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THE PROSPECTS FOR USING MARKET INCENTIVES FOR
CONSERVATION OF BIOLOGICAL DIVERSITY

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The problem of maintaining genetic diversity, preserving endangered plants and animals, and protecting sufficient habitat is both critical and growing. Arguably, many of the large, aesthetically attractive species may be saved in zoos, preserves, and safari parks. But to preserve these species in the wild, and to save the untold numbers of plants, invertebrates and the smaller fish, amphibians, reptiles, birds, etc. - we will need to preserve their habitats.

In their efforts to stem the loss of wildlife, the nations of the world have relied primarily on trade restrictions, publicly maintained habitat, and governmental control of the rate of exploitation. The results have been mixed at best. Illegal taking and trade have severely taxed enforcement resources, and public budgets for habitat protection have been inadequate to withstand the press of development. Many observers are resigned to the belief that the best that can be expected from the current preservationist strategy is a postponement of the inevitable depletion of species, habitat and ecosystems.

There are two important aspects to the loss problem. First the burgeoning illicit trade in wildlife products (which has encouraged overharvesting of the more valuable species) together with the poaching of endangered species, even in the most protected parks and preserves, is rapidly outstripping the financial resources of most Third World (and many developed) countries to cope with the problem. Secondly, and more importantly, the vast majority of species losses is no longer due to man's taking in the wild. Instead, the rapid growth of indigenous populations with their concomitant demands for food, fiber, housing, and energy, together with the development of natural resources for export revenues is eliminating many wild places altogether.¹

¹For example, the Brazilian government estimates that between 1966 and 1975, 38 percent of all deforestation in the Brazilian Amazon was attributable to large-scale cattle ranching (primarily for export), 27 percent to highway construction, and 31 percent to agricultural colonization. At the current rate of clearing 63 million acres will be lost by the end of the century. That rate is likely to increase, however: 60 percent of all deforestation
(continued...)

One of the principal reasons for the discouraging results of the preservationist efforts emanates from the status of wildlife as a common property resource. Wildlife are considered to be in the public domain, to be owned by all and hence by none, to be common property. Common property status for wildlife puts almost the entire burden for preserving wildlife on the public sector. It does nothing to motivate the self-interest of individuals and create private incentives to husband wildlife or preserve habitat.

The urgency of the current crisis has led a number of conservationists, scientists, and economists to argue that unless the living resources and habitat can generate some economic benefits, in the long-run protectionism will be overwhelmed. The pressures for development will cause the wildlife to be eliminated and much of the habitat to be converted to farm land, grazing pastures, or simply cut down for fuel and housing materials -- at best only converted to monoculture woodlots or plantations. This group has called for greater reliance on commercialization, economic incentives, and private property rights to encourage people to harvest wildlife on a sustained-yield basis and to preserve habitat.

The use of market incentives and property rights is not the only approach to managing the commons, the principal non-market techniques being limitations on factors of production (e.g., restrictions on equipment or on harvesting methods, limitations on season length) and direct output controls (e.g., harvesting quotas). There are also a number of mixed strategies: taxes, royalties, fees, licenses, and franchises. These may have more

¹(...continued)

in the Brazilian Amazon occurred in the three years between 1975 and 1978 (Caufield 1985). In southern Kenya, adjacent to some of the largest and most important national parks, the human population (including in-migration) is growing at 8-10 percent annually (Myers 1982). With pressure like that, enforcement alone is unlikely to prevent the conversion of wildlife habitat to farm land and grazing land, nor deter people from poaching elephants and rhinos, slaughtering wildlife which compete with cattle for grass and water and killing off predators. In spite of Kenya's well-publicized, able and well-financed efforts at protectionism, over the past decade its elephant population dropped from 165,000 to 50,000 and the rhino population from 15,000 to less than 1,000 (Myers 1981).

or less economic content, depending upon the criteria used for determining the magnitude of the taxes, royalties, or fees or the allocation of the licenses or franchises.²

In this paper I examine the prospects for conserving wildlife and their habitats by establishing markets in wildlife where an unmanaged commons existed previously. Several markets in wild species (seabirds, crocodiles, and butterflies) are examined to determine whether trade was organized successfully to avoid the tragedy of the commons; what conditions...political, social, economic, and biological...led to success or failure; and whether these conditions are unique or likely to be encountered or replicable elsewhere.³ To establish a context for examining the case studies I briefly review the supporting arguments for commercialization as a conservation strategy and some of the difficulties likely to be encountered in implementing such a strategy.

