Ecotourism for the survival of sea turtles and other wildlife

Article *in* Biodiversity and Conservation · September 2002

DOI: 10.1023/A:1016833300425 · Source: OAI

2 authors:

Clement Allan Tisdell
The University of Queensland
1,784 PUBLICATIONS **10,139** CITATIONS
SEE PROFILE

Clevo Wilson
Queensland University of Technology
208 PUBLICATIONS **2,054** CITATIONS
SEE PROFILE

Biodiversity and Conservation **11:** 1521–1538, 2002.

Ecotourism for the survival of sea turtles and other wildlife

CLEM TISDELL* and CLEVO WILSON
*School of Economics, The University of Queensland, Brisbane, Qld 4072, Australia; *Author for correspondence (e-mail: c.tisdell@economics.uq.edu.au)*

Received 11 December 2000; accepted in revised form 10 September 2001

Key words: Biodiversity, Economics, Ecotourism, Sea turtles, Sustainable tourism, Wildlife conservation

Abstract. This paper discusses generally why humans should bother to conserve sea turtles. In doing so, it considers both economic and non-economic reasons and outlines threats to the existence of sea turtles and ways in which tourism may either contribute to the conservation or decline of their populations. Turtle-based ecotourism at Mon Repos in southern Queensland is described. As a result of a survey conducted by the authors, it is shown that turtle-based ecotourism at Mon Repos has positive social (indirect) consequences for the conservation of sea turtles. Furthermore, it is argued that ecotourism operations at Mon Repos have positive direct impacts on the sustainability of populations of sea turtles. However, using a simple model, it is emphasised that this impact is limited because turtles are migratory. A model is also developed to capture the possible relationship between turtle populations and the sustainability of ecotourism dependent on turtle populations, and is extended to other wildlife species. Significant interdependence exists between the sustainability of these two variables. The theory is related to Ciriacy-Wantrup's social safe minimum conservation standard for species' survival.

Introduction

All species of sea turtles are listed by the IUCN as being endangered, and the Hawksbill *Eretmochelys inbracata* is listed as critically endangered (IUCN 1996). Sea turtles have become endangered as a result of the adverse consequences of human activities. Positive human action is required to ensure the survival of most species of marine turtles.

In this article, the potential of tourism development based on turtle-watching to contribute to the sustainability of populations of sea turtles is explored. Empirical results are based on findings from a survey of tourists visiting Mon Repos Conservation Park in southeastern Queensland in order to observe turtles. An analysis is developed to specify likely interactions between turtle-watching and the conservation of turtle populations. The sustainability of tourism based on turtle-watching and that of turtle populations is shown to be interdependent for a variety of factors involving both direct and indirect impacts from tourism based on turtle-watching. Extensions of the analysis to conservation of other types of wildlife are suggested and the importance of Ciriacy-Wantrup's concept of social safe minimum standard for the survival of wildlife is highlighted. In many circumstances, this concept is of greater policy relevance than his biological safe minimum standard.

This subject will be explored by considering the following matters sequentially:

1. threats to marine turtles and turtle-based tourism in a general context;
2. turtle-based ecotourism at Mon Repos beach in Queensland – background description;
3. economic, political, communal, educational and indirect conservational consequences of turtle-based tourism at Mon Repos as revealed by a survey of visitors;
4. analysis of direct positive impacts of ecotourism operations in sustaining the population of sea turtles as suggested by experience at Mon Repos; and
5. analysis of the sustainability of ecotourism dependent on turtle-watching or on the viewing of other wildlife, and observations on social safe minimum standards for species' survival, followed by
6. concluding observations.

Why should humans bother to conserve marine turtles?

Before discussing these points, it is relevant to consider why humankind should make a special effort to save sea turtles from extinction. Different social groups often give different reasons.

For economists, the desirability of special action to save sea turtles usually hinges on whether market failure is present and whether a Kaldor–Hicks or a potential Paretian improvement would be achievable as a result of intervention to conserve turtles. Taking a man-centred approach, economists, in order to justify intervention, usually search for evidence of market failure arising from such factors as the presence of externalities and public good characteristics. Given the migratory behaviour of turtles, often transboundary or international in nature, these fugitive resources give rise to economic externalities. Furthermore, public good characteristics are present. For instance, many individuals in society value the pure existence of these animals (existence value) and may collectively desire their conservation for the benefit of future generations (bequest value). Option values are also likely to be present. Some individuals may wish to keep open the option of seeing turtles in the future and this option value may not be fully taken account of in the marketplace. Furthermore, wild turtles in the future could provide or contribute to new products as yet uncertain or unknown, e.g. medicines, and could supply inputs to turtle farming. This uncertainty-option element can provide an additional reason for conserving turtles (Krutilla 1967) or at least, minimal viable populations of turtles, i.e. relatively safe minimum populations (Krutilla 1967; Ciriacy-Wantrup 1968; Bishop 1978; Hohl and Tisdell 1993).

For some philosophers, however, the desirability of conserving species is not purely to be determined by reference to the desires of mankind – values independent of human wishes are recognised. For example, Leopold (1996) argued in favour of preserving ecosystems as a whole because of their intrinsic value as expressed in his land ethic. Passmore (1974) sees humankind as having responsibility to provide stewardship for nature and Sagoff (1988, 1994) argues in favour of the rights of animals and their rights to continue to exist.

In modern times also, the conservation of species, or more widely of biodiversity, has been linked to the possibility of achieving sustainable development. Sometimes it is argued that conservation of biodiversity is necessary to achieve ecologically sustainable development or even sustainable economic development (Tisdell 1999, Chapter 3).

In relation to ecologically sustainable development, it is useful to distinguish between at least two possible objectives:

1. the achievement of economic development or economic growth subject to a specified degree of ecological conservation, and
2. the maintenance of ecological conservation to the extent necessary to ensure sustainable economic development.

Conservation of all species is unlikely to be required to achieve (2), and objective (1) *may* involve a greater degree of biodiversity preservation than (2).

