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An assessment of ecosystem services of Corbett Tiger Reserve, India

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Abstract This paper examines the economic value of selected ecosystem services of Corbett Tiger Reserve, India. The direct cost was derived from secondary sources, and indirect and opportunity costs through socioeconomic surveys. For recreational value the individual approach to travel cost method was used, and to assess carbon sequestration the replacement cost method was used. The maintenance cost of the reserve was estimated as US $2,153,174.3 year^{-1}. The indirect costs in terms of crop and livestock depredation by wild animals ranged from US $2,408 to US $37,958 village^{-1} over a period of 5 years. The dependence of local communities was for fuel wood (US $7,346 day^{-1}), fodder (US $5,290 day^{-1}), small timber, and other nontimber forest products. The recreational value of the reserve was estimated as US $167,619 year^{-1}. With the cost per visitor being US $2.5, the consumers' surplus was large, showing the willingness of visitors to pay for wildlife recreation. The forests of the reserve mitigate carbon worth US $63.6 million, with an annual flow of US $65.0 ha^{-1} year^{-1}. The other benefits of the reserve include US $41 million through generation of electricity since 1972. The analysis reveals that, though the benefits outweigh costs, they need to be accrued to local communities so as to balance the distribution of benefits and costs.

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1 Introduction

The concept of ecosystem services provides a robust rationale for biodiversity conservation complementary to traditional arguments based on intrinsic value. In principle, it also provides a mechanism for optimizing investments in biodiversity conservation and directing them to where they are most useful (Kinzig et al. 2007). This requires the valuation of ecosystem services, and in particular, the contribution that biodiversity makes to that value. The establishment of protected areas (PAs) forms the cornerstone of the strategy for biodiversity conservation; however, in economic and development terms, it is difficult to justify the costs involved. In most countries, development imperatives favor uses of land, natural resources, and funds that yield immediate and demonstrable financial returns. Given society's increasing demands for employment, income, and infrastructure, development decisions tend to maximize short-term economic gains. Prices generated for natural resources often do not reflect the true social costs and benefits of resource use, convey misleading information about resource scarcity, and provide inadequate incentives for management, efficient use, and conservation of natural resources (Panayotou 1993). When PAs are undervalued, their conservation appears to be less desirable in development terms. Because it is difficult to demonstrate the high economic value of PAs or to make the case for PAs as an option that economically benefits land, resource, and investment, it is also difficult to argue for their establishment, to ensure that they are managed sustainably, or to defend them against conversion to other land uses.

Protected areas generate significant economic, environmental, and social benefits (Myers 1990; Dudley and Stolton 2005). These benefits are realized at local, national, and global levels. However, people living in and around PAs, while deriving little benefits from conservation, pay enormous costs in terms of lost access to their life-support system, particularly in developing Third World countries (Wells 1992; Brockington 2002). Three types of costs are associated with PAs, viz. direct costs that include acquisition costs, management costs, and transaction costs; indirect costs associated with damage to economic activities arising from conservation, for example, damage to crops, livestock, and human beings from wild animals living in PAs adjacent to human settlements (Hoare 2000; Naughton et al. 1999); and opportunity costs or benefits forgone from the next best use of the resource: in case of terrestrial PAs, the highest extractive value of that land (Naidoo et al. 2006; Adams et al. 2010). Unless the costs of conservation are assessed and it is clear who pays these costs and what they get in return, conservation interventions will not be effective. Compensation for impoverishment caused by PAs requires knowledge as to who has been affected and how it has influenced their lives. Appreciation of the multiple benefits of conservation will be incomplete without good understanding of the costs involved. Hence, measures devised to conserve biodiversity must provide economic incentives to increase net local benefits from conservation and sustainable resource use, along with good community engagement and education.

To ensure their sustainability and develop rational natural resource use policies, valuation of ecosystem services provided by PAs has become an essential analytical tool. Ecosystem services are the processes and conditions of natural ecosystems that support human activity and sustain human life (Daily 1997). The type, quality, and quantity of services provided by an ecosystem are affected by resource use decisions of individuals and communities (Jack et al. 2008). At the landscape level, conservation of biodiversity and maintaining the sustained flow of ecosystem services that it provides are now increasingly becoming the focus of ecosystem-based natural resource management (Ehrlich and Wilson 1991; Fisher et al. 2008). Some recent studies have attributed the sustained flow of services to the health of ecosystems resulting from improved conservation (Naidoo and Ricketts 2006; Chan et al. 2006). Despite the vital importance of ecosystem services, there has not been much progress in incorporating these into conservation planning, largely due to poor characterization of the flow of services from conserved ecosystems such as PAs (Chan et al. 2006). Inclusion of ecosystem services in conservation planning would provide opportunities for biodiversity protection (Naidoo et al. 2006) as well as for advancing human well-being. Valuation of ecosystem services can help resource managers deal with the effects of market failures, by putting a price on use and nonuse values, which otherwise are generally hidden from traditional economic accounting (Daily et al. 1997).