TRADE AS A CONSERVATION DEVICE

The essence of the argument in support of commercialization is that if property rights and incentives for private sector management and maintenance of species and their habitat are established, then trade in wild species (either wild or captive reared) can contribute to conservation. If the wildlife and habitat have a marketable value, landowners or lessees vested with enforceable property rights have an incentive to nurture and protect these resources. If trade is prohibited or property rights are vague or unenforceable, no such private incentive exists, and virtually the entire responsibility and cost of husbanding wild resources falls upon the public sector.

²For an excellent survey of techniques used in attempting to manage natural resources that are common property see National Oceanic and Atmospheric Administration, 1984.

³In 1983, I coauthored a paper which examined trade in a number of species and attempted to determine whether commercialization relieved pressure on the wild populations (Smith, et al., 1983). Later I discovered that one of my coauthors had been quite selective in his use of facts and that the evidence simply did not support the earlier findings. A formal request to the journal editor to publish a retraction was denied. I have extended the research and corrected the analysis below.

Indeed, public costs are likely to be exacerbated by the absence of appropriately designed private incentives to preserve wildlife. Habitat frequently has competing commercial uses, which make conversion attractive and increase the price which public entities must pay for acquisition. Wildlife can be pests and predators, thereby creating an incentive for their control and elimination, an incentive which is not mitigated if there is no capturable commercial value associated with the wildlife. The incentive for private efforts to control wildlife that are pests and predators makes it more difficult and more expensive for public wildlife managers to maintain any given wildlife population level. Where there are penalties associated with the taking or trading of wildlife, but no private property rights, the cost of controlling illicit activity is borne entirely by the public sector. If rights to the wildlife were vested in private entities, there would be considerably more identification, prevention, and reporting of illicit activity by the private sector.

Obstacles to Implementation: Market mechanisms are remarkably efficient devices for achieving socially desirable objectives. In many instances they are self-enforcing, requiring few supporting public resources and limited governmental oversight and regulation to function properly. Where such mechanisms can be designed for the wildlife sector, they can ease the burden of conserving wild species and their ecosystems.

However, no one but an unreconstructed zealot would contend that laissez faire commercialization is a panacea for the problems of preserving wildlife. For many species the concept cannot be applied, because many species have no apparent economic value. Even for species which have obvious utility, a market-oriented solution may be difficult or impossible to design. For migratory species it may prove difficult for habitat owners to capture the contribution of their resource. In less developed countries (LDCs) political instability, unreliable biological information, and primitive permitting procedures, complete with mountains of numbing documentation, frequently complicate the problem of implementing a conservation-oriented, commercialization strategy. In many instances biological constraints and/or economic or social institutions will make it difficult to establish property rights. Where property rights can be established, the cost of enforcing them may be prohibitive. Even where enforceable property rights can be established, management of the species on a sustained yield or profit-maximizing basis in perpetuity is not assured: there are conditions under which harvesting of the entire stock (liquidation of the firm and extinction for the

species) is financially preferable for the resource owner (Clark 1974; Fife 1971). The list of potential problems is lengthy, well-broadcast, and often legitimate.

Conditions Favorable to Commercialization: There are however conditions which favor commercialization and the establishment of property rights. If the product is such that a reliable supply is important to maintain commerce, opportunities are likely to exist for undermining illicit trade and poaching. If the range of a species does not cross political boundaries, the problems of establishing a market and enforcing property rights may be simplified. If the conditions under which a species can be raised or marketed lend themselves to self-enforcement, public funds now devoted to protection or enforcement can be saved, and commercialization may prove attractive. Conversely, a market solution may not be appropriate for species that require extensive support from law enforcement in order to establish a market structure which contributes to conservation.

Trade in species for which the cost of farming or ranching is less than the cost of taking from the wild can be used to relieve pressure on wild populations. Although this is often difficult to effect, budgies, canaries, and fresh-water tropical fish are cases in point. Extensive trade occurs in these species, all of it with specimens bred and reared in captivity. If a uniform product is desirable, captive breeding has an advantage. Obvious examples are species used for research and testing and some animals used in the fur trade. Indeed, either because of diet modification or because the captive population is shielded from the hazards of the wild, captive breeding and raising can be used not just to generate a uniform product, but an enhanced, more valuable product.

