Crocodile Tears and Skins: International Trade, Economic Constraints, and Limits to the Sustainable Use of Crocodilians

Over the past three decades, the captive rearing and managed harvests of crocodilians have been held up as a success story in the search for balanced, sustainable use of wildlife and the generation of wildlife products for international trade. The success of managed-harvest programs in the United States, Zimbabwe, Papua New Guinea, and Venezuela encouraged similar efforts in a variety of other countries: by the late 1980s, more than 40 nations had crocodilian management programs based on some form of regulated commercial use (Thorbjarnarson 1992). In the 1980s, as prices rose, trade in crocodilian skins was a lucrative business and the sustainable-use approach was touted as a practical solution for the conservation of what was generally seen as an unlovable group of animals (Messel 1991; Ross 1995).

In the early 1990s, a weakened market and falling skin prices created cause for alarm (Woodward et al. 1994). After a brief recovery, prices nose-dived again in 1997–1998, largely as a result of widespread economic woes in Asia, a primary consumer of crocodilian skin products. The drop in skin prices has caused great economic hardship for many skin producers, leading to the closure of some sustainable-use management programs. Although fluctuations in supply, demand, and skin prices have been characteristic of past, largely unregulated exploitation of crocodilians, today the increased, steady production of skins from a large number of sustainable-use programs, a relatively limited market, and competition from other, cheaper exotic skins (e.g., ostrich) presents an unsettled future for crocodilian management programs based entirely on the commercial consumptive use of their skins. This boom-and-bust cycle and fears for the lack of market elasticity demonstrate the vulnerability of conservation programs based entirely or primarily on the sale of wildlife products for essentially luxury markets.

The history of the international trade in crocodilians provides unusual, perhaps unique, insights into the value and limits of a sustainable-use approach to conservation. I review the history of the exploitation of crocodilians and the effects of that exploitation on the conservation status of species involved in trade.

Unregulated Commercial Hunting

For over a century, the skins of crocodilians have been used for the manufacture of exotic leather products, and the resulting commercial hunting has led to drastic population declines and the designation of the majority of these modern-day archosaurs as endangered species. In the early 1800s, the first large-scale commercial use of crocodilian skins resulted in the widespread hunting of the American alligator (*Alligator mississipiensis*) in the United States (Joanen et al. 1997). Because the leather did not prove to be well suited for footwear, the hunting of alligators declined during the 1820s, but during the American Civil War (1861–1865) a naval blockade of southern U.S. ports created a shortage of cowhide and revived the use of alligator leather for boots and saddles. Crocodilian skins first became fashionable shortly after the Civil War (Glasgow 1991) and since that time have been used for the elaboration of a variety of exotic leather products, from shoes and bags to wallets and belts. The demand for skins, and the hunting of wild populations, has followed the typical boom-and-bust cycle of unregulated resource hunting, often dictated by the health of the economies of consumer nations and the whims of the fashion industry. Exotic leather fashions swept into Europe by the late 1800s, and to meet the growing demand the skin hunting business expanded into Mexico, Central America, and the Caribbean. By the 1930s, many of the skins tanned in Europe came from northern South America. Following World War II and the rebuilding of the European tanning industry, the demand for skins redoubled and hunting resumed in the Neotropics and spread into Africa, Asia, and Australia.

For many species, hunting was intense and quickly resulted in the depletion of wild populations. In Louisiana an estimated 3–3.5 million alligators were killed between 1880 and 1933 (McIlhenny 1935). From 1950 to 1965, 7.5 million caiman skins were exported from Amazonas State in Brazil (Smith 1980). By 1980 Medem

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(1981) calculated that a minimum of 11.65 million caiman skins had been exported from Colombia. In South America, the annual number of caiman exploited during the 1980s was estimated to be in excess of 1 million (M. Jenkins & Broad 1994).

Trade Controls and Population Recovery

A variety of national and international restrictions on hunting and trade have been enacted over the last 30 years, and populations of a variety of once-overexploited species are recovering (Messel 1991; Ross 1998). Beginning in the 1960s, the scarcity of skins also had significant effects on the reptile leather business: many tanneries closed, purchased illegal crocodilian skins, or switched to the hides of other reptiles, including sea turtles, lizards, and snakes (King 1978). With the adoption of the Convention on International Trade in Endangered Species of Flora and Fauna (CITES) in 1975, the first steps were taken to regulate wildlife trade at an international level. Nevertheless, because of the high demand for skins, considerable illegal trade continued (Inskipp & Wells 1979).