Cost–benefit analyses, where the economic costs and benefits of conservation are estimated and incorporated into decision-making, would help planners to make informed decisions regarding allocation of resources to PA conservation as well as to understand their distributional impacts. They would also indicate the overall economic efficiency of various competing uses of natural resources and thereby help society to make informed choices about trade-offs (Loomis 2000; Christe et al. 2006; Pearce 2001; OECD 2001). This approach can also identify marginalized stakeholders who threaten natural resources due to unsustainable use and indicate ways of capturing the values derived by beneficiaries, thereby guiding management practices in terms of efficiency and distributional impacts (Howarth and Farber 2002; Costanza 2001; Costanza and Folke 1997).

India has a large number of PAs which correspond to International Union for Conservation of Nature (IUCN) categories II, IV, and VI. The first among these is Corbett National Park. Established as India's first national park on August 8, 1936, it was named Hailey National Park after Sir William Malcolm Hailey, then governor of Uttar Pradesh State, who was instrumental in its creation. Following independence, its name was changed to Ramganga National Park in 1954 and then in 1957 to its present name, Corbett National Park, in memory of Jim Corbett, the legendary hunter and naturalist. With the launching of Project Tiger on April 1, 1973, the park was selected as one of the nine tiger reserves. Since then it has been known as Corbett Tiger Reserve (CTR), comprising Corbett National Park (520.82 km^2), Sonanadi Wildlife Sanctuary (301.18 km^2), and a buffer zone (466.32 km^2).

The present paper (a) examines the costs associated with the maintenance of CTR, India, (b) evaluates some consumptive and nonconsumptive benefits derived from the reserve, and (c) assesses the awareness and perceptions of key stakeholders, i.e., local communities and tourists, regarding the ecosystem services of CTR.

2 Study area

CTR is situated in the ecologically important Bhabar-Terai Region, a strip of land skirting the southern part of the Shivalik Mountains in northern India. It is located in the Kumaon and Pauri-Garhwal Regions of Uttarakhand State in the foothills of the Central Himalayas. The geographical extent of the area is from 78°05′E to 79°08′E longitude and 29°25′N to 29°48′N latitude (Fig. 1). The vegetation of the

