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# **ECONOMICS, ECOLOGY AND THE ENVIRONMENT**

**Working Paper No. 126**

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Saltwater Crocodiles: An Australian Case Study  
of Sustainable Commercial Use**

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# Management, Conservation and Farming of Saltwater Crocodiles: An Australian Case Study of Sustainable Commercial Use

## ABSTRACT

Opinions differ about what types of policies are likely to be most effective in conserving wildlife species. For example, the Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES) is based on the premise that curbing the commercial use of endangered species favours their conservation, whereas the Convention on Biological Diversity envisages the possibility that such use may contribute to the conservation of species. In Australia, as illustrated in the case of the saltwater crocodile, the governments of the Northern Territory and Western Australia have favoured the latter policy in recent years whereas Queensland has favoured the former approach. The saltwater crocodile management plan of the Northern Territory provides an instructive case study of the consequences of adopting a commercial use strategy to promote wildlife conservation. The methodology used in this study, which involves a survey of crocodile farm managers and managers of cattle properties in the Northern Territory as well as secondary data, is outlined, after providing background on the conservation status of saltwater crocodiles in Australia and the saltwater crocodile management plan of the Northern Territory. In the results section, after outlining the nature and structure of the Northern Territory crocodile farming industry, evidence is presented on whether or not the crocodile management plan of the Northern Territory encourages pastoralists to conserve crocodiles on their properties. This study concludes with a discussion of the overall conservation effectiveness of the crocodile management scheme of the Northern Territory and considers its possible implications for saltwater crocodile management in areas of Asia where the species occurs.

**Keywords:** Australia; conservation economics; Convention on Biological Diversity; Convention on International Trade in Endangered Species; *Crocodylus porosus*; property rights; saltwater crocodiles; sustainable use; wildlife conservation.

# Management, Conservation and Farming of Saltwater Crocodiles: An Australian Case Study of Sustainable Commercial Use

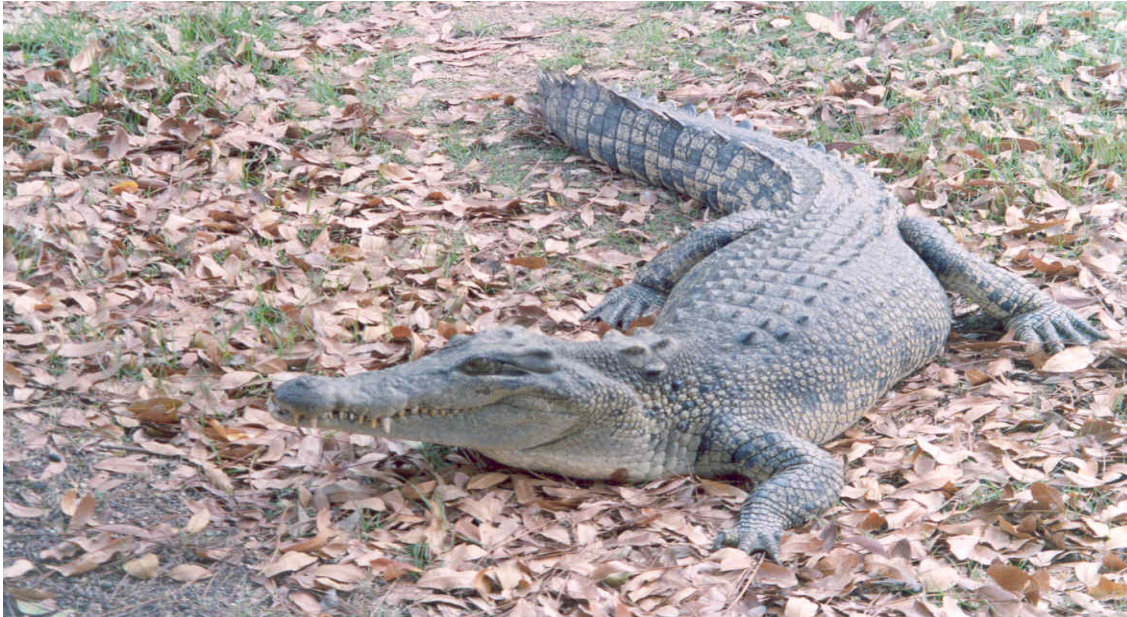
## 1. INTRODUCTION

There are several different approaches to conserving wildlife species. One that has obtained growing support in recent years is the use of economic incentives to encourage the sustainable use of wildlife. This policy has, for example, been espoused in *Caring for the Earth* (IUCN-UNEP-WWF, 1991) and has been reflected in the framing of the Convention of Biological Diversity. This approach is motivated by the view that in the absence of economic incentives to conserve wildlife species on their land, landholders (which can include private, state and communal landholders) will obtain no economic benefits from wildlife on their properties. They will, therefore, have little or no economic reason to conserve wildlife because of their inability to appropriate economic returns from it. With some qualifications, this point of view has been endorsed by economists such as Swanson (1997). The ban on trade in ivory which was once adopted under CITES (Convention on International Trade in Endangered Species of Wild Flora and Fauna) as a strategy to prevent the decline in African elephant populations has been used as an example (Barbier *et al.*, 1990). This strategy was claimed to be counterproductive because it reduced funds available to those African governments which were genuinely pursuing the conservation of elephants. It also denied local communities legal economic benefits from elephants thereby taking away any motivation they might have had to help conserve them.