Despite the considerable economic incentives to kill crocodilians, in any one region commercial hunting usually was no longer productive long before populations reached levels close to biological extinction, so no species has gone extinct as a result of hunting. Where habitat loss has been a significant factor, however, commercial hunting or the killing of unwanted animals has led to a crisis situation. Today, the most critically endangered crocodilians, including the Chinese alligator (*A. sinensis*) and the Philippine (*C. mindorensis*) and Siamese (*C. siamensis*) crocodiles, are the victims of past over-hunting and current habitat loss (Ross 1998). Nonetheless, among most species for which habitat loss was not a significant factor, the reduction or elimination of commercial hunting initiated a phase of population recovery. Although this was most dramatic in the case of the American alligator, the recovery of other species such as Morelet's crocodile (*C. moreletii*), the Australian freshwater crocodile (*C. johnsoni*), and the Nile (*C. niloticus*) and saltwater (*C. porosus*) crocodiles (Ross 1998) has demonstrated the benefits of increased protection worldwide.

Managed Use Battles Trade Restrictions

Beginning in the mid-1960s and early 1970s, the United States and Zimbabwe sought to develop management plans that included the harvest of growing crocodilian populations (Child 1987; Joanen et al. 1997). During the same period another managed-harvest program was launched in Papua New Guinea, where, as a result of large expanses of habitat and low human population densities, the crocodile populations had never been considered endangered (Hollands 1987). The recovery of populations from overhunting and the success of these three programs demonstrated that crocodilians could be managed on a sustainable-use basis. But despite the growing capacity of nations to harvest crocodilians sustainably, the commercial success of sustainable-use programs depended largely on the skin-producing countries being able to export hides to countries where skins could be tanned and manufactured into products.

After 1975 CITES regulations prohibited international commercial trade in endangered animals, which included alligators and nearly all the true crocodiles (CITES Appendix I). In the United States, the dramatic and well-documented recovery of alligator populations resulted in that species being downlisted to CITES Appendix II in 1979, thereby allowing regulated commercial trade. In many developing nations, however, only limited funds were available for wildlife management, which greatly restricted their ability to document the recovery or current status of wild populations. Many African nations also argued that their populations of Nile crocodiles had never been endangered and should not have been listed on CITES Appendix I in the first place (Hutton 1992). The desire of these African nations to commercially manage Nile crocodiles added to a dialogue within CITES over the value of commercial trade to promote "value-added" conservation.

For crocodiles, what resulted was a series of CITES resolutions that loosened the requirements for legal trade, either by promoting crocodile ranching programs or by establishing temporary CITES-approved annual export quotas of skins from cropping programs. Ranching was seen as a robust management approach that had few biological risks for wild populations, and the harvest quotas were designed as an interim measure to provide nations with the financial resources to implement management programs based on ranching, and eventually lead to the full downlisting of the country's crocodile population to Appendix II. The CITES Secretariat, working with crocodilian biologists Crocodile Specialist Group of the World Conservation Union–Species Survival Commission (IUCN–SSC), played an important role in providing funds and technical assistance that allowed African nations to develop proposals for managed use under the CITES guidelines. By the 1990s, Cameroon, Congo, Ethiopia, Somalia, Sudan, South Africa, Botswana, Kenya, Madagascar, Malawi, Mozambique, Tanzania, Zambia, and Uganda had taken advantage of these resolutions to export crocodile skins.

In the New World, the large ongoing trade in caiman skins resulted in a different pattern of crocodilian trade and managed use. Caiman (common caiman [*Caiman crocodilus*] and yacare [*C. yacare*]) skins were long considered to be inferior to the "classic" crocodile and alligator skins because they contained bony osteoderms in

the ventral "belly" scales that complicated tanning and produced a pitted and discolored appearance in the finished skins. Due to the scarcity of classic skins, however, the sides or flanks of Neotropical caiman became the mainstay of the reptile leather industry in the 1960s. By the late 1970s, the more rigid CITES controls on classic skin species provided further incentives to trade caiman skins.