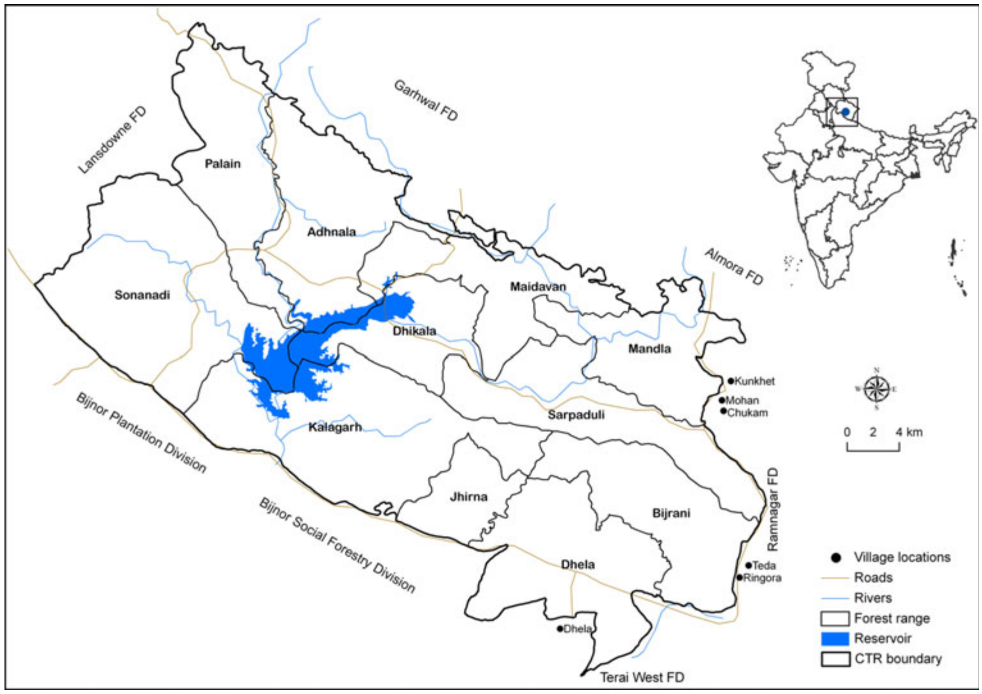

Fig. 1 Map of Corbett Tiger Reserve, India with location of study villages

area is a mosaic of dry and moist deciduous forest, scrub savannah, and alluvial grassland. Five broad vegetation communities are found in the area: (1) sal (*Shorea robusta*)-dominated forest, (2) sal mixed forest, (3) riverine forest, (4) mixed or miscellaneous forest, and (5) plantation. Two additional vegetation types, namely grassland and open scrub, are also found. The most dominant and widely distributed species is *S. robusta* followed by *Mallotus philippensis* and *Syzygium cumini*. Plantations constitute a significant part of the landscape, with species such as *Tectona grandis* and *Dalbergia sissoo*. The park is home to rich and diverse fauna, which includes 50 species of mammals, 575 species of birds, 33 species of reptiles, and 7 species of amphibians. The park has a high density of tigers (*Panthera tigris*) and a sizeable population of Asian elephants (*Elephas maximus*).

The management objectives of the reserve include biodiversity conservation and protection of naturalness of the area for scientific, educational, and recreational use. There is no human settlement in the core zone of CTR; however, there are 92 villages situated within 3 km of the reserve boundary. Most of the people in and around the reserve depend on buffer-zone forests for fuel wood and fodder, and for grazing livestock. After the declaration of the whole of the national park as a core zone of the tiger reserve, some villages were left just near the fringes of the core zone. The buffer forests also serve as habitat for spillover population of wildlife from the core zone. This increased interaction between humans, livestock, and wildlife has resulted in crop raiding, predation of livestock, and loss of human life.

3 Methods

3.1 Assessment of costs

Major costs and benefits considered in the present study are listed in Table 1. The information on the maintenance cost of the reserve was derived from official records of the reserve. The villages around CTR are heterogeneous in size, community, and occupational pattern. Based on representativeness, ease of accessibility, and distance from the reserve boundary, we selected six villages to examine the costs borne by villagers in terms of crop damage by wildlife such as wild boar (*Sus scrofa*), nilgai (*Boselaphus tragocamelus*), and Asian elephants (*Elephas maximus*), and livestock depredation by large carnivores such as tiger (*Panthera tigris*) and leopard (*Panthera pardus*). We conducted socioeconomic surveys in 15% of the households in each of these villages following Burgess (1982), Clarke (1986), and Chambers (1994).

Indirect and opportunity costs were derived from surveys where we examined the economic status of local communities, their resource use patterns, crop damage by wildlife (extent and economic value), livestock depredation and its economic value, number of cases of human injury or death caused by wildlife, and the amount of compensation paid by

Table 1 Major costs and benefits considered in this study

Cost/benefit	Description	Method of study
Direct costs	Budget outlays and maintenance costs; costs of land acquisition	Review of records and other secondary information
Indirect costs	Cost of crop damage, livestock depredation, loss of life and property	Household survey and secondary information
Opportunity costs	Foregone outputs from PAs in terms of forestry products and/or alternative use of the area	Household survey and assessment of alternative land use options
Direct use value	Fuel wood, fodder grazing, and revenue generation	Household survey
	Recreation benefits	Travel cost method
Indirect use value	Carbon sequestration	Replacement cost method
	Watershed protection	Review of records and other secondary information
	Increased soil fertility	Household survey and secondary information

the government. Resource dependency of local people on the forests for fire wood, fodder, and other nonwood forest products (NWFP) was also examined to analyze the benefits derived by people from the reserve. Information on price of fuel wood and fodder was collected from the local market. Calculations were done by considering 100 kg of fuel wood at US $5.0 and 100 kg of fodder at US $2.5. Income from and damage to agricultural produce was estimated by considering the market price of paddy and wheat. The government support price for wheat is US $14 per 100 kg and for paddy US $11 per 100 kg. Loss of livestock was converted into monetary terms by considering the current market price of livestock and calculating the net loss. If any compensation had been paid, this was accounted for while calculating the net loss. The market price of different types of livestock at different maturity levels varied, but for the present study, the market price of a buffalo of local breed was averaged at US $300, a cow at US $125, a subadult buffalo at US $50, a calf at US $25, and a bull at US $62. The compensation amount was US $62 for a buffalo, US $30 for a cow, US $11 for a calf, and US $20 for a subadult buffalo. Table 1 lists the major costs and benefits of CTR considered in this study as well as the methods used.