However, this sustainable use strategy is in conflict with the conservation policy underlying CITES. When a species is endangered, the main strategy adopted by CITES is to ban trade in the species, thereby removing market-based economic incentives for its commercial exploitation. If the species is an open-access resource (freely available to all to exploit), this can reduce harvesting pressure on it and help conserve it. This would be so, for instance, for species in the open seas (*cf.* Hardin, 1968). In the case of a species exploited by open-access, the higher the market gains from its exploitation, the higher is the intensity of exploitation. In this case, an increase in commercial economic gains raises the likelihood of extinction of the species (Tisdell, 2002, Ch. 8; 2005). By contrast, if populations of the species are the exclusive and effective

property of landholders (or sea-space holders), the opposite result follows: as the commercial or marketable economic benefits from the species rises, landholders will become more eager to manage the species so that its population is sustained. However, the market-based gains must be enough to give a positive return to the landholder from husbanding the species for the landholder to have an incentive to conserve it (*cf.* Tisdell, 2004a, b).

The saltwater crocodile *Crocodylus porosus* (illustrated by Figure 1) is a species with considerable commercial use value. Therefore, it is possible that it might be conserved by giving landholders exclusive property rights to crocodiles on their properties and by allowing the marketing of crocodiles and products derived from them. This sustainable use approach to conserving crocodiles has been adopted by the governments of the Northern Territory (of Australia) (NT) and of Western Australia (WA) whereas the Queensland government continues to ban the commercial sale of crocodiles (including their eggs) from the wild. The result has been that ranching of saltwater crocodiles occurs in NT and WA but not in Queensland, the only Australian states in which crocodiles occur in the wild (see for example, Tisdell, *et al.*, 2005). However, commercial crocodile farms exist in all three Australian states. Farms in Queensland rely mostly on the incubation of eggs laid by crocodile brood stock on the farms whereas those in NT and WA rely heavily on crocodile eggs and adults collected from the wild and for which they pay landholders a fee.



**Figure 1: A photograph of an adult saltwater crocodile in the Northern Territory of Australia.**

The purpose of this article is to consider and assess the policy of the NT for managing and conserving saltwater crocodiles using information provided to the authors by crocodile farmers and by managers of pastoral properties primarily producing beef cattle. The presentation is developed as follows: After providing some brief historical background on the status of saltwater crocodiles in Australia and the crocodile management plan of the Northern Territory, the methodology used for surveying crocodile farmers and pastoralists in NT is outlined. The results are then reported and discussed. In this study, we give particular attention to whether crocodile farming is likely to remain commercially viable in the NT. In the absence of the continuing economic viability of this sector, the NT's commercial use strategy for conservation of crocodiles will be jeopardised. Secondly, we enquire whether managers of NT pastoral properties from which crocodile eggs are collected by crocodile farmers and for which the landholders receive a payment do in fact adopt practices that help to conserve saltwater crocodiles as a result of the payments they receive.

## **2. BRIEF BACKGROUND ON THE CONSERVATION STATUS OF SALTWATER CROCODILES IN AUSTRALIA AND THE CROCODILE MANAGEMENT PLAN OF NT**

Crocodiles were effectively open-access resources in Australia until 1969. From the mid-1940s onwards, they were increasingly hunted for recreational and commercial purposes. The commercial harvesting of saltwater crocodiles was mainly for the skin trade (Webb *et al.*, 1987; PWCNT, undated). By around 1965, overharvesting had greatly reduced Australia's population of saltwater crocodiles. In the NT, for example, the estimated initial population of saltwater crocodiles of about 100,000 individuals (Webb *et al.*, 1984) had been reduced by around 95% to around 5,000 individuals (Webb *et al.*, 2000). The species had become endangered in Australia. This resulted in both WA and NT fully protecting crocodiles in 1969 and 1971, respectively, and Queensland followed suit in 1974 (Letts, 1987). Recreational harvesting and hunting of crocodiles for commercial purposes were banned. However, Australian Aborigines still retained the right to hunt crocodiles for their own subsistence.

Research on the possibility of farming saltwater crocodile possibly began in 1969 in Queensland when a crocodile farm was set up under a State government scheme. It aimed at conserving crocodiles while at the same time providing employment to local indigenous people (Onions, 1987). No commercial crocodile farming operations were in existence then.

As a result of protection given to saltwater crocodiles in the NT, their population rose and it is estimated that by the early 1990s that their population had returned to pre-exploitation levels (Webb *et al.*, 1986; Webb *et al.*, 1994). Even by the beginning of the 1980s, the number of crocodiles had increased and there were calls for culling them, especially after crocodile attacks were reported (Webb, 2002, p. 17). Australia's management of saltwater crocodiles responded to include a public education programme about the recovering crocodile population and dangers that they may pose, a programme to remove problem crocodiles so as to minimise hazards to livestock and humans, and crocodile farming and ranching (the collecting of crocodile eggs from the landholders in exchange for money) (Webb, 2002, p. 17). Egg harvesting from the wild started in NT in 1979/1980 on a small scale with collections numbering in the hundreds. In the mid-1980s, when Australia's proposal to move its saltwater crocodile population to Appendix II



of CITES succeeded, collections were scaled up, and since 1989/1990, between ten to twenty thousand eggs were harvested annually. In the mid-1990s, the NT government started to allow limited harvesting of hatchlings, juveniles and adults by commercial crocodile farms. The number of adult crocodiles harvested in 1997 was 17 individuals and recently, it was as high as 600 adult individuals. Increasing commercial harvesting since the 1980s has been accompanied by gradually increasing saltwater crocodile populations in the wild (Webb *et al.*, 2000; PWCNT, undated).