As a result of the large demand for caiman skins, the scarcity of legal sources, the low prices of illegal skins, and the inability of countries to adequately regulate export and imports, a complex web of illegal trade in caiman skins emerged (Medem 1980; Gaski & Hemley 1988). Prior to 1984, CITES export statistics—which do not take into consideration the illegal and undeclared trade of skins—demonstrate that <20% of the caiman hide trade was even potentially legal (Luxmoore et al. 1988). Although both common and yacare caiman are widespread and ecologically adaptable species, exports in excess of one million skins a year led to concern about the effects of the unmanaged harvest on wild populations and underlined the need for programs based on a managed harvest.

Venezuela was the first country to initiate a large-scale, legal cropping program for caiman. Soon after Venezuela's program was begun, Honduras, Nicaragua, Guyana, Paraguay, and Colombia initiated the large-scale production of skins from a farming, or captive-breeding, program. As in the case of Nile crocodile, CITES and the IUCN–SSC Crocodile Specialist Group played an important role by working with national management authorities to conduct caiman population surveys and by recommending export quotas.

Sustainable-Use Successes

Crocodilian sustainable-use programs have become a profitable wildlife business worldwide, with a wide variety of stakeholders ranging from hunters, skinners, landowners, and ranchers to skins traders, tanners, and leather manufacturers. In Louisiana the sale of alligator meat and skins was $25 million per year in the early 1990s (Joanen et al. 1997). In Venezuela the peak export value (in 1990) was approximately $25 million. Although it is difficult to quantify the role of economic benefits in generating conservation incentives among local communities and landowners, it is clear that at the national level crocodilian management is given a higher priority because of its economic potential (Child 1987). Commercial use can also generate a more positive image of crocodilians among the general populace, and, through the use of severance fees and taxes, these programs can generate funds for cash-strapped wildlife management agencies, as was the case in Venezuela.

Within the context of CITES, success has largely been the result of a carrot-and-stick approach of restricting illegal and excessive trade and working with national management authorities to develop harvest programs that comply with CITES regulations (R. W. G. Jenkins 1987; David 1994). One of the biggest obstacles for the successful development of managed-harvest programs was the continued traffic of skins from illegal or unmanaged harvests. Both the dwindling supplies of skins and CITES trade restrictions, however, set the stage for collaboration with the reptile leather industry and national management authorities to promote the supply of legal skins from managed-harvest programs and reduce illegal trade (Messel 1991).

Pressure from CITES resulted in national laws enacting trade controls, changes that were sometimes a result of threatened or enacted CITES trade bans on noncompliant nations (e.g., Italy, Thailand). Working through the CITES Secretariat, and largely with funding from the reptile leather industry, the Crocodile Specialist Group acted through a network of crocodilian experts to assist nations to plan and implement programs that provided a legal source of skins and did not endanger the status of wild populations (David 1994). Skin traders and tanners who dealt largely in illegal skins in the 1970s shifted more and more to legal skins as the supply increased and as CITES trade controls were enforced more rigorously. By the late 1980s, it was evident that illegal trade in classic skins had been significantly reduced (Collins & Luxmoore 1996). Although illegal caiman trade remained a complex problem, the adoption of the Universal Tagging Resolutions by CITES in 1992 and 1994 has provided an important tool for identifying the origin of skins and regulating trade (Collins & Luxmoore 1996); all evidence points to a significant decline in illegal caiman trade over the last 10 years.

Unlike the historical patterns of commercial hunting in which short-term profits were the primary objective, today's managed harvests are based on an understanding of the population biology of the species involved and adopt sustainability as their primary objective. The monitoring of harvested populations is generally given a high priority among crocodile sustainable-use programs (Ross 1997). Although a basic understanding of the effects of the harvest on wild populations is available for only a few areas, harvests have been designed to minimize the negative demographic effects (in most cases by targeting juveniles or adult males), and most evidence suggests that hunting levels have been set within sustainable levels (Ross 1998). In Australia and the United States, detailed population monitoring and ecological research programs have demonstrated that harvested crocodilian populations can continue to grow (Webb et al. 1994; Woodward et al. 1994; Joanen et. al 1997).