Given perspective (2), it might seem important to show that turtle species do have a keystone role in the maintenance of ecosystems of economic significance to humankind or to show that they could have. Yet the conservation of sea turtles does not seem necessary to achieve (2) because none may be keystone species and none seem to be very important resources for material consumption by humans. Nevertheless, there is a possibility of some species of turtle, such as the green turtle, as a result of its associations with seagrass beds (Jackson et al. 2001, p. 634), being keystone species. However, economic support for conservation of a species does not necessarily depend on its consumptive value nor on whether it is a keystone species in an ecosystem of economic value to mankind. If sea turtles have economic value in themselves, for example, for ecotourism or for the non-use values of total economic value (see Pearce 1993), conserving them may still be socially worthwhile from an extended utilitarian economic perspective, even if turtles are not keystone species. Thus, both non-anthropocentric views and anthropocentric utilitarian arguments can be used to argue in favour of conservation of species, like turtles, even if their consumptive value[1] is not of importance and if they are not keystone species. With this background in mind, let us turn to more specific aspects of conservation of sea turtles.

Threats to marine turtles and the general role of tourism in the conservation and decline of their populations

Although marine turtles face many natural threats to their existence, they have primarily become endangered due to human activities. Some indigeneous communities continue to hunt sea turtles for meat and collect their eggs for consumption.

[1] Actually, most species of marine turtles do have consumptive values, for instance for their meat, eggs and shells, and are eagerly sought by many indigenous communities for consumptive purposes. In Australia, although Aborigines and Torres Strait Islanders are permitted to harvest sea turtles for subsistence purposes, other Australians are prohibited from doing so.

Turtle shells may be used for jewellery and tortoiseshell items. Their leather can also be utilised and tourist souvenirs and curios can be produced from these items. Turtles are subject to damage by power boat strikes, especially if struck by propellers, and may be caught in crab pots or fishing nets and often die in prawn trawl nets. Furthermore, they can become entangled in fishing gear and tackle, plastic ropes and other debris floating at sea and drown, and some species which eat jellyfish are prone to ingest plastic bags and bottles that they apparently mistake for jellyfish and this can result in their death. Pollution, for example, of water by oil spills, poses a risk. In many parts of the world, seagrass (*Sargassum*) beds are being threatened by human impacts and this reduces available sources of food for the Green turtle, *Chelonia mydas*, and shelter for baby turtles. In several countries, urban development along the foreshores of beaches where turtles nest creates major problems for the conservation of turtles. Urban residents may disturb nesting turtles and be tempted to collect their eggs. But more significantly, turtle hatchlings are likely to be disoriented by light from land-based development.

Depending upon the way in which turtle-based tourism is developed, it can either be a positive force supporting the conservation of turtles or a destructive force.

Destructive-type tourism occurs when turtles are utilised unsustainably as a part of such tourism, for example, when they are used to supply specialty turtle-based goods, produce curios, souvenirs and other specialty items for tourists. While the Convention on International Trade in Endangered Species (CITES) helps to reduce the demand from international tourists for turtle-based souvenirs and other durable items made from turtles, it has not completely eliminated this trade or other forms of international trade in turtle-based products. For example, tortoiseshell still finds its way to Japan for the bekko trade, even though Japan is a signatory to CITES.

Tourism can also be destructive of turtles when it does not have proper regard for their ecological needs (cf. Heng and Clark 1991, pp. 33–36). For example, if tourist development results in light distracting to turtle hatchlings or if tall tourist or other buildings shade beaches so that turtle eggs receive insufficient heat to incubate, the turtle sub-population nesting on the beach concerned will eventually be eliminated. Similarly, if tourists cause distress to turtles attempting to nest, they may fail to nest.

Tourist attractions merely based on captive turtles held in aquaria can have a negative impact on turtle populations. This they can do if such turtles are captured from the wild, thereby depleting wild stocks, if the aquaria act as a substitute for ecotourism based on the presence of real turtles, and if they provide little or no conservation message. Much depends on how aquaria-based turtle tourism is developed, and whether or not it is locally seen as a substitute for conserving the rookeries of sea turtles.

Aquaria do have the advantage, from a commercial point of view, of enabling turtle-based tourism to take place during the day and operations are much less labour intensive than those associated with ecotourism reliant on the nesting of wild turtles. Furthermore, captive sea turtle-watching has the advantage that it is not seasonal, as the watching of wild turtles often is, and the tourist is sure to see turtles. This is not the case for ecotourism based on the viewing of wild turtles.

Ecotourism reliant on the viewing of wild turtles is a night-time activity and is

seasonal as a rule. It requires considerable care to be taken by tourist guides in crowd control and a good deal of patience, both on the part of tourists and guides. But for most individuals seeing wild turtles, and even touching the carapace of nesting females (a hands-on experience), in vital parts of their life cycle, it is a special experience building a degree of empathy with turtles that cannot be replicated by a visit to an aquarium holding sea turtles. It is ecotourism of this type that has been developed at Mon Repos beach in southern Queensland.

Sometimes turtles in aquaria are also combined with night-watching of wild turtles, as has now happened at Praia do Forte in Brazil. But in Reunion, for example, turtle-watching is entirely reliant on sea turtles in aquaria. By contrast, at Mon Repos sea turtle-watching is entirely of an ecotouristic nature, depending only on the viewing of wild marine turtles.

Turtle-based ecotourism at Mon Repos beach: background description

Ecotourism is a form of tourism that is usually wildlife based and careful of the environment (Weaver 2001). It is, therefore, likely to be sustainable. Many writers also suggest that ecological/biological education should be an important part of an ecotouristic experience (Wight 1993). The whole experience is likely to leave tourists with a positive attitude towards the conservation of nature.

Turtle-watching at Mon Repos beach near Bundaberg in southeastern Queensland (see Figure 1) satisfies the required conditions for ecotourism. Turtle-watching at this beach is managed by the Queensland Parks and Wildlife Service (QPWS). Turtles may be seen here in the period from mid-November to the end of March of each year, the hottest period of the year in Australia. Mostly loggerhead turtles, *Caretta caretta*, nest on this beach.

Turtle-watching takes place at night under the guidance of QPWS rangers and volunteers. During the turtle season, evening visitors to Mon Repos Conservation Park pay a small fee for entry (see Table 1). The fee enables visitors to see the display on sea turtles at the information centre, participate in the presentation at the outdoor amphitheatre and join a group of up to 70 persons to be guided to the beach to see turtles nesting, if they appear, or to see hatchlings emerging at times when this occurs. QPWS rangers assisted by volunteers explain what is being observed and undertake crowd control. At the same time, they collect scientific data on nesting turtles and hatchlings.