3.2 Recreational benefits

The individual approach to travel cost method (TCM) was opted to estimate the worth of CTR for recreational purposes (Brown and Nawas 1973; Dobbs 1993; Sohrabi et al. 2009). TCM assumes that the value of the site or its recreational services is reflected in how much people are willing to pay to reach it. It is referred to as a “revealed preference” method, because it uses actual behavior and choices to infer values. Thus, people’s preferences are revealed by their choices. The basic premise of the travel cost method is that the time and travel cost expenses that people incur to visit a site represent the “price” of access to the site. Thus, people’s willingness to pay to visit the site can be estimated based on the number of trips that they make at different travel costs (Hecht 1999). This is analogous to estimating people’s willingness to pay for a marketed good based on the quantity demanded at different prices.

Primary data on the place of origin of tourists, group composition, educational level, income, reasons for visit, and travel expenses were generated by randomly interviewing 308 tourists at the three entrance gates of the reserve. Secondary data on entrance fees, average distance of CTR from major cities, and annual tourist visitation for the year 2004–2005 were collected from the CTR office, Ramnagar. The average cost of travel and average cost of time spent on that travel by the visitors (Iamtrakul et al. 2005) were derived from these data sets. Using the total cost of travel and number of visitors, a regression graph was plotted. The equation of the regression curve was analyzed to work out the consumer’s surplus (at different hypothetical entrance fee values), which gave the economic benefit of CTR to the visitors. The total cost of travel was calculated for each tourist by adding the travel cost and the monetary value of the time spent in travel to get to CTR. The travel cost was the round-trip cost by the mode of transportation used, while the cost of time spent was estimated from the average wage per hour and the time spent on the round trip. Summed together, these gave the total cost of travel. This did not include the cost of stay at CTR, the entrance fee, or the cost of taking a safari into the park.

Visitors being interviewed for the travel cost calculation were also asked to state the principle benefits of CTR from their perspective. Similarly, 100 villagers from villages surrounding the reserve were asked to state the prime advantage of the reserve to them.

3.3 Carbon sequestration

To derive the carbon sequestration value of the forests of the reserve we used the replacement cost approach

(Bann 1997). This method assigns a value to the environmental service by estimating the cost of replacing the environmental benefit with alternatives (Dixon and Sherman 1990). It focuses on the costs of providing man-made substitutes for ecosystem services and regards the value of an ecosystem service as the price of the cheapest alternative (Woodward and Wui 2001; Hussain and Badola 2008). Following Lal and Singh (2003), the total growing stock of the forest was multiplied by an expansion ratio (ER) to derive the total biomass, including branches, twigs, and foliage. The ER is applied to account for nonstem biomass which is not accounted for in volume estimation. In this study the ER value was determined on the basis of earlier studies in India, Nepal, and Myanmar (Cannell 1982; Singh and Negi 1997), being 1.16 for *Shorea robusta*, 1.34 for *Tectona grandis*, 1.25 for conifers, 1.40 for broadleaved species, and 1.32 for hardwood mixed with conifers. To convert the aboveground biomass into dry matter, it was multiplied by a conversion ratio (CR), which is a constant (0.5) for mixed forests (IPCC 1996). The CR is defined as the ratio of aboveground oven-dry biomass of entire tree to oven-dry biomass of inventoried volume or growing stock (FAO 1997). This value was then divided by the area of forests and discounted at 10% to obtain the annual flow of carbon in CTR forests. This gave the worth of additional aboveground carbon stored in the forests of CTR on an annual basis, which was 3.84 million tons, after deducting biomass extracted for fuel and fodder by local communities ($\sim$2,000 ton).

