of the northern part of the state of Maharashtra (Fig. 1). The forest type is southern tropical dry deciduous forest (Champion and Seth, 1968). The floral diversity is dominated by teak (*Tectona grandis*) and includes other species such as Indian laurel (*Terminalia tomentosa*), white marudah (*Terminalia arjuna*) and bamboo (*Bambusa arundinacea*). The faunal diversity includes 33 species of mammals including tiger, leopard, spotted deer and over 160 species of birds, reptiles, and fishes. Overall topography of the region is undulating, the highest peak inside the park being 583 m. Most of the annual precipitation (1050 mm) is received between June and September, with temperatures varying from 14 to 43 °C.

PTR, Maharashtra shares its name and the northern boundary with PTR, Madhya Pradesh (Fig. 1). These two reserves form together the first inter-state tiger reserve of India. However, they fall under the jurisdiction of two different states, and thus two state forest departments. PTR, Maharashtra (area: 257.2 km²) was

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