Turtles about to nest usually come ashore in the evening on the high tide and make their way up the beach to find a suitable site to nest. Once a turtle has been noticed by personnel of QPWS, and has found a suitable spot to nest and has become settled at that spot, a group of visitors is brought from the information centre to witness the nesting process. After egg laying is completed and the eggs are covered by the female turtle, visitors accompany it on its return to the sea. Similarly, visitors watch hatchlings emerge and accompany them to the sea.

However, visitors are not assured of seeing turtles and the entry fee is payable whether or not turtles are seen. Furthermore, the time of arrival of any nesting turtles

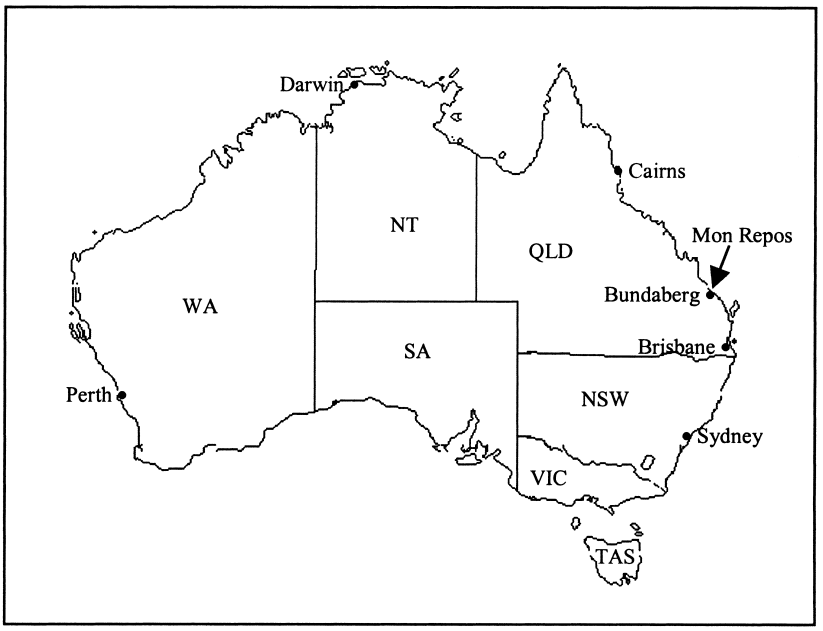

Figure 1. Map of Australia showing the general location of Mon Repos.

Table 1. Nightly entrance fees to Mon Repos during the turtle season (mid-November to the end of March inclusive) 1999/2000.

Single visit ticket	Fee (Aus$)	Season ticket	Fee (Aus$)
Child (5–15)	2	Child (5–15)	5
Pensioner	2	Pensioner	5
Adult	4	Adult	10
Family	10	Family	25
School groups	1 per student	–	–

Source: Queensland Department of Environment and Heritage (1999, p. 3).

is variable. Visitors may have to wait until quite late before a nesting sea turtle is available for viewing. Tourist operations are combined with collection of data about turtles which is used for scientific purposes.

The Queensland state government began the process of creating Mon Repos Conservation Park for the conservation of sea turtles in 1981 by its acquisition of an initial parcel of private land. However, turtle research at Mon Repos beach had already commenced in 1968 as part of the Queensland Turtle Research Programme. In 1985, research staff at Mon Repos commenced formal turtle-watching programmes in order to manage growing crowds of visitors. In 1993, an Information Centre and Amphitheatre were constructed at Mon Repos and in the following 1994/1995 turtle season, ecotourism involving turtle-watching was formalised with an entry fee being charged. In 1991, Woongarra Marine Park was established in

Table 2. Annual number of visitors to Mon Repos Conservation Park for turtle-watching 1993/1994–1999/2000 seasons.

Year	Visitor number
1993/1994	23580
1994/1995	14868
1995/1996	19962
1996/1997	18284
1997/1998	17394
1998/1999	18421
1999/2000	23485

Source: Queensland National Parks and Wildlife Service (unpublished data).

order to protect turtles offshore from Mon Repos and nearby beaches during their breeding season.

Although Mon Repos Conservation Park is only 45 ha in size, it protects the leeward side of Mon Repos beach for a distance of about 1 km, and has prevented urban development of this foreshore area which was mooted in the late 1970s and early 1980s. This, combined with a tree planting programme to reduce light from onshore provides effective protection to turtles at Mon Repos, a major Australian rookery for loggerhead turtles.

The number of visitors to Mon Repos Conservation Park in recent years for the purpose of turtle-watching are shown in Table 2. It can be seen that in the 1994/1995 season the number of visitors fell considerably compared to the 1993/1994 season. This may have been due to an initial adverse reaction to the introduction of fees. However, during the 1999/2000 turtle season, the number of visitors was over 23000 and had returned almost to its 1993/1994 level.

Turtle-based tourism at Mon Repos: its economic impacts and social consequences for the conservation of sea turtles

Ecotourism can have directly beneficial consequences for the conservation of nature as well as indirect benefits. Direct benefits for sea turtles from ecotourism at Mon Repos are specified in the next section. This section concentrates on indirect benefits. These may occur because tourists, as a result of their turtle experience, become more aware of threats to populations of marine turtles, show greater appreciation of the value of turtles and develop greater empathy for them and learn of ways in which they can foster the conservation of turtles.

A survey of visitors to Mon Repos turtle rookery undertaken by the authors in the period December 1999 to the end of March 2000 with the assistance of QPWS staff and volunteers revealed that the turtle experience of tourists at Mon Repos has a strong positive impact on their support for conservation of sea turtles.

A total of 1200 survey forms were distributed to visitors to Mon Repos Conservation Park intending to see turtles. A total of 519 usable complete forms were

obtained. About 15 questionnaires per day were randomly distributed, either with sales of entrance tickets or to visitors waiting to view sea turtles. Completed survey forms were either left with rangers or volunteers at Mon Repos or returned to us in a pre-paid envelope.

Nearly all respondents (99%) said that they found turtle-watching at Mon Repos Conservation Park informative. About a third of respondents learnt about threats to sea turtles for the first time, and 54% said they learnt more about such threats as a result of their visit. So about 87% of respondents were, according to their perceptions, better informed about threats to marine turtles as a result of their visit.