Captive breeding and rearing has its limitations as a conservation device, however: although it can be used to reduce taking from the wild, captive breeding and rearing does not create property rights in wild populations and their habitats, and in and of itself establishes no direct incentive to maintain these populations and their habitats. Thus, where development threatens, captive breeding and rearing has minimal benefits as a strategy for maintaining the wild.

Identifying species for which market mechanisms can be used in solving the problems of preservation together with designing the appropriate mechanisms is a fairly ambitious task. Given the number of species, populations, and habitats in need of attention, the problem takes on discouraging dimensions. But the

current protectionist strategy has failed to halt the precipitous decline in wildlife populations, and without a massive increase in funding (funding which does not seem to be forthcoming) the prospects for protectionism are dim. Although the decline in wildlife populations is generally unwanted and dangerous to the stability of the biological labyrinth, unless a way can be developed to make it in people's self-interest to preserve wildlife populations and habitats, extensive depletion is inevitable during this century. It is not noble to have to consider and engage in the exploitation of the rest of the earth's species in order to create conditions under which they are valued enough to be preserved. In light of the precarious status of numerous species, it would be even less honorable to avoid consideration of commercialization because of its offensive nature.

We move now to the examination of the case studies and some of the difficulties encountered in marrying conservation and commercialization.

SEABIRDS

In Iceland, seabirds...eiders, murres, razorbills, kittiwakes, and puffins...have been exploited for food and feathers for over 1000 years. Since the eleventh century there have been a variety of efforts instituted to protect the birds, control overharvesting, and supplant the commons. Indeed, as early as 1281, the civil and ecclesiastical codes stated that the birds belonged to the occupiers of the lands where they occurred (Doughty 1979). Protective efforts were largely ineffective, however, and over-exploitation continued until the middle of the 19th century when enforcement became more vigorous. Currently, the management schemes for eiders, murres, razorbills, and kittiwakes make the most use of property rights, while that for puffins is more like a regulated fishery. In all of this, however, government enforcement, protection, and penalties play an important role.

Eider Farming: Eiders serve as a source of meat, eggs, and especially down. The landowners conduct fairly classical husbandry operations: creating artificial nesting sites, gathering down, collecting eggs and inducing double-clutching,

and protecting the nesting colonies from poachers and natural predators.'

The number of such farming operations grew during the 19th century and peaked during the 1920s at 250 farms. The movement of many farmers into towns together with the development of synthetic substitutes have reduced the number of farms to about 200, and eiderdown production is now only about half of its peak. One result of this decline in farms has been an increase in predation by gulls, ravens, and feral mink and fox.

Despite the protection afforded by the remaining farmers and the government, Iceland's eider population has declined in recent years, while eider colonies elsewhere have grown. The fall in population has been attributed to a combination of unusually severe weather conditions, pollution attendant to development (oil, industrial wastes, and agricultural chemicals have invaded coastal waters), the increased predation (also due to human activities, since gulls are camp followers, and have thrived on municipal dumps), and the reduced number of farms (Doughty 1979).

As indicated, among the examples of commercialization of wildlife, eider farming is one of the closest to the pure property rights paradigm. A key element, however, is that eiders are fully protected in Iceland. The government enforces the property rights, allowing no taking on public nesting grounds and imposing sizable penalties for poaching. Thus, the "commons" has been replaced by a combination of private farms and government protection. The latter is central to managing the species, as well as managing the industry. The publicly protected, non-privately owned nesting sites add to the population, and, protected from competition from poachers on public lands, the farmers are encouraged to incur costs in husbanding the nests on their property. Further-supporting the management scheme is the long tradition of eider conservation, the availability of other employment and income sources, and the small, slow-growing human population. The close-knit nature of the community probably serves to further discourage poaching. Competition from synthetics and continued development, in Iceland could undermine

'In the official terminology of CITES (the Convention on International Trade in Endangered Species of Wild Fauna and Flora) "farming" involves closed-cycle, captive-breeding of wildlife, while "ranching" involves taking eggs or young from the wild and rearing them in captivity. In this paper "farming" will be used for all controlled-rearing activities.

the arrangement, however, and might weaken protection of the colonies. There is a symbiotic relationship here: protection of the eiders encourages the industry, and a healthy industry results in a constituency which supports government protection. Should the industry continue to decline, interest in protection could erode.