The carbon content of live matter was calculated by taking the carbon fraction in biomass as 0.5. The carbon content was multiplied by 44/12 to obtain tons of CO_2 stored. Monetary value was converted into annual flows by discounting it at a market interest rate of 10% (IPCC 1996). We used the average costs (US\$ t^{-1}) of CO_2 mitigation as per the existing market price of certified emission reductions (CER) from registered projects in India, which is the second largest market for Clean Development Mechanism (CDM) projects. Prices for CERs from registered projects were quoted between €13–16 (US \$17–21) during 2008 (Tvinnereim et al. 2009).

3.4 Other indirect benefits

Data regarding the average yield of agricultural crops and fertilizer used were collected from inhabitants of surrounding villages. The total number of visitors in the last 5 years and the revenue generated were obtained from the CTR Head Office at Ramnagar. The details about the Kalagarh Dam on Ramganga River and the amount of electricity generated were collected from the Irrigation Department at Kalagarh. Data regarding direct benefits and employment generated were taken from secondary sources.

4 Results

4.1 Socioeconomic characteristics of the villages

Socioeconomic characteristics of the study villages are presented in Table 2. The villages are mostly agrarian. Around 84% of the total land holdings of the households were used as agricultural land and varied in productivity depending on the availability of irrigation facilities. There are two major cropping seasons; *kharif* (June–September) and *rabi* (October–March). Paddy is the main *kharif* crop, and wheat is the main *rabi* crop. Soybean and ginger are the main cash crops grown. The mean cattle holding ranged from 2 to 5 family^{-1}. The contribution of forests to the total income of the villagers ranged from 31% to 50% of total income.

Table 2 Socioeconomic characteristics of the six study villages situated around Corbett Tiger Reserve, India ($N = 119$ households; ± standard error)

Parameter	Village					
	Kunkhet	Chukam	Mohan	Teda	Ringora	Dhela
Distance from reserve boundary (km)	3	3	2	2	0	0
Total village area (ha)	57.04	115.34	83.19	95.91	3.74	188.19
Mean household size	8.25 ± 0.95	6.33 ± 0.58	6.58 ± 0.57	6.6 ± 0.37	5.4 ± 0.98	6.91 ± 0.5
Population having livestock (%)	83.33	100	100	100	60	100
Mean livestock holding family^{-1}	1.58 ± 0.13	3.73 ± 0.69	3.58 ± 0.61	2.83 ± 0.35	4.0 ± 1.38	3.76 ± 0.71
Per capita income year^{-1} (US\$)	164.3	278.6	252.7	269.5	164.0	276.8
Income from occupation (%)	27.72	36.78	48.75	40.29	50.80	52.58
Income from agriculture (%)	23.31	13.25	12.26	15.10	6.87	16.69
Income from forest (%)	48.98	49.97	38.99	44.61	42.33	30.73

Table 3 Maintenance cost (US$) of Corbett Tiger Reserve, India during 2004–2007

Year	Maintenance cost	Salaries	Total
2006–2007	1,378,571	1,050,000	2,428,571
2005–2006	1,176,190	1,007,143	2,183,333
2004–2005	857,143	990,476	1,847,619
Mean ± standard error	1,137,301.3 ± 51,773.9	1,015,873 ± 17,728.8	2,153,174.3 ± 168,382.9

4.2 Direct and indirect costs

Between the years 2004–2005 and 2006–2007, the mean maintenance cost of the reserve was US $2,153,174.3, of which US $1,015,873 (47.2%) was spent on staff salaries and US $1,137,301.3 (52.8%) on actual management of the reserve (Table 3). Most of the funds came from the government, and the resources generated from the reserve were deposited with the government. During 2000–2004, a total of 1,003 cases of crop damage by wildlife were reported. About 88% of all respondents said that their fields were raided by wild animals. This covers an area of 110.9 ha of crop land. The cases were largely crop damage by elephants which stray into cultivated areas. The government compensates at the prevailing market price of US $0.11 kg^{-1} for paddy and US $0.14 kg^{-1} for wheat. Crops damaged by other wildlife went unreported, as there was no provision of compensation for losses incurred due to these. The economic loss ha^{-1} is the sum total of losses (kg ha^{-1}) of paddy and wheat damage, multiplied by their respective market price (Table 4).

During 2000–2004, a total of 2,283 cases of cattle depredation were recorded in the villages surrounding CTR. The cattle kills were generally attributed to tigers in the plains and leopards in the hills. Around 98% of the livestock loss was attributed to tigers, while leopards accounted for only 2.04%. About 41% of the respondents reported loss of livestock in the last 5 years. From April 1999 to March 2004, 5 people were killed and 13 injured, mostly by tigers.