Responses to our survey indicate that the visit convinced the majority of visitors to adopt personal behaviours that would support the conservation of sea turtles. After their visit, 62% of respondents said they would be more careful of disposing of plastics and 47% said this in relation to fishing gear. Most said they would exercise greater care in switching off lights near beaches (68%), avoiding the purchase of tortoiseshell products and turtle eggs, meat and soup (73%) and in using beaches where turtles nest (75%). Furthermore, after their turtle experience at Mon Repos, two-thirds of respondents said that they are likely to report the sighting of sick or injured sea turtles, and 88% said they would report the poaching or mistreatment of sea turtles.

After their visit, 87% of respondents said they were convinced of the urgency of protecting/taking action to conserve sea turtles, and 98% were convinced that *more* action should be taken to minimize threats to sea turtles.

A considerable percentage of responding visitors (40%) said that their visit to Mon Repos will influence them to contribute more money for sea turtle conservation than before. Another 27% said they would contribute the same amount as prior to their visit to Mon Repos, whereas only 1% said they would contribute less. However, 32% did not answer this question. Just over half of the respondents (268 out of 517) indicated that they would be willing to contribute an average of Aus$2.49 per week to protect turtles in Australia, that is over Aus$125 per year per person. This was in response to the following question (8.4): 'In order to protect sea turtles that come to nest in Australia what is the maximum amount you would be willing to pay per week for the next 10 years? (Please bear in mind that this is only one of the many environmental issues which may cost you money and that this may have to come from your family budget.)'. It can be inferred that the visitors to Mon Repos for the 1999/2000 season involved in turtle-watching would be prepared to pay at least Aus$250 000 per year to protect Australian sea turtles. When this is combined with the willingness to pay by turtle-watchers from previous years plus the willingness of some non-visitors to pay for protection of turtles, considerable collective economic value is clearly placed on the conservation of Australian marine turtles. This can also be expected to translate into political support for state programmes for the conservation of marine turtles.

In our survey of visitors to Mon Repos turtle rookery, we asked those interviewed their willingness to pay to conserve marine turtles nesting in Australia. Willingness to pay (per week in Australian dollars and cents) was found using Tobit regression analysis to be positively related to the level of the respondent's educational qualification (coefficient 0.334), the respondent's income (coefficient 0.233) and to

whether or not marine turtles were seen (coefficient 0.299). The relationship was significant at the 1% level for the first two variables and at the 10% level for the latter (Tisdell and Wilson 2000a). The sample consisted of 330 respondents. This provides some evidence (using the contingent valuation method) that seeing marine turtles (adults or hatchlings) has an influence on willingness of ecotourists to contribute funds for the conservation of turtles.

We also asked those interviewed whether they would be more likely to report the sighting of injured or sick turtles to the QPWS after their visit. The change in probability of reporting, depending upon whether or not tourists saw turtles, was found to be significant using a binomial logit model (Tisdell and Wilson 2000b). This binomial logit model relied on 323 usable observations. It, therefore, seems that sighting turtles by visitors influences their likelihood of taking personal actions to conserve marine turtles.

Political support for ecotourism and conservation of turtles at Mon Repos can also be expected from those other than ecotourists. To the extent that turtle-watching at Mon Repos attracts tourists to the Bundaberg region, it has positive local economic impact. From our survey, it was found that 40% of respondents would not have visited the Bundaberg region had turtle-watching not been possible (at Mon Repos) and that a further 19% would have reduced their length of stay in the Bundaberg region. This would have resulted in a fall in initial tourism expenditure in the Bundaberg region by about $0.8 million in the 1999/2000 turtle season.

Furthermore, support for turtle conservation and ecotourism at Mon Repos can be expected from community involvement in these activities. A significant number of community volunteers (36 volunteers contributing 4 hours per week for 5 months) help guide visitors to see turtles at Mon Repos, assist with scientific data collection, and help in other ways. Such communal help fosters community support for the conservation of marine turtles.

Our survey found that respondents obtained a high degree of consumers' surplus on average after the turtle-watching experience. From responses, it can be inferred that on average the consumer's surplus of individuals was more than double their entry fee. This surplus indicates a high degree of economic satisfaction with the turtle-watching experience, and is likely to add to political support for the ecotourism programme at Mon Repos. In addition, the fact that a large proportion of respondents (98%) intended to share their experiences at Mon Repos with friends and relatives would provide an additional avenue of support for conservation of sea turtles.

All in all, the turtle-watching experience at Mon Repos fosters major support, social and economic, for the conservation of marine turtles. This indirect effect via humankind may be as important or more important for turtle conservation than the direct consequences of turtle-watching for the conservation of sea turtles. Consider now the direct impacts.

Analysis of direct positive impacts of ecotourism operations in sustaining the population of sea turtles

Ecotourism (of the type practiced at Mon Repos) can be very effective in protecting

the breeding grounds (rookeries) of turtles. This is particularly so when the rookeries are concentrated in a small area, as is the case at Mon Repos beach.

During the breeding seasons for turtles at Mon Repos, from mid-November to the end of March, turtle-watching visitors are catered for at Mon Repos Conservation Park. This means that the beach is under almost constant surveillance by QPWS rangers and associated volunteers from dusk until past midnight when most female turtles come ashore to nest. Turtles come ashore at night to nest. During the night-time unauthorised entry to this beach is prohibited.

Park rangers and volunteers guiding ecotourists to watch turtles at Mon Repos have the indirect effect of guarding turtles against illegal human intrusion. Furthermore, predators are kept at bay during nesting of turtles because most female turtles are watched during the whole of their nesting activities and are accompanied by turtle-watchers until they return to the sea. Moreover, emerging baby turtles are likely to be under protective surveillance for much of the night because of the presence of turtle-watchers. So large batches of young turtles on land at night are given some extra protection before they enter the sea as a result of the presence of turtle-watchers.

Hence, it can be argued that the development of turtle-based ecotourism has a positive *direct* impact on rookeries such as that at Mon Repos in protecting turtle populations. This is so apart from any indirect impact, for example, through increased political support for turtle conservation.

In addition, turtle ecotourism at Mon Repos has led to some investments which help to increase the likely survival of baby turtles. For example, there has been planting of casuarinas (she-oaks) along the leeward side of the beach to reduce light emissions from land. Light from the land disorientates hatched turtles. They are photosensitive and move towards the area emitting the greatest amount of light. In normal circumstances, this is the sea. But artificial light from the land may cause baby turtles to move inland where they meet their death.