Local Benefits and the Conservation Implications of Farming versus Harvesting

Many of the potential conservation benefits of crocodilian sustainable-

use programs are facing a potential threat from the expansion of farming, or captive-breeding, programs. The theoretical underpinning of sustainable use as a conservation tool is based largely on the creation of incentives that make the conservation of wildlife populations and their habitat in the best interest of those who benefit from the harvest. For crocodilians it is argued that managed harvests provide benefits to several constituencies, including local people who would otherwise balk at the idea of sharing their backyards with large, potentially dangerous carnivores (Ross 1995). How sustainable-use programs benefit local communities or landowners and how these benefits are affected by the attributes of the program, the relative value of the harvest, and land-tenure systems are important but have rarely been addressed. In Venezuela landowners can receive a high return on their investment harvesting caiman, but this is done primarily within the context of managing their lands for cattle. Caiman are seen largely as a quick and easy source of money but not a major factor in deciding land-use practices. On the other hand, ranching programs can generate important sources of funds for rural communities that collect eggs or neonates (Ross 1995).

Although ranching and cropping programs have inherent potential for generating these incentives, closed-cycle breeding, or farming, programs do not. Farms are closed-cycle operations in which captive adult animals lay eggs that produce the farm's stock. Ranches rely on the collection of eggs or neonates from the wild. Farms can be economically successful operations that generate political interest in crocodilians and can provide wildlife educational opportunities for the public, but they are not naturally linked with the maintenance of wild populations and their habitat and so do not generate the economic links for conservation that form the basis of sustainable-use programs. Other than the few people who work at the farm feeding animals or cleaning pens, there is little opportunity for local communities to benefit economically from farms. Yet, because they are self-contained operations and do not depend on the vagaries of wild egg production, farms may offer certain advantages for businessmen interested in selling crocodile skins. For instance, in Zimbabwe, which pioneered the ranching of Nile crocodiles, recent difficulties working with communal groups have led many crocodile ranchers to turn more and more to farming, and now in excess of 50% of annual skin production comes from farmed animals (Crocodile Specialist Group 1998).

Farms are a major source of legal skins in the market today. Presently, the greatest volume of crocodile skins from any one country come from Colombia, where caiman farms are exporting nearly half a million skins a year (Collins & Luxmoore 1996). The potentially negative economic impacts of large numbers of farm skins on the commercial viability of sustainable-use cropping and harvesting programs are unclear but are bound to intensify as farms proliferate and competition increases for crocodilian-skin market niches. The international trade of live animals for farm breeding stock has also led to the widespread establishment of crocodile farms with non-native crocodilians, reducing the potential for developing sustainable-use programs based on native species and increasing the likelihood of introducing exotic species through escapes. Farming also has the potential to lead to specialization and genetic improvements of stock, which, given the limited demand for skins, could potentially reduce or eliminate the value of wild harvests. One example is the interbreeding of saltwater and Siamese crocodiles in a farm in Thailand that produced hybrids that grow faster, have superior hides, and are commercially preferable to either of the parent species (Youngprapakorn 1990).

Funding Opportunities versus Conservation Priorities in Crocodilian Management

For both the classic skin-producing species (crocodiles and alligators) and caiman, the CITES Secretariat and the CSG have worked closely with national management authorities to develop programs that limit production to sustainable levels. Funding, largely from the reptile leather industry, has supported population surveys to develop proposals to downlist populations to CITES Appendix II and allow commercial exports (classic species) or to recommend export quotas for caiman. Through agreements with CITES and the Crocodile Specialist Group, surveys of crocodilian populations were conducted in Honduras, Nicaragua, Cuba, Venezuela, Guyana, Brazil, Bolivia, Paraguay, Argentina, Botswana, Kenya, Madagascar, Malawi, Mozambique, Tanzania, Zambia, and Indonesia. Because of the focus on programs to allow legal exports, the funding was devoted almost exclusively to four species of commercial interest: the common caiman, the yacare caiman, the Nile crocodile, and the saltwater crocodile. In addition, nations with developed sustainable-use programs, such as the United States, Zimbabwe, Papua New Guinea, and Australia, used their own funds for population monitoring and ecological research programs for commercially exploited crocodilians. As a result, a flood of information on the status and ecology of the main species in commercial trade emerged in the 1980s and 1990s.