The saltwater crocodile was considered to be an endangered and vulnerable species in the past, but now is considered at 'lower risk' or of 'least concern' according to the IUCN (World Conservation Union) Red List (Crocodile Specialist Group, 1996). The species is classified under Appendix II in CITES and controlled trade is permitted for Australia, Indonesia and Papua New Guinea. For all other countries including India (UNEP-WCMC, 2005), where its populations have been extirpated from most of its range and are low, the saltwater crocodile remains listed under Appendix I, prohibiting harvest for trade. India's remaining populations are found mainly in nature reserves in Orissa and West Bengal and in the Nicobar and Andaman Islands (Whitaker, 1987).

Saltwater crocodile skins produce the highest quality leather of all species of crocodiles (Peucker, 1997; Department of Primary Industries and Fisheries, 2005), and these are the primary products of Australia's crocodile farms. Australia exports crocodile skins for the manufacture of leather goods and, on a smaller scale, produces its own finished products such as shoes, belts, watchstraps and handbags (Ashley and David, 1987; Brazaitis, 1987). Crocodile meat, a byproduct, is mainly consumed domestically but it is also exported (Peucker, 1997; Department of Primary Industries and Fisheries, 2005). The fascination with crocodiles as powerful and dangerous beasts in the wild has spawned a vibrant tourism industry based on crocodile viewing in the Northern Territory, Western Australia and Queensland (Ryan, 1998). The crocodile skin, meat and tourism businesses generate millions of dollars in revenue annually (Stubbs, 1998; Australian Senate, 1998a).

In summary, the NT scheme for sustainable commercial use of saltwater crocodiles has the following characteristics:

- (1) Quotas for crocodile (mostly eggs and some hatchlings) are allocated by government permit to landholders;
- (2) Registered crocodile harvesters, almost invariably crocodile farm operators, negotiate with landholders to harvest crocodile eggs, hatchlings and other crocodiles covered by the landholders' quota. They agree to pay a fee to landholders for permission to harvest, for example, an agreed price per egg collected.

Harvesting quotas are determined by the Parks and Wildlife Commission of the Northern Territory (referred to as PWCNT hereafter) in a way that sustains the population of saltwater crocodiles in the NT. Quota setting is informed by annual or biannual spotlight monitoring of saltwater crocodiles in several important rivers in the NT and by survey of data obtained from harvesting (PWCNT, undated). Thus the approach of PWCNT to managing saltwater crocodile populations is a regulated market-based approach in which it assigns limited property rights in crocodiles to landholders. Consider now is the methodology adopted to study this management strategy.

### **3. STUDY METHODOLOGY**

Some crocodile farm managers and pastoral landholders in the Northern Territory were interviewed during a field trip in 2004, and a more extensive survey of crocodile farms and landholders in the Northern Territory was conducted using structured questionnaires in 2005. Aboriginal landowners in native title land also participate in crocodile harvesting, but they are not part of this study because of difficulty in procuring information and cost constraints. However, an officer from the Northern Land Council, an organization representing indigenous (Aboriginal) communities of the Northern Territory, was interviewed about the crocodile harvesting activities of Aboriginal communities and the possible benefits these communities may derive from these activities. Also interviewed about crocodile harvesting was a government scientist from the Parks and Wildlife Commission of the Northern Territory.

Two sets of questionnaires were prepared for the two groups, and accompanying each questionnaire was a self-addressed postage-paid envelope for their convenient return. The questionnaires for crocodile farmers were mailed directly to each of the then six crocodile farms in the Northern Territory. Out of these, three responded whereas two did not. The sixth crocodile farm is no longer operational. One of the crocodile farmers who responded and one who did not respond (owners of two of the largest crocodile farms in the Northern Territory) were previously interviewed. Therefore, feedback received through the questionnaires account for more than half of all operating commercial crocodile farms in the Northern Territory, and if the interviews were also considered, 80% (all but one) of the operating crocodile farms were surveyed for the study.

Forty questionnaires for pastoral landholders were sent to the Cattlemen's Association of the Northern Territory, the umbrella body that represents Northern Territory pastoralists. The association then distributed the questionnaires to its members. We have obtained responses from seven pastoralists so far. This is in addition to two other pastoralists who were interviewed on an earlier occasion. The surveyed pastoral properties lie 100 to 850 kilometres away from Darwin, the capital city of the Northern Territory. The sizes of these pastoral properties range between 200 to 4,500 square kilometres. In total, the properties of the surveyed pastoralists cover an area of at least 16,420 square kilometres, more than twice the size of the Indian state of Sikkim or more than a third the size of the state of Haryana.