Scientific data collection, such as that obtained by tagging of turtles, egg counts and so on, is combined with turtle-watching at Mon Repos. Because of the presence of visitors a greater number of volunteers may be available to help with collection of scientific data. In the long term, these data could assist in the development of improved policies for managing turtle populations. Scientific data collection and research involve an investment likely to enable more effective strategies to be developed to sustain turtle populations.

Furthermore, the presence of ecotourism at Mon Repos provides some stimulus to programmes to control predators of turtle eggs. The fox, *Vulpes vulpes*, introduced to Australia from Britain is, for example, a significant predator of turtle eggs. Baiting programmes to reduce the population of foxes in the vicinity of Mon Repos beach have been introduced.

However, even if the number of turtle hatchlings reaching the ocean is increased by ecotourism activities at Mon Repos, it will take a long time before this is translated into a larger number of female loggerhead turtles coming ashore at Mon Repos to nest. This is because it takes 30–50 years before females are mature and lay their first clutch of eggs (Queensland Turtle Research 1994, p. 27). Conservation in this case requires a long-term perspective to be taken.

Like salmon returning to their stream of birth, marine turtles usually return to nest on the beach where they were born. It is suggested that they are able to do this because of geomagnetic sensitivity and memory. This raises an interesting 'property rights' or appropriation perspective. If the distribution of mortality of turtle hatchlings entering the sea at the rookery is constant, and in particular if the relative frequency distribution of turtles reaching adulthood is constant and is positive, in the long term the population of adults nesting at a rookery will rise if the population of hatchlings from the rookery entering the sea increases.

Ignoring overlapping generations, then roughly the population of nesting turtles at a rookery in period $t + n$ (where n is the period required for turtles to reach maturity and t represents the time of birth of turtles) might be represented as

$$y_{t+n}=f(x_t), \quad \text{where } f'>0 \tag{1}$$

and y represents the population of nesting turtles and x_t the number of female hatchlings entering the sea at time t.

Consider the simple linear case

$$y_{t+n}=ax_t \tag{2}$$

where a is the coefficient of survival of female hatchlings to adulthood.

Note that only females come ashore to nest, and different beaches have different ratios of females to males in their population of turtle hatchlings. The sex composition of hatchling populations is temperature dependent. Warmer beaches tend to produce a higher proportion of females, and the proportion of female hatchlings at Mon Repos is high. If X_t represents all hatchlings entering the sea and Θ represents the proportion of females, then Equation (2) can be rewritten as

$$y_{t+n}=a\Theta X_t \tag{3}$$

If the 'appropriation' of ecotourism benefits from conservation of sea turtles at the rookery is dependent on the long-term return of females, this benefit will be greater, other than things unchanged, the easier it is to increase or maintain X_t and the higher is a, the survival coefficient.

The coefficient a depends on two elements, the natural rate of mortality (b_1), and mortality due to anthropogenic factors (b_2), that is:

$$a=1-(b_1+b_2) \tag{4}$$

While it may be impossible or considered undesirable to try to increase b_1, there may be scope to reduce b_2. In Australia, measures to reduce b_2 include limitations on the speed of boats in the neighbourhood of turtles, turtle-excluding devices on prawn trawlers, and trawler exclusion zones such as that during the turtle-breeding season at Woongarra Marine Park abutting Mon Repos and surrounding beaches. But additional reductions in b_2 are possible, for instance, by avoiding disposal of plastic bags and containers into marine areas where some species of turtles ingest these and die. Moreover, mortality can be further reduced by ensuring that fishing gear, tackle, plastic ropes and nets are not left at sea for turtles to become entangled in.

However, because sea turtles are international transboundary resources (they

migrate over long distances and between countries), the countries where they nest do not have complete control over b_2, because of their mortality in international waters and in the exclusive economic marine zone of other countries. In these circumstances, reducing b_2, or preventing it from rising, is likely to depend significantly on international cooperation (cf. Tisdell 1986).

Analysis of the sustainability of ecotourism dependent on turtle-watching or the viewing of other wildlife, and observations on social safe minimum standards for species' survival

Judging from the responses to the survey of visitors to Mon Repos for the purpose of seeing turtles, ecotourism can be very effective in building community support for programmes to conserve turtles, as reported earlier. However, it seems likely that the demand for the opportunity to watch turtles nesting or hatchlings at a locality will depend on the probability of seeing them.

Other things equal, the probability of seeing turtles on a beach will depend on their population. As the population of turtles declines on a beach, the demand to engage in turtle-watching there can be expected to decline. The sustainability of tourist visits, therefore, depends on the extent to which turtle populations visiting a beach are maintained. In turn, given that community support for turtle conservation programmes is to a considerable extent experiential (that is, dependent on human interaction with turtles), political and private support might vary in a similar way to the frequency function for visits by tourists.

The frequency function (total number of visits for turtle watching) might take the form of the logistic type as shown in Figure 2. As drawn, this suggests that there may be a threshold at which the demand for visits by turtle-watchers to a rookery declines precipitously as the population of (female) turtles visiting the rookery during the breeding season declines. Thus, unless turtle populations visiting a rookery can be saved early enough from significant collapse, tourist visitor numbers and communal support for turtle conservation could crash, thereby compounding the problem of reversing the unfavourable downward trend in sea turtle populations. In the most extreme case, mathematical catosphere theory would apply because a discontinuous decline or 'jump' in social support for conservation of turtles may occur, and the situation may become irreversible from a social or political viewpoint as well as biologically if programmes to conserve turtles are subsequently scaled back.

This interesting sustainability phenomenon is not, however, confined to ecotourism based on turtle-watching. It is likely to occur for ecotourism and recreation involving the viewing of most wild animals. It may also be present for the recreational hunting of wildlife, given that hunters are often strong supporters of conservation of their hunting stock.