Murres, Razorbills, and Kittiwakes: Seabirds and eggs are harvested from the steep, sea-cliff, breeding colonies of the murres, razorbills, and kittiwakes. The management and farming technique is somewhat different from that for eiders, but property rights continue to play an important role. Artificial habitat is not created to attract the birds; rather property rights have been established by farmers on the natural breeding sites (Hyman 1982). No common area remains. The entire breeding area has been subdivided into private farms, and owners frequently rent the harvesting rights to hunters. Although the law allows the taking of full grown birds, their eggs and young, breeding stock is conserved through a combination of government controls and self-imposed husbandry practices.

Hunting methods that primarily select adults are banned by law. This is in marked contrast to the days when Iceland's nesting cliffs were known as the country's breadbasket and as many seabirds as possible were slaughtered. Taking was uncontrolled, hunting being conducted at sea and on land with nets, hooks, snares, and guns. Severe population declines occurred, and one-species, the great auk, became extinct.

Eggs are collected early in the season, allowing most birds to relay. This, together with concentrating the hunting on young birds and nestlings which have a high natural mortality rate, tends to preserve the populations.

All of these conservation, management, and farming practices might be for naught, however, if it weren't for the fact that the birds are extremely faithful to their nesting sites. It is this natural tendency (together with the birds' relative lack of vulnerability while dispersed at sea in the off-season) which makes it possible to establish fairly dependable "ownership rights" to the breeding population and allow substitution of a property rights structure consistent with conservation for a commons which encouraged over-harvesting. If the birds tended to pioneer easily, each farmer would have an incentive to harvest as many birds as possible each year, assured that the nesting population on his land in year t was independent of his activities in year $t-1$. Thus, in the absence of the birds' site

fidelity characteristics, a commons would reemerge despite enforceable property rights to the breeding habitat.

Puffins: The management arrangements that have evolved for puffins are similar in many respects to those for murrelets et al. Property rights, at least tacit property rights, play an important role in the management and conservation of puffins, but government regulation of harvesting methods has certainly been critical to the recovery of the populations from the decimated levels of the mid-1800s.

Puffins are hunted for their meat and feathers. Like the murrelets, razorbills, and kittiwakes, puffins are cliff dwellers, making their nests in burrows. Until the middle of the 19th century hunters netted the birds at their burrow entrances, a practice which had a devastating effect on the populations. In 1875, a long-handled net called a hafur was introduced to Iceland (Hyman 1982). It is used to capture the birds in mid-flight. Despite its unwieldy nature (12 feet long), no substitute has emerged for the hafur during the intervening century, and Icelandic law designates it as the only instrument that can be used to harvest puffins. Guns are specifically outlawed, because the noise frightens the birds away from the colonies, leaving the young uncared for and the eggs unprotected.

The largest puffin colonies are found in the Westmann Islands off Iceland's southern coast. The Town of Westmann Islands owns the islands, and leases each harvesting site (island) to local hunters. Rental fees are nominal, and do not serve an allocative function. Rather, by tradition, the same group of hunters leases the same island year after year, and tacit ownership rights have evolved for each harvesting site (Peterson 1985). This is important, because in conjunction with the island-faithfulness of the birds, it provides an incentive not to overharvest an island. Puffins will pioneer and recolonize an overharvested site, but recolonization takes time, and in the interim, harvest sizes will suffer.

In order to conserve the breeding population and avoid overexploitation, Westmann Islanders hunt only on the periphery of the breeding colony, stationing themselves on the cliffs and attempting to net birds as they fly by. Hunting is conducted only during the summer months, when the bird population milling about the cliffs is composed largely of young and immatures. Adults rarely fly along the cliffs during the summer, traveling instead straight out to sea from their burrows in search of food for their young. Catch statistics reflect the selective nature

of these hunting practices: 93 percent of the take is composed of nonbreeding juveniles (Hyman 1982).

These restrictive hunting practices are all self-imposed. The government sets no bag limits or season lengths, requiring only that hunting be conducted with the hafur. Hunters who deviate from the accepted harvesting methods are quickly sanctioned by the small community. Further, the commitment of the Westmann Island hunters to harvesting practices which conserve the breeding population is almost certainly related to the long-term leases and tacit ownership rights which they enjoy to the harvesting sites. On islands to the north where leases are determined annually and hunters have no long-run claim to the harvesting sites, hunting is conducted from the middle of the colonies, rather than on the periphery. Puffin populations on these islands have declined significantly (Peterson 1985).

Assessment: The arrangements for exploiting seabirds in Iceland used to be in the form of a commons, and, as expected, overharvesting occurred to the detriment of the species. Clearly, the seabirds are conserved better under the current harvesting structures than they were under a commons.