Net loss due to livestock depredation ranged from US $603 to US $11,633 per village over a 5-year period (Table 4). The indirect costs in terms of crop and livestock depredation by wild animals ranged from US $2,408 to US $37,958 village^{-1} over a 5-year period (Table 4).

4.3 Provision of biomass

Of all households surveyed in the six villages ($N = 119$), 97.6% were wholly or partially dependent on forest for fuel wood. Of all households owning livestock ($N = 113$), 94.7% were wholly or partially dependent on forest for fodder. In the study area, 63.9% of the population was wholly or partially dependent on forest for small timber. The cost of fuel wood derived from forest by these villages was US $7,346 day^{-1}. Around 50% of cattle were grazed only in forest, while 34.2% were grazed both in forest and on fallow land. Even if all cattle were not grazed in forest, the majority of fodder requirement was met by forest. Thus, fodder from the buffer zone of the reserve fed, by either grazing or extraction, ~10,580 cattle day^{-1}. The average fodder consumption per cattle was 20 kg day^{-1}. The cost of fodder derived from the forest came to US $5,290 day^{-1}. Bhabhar (*Eulaliopsis binata*), a seasonal grass, was extracted in summer, with value added by local people by making it into rope, supplementing their livelihoods at the rate of US $12 per 100 kg.

4.4 Revenue generated from tourism

The total number of day visits to the reserve via all entry gates during 2004–2005 was 110,000, generating revenue

Table 4 Economic loss due to wildlife around Corbett Tiger Reserve, India during 2000–2004

Parameter	Kunkhet	Chukam	Mohan	Teda	Ringora	Dhela
Crop damage						
Agricultural area (ha)	5.13	5.9	3.64	10.22	0.81	22.98
Losses ha^{-1} (US$)	1,776	1,737	1,477	15,265	833	1,146
Total loss (US$)	23,396	10,250	5,376	15,601	663	26,325
Livestock depredation						
Total loss (US$)	1,143	976	2,310	1,417	1,476	13,238
Compensation paid (US$)	36	373	282	307	269	1,605
Net loss (US$)	1,107	603	2,028	1,110	1,745	11,633
Total loss due to crop and livestock depredation (US$)	24,503	10,853	7,404	16,711	2,408	37,958

Table 5 Direct benefits derived by Corbett Tiger Reserve, India from tourism during 2004–2007

Year	Number of tourists	Revenue (US$)
2006–2007	144,000	564,286
2005–2006	132,000	461,905
2004–2005	110,000	432,541
Mean ± standard error	128,666.7 ± 9,955.5	486,244 ± 39,931.1

of US $432,541. The number of tourists increased from 132,000 in 2005–2006 to 144,000 in 2006–2007, with a corresponding increase in revenue generated. Total revenue generated from tourism in CTR from 2004 to 2007 was US $1,458,732 (Table 5).

4.5 Recreational value

A total of 308 tourists were interviewed regarding their cost of travel, distance traveled, time taken to reach the destination, reason for travel, and number of visits in a year. Table 6 presents a profile of the 308 tourists interviewed. The number of visitors from different income classes visiting CTR and their cost of travel was regressed to obtain a demand curve. From the function obtained for the demand curve $y = 88{,}243 - 551.98x$, we replaced the value of the ticket fee with succeeding higher values to obtain the consumer surplus. These values gave the final demand curve, the area under which was about US $167,619. This was the consumer surplus, which is the difference between the price which one is willing to pay and the price one actually pays. This was the economic estimate of the recreational services of CTR. The average number of visits per year during 2000–2005 was 77,612. Hence, the average cost per visit was US $2.5.

4.6 Carbon sequestration

Table 7 summarizes the results of carbon stored as standing biomass in the forests of CTR. The minimum price (US $17) of 2008 for CERs projects in India (Tvinnereim et al. 2009) was taken to estimate the value of carbon stored. This value was then divided by the area of forests and discounted at 10% to obtain the annual flow of carbon. This gave the amount of aboveground carbon stored in the forests of CTR on an annual basis, which was 3.84 million tons (Table 7). The total cost of CO_2 mitigation by the forests of the reserve was estimated as US $63.6 million, with annual flow of US $65.0 ha^{-1} year^{-1}.