It is, therefore, hypothesised that the number of ecotourism visits for viewing most wildlife species displays a similar relationship to that illustrated in Figure 2. What explains the sigmoidal- or logistic-like curve, which may decline even more

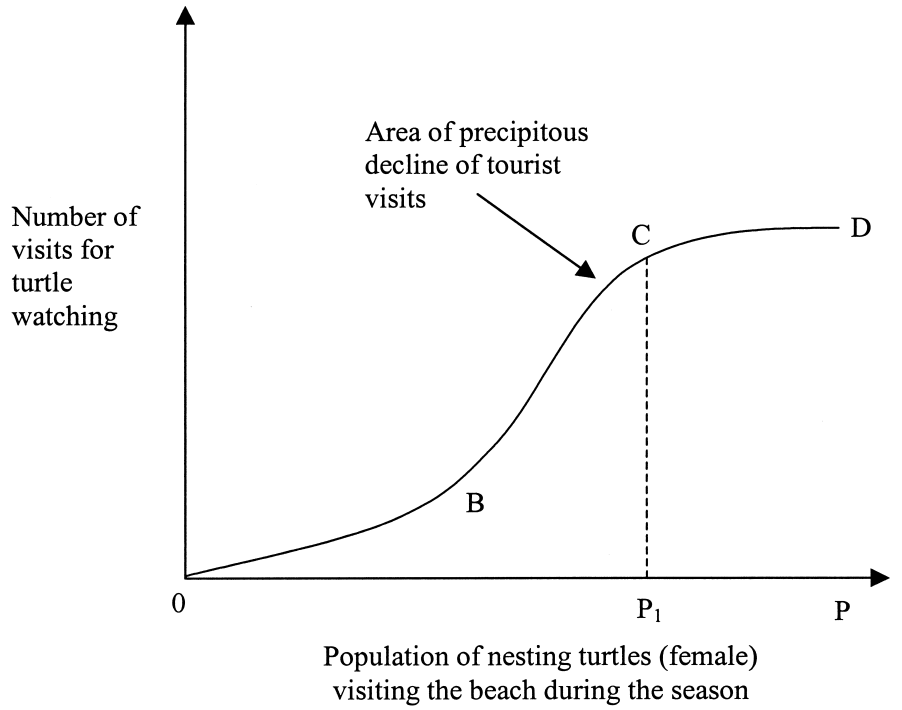

Figure 2. Sustainable ecotourism and sustainability of populations of turtles are interrelated.

precipitously than shown in Figure 2 when the abundance of the targeted species falls below critical levels? Depending on circumstances, one or more of the following factors are relevant:

1. the likelihood of observing animals (as pointed out by a reviewer[2]) may be a non-linear function of their population density;[3]
2. while viewing an increased number of animals of the same species may provide extra benefit or utility to an ecotourist, this increase in utility (in view of the law of eventually diminishing marginal utility) is likely eventually to be at a decreasing rate; and
3. ecotourists incur costs in order to engage in the viewing of animals.

Particularly when it is combined with the other factors, the last mentioned factor may be especially important in explaining a precipitous decline in the number of

[2] An anonymous reviewer suggested that halving the abundance of turtles might reduce the probability of turtles being encountered by a tourist by one-quarter. This suggests that if r is the probability of a tourist encountering a turtle, a is a parameter, and P is a measure of the abundance of turtles, then $r = aP^2$ for values of P below some specifiable level.

[3] An additional influence, of importance in some cases, is the number of individuals or tourists wanting to view the animals. This is assumed to be constant in the model outlined but the theory of this can be developed further. It is important in some situations involving tourists.

visits by ecotourists once the abundance of the targeted species falls below critical levels.

The theoretical importance of the above-mentioned elements can be demonstrated in terms of a simple benefit-cost model. Assume that the decision by an ecotourist of whether or not to visit a site in order to view a species depends upon whether the ecotourist anticipates a positive or negative net benefit from the visit, that is, on whether the expected benefit from the visit less the cost of it is positive or negative.

The curve of expected benefit from the visit (other things constant) is a function of the abundance of the targeted species at the site and may typically be similar to curve 0AD in Figure 3. The nature of this curve depends on the probability of seeing members of the species and on the benefit or utility derived (or expected to be derived) from this experience. The probability of seeing animals as a function of their population will vary by species and with such factors as their size, the presence of vegetation or similar cover and with their behaviour (cf. Seber 1982, p. 19). Possibly the coefficient of variation of sightings also increases as the population density of a species declines (cf. Cormack 1979) and this can also contribute to the rapidity of decline in the expected utility of a viewer as the population density of a species declines. Furthermore, the shape of the curve refects the law of eventually declining marginal utility.

In Figure 3, the cost of a visit to view the targeted species is shown by line FG, and therefore, is independent of the abundance of the targeted species. We observe that if the abundance of the species exceeds P_1, the individual tourist will obtain a net benefit from visiting the site but once the species' population at the site falls below P_1, a visit is unattractive. Thus, whether or not the individual tourist visits is a function stepped at P_1. Therefore, P_1 is the threshold for this individual tourist.

Now not all ecotourists (or individuals) have the same cost functions for visits to see wildlife and some derive greater anticipated benefits from visits than others. This means that the thresholds of individuals for visits can be expected to differ to some extent. Nevertheless, these thresholds are likely to show some clustering. Consequently, in the animal population density range in which clustering occurs, the total number of ecotourist visits to the wildlife viewing attraction can be expected to decline rapidly as the population of the targeted wildlife species falls. Nevertheless, the total visitation curve, in view of the aggregation involved, may be continuous, although it need not be.

A further possible extension of the theory is to consider the connection between the number of ecotourists viewing the population of a species and political or social support for its conservation. While it is not possible to develop the theory here, the possibility ought to be recognised that this is probably a non-linear function of the level of use of the targeted species for tourism. Below some level of visits, political support may fall off abruptly, mainly because of the transaction costs involved in political activity. If this is true, there is also possibly a second social type of threshold to consider in relation to wildlife conservation, where V is an indicator of political support for conserving a species, y is the number of visits by ecotourists for viewing the species and P is the population abundance of the species. The nature of relationships $V = g(y)$ and $g[f(P)]$ can be of critical importance (in a social context) for the survival of the species.