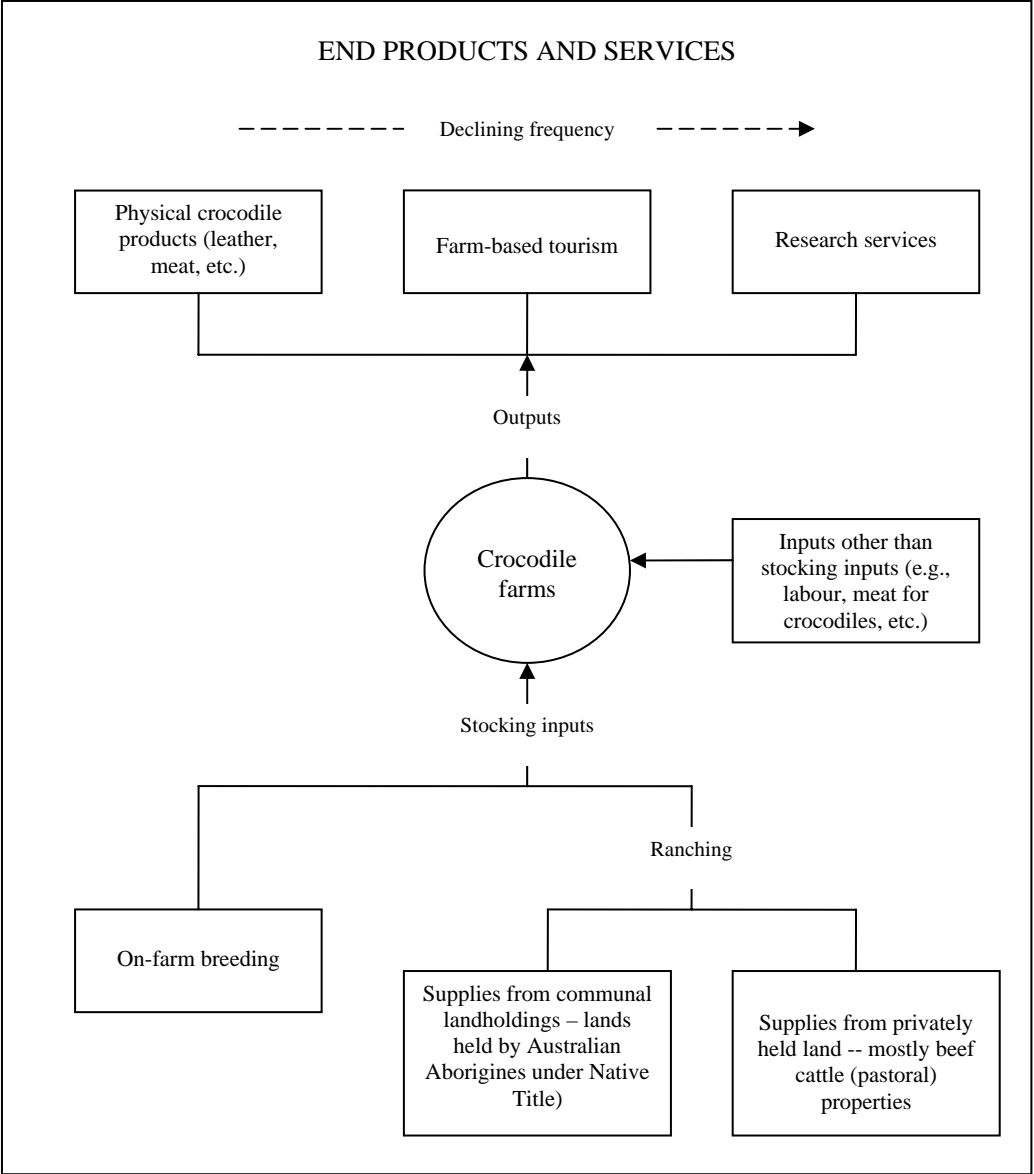
Crocodile farm managers and landholders were asked to provide background data about their crocodile farms or cattle properties. Both groups were asked to comment on the crocodile management plan of the Northern Territory government. Views of crocodile farmers were sought about the features of their farming operations, trends in the crocodile farming industry, harvesting practices, and whether the attitudes of landholders towards the conservation of crocodiles had altered as a result of the NT crocodile management plan. Pastoral landholders were questioned about the crocodiles and crocodile habitat on their property in general, their thoughts about crocodile harvesting and sustainable use, and their attitude towards the conservation of crocodiles and their habitat.

The preliminary findings presented in the results section are based on the interviews and questionnaires as well as information obtained from relevant secondary sources, such as management plan reports and scientific literature.

## **4. RESULTS**

### *4.1. The Structure of the NT Crocodile Farming Industry*

Figure 2 provides a schematic overview of the crocodile farming sector in NT. The crocodile farming industry is centred on crocodile farms and there are currently five of them operating in NT. A sixth has been closed due to injuries sustained by the owner-manager while collecting crocodile eggs. It is not clear if it will re-open and when. All five farms produce physical crocodile products – meats and skins. For two farms, tourism (see Figure 3) is also a significant source of revenue, and in the case of a third, there is some income from tourism (e.g., crocodile viewing). One farm, Crocodylus Park, engages heavily in research and tourism. Research into production technology is viewed as an important component in crocodile farming as farms seek to improve production and reduce production costs to compete internationally.



**Figure 2: The product chain in the NT crocodile farming industry.**



**Figure 3: Keepers feeding a fowl to a crocodile at Darwin Crocodile Farm in NT to entertain tourists. The tourists are watching behind an iron-mesh fence but cannot be seen in this photograph.**

Farm stocks of crocodiles are replenished from two sources: (1) eggs laid by brood stock on the farm which are hatched and raised to 2 or 3 years old of age before processing, and (2) eggs collected from landholdings for which landholders have been allocated a harvest quota by the PWCNT, and to some extent hatchlings, juveniles and occasionally adults harvested from the same source. The major source of eggs for restocking farms is ranching rather than eggs laid on crocodile farms. The quantity of crocodile eggs and adults harvested by some of the farms surveyed are shown in Table 1. Present annual quotas for wild harvests are 25,000 eggs and 575 adult crocodiles (see PWCNT, undated).

**Table 1: Size of the crocodile harvests and production statistics of crocodile farms in NT, 2003/2004 (information obtained from interviews and survey questionnaires except where stated otherwise).**

Crocodile farm	Number of eggs harvested overall in the last year (2003/2004)	Number of adult crocodiles harvested in the last year <sup>a</sup>	Percentage of collected eggs from Aboriginal land	Head of crocodiles processed annually (as of 2004, unless stated otherwise)
A	8,000	200	70	9,000
B	N/a	N/a	80	5,000 <sup>b</sup>
C	4,000	20	40	3,000
D	2,428	0	0	0
E	N/a	N/a	N/a	4,800 <sup>c</sup>

<sup>a</sup> Numbers may be in addition to problem crocodiles caught separately and sold to farmers by the Parks and Wildlife Commission of the Northern Territory.