Although significant funds were available for surveys of the trade species, at the same time the highly endangered crocodilians were being virtually ignored except for a few small to modest projects supported through conservation groups (Thorbjarnarson 1992). The result was a topsy-turvy situation in which conservation funds were scarce for highly threatened species such as

the Orinoco crocodile (*Crocodylus intermedius*) and the Chinese alligator, and in which the main focus of the efforts and the funding of CITES and the Crocodile Specialist Group were the species with the lowest conservation priorities. Although some of their efforts were subsequently carried out on threatened species (Crocodile Specialist Group 1992), the focus of these and other efforts remained on conservation through commercial use. One recent exception to this pattern has been funding from the reptile leather industry for surveys and ecological studies of the Malayan gharial (*Tomistoma schlegelii*) in Indonesia (Bezuijen et al. 1997), which, it is hoped, can serve as a model for similar efforts with other species.

Limits to Sustainable Use of Crocodilians

As the number of crocodilian harvest programs proliferated, the supply of legal skins increased. By the mid-1990s, trade in classic skins was approaching the historical high of 500,000 skins a year, and the caiman trade remains in excess of 1 million skins a year (World Conservation Monitoring Centre 1998). At the same time, market demand for reptile leather products has remained relatively stable (Ashely 1998) and is facing increasing competition from other exotic leathers such as ostrich (Takehara 1998.). In most markets, crocodilian skin prices rose throughout the 1980s but fell sharply in 1991–1992. The drop in skin prices was a worldwide event for all crocodilians traded commercially and has been attributed to a number of factors, including low demand for products in Japan, a poor world economy, consumer resistance to wildlife products, a paucity of manufacturing facilities worldwide, an imbalance of production and consumption in the United States, a ban on wildlife trade with Italy, and oversupply of skins worldwide (van Jaarsveldt 1992; Woodward et al. 1994). The result was a significant reduction in purchases of crocodilian skins, with major repercussions for crocodilian management programs based on commercial use. Harvest levels in Venezuela were drastically curtailed (Thorbjarnarson & Velasco 1998), and in Brazil a large number of caiman ranches closed (W. Magnusson, personal communication). Prices rebounded in the mid-1990s, but declined again sharply in 1997–1998 as a result of an economic slowdown in Japan; the financial crisis in a number of Asia nations, including Singapore, Indonesia, and Thailand, and the resulting weakened exchange rates; declining prices of ostrich skins (which compete with reptile leather); and an abnormally increased supply of skins, particularly from Papua New Guinea, where the El Niño drought resulted in a larger than normal harvest (Koh 1998). The effects of the recent downturn in prices remains to be seen, but already there are reports that ranching programs in Botswana, Mozambique, Malawi, Uganda, and Ethiopia have closed or are about to (Crocodile Specialist Group 1998).

The history of crocodilian managed-harvest programs shows both the advantages and disadvantages of an approach based on sustainable use. The demand for crocodile skin products made commercial management of the more common species an attractive alternative for businesspeople and national wildlife management authorities. Over the last 20 years the success of these approaches can be measured by the number of nations that began managed harvests, the global shift from mostly illegal to legal skins, the amount of research and population monitoring of commercially managed species, and the population recovery of a variety of crocodilian species (Messel 1991; Ross 1995).

The limitations of a sustainable-use approach to management of crocodilians are evident in the lack of effectiveness this approach has shown in dealing with the most highly endangered crocodilians, particularly where habitat loss has been a major contributing factor (e.g., the Chinese alligator and Philippine crocodile). For the most part, the focus on sustainable use has shifted the attention of crocodilian managers away from highly threatened species to the more common ones with high commercial value. The limited and provisional success of this approach notwithstanding, we must identify and develop national and international mechanisms that allow the economic benefits derived from sustainable-use programs for the relatively abundant species to be used to benefit conservation activities for highly endangered species.

Attempts to establish conservation programs for crocodilians based entirely on sustainable use show that the "sustainability" of this approach is ultimately dependent on the vagaries of the exotic reptile leather market, a market that appears to be cyclical and not solely related to the production of skins. The importance of this last fact has yet to be gauged but argues strongly that countries with have crocodilian sustainable-use programs, or those that want to establish them, must be increasingly critical of programs aimed solely at skins and should examine ways to diversify into local meat production or other industries that add value, particularly local value, to the harvest. In addition, programs should give more attention to nonconsumptive uses such as ecotourism. For crocodilians in particular, and probably for managed populations of wildlife of potential high value in general, a single, economically based approach to conservation will remain susceptible to market forces in a world in which market forces are imperfect and short-term vagaries can grossly undermine the long-term conservation goals of these programs.

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