Table 6 Profile of the 308 tourists interviewed at Corbett Tiger Reserve, India (values in parentheses indicate number of tourists in that category)

	Tourist category				
	I	II	III	IV	V
Annual income (US$)	<2,285 (1)	2,286–4,572 (49)	4,572–7,143 (80)	7,143–11,429 (101)	>11,429 (77)
Distance traveled to reach CTR (km)	<400 (136)	400–800 (20)	800–1,200 (72)	1,200–1,600 (4)	1,600–2,000 (76)
Reasons for visiting CTR	Nature appreciation (90)	Tiger attraction (49)	Leisure (92)	En route (45)	Educational tour (32)
Cost of travel time (US$/individual)	<25 (164)	25–50 (49)	50–75 (33)	75–100 (25)	>100 (37)

Table 7 Estimation of carbon stored in the forests of Corbett Tiger Reserve, India

Forest type	Area (km^2)	Growing stock (mt)	Expansion ratio (ER)	Conversion ratio (CR)	Aboveground forest biomass (mt)	Aboveground forest biomass density (t/ha)	Aboveground crop biomass density (t/ha)	Net change in biomass (mt)	CO_2 stored (mt)
Shorea robusta	544.92	2.565	1.16	0.720	2.142	39.309	10	1,597,106.028	2.928
Tropical dry deciduous forest	433.29	1.345	1.45	0.500	0.975	22.502	10	498,370.158	0.914
Total	978.21								3.842

Source: (a) Forest types and extent: Mathur and Tiwari (1979), (b) growing stock: Mathur and Tiwari (1979), (c) expansion and conversion ratio: Cannell (1982), Singh and Negi (1997), Lal and Singh (2003)

mt million tons

4.7 Catchment protection

The reserve has Ramganga, Sonanadi, Mandal, and Palain Rivers flowing through it. The length of Ramganga River is 627 km. A major part of its watershed (8,676 km^2) is in northern hilly parts of the reserve. The Ramganga Dam Project at Kalagarh has generated over 8,200 kilowatt of electricity with total earnings of US $41 million and over 88810.7 million m^3 of water for irrigation since 1974, without any direct investment in catchment treatment or significant siltation problems.

4.8 Fixing and cycling of nutrients

Forests facilitate breakdown of various nutrients and help them leach to nearby agricultural fields. This is evident in the fertility of the agricultural fields in areas surrounding CTR. Several farm lands in villages inside the buffer are rain fed, with no fertilizers used. Average crop yield here is about 2,000 kg ha^{-1} as compared with the national average of 2,300 kg ha^{-1} even though the amount of fertilizer used is low (125 kg ha^{-1} $crop^{-1}$) as compared with the national average of 450 kg ha^{-1} $crop^{-1}$.

4.9 Perceptions of tourists and local communities

The majority of tourists viewed recreation as the key purpose of PAs such as CTR. A healthy number also assigned importance to biodiversity conservation and the information function of the reserve. Preservation of forests for esthetic purposes and recent awareness of the CO_2 mitigation value of conserved forests were recognized as key functions of the reserve by some tourists. Local people valued consumptive benefits such as fuel wood and fodder extracted from the buffer zone of the reserve, and employment generated due to tourism. Ecological services such as air purification and watershed protection were also appreciated by local people (Fig. 2), although CTR for them meant a fuel wood source, grazing land for their cattle, and employment in the tourism industry.

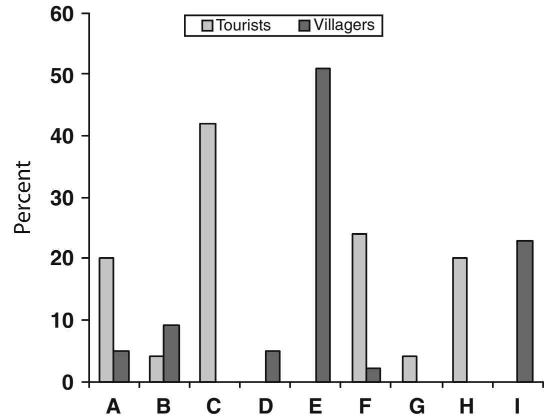

Fig. 2 Responses of tourists visiting Corbett Tiger Reserve, India and local communities surrounding the reserve. *A* purification of air, *B* watershed protection, *C* recreation, *D* soil fertility, *E* fuel and fodder, *F* biodiversity conservation, *G* education, *H* esthetics, *I* employment due to tourism