<sup>b</sup> Estimate (possibly for 2004) obtained from data available on the crocodile farm's Internet website (Porosus Pty. Ltd., 2004). The estimate was obtained as follows. The farm plans to increase output to 10,000 animals a year from 320 female breeders and a stock of 30,000 individuals. It currently has 148 female breeders (half of the planned 320 breeders). Therefore,  $10,000 \times \frac{1}{2} = 5,000$  processed animals a year at present. The number of one- and two-year old animals in this farm is about 5,000 individuals. This value may also serve as a surrogate measure of animals skinned a year, and is consistent with the value calculated above.

<sup>c</sup> Estimate (possibly for 2000) from the Australian Government Rural Industries Research and Development Corporation publication (Hyde, 2000). The book features the farm concerned. It is mentioned that the farm ships out 400 skins to overseas markets a month. Multiplying this by 12 months (assuming production is carried out throughout the year) gives the tabulated value.

The largest proportion of eggs collected from landholders is from communal lands held by Australian Aborigines under Native Land Title; around 70% and 80% of the crocodile eggs collected by two of the largest crocodile farms came from this source (Table 1). On average, about 65% of eggs are collected by all farms from Aboriginal land. The remainder are obtained from pastoral landholdings. Almost 50% of NT's area is under pastoral lease, and these beef cattle properties are very large in size (the largest single pastoral property in NT is more than 12,000 sq. km). Because of the ease of establishing communication with the latter group, due to assistance from NT Cattlemen's Association, we have concentrated on feedback from this latter group.

#### 4.2. *The Crocodile Farming Sector: Nature, Economic Viability, Future Trends*

The five commercially operating crocodile farms in NT at present process between 3,000 and 9,000 head of crocodiles annually (refer Table 1), with one farm planning to increase its output to process 10,000 crocodiles annually in the near future. Crocodile farms in NT produce 60% of Australia's exported saltwater crocodile skins and their main export destinations are France, Italy, Japan and Singapore (Isberg *et al.*, 2004).

Each viable egg can cost between Aus\$5 to Aus\$20 (Aus\$1 = US\$0.75; 18 July 2005), according to an interviewed crocodile farmer. Other crocodile farmers stated that the average price they paid for each crocodile egg was Aus\$8 (one of them), and Aus\$20 (two of them). The crocodile farmers state that the main factors that result in the variation in crocodile egg prices between landholdings are the cost of collection (ease of access, logistics) and competition. One crocodile farmer stated that he paid the same price for all eggs. First grade crocodile skins that are exported by crocodile farms to overseas markets fetch prices that range between Aus\$4.50 per cm for skins that are 18 to 24 cm wide and up to Aus\$10.00 per cm for those with widths of 40 to 45 cm (Isberg *et al.*, 2004).

Crocodile farmers stated that the advantages of crocodile farming in the Northern Territory are the climate (the heat suits crocodile growth) and the easily available crocodile and crocodile egg stocks. Among the disadvantages cited are the costs of acquiring crocodile feed, the cost of labour and capital costs.

The number of crocodile farms operating in NT rose from its level in 1984 to reach a peak in 1997 and has declined since then. Crocodile farms were established in NT in the early and especially mid-1980s when the CITES listing of Australian saltwater crocodile populations was changed from Appendix I to II. In 1984, there were three crocodile farms in NT (Onions, 1987). Between 1987 and 1990, there were four crocodile farms in NT (PWCNT, undated). By 1991, this number had risen to six (Australian Senate, 1998b; PWCNT, undated) and by 1997, to eight (PWCNT, undated). It fell by 2001 to six farms (PWCNT, undated), and at present, there are only five commercially operating crocodile farms in NT.



The crocodile farmers interviewed and those surveyed by post gave their reasons for why there has been a rise and decline in the number of crocodile farms in NT. Competition from overseas, such as from Nile crocodile (*Crocodylus niloticus*) farms in southern Africa, could have, in their opinion, led to the closure of some local farms. Economic competition as well as the importance of economies of scale resulted in greater consolidation of farms, according to another crocodile farmer. Differences in business skills and experience in crocodile farming of entrants may also have influenced survival in the industry. Crocodile farming is difficult because there is no established history of raising crocodiles as with domesticated animals such as cattle.

Three out of the four crocodile farmers surveyed believe that the number of crocodile farms in NT will remain unchanged. They claim that all, or virtually all, egg collection areas are being exploited and that the cost of entering the industry is high. Therefore, new farms are unlikely. However, one farmer stated that the process of specialisation in specific parts of production could bring in new players. All the crocodile farmers nevertheless expect the total production of NT crocodile industry to increase in the future. This is anticipated as demand rises and as learning and experimenting in the production process leads to possible falls in production costs. Most farms put crocodile production ahead of tourism as a contributor to the success of their businesses. Only one crocodile farm placed a higher priority on tourism as a contributor to its business success.

The continuing economic viability of saltwater crocodile farming in NT is crucial for the maintenance of the NT's crocodile management programme. If this sector should become uneconomic, then there will be no demand for harvesting of crocodile eggs or crocodiles in other development stages from landholdings. The strategy of crocodile use via sustainable use would become unworkable.