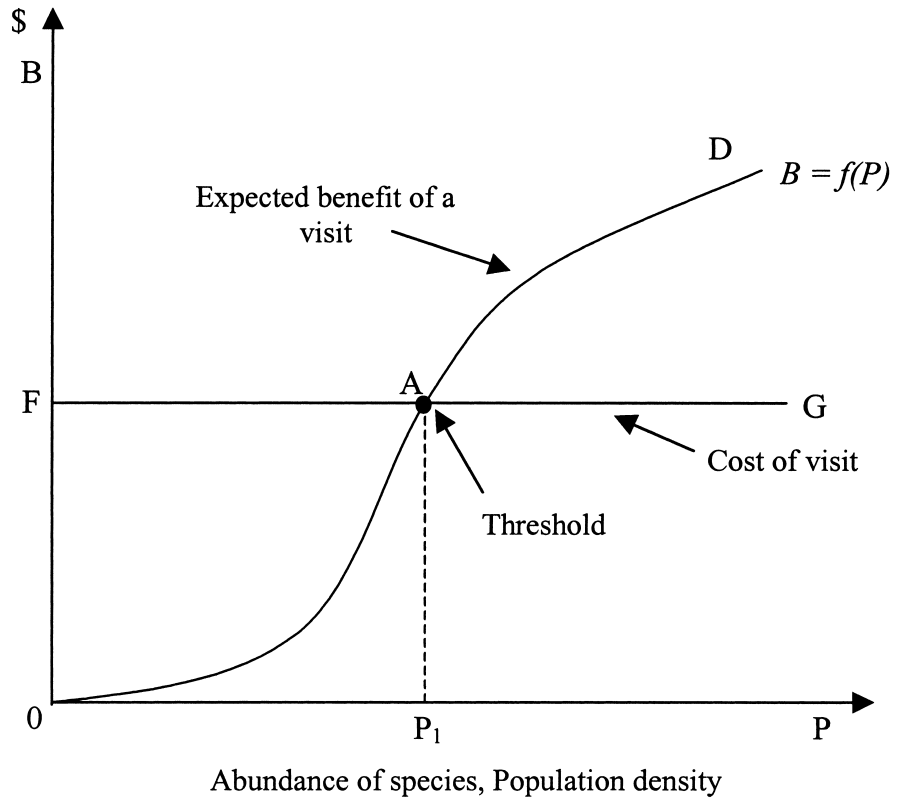

Figure 3. An ecotourist's decision to visit a wildlife site for viewing a species depends critically on the benefit and cost of doing so, and benefit is a function of the species abundance at the site, other factors held constant.

The occurrence of a population threshold, below which social support for conservation of a species declines abruptly, can be expected to increase the risk of biological extinction of an already vulnerable species. For some vulnerable species, it implies that unless their populations are kept above the social-support threshold, biological extinction becomes inevitable. Ciriacy-Wantrup (1968) stressed that in conservation policy both safe minimum social and biological thresholds are important and that the safe minimum social standard (such as the minimum population of a species) is often in excess of the biological one (cf. Seidl and Tisdell 2001). This may be especially so for species which are mostly dependent on ecotourism to generate social support for their conservation.

Nevertheless, we do not also rule out the opposite possibility to that considered above, namely, in some cases a reduced population of a species might result in increased social support for their conservation when their population falls below some threshold. But this case seems unlikely for social support stemming from ecotourism, because demand for ecotourism depends on the likelihood of tourists seeing populations of targeted species. In any case, both human social processes

impacting on nature conservation and biological constraints and thresholds for the conservation of species must be considered in devising policies for the conservation of biodiversity.

Concluding comments

The type of ecotourism developed at Mon Repos Conservation Park based on turtle-watching has both, as outlined, positive indirect and direct consequences for the conservation of loggerhead sea turtles. Possibly, the population of nesting sea turtles at Mon Repos beach has not as yet fallen below the critical level (see Figure 2) for sustaining support from tourists for sea turtle conservation.[4] In the four turtle seasons 1996/1997–1999/2000, a seasonal average of 183 loggerheads, six flatbacks and two green turtles were recorded as nesting at Mon Repos. This may be just above the critical tourist threshold in Figure 2. So from this point of view, the conservation position at Mon Repos seems precarious: any significant decline in numbers of turtles currently nesting at Mon Repos may result in a major decline in its visitors to watch turtles.[5]

[4] Insufficient data were available to test the theory at Mon Repos.

[5] Note that given the estimated average number of sea turtles visiting Mon Repos each season, the maximum average number of visitors that Mon Repos could cater for actually watching egg-laying is 13370β per season where β is the average number of clutches laid by a nesting female in a season, that is 191 (average number of nesting turtles per season) times 70 (maximum number of tourists per nesting turtle allowed to have the encounter) times β. If an equal number of tourists are able to observe hatching, the average total maximum number of tourists able to observe either nesting or hatchlings per year would be 26740β. In the 1999/2000 season, visitor numbers were 23485, see Table 2.The exact value of β is not certain. Limpus and Reimer (1990, p. 39) report that in any single breeding season each nesting female lays 2–6 clutches of eggs at about fortnightly intervals. If the average and the median coincide, then $\beta = 4$. Thus, if tourists availed of all viewing opportunities, 106960 visitors could be catered for at a maximum to view either egg-laying or hatching but not both.A clutch of turtle eggs all hatch at about the same time, so there is a high positive (but not perfect) correlation between hatching of clutches and previous nesting activity. Some clutches fail to hatch because of predation, infertility and negative environmental effects. So if a maximum of 70 persons is allowed per clutch to witness hatchlings emerging and making their way to the sea, the total number of tourists able to witness this event will be fewer than the number able to witness egg-laying. Hence, even the above average upper limit of 106960 observations by tourists of egg-laying by turtles or hatching activity is too high. If z is the number of clutches of eggs laid in a season, λ the proportion of clutches able to hatch and 70 the maximum number of tourists per event, then the total maximum number of tourist observations for these events is $70(z + \lambda z)$ per season. Given the uneven pattern of visits by tourists, of arrivals of turtles and the hatching of their eggs as well as other tourist capacity limitations such that not all turtle events at Mon Repos can be observed by tourists, some visitors in the 1999/2000 season did not see marine turtles. Other things equal, the relative frequency of visitors to Mon Repos being unable to view marine turtles can be expected to rise if visitor numbers further increase, even though visitor numbers are still well below absolute capacity. Thus, the factor mentioned of the number of individuals wanting to view turtles could be of growing importance for ecotourism at this site. Any decline in turtle numbers will worsen the situation and as observed by Limpus and Reimer (1990, p. 39), there is a continuing danger of ''insufficient nesting turtles [in the future] to maintain a viable public environmental education program centred on the turtle rookery of Mon Repos and the adjacent Bundaberg beaches''.