5 Discussion

Demonstrating the economic value of natural resources can make a convincing case for conservation of ecosystems. Higgins et al. (1997), for example, valued South Africa's mountain ecosystems in order to argue for increasing funding and protection. Spurgeon (1998) showed how valuation can be used to support ecosystem rehabilitation and protection in coastal and marine habitats. Kumari (1995, 1996) calculated the economic value of forests and wetlands in North Selangor to make the case for increased international financing to secure global benefits. Specifically for the case of PAs, the valuation of economic benefits can be used to defend the declaration of new locations or to argue against changes in their protected status. Emerton et al. (1999) calculated the economic value of ecosystem services and livelihood benefits from Nakivubo Wetland in Kampala, Uganda at more than US $1.5 million a year, using the results to make a strong case for it to be protected as part of the city's green belt.

However, the true economic value of PAs is often difficult to measure. These areas may be the repository of unique or very valuable natural assets, yet the short-term gains from exploiting their natural resources can often appear more attractive than the long-term benefits of conservation (Dixon and Sherman 1990). The value of many types of natural capital and ecosystem services may not be easily traceable through well-functioning markets, or may not show up in the market at all. A large part of the contribution of ecosystem services to human welfare is of a purely public goods nature. They accrue directly to humans without passing through the money economy. Economic evaluation of PAs is a novel step in the direction of drawing attention to the wide range of benefits of the ecosystems they provide. The assessment of the services provided by CTR was a stride forward in this direction.

With the capacity to store carbon worth about US $220 $year^{-1}$ ha^{-1}, forests have immense carbon mitigation potential. With estimated annual worth of about US $1,676,190, even with the cost per visitor being as low as US $2.5, the consumer's surplus is huge, showing the willingness of visitors to pay for wildlife recreation. Other benefits such as provision of income and employment, climate control, biodiversity, and watershed management, although not evaluated in detail, are significantly important. At a time when PAs need to justify their designation and management, combining utilitarian needs with wildlife management can provide an excellent argument for protection and one that is likely to be increasingly needed in the future (Dudley and Stolton 2005). This study has also made an attempt to look at the cost–benefit distribution and the perception of key stakeholders, i.e., tourists and local people. It is clear that most of the costs of CTR, i.e., indirect costs due to damage by wildlife as well as opportunity costs in terms of lost access to their life-support systems, are borne by local people, yet little direct tangible benefits accrue to them. Use of forest resources by local people is de facto and indiscriminate, and they have no stake in conservation of the forests (Badola 1999). Overuse of forests due to tenure insecurity as well as the imbalance in cost–benefit distribution are major factors in the lack of investment and interest in improving the productivity of the system by local people (Badola and Hussain 2003; Badola et al. 2000).

In order to apply valuation of ecosystem services to support decision-making on ecosystem management, it is necessary to explicitly consider the scales at which ecosystem services accrue to the different stakeholders, particularly in developing countries such as India, where a large proportion of the population still remain dependent on biomass resources for their livelihoods. Identification of scales and stakeholders allows analysis of potential conflicts in environmental management, in particular between local stakeholders and stakeholders at larger scales, particularly if services relevant at higher scales restrict use of local production services. In the case of CTR, it may be recreational, biodiversity, and watershed services that restrict the use of forest by local stakeholders. Analysis of the (opportunity) costs and benefits of ecosystem management for stakeholders at different scales also provides a basis for determining the size of potential compensation payments to local users (Hein et al. 2006).

Much needs to be researched upon to arrive at a value closer to the actual worth of ecosystem services of CTR and other PAs, which is currently the focus of our research. When all factors are taken into account, most natural ecosystems and PAs have a highly positive benefit-to-cost ratio. It is therefore important to increase efforts to investigate the full economic value of PAs. Quantification of the economic value of PAs can show whether goods and services are currently underpriced and also can capture PA benefits as cash values or monetary values as well as for generating revenues. Prices and market measures can provide an effective means of regulating the demand for resources and incentives for sustainable management (Brockington and Schmidt-Soltau 2004). Better information on the economic value of PAs will most likely provide an important incentive to allocate sufficient funds for their continued conservation and to stimulate sustainable utilization of the important functions of these areas (de Groot 1994). It would also provide adequate information to resource managers and policy makers to adequately address the issues of equity, efficiency, and sustainability in biodiversity conservation.

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