#### *4.3 Crocodile Farmers' and Pastoral Landholders' Assessment of the Northern Territory Government's Crocodile Management Plan*

The crocodile farm managers/owners stated that they had very good or good knowledge of the current NT crocodile management plan. None stated that their knowledge of it was poor. The crocodile farmers surveyed expressed their satisfaction with it, and do not think that any significant changes to the current plan are required. However, two out of the three respondents to

the posted questionnaire stated that they would like to see changes in the Australian Government's policies that affect their industry. This concerns CITES. One respondent stated that he would like speedier application and processing of CITES export permits and would prefer permits be issued by State governments rather than by the Federal government. Another stated that live commercial exports should be allowed. Such comments may come as no surprise to some considering that the requirements of the Australian Federal government for trading in crocodiles are more stringent than those of CITES itself (Onions, 1987).

Pastoralists had varying degrees of knowledge about the crocodile management plan. One did not answer this question about knowledge of the management plan (this landholder stated that he did not have crocodiles on his property) and one stated no knowledge of the management plan (he stated that he does not know if he has crocodiles on his property). Of the landholders who said they have crocodiles on their property, two stated that they are aware of the management plan but their knowledge of it is poor, three mentioned that their knowledge of it is moderately good, and one maintained that it was excellent (one of the interviewed pastoral landholders).

Pastoral landholders gave their opinions about the NT crocodile management plan. Most stated that management is good and is better than if there were no management at all (e.g., the PWCNT helps remove problem crocodiles), but there were others who stated that (i) crocodiles are thriving on their property and the present quota for the harvest of adult saltwater crocodiles of 600 individuals is too low, and (ii) that management appears to be more concentrated on populated areas and pastoralists are 'ignored' – not listened to. They suggest that more open communication is required between pastoralists and those administering the crocodile management plan.

#### 4.4 Crocodiles on Pastoral Properties and Crocodile Conservation Impacts on Pastoralists of the NT Crocodile Management Scheme

##### The prevalence of crocodiles on the properties of the pastoralists surveyed

Most of the pastoralists said that they have crocodiles on their property. Of the two pastoralists who did not answer ‘yes’, one said that he does not have crocodiles on his property and the other said he was unsure of whether he had crocodiles on his property. At least 10% of the land area of the properties of each pastoralist surveyed constituted crocodile territory if they had crocodiles on their land. One pastoralist even stated that 100% of his land is crocodile territory.

**Table 2: The prevalence of crocodiles on the properties of the pastoral landholders surveyed.**

No. of pastoralists	No. who have saltwater crocodiles on their property	No. who have problem crocodiles on property	No. who have saltwater crocodiles nesting on their property	No. stating the percentage of their property considered crocodile territory (applies to those who said ‘yes’ to having crocodiles on their properties)		
				Less than 10%	10% to 25%	More than 50%
Surveyed with questionnaires ( <i>n</i> = 7)	5	4	3	-	2	3
Interviewed ( <i>n</i> = 2)	2	2	1	-	-	-

##### Attitudes towards crocodile number on pastoral properties

Virtually all the pastoralists surveyed stated that the number of crocodiles on their property has increased over the past decade, and most would like numbers to decrease (Table 3). Almost all of the pastoralists responding thought that the present annual quota for crocodile harvesting was too low and are in favour of increasing its size. They unanimously consider crocodiles as both pests (because attack cattle stock and endanger humans) and assets (because they have financial value).

**Table 3: Views of pastoralists on crocodiles on their properties and their attitudes towards them.**

Pastoralist	Has number of crocodiles on property increased in the last 10 years?	Are saltwater crocodiles on your property pests, assets or both?	Would you like to see saltwater crocodile numbers on your property increase/ decrease/ remain about the same?	Size of the annual quota for harvesting crocodiles: favour increase, decrease or prefer it left unchanged?
<b>Pastoralists surveyed with questionnaires</b>				
1	Yes	Both	Decrease	Yes, increase considerably
2	Yes	Both	Decrease	Yes, increase a little
3	Yes	Both	Decrease	Yes, increase considerably
4	Yes	N/r	N/r	Yes, increase a little
5	Yes	Both	Remain about the same	Yes, increase a little
6	Yes	Both	Decrease	Yes, increase a little
7 (no croc. on property)	-	-	-	-
<b>Interviewed pastoralists</b>				
8	Yes	Both	Decrease	-
9	-	-	Remain about the same	Yes

The main reason given by all pastoralists for obtaining permits to harvesting saltwater crocodiles and crocodile eggs on their properties is to curb the loss of cattle resulting from crocodile attacks. Their following comments are illustrative:

*Mainly to reduce crocodile numbers; income too, but what is received is not much; the amount received is not worth worrying about (Pastoralist No. 1)*

*To reduce crocodile numbers; [for income] to neutralise or recoup losses incurred from crocodile kills of cattle; if you don't manage, in five years plus you will be overrun by cow killers (Pastoralist No. 3)*

*To reduce crocodile numbers; to support local business (Pastoralist No. 6)*

*To decrease crocodile numbers (Pastoralist No. 8)*

*Done just to reduce crocodile numbers (Pastoralist No. 9)*

*[For] income (Pastoralist No. 2)*

Do pastoralists find crocodile harvesting economically worthwhile to them?