While turtle-based tourism at Mon Repos appears to fulfil the ideal conditions for ecotourism, this is not true of all turtle-based programmes. Whether or not aquaria-based turtle tourism helps to conserve populations of turtles depends upon how such attractions are managed and their programmes generally. Some appear to be purely captive facilities without breeding programmes for turtles, and without significant educational or other programmes to support the conservation of sea turtles. Others are associated with programmes to purchase turtle eggs from local people, hatch them under protection and release them, provide education about the conservation of sea turtles as well as to provide local employment. This is the case at the Kosgoda Turtle Hatchery in Sri Lanka (Gampbell 1999) and at Praia de Forte in Brazil (Vieitas et al. 1999; see also Marcovaldi and Marcovaldi 1999). There has also been development of ecotourism based on non-captive populations in less developed countries, for example in Costa Rica (Place 1991; Lee and Snepenger 1992). How successful that has been compared to the programme at Mon Repos has yet to be assessed.

This paper highlights the importance for conserving a species of thresholds in the demand for visits by ecotourists to view it, and in turn of thresholds in political and social support for conserving the species, as a function of its abundance. Thus, the significance of Ciriacy-Wantrup's concept of a social safe minimum standard is underlined. This significance often transcends the importance of the biological safe minimum standard.

Acknowledgements

We are grateful to the Cooperative Research Centre for Sustainable Tourism for providing some financial support for the case study, and to rangers, especially Cathy Stutchbury, and volunteers at Mon Repos for their assistance. We also wish to thank Dr Colin Limpus of the Queensland Parks and Wildlife Service for his assistance and Dr Bob Prince of The Western Australian Department of CALM for supplying useful references, and an anonymous reviewer of this journal for constructive comments on an earlier draft of this paper. The usual *caveat* applies.

References

Bishop R.C. 1978. Endangered species and uncertainty. The economics of the safe minimum standard. American Journal of Agricultural Economics 60: 10–18.

Ciriacy-Wantrup S.V. 1968. Resource Conservation: Economic and Policies. 3rd edn. Division of Agricultural Science, University of California, Berkely, California.

Cormack R.M. 1979. Models for capture–recapture. In: Cormack R.M., Patil G.R. and Robson D.S. (eds), Sampling Biological Populations. International Co-operative Publishing House, Fairland, Maryland, pp. 217–256.

Gampbell J. 1999. To save the turtles. Reader's Digest May: 49–55.

Heng C.E. and Clark L.H. 1991. The Leatherback Turtle – A Malaysian Heritage. Tropical Press, Kuala Lumpur.

Hohl A. and Tisdell C. 1993. How useful are safe minimum standards in economics? The example of safe minimum standards for protection of species. Biodiversity and Conservation 2: 168–181.
IUCN 1996. 1996 IUCN Red List of Threatened Animals. IUCN, Gland, Switzerland.
Jackson J.B.C., Kirby M.X., Berger W.H., Bjorndal K.A., Botsford L.W., Bourque B.J. et al. 2001. Historical overfishing and the recent collapse of coastal ecosystems. Science 293: 625–635.
Kay A. 1995. Sea Turtle Encounters, Mon Repos Conservation Park. Department of Environment and Heritage, Brisbane, Australia.
Krutilla J.V. 1967. Conservation reconsidered. American Economic Review 57: 777–786.
Lee D.N.B. and Snepenger D.J. 1992. An ecotourism assessment of Tortuguero, Costa Rica. Annals of Tourism Research 11: 367–370.
Leopold A. 1996. A Sand Country Almanac: with Other Essays in Conservation from Round River. Oxford University Press, New York.
Limpus C. and Reimer D. 1990. The loggerhead turtle, *Caretta caretta* in Queensland: a population in decline Proceedings of the Australian Marine Turtle Conservation Workshop, 14–17 November 1990, Sea World Nara Resort, Gold Coast, Australia. Queensland Department of Environment and Heritage and the Australian Conservation Agency, Brisbane, Australia, pp. 39–59.
Marcovaldi M.A. and Marcovaldi G.G. 1999. Marine turtles of Brazil: the history and structure of projeto TAMAR-IBAMA. Biological Conservation 91: 35–41.
Passmore J.A. 1974. Men's Responsibility to Nature: Ecological Problems and Western Traditions. Duckworth, London.
Pearce D. 1993. Economics Values and the Nature World. Earthscan, London.
Place S.E. 1991. Nature tourism and rural development in Tortuguero. Annals of Tourism Research 10: 186–201.
Queensland Turtle Research 1994. A Matter of Time: Sea Turtles of Queensland. Department of Environment and Heritage, Brisbane, Australia.
Queensland Department of Environment and Heritage 1999. Turtle Watching Guide–Mon Repos Conservation Park. Queensland Department of Environment and Heritage, Bundaborg, Australia.
Sagoff M. 1988. The Economy of the Earth. Cambridge University Press, Cambridge, UK.
Sagoff M. 1994. Should preferences count? Land Economics 70: 127–144.
Seber G.A.F. 1982. The Estimation of Animal Abundance and Related Parameters. 2nd edn. Charles Griffin and Company, London.
Seidl I. and Tisdell C.A. 2001. Neglected features of the safe minimum standard: socio-economic and institutional dimensions. Review of Social Economy 59: 417–442.
Tisdell C.A. 1986. Conflicts about living marine-resources in Southeast Asia and Australian waters: turtles and dugongs as cases. Marine Resource Economics 3: 89–109.
Tisdell C.A. 1999. Biodiversity, Conservation and Sustainable Development: Principles and Practices with Asian Examples. Edward Elgar, Cheltenham, UK.
Tisdell C.A. and Wilson C. 2000a. Wildlife-based tourism and increased support for nature conservation financially and otherwise: evidence form sea turtle ecotourism at Mon Repos. Economic, Ecology and the Environment, Working Paper No. 54. Department of Economics, The University of Queensland, Brisbane, Australia.
Tisdell C.A. and Wilson C. 2000b. Environmental education and ecotourism: a study of turtle-watching. Economics, Ecology and Environment, Working Paper No. 55. Department of Economics, The University of Queensland, Brisbane, Australia.
Vieitas C.F., Lopez G.G. and Marcovaldi M.A. 1999. Local community involvement in conservation – The use of mini-guides in a programme for sea turtles in Brazil. Oryx 33: 127–131.
Weaver D.B. 2001. Ecotourism in the context of other tourism types. In: Weaver B. (ed.), The Encyclopaedia of Ecotourism. CABI Publishing, Wallingford, UK, pp. 73–83.
Wight P. 1993. Sustainable tourism: balancing economic environmental and social goals within an ethical framework. Journal of Tourism Studies 4: 54–66.