Despite acknowledging the financial value of saltwater crocodiles, almost all of the pastoralists surveyed consider their earnings from crocodile harvesting to be insignificant (Table 4). The interviewed pastoralists stressed that their main business and concern is cattle-raising. Only one landholder (Pastoralist No. 3) thought that earnings from crocodile harvesting are significant. Nevertheless, income from having permits to harvest crocodiles constitutes a very small portion of the net income obtained on all pastoralists' properties. At most, it is 5% of total earnings (in the case of Pastoralist No. 3 who claimed that income from crocodile harvesting is significant). Some landholders (particularly those with smaller-scale cattle operations— less than 4,000 head of cattle) said that earnings from crocodile harvesting may compensate for some (but not all) of their cattle losses due to crocodile attacks (see last column, Table 4). In contrast, Pastoralist No. 6, who runs an operation of a more typical size and has had fairly large losses of cattle from crocodile attacks, considers coverage of these losses from gains in crocodile harvesting to be nil.

**Table 4: Economic aspects of crocodile harvesting, including estimates of losses resulting from crocodile predation on cattle as reported by pastoralists.**

Pastoralist	Pastoral property size in sq. km (and no. of cattle held)	Ever applied for a permit allowing the harvesting of saltwater crocodiles on property?	Do you regard income earned from crocodile harvesting as significant?	Income from having permits for crocodile harvesting as a percentage of net income from property	No. of cattle lost annually	Total value in Australian dollars of cattle stock lost annually to crocodile attacks	Percentage of dollar amount of stock losses covered by earnings from crocodile harvesting
<b>Pastoralists surveyed with questionnaires</b>							
1	200 (4,000)	Yes	No	0.2	50	33,000	2
2	320 (2,500)	No*	No	N/r	10	8,000	6
3	400 (1,100)	Yes	Yes	5	25	30,000	90
4	3,800 (15,000)	No	N/r	N/r	0	N/r	N/r
5	4,200 (18,000)	No <sup>†</sup>	N/r	N/r	0	0	0
6	4,500 (30,000)	Yes	No	N/r	300	180,000	0
7 (no croc. on property)	3,000 (27,000)	-	-	-	-	-	-
<b>Interviewed pastoralists</b>							
8	-		No	0.01	12 to 20	N/r	N/r
9	-(5,000)		No	N/r	150	75,000	N/r

\* This pastoralist stated that he does not apply for a permit to harvest but has ‘professionals’ (farmers/harvesters) come over to do the harvesting for him (which would still require him, the landholder, to provide a written consent for permit applications).

<sup>†</sup> This pastoralist may not have applied for permits to harvest crocodiles but may have either had farmers/harvesters do the harvesting for him (with him giving a written consent for permit applications, as in the case of Pastoralist No. 2) or may have had problem crocodiles removed by the PWCNT.

Views on whether land-use practices of managers of beef properties are altered to conserve crocodiles and their habitats

Three out of four crocodile farmers are of the opinion that paying landholders for rights to harvest crocodiles and their eggs will encourage landholders to conserve crocodiles on their property (Table 5). Their argument is that payments would make landholders more tolerant of crocodiles on their property. The fourth crocodile farmer was unsure whether crocodiles will be

conserved by all landholders as a result of payments received from harvesting. He added that only smaller graziers, rather than larger landholders, may find it a worthwhile engagement.

**Table 5: Views of crocodile farmers on whether pastoralists will conserve crocodiles and crocodile habitat as a result of crocodile harvesting on their lands.**

Crocodile farmer	Do you think paying landholders for rights to collect crocodile eggs and crocodiles on their land encourages them to conserve crocodiles?	Further comments	Do you believe pastoralists are likely to conserve more crocodile habitat as a result of receiving payments for crocodile harvesting?	Further comments
<b>Farmers surveyed with questionnaires</b>				
A	Yes	Pastoralists are tolerant of and more interested in crocodiles since some money is received	Yes	Not all pastoralists alter land management to take advantage of crocodile business. As farming/harvesting becomes more professional, efficient, and lucrative, some stations are seeing the logic of this [conserving crocodile habitat]. However, many stations have absentee owners relying on managers who may not be professional or interested
C	Yes	-	Unsure	Cow feed is at a premium and as cattle prices increase, this can compromise [crocodile] habitat
D	Yes	Positive attitude towards crocodiles and greater likelihood to tolerate crocodiles on their land	Unsure	-
<b>Interviewed farmer</b>				
B	Unsure	Large landholders might not care, probably want to get rid of them, but smaller graziers may earn something substantial	Unsure	They would not necessarily change land-use practices to suit crocodile harvesting

Crocodile farmers were also asked whether holders of cattle property are likely to change land use practices to conserve more crocodile habitat as a result of crocodile harvesting on their land. Three out of four crocodile farmers were unsure of this, and the only farmer who gave a positive

response indicated that it is conditional upon farming becoming a more profitable business and so that crocodile farmers could pay landholders more money for their crocodiles and crocodile eggs (see Table 5).

The views of the crocodile farmers mirror those of the pastoralists themselves: virtually all pastoralists stated that income from allowing crocodile harvesting has *not* induced them to alter their land-use practices or pastoral management in any way, or to conserve any habitat or area suitable for saltwater crocodiles or crocodile nests (Table 6). Only Pastoralist No. 3 stated that income from crocodile harvesting provided an incentive to alter land-use practices or to conserve crocodile habitat. This landholder stated that she maintained existing crocodile nesting sites and tried to increase available nesting areas by removing a harmful introduced weed (*Mimosa pigra*). Another landholder (Pastoralist No. 9) would like to encourage crocodiles to nest on his property so he can harvest the eggs (see Figure 4). Pastoralist No. 8 said that while he would be happy to sell farmers/harvesters crocodile existing eggs from his property, but he would not change his land practices to suit crocodile harvesting. He stated that the returns from wildlife must be worth its while or significant enough for cattle station owners to seriously consider taking action to conserve wildlife.



**Table 6: Whether pastoralists change their land-use practices because of income from crocodile harvesting.**

Pastoralist	Has your income from allowing crocodile harvesting altered your land-use practices or farm management in any way?	Have you conserved (not altered) any habitat or area that suits saltwater crocodiles or their eggs because you have obtained income from their harvesting on your property?
<b>Pastoralists surveyed with questionnaires</b>		
1	No	No
2	No	No
3	Yes	Yes
4	-	-
5	No	No
6	No	No
7 (no croc. on property)	-	-
<b>Interviewed pastoralists</b>		
8	No	N/r
9	N/r	May do so (wants to have nesting area for crocodiles)



**Figure 4:** These wild (feral) Asian buffaloes (*Bubalus bubalis*) were seen near the Mary River in the Northern Territory in an area where saltwater crocodiles are abundant. There are plenty of nesting materials for crocodiles in this vicinity. However, the manager of the ‘Melaleuca’ cattle property located downstream reported that while crocodiles occur on this property, they do not nest because of lack of nesting materials.

#### Pastoralists view on the trophy hunting of crocodiles

Most pastoralists are in support of trophy hunting (six out of nine), because it could add more value to crocodiles. But some (two) commented that the big crocodiles that are the proposed targets of trophy hunting (animals over 3.5 m in length) (PWCNT, undated) are “not the problem”, and that the smaller animals (juveniles) should be hunted too. According to one interviewed pastoralist (Pastoralist No. 9), the big crocodiles keep many smaller crocodiles at bay and hence reduce the number of cattle taken.

## **5. DISCUSSION**

The NT crocodile management plan allows the regulated commercial use of saltwater crocodiles. There are claims that this plan encourages landholders to conserve saltwater crocodiles (Australian Senate, 1998b). However, although they are favour of sustainable commercial harvesting of crocodiles, our surveys indicate that NT cattlemen have not altered their land

management significantly as a result of being able to earn some income from crocodiles on their properties. This is because their returns from sales of crocodile eggs and from crocodiles in the later stages of their development are too low to make it profitable to ‘husband’ crocodiles. On all cattle properties surveyed, revenues from sales of the rights to crocodile farmers to collect crocodile eggs and crocodiles are insufficient to compensate landholders for their estimated annual loss of cattle due to predation by crocodiles. Thus for all holders of cattle properties surveyed having crocodiles, saltwater crocodiles remain a net pest. It is, therefore, not surprising that virtually all holders of cattle properties surveyed would like to see larger harvests of crocodile populations to reduce their numbers.

Only one cattle property indicated that it had changed its land management as a result of the NT crocodile management plan. It had used the money paid by crocodile farmers for rights to collect crocodile eggs and crocodiles on its property to remove the weedy invasive shrub (*Mimosa pigra*). This removal may have benefited the nesting of saltwater crocodiles *as well as* provided more grass for cattle.

Much higher prices would need to be paid for crocodile eggs and crocodiles harvested from cattle properties before pastoralists would be likely to husband crocodiles or significantly alter their land use practices so as to conserve crocodiles. Our results accord with a general proposition of Ross (2001) that “the relative returns of sustainable levels of crocodilian use are much lower than alternative uses”. However, the present NT scheme does provide some, but far from complete, financial compensation to pastoralists for stock losses caused by crocodiles and does allow cattlemen to maintain limited population control of saltwater crocodiles on their properties. This increases the social acceptability of the current management scheme to NT cattlemen. Naturally, those who operate crocodile farms support the scheme and the general community can see economic benefits from the scheme. This support is reinforced by economic benefits that have been realised from the substantial tourism industry that has developed in NT based on the viewing of crocodiles in the wild.

The sustainability of the NT crocodile management scheme depends on the continuing economic viability of crocodile farming in NT. Crocodile farmers are confident of its continuing viability

and foresee the possibility of a limited expansion in production. At the same time, they are aware of considerable economic competition, particularly internationally from production in Africa based on utilisation of the Nile crocodile.

There may be some pressures from cattlemen in NT to increase quotas for harvesting crocodiles, including juveniles as well as adults. Just how much scope there is for increasing harvesting quotas without reducing stocks of wild saltwater crocodiles significantly in NT is not known. Now that populations of saltwater crocodiles in NT have recovered to pre-1945-1965 harvest levels, they may be able to withstand considerable harvests before registering a large decline in their populations because they seem to exhibit a high degree of intraspecific competition (Tisdell *et al.*, 2005).

The present (crocodile harvesting) scheme of NT is weighted in favour of egg collection and crocodiles in their early stages of development. This has much to recommend it because less than 25% of saltwater crocodile eggs laid in the wild hatch in the NT, and of those hatching, only about 50% appear to survive until about one year of age (Webb and Manolis, 1989, pp. 82-83). Therefore, the annual collection of 25,000 crocodile eggs from the wild (the NT quota) could be expected to reduce the population of one-year old crocodiles by about 3,000, or only by about three percent of the estimated current population. The hatching rate of crocodile eggs on crocodile farms using artificial incubation is high as is the survival rate of hatchlings.

Thus current crocodile harvesting policies pose no danger to wild population of crocodiles in the NT. However, if harvesting policies should become heavily biased in favour of harvesting adult crocodiles, the impacts on wild populations would become more pronounced. So, caution is required in altering the weighting.

Whether similar sustainable use policies to those of NT could be adopted successfully in eastern India, Myanmar and Southeast Asian countries to conserve their saltwater crocodiles is unclear. Given the large size of landholdings in NT and that only extensive land use is economic there, it is doubtful if NT experience would transfer easily to Asian countries where landholdings are small and intensive land-use is the rule rather than the exception.

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