Are the bird populations larger than they would have been if commerce had been prohibited? The eider population may be, because farmers create artificial habitat for them and the birds' commercial value encourages both private and public efforts to protect them from natural predators. This is probably not the case for the puffins and the murrelets et al. The management arrangements for these species do not involve habitat enhancement or predator control. Thus, if commerce were banned, the populations of puffins and murrelets et al. might well be larger. However, the implicit assumption here is that even if commerce were prohibited, the protective efforts would continue, and that is probably not the case, at least not at the level now enjoyed by the birds. On the whole, seabirds seem to have been well-served by commercialization and the institutional arrangements devised for harvesting them...far better than under a commons and very likely better than if commerce were prohibited.

It is noteworthy that this was accomplished without having to extend protective controls or property rights to the birds' entire range. The birds are primarily pelagic, colonizing only during the breeding season. Since the cost of harvesting them at sea is prohibitive and the rest of their habitat (the open ocean) is not terribly vulnerable, it is only necessary to control their

breeding grounds to protect them.⁵ At the risk of stating the obvious, when the portion of the commons to which protection or property rights need to be extended can be confined, commercialization consistent with conservation becomes much easier to effect.

Another principle evident from the Icelandic experience with seabirds is that in some cases (like the eiders) privatization of the commons with minimal government support of property rights may be sufficient for commercialization to be consistent with conservation; in others (like the puffins) more government involvement, scrutiny, and protective actions may be required. For financially pressed and overburdened governments in LDCs, providing the latter may be difficult.

There is one important condition operating in Iceland which unfortunately is not duplicated in much of the tropics: in Iceland the breeding habitat is not under pressure from alternative forms of development. The human population is stable, and there does not appear to be much use for the land except as habitat. Clearly, this is often not the case in the tropics, where the commercial opportunity costs associated with retention of the land as habitat are often high and may swamp the revenues that can be extracted from the land in its natural state.

CROCODILES

Some species of crocodiles have been on earth for 200 million years. However, all of the remaining 26 or so species have undergone such rapid depletion during the past 30 years that most of them are now listed as either threatened or endangered, and the prospects for their survival in the wild is tenuous at best. In the face of a continuing world-wide demand for crocodilian leather products, there is little future for crocodiles if they remain only a common property resource.

Papua New Guinea (PNG) saw its wild crocodile populations crash in a short period of time following the wide-scale development of commercial shooting which began in the mid-1950s. PNG has both fresh- and salt-water species of crocodiles. The trade in both

⁵This would not have been sufficient for Norway where overfishing has reduced the food supply for seabirds and caused the populations to decline.

species peaked in 1965-66, when \$1 million in skins were exported. After 1966, exports plummeted as both species disappeared from accessible areas. By 1967, populations of both species were depleted, and in 1968, even with increased hunting effort, the yield dropped by half. By 1969, the salt-water crocodile was rare in most of its range throughout the country. In 1970, the PNG government estimated that all breeding-age crocodiles would be gone within 5 years. In 1971-1972, the total value of exports of both species had been reduced to \$198,000 (National Research Council 1983).

In the late 1960s, the government began to develop a radical national plan to incorporate all of the Nation's wildlife as part of a constitutionally protected, sustainable national resource. Aware of the effects of development on other tropical regions, the government sought ways to utilize the nation's natural resources to improve the standard of living, while maintaining the traditional lifestyle of the indigenous peoples and the integrity of the ecosystem. PNG embarked upon a program of wildlife farming, encouraging individuals to establish enhanced habitat areas on the fringe of natural environments. The farming program included plans for cassowaries, megapodes, wallabies, deer, butterflies, and crocodiles. PNG's butterfly and crocodile farms were designed as export industries. The other wildlife farms were conceived of as a source of domestic protein (National Research Council 1983).

In 1968, the government formulated its first crocodile regulations, including licensing at all stages of the trade, data collection, and a ban on the possession, sale, and export of all skins exceeding 20 inches in belly width (about 8 feet long). The belly-width ban was designed to conserve the most critical portions of the crocodile populations, the mature, breeding adults. Breeding, fresh-water crocodiles sometimes fall below the 20 inch belly-width limit, but for the most part the ban is well conceived and still in effect (King 1990). There was, however, no attempt to institute a ban on the killing of crocodiles for domestic consumption; the government believed the people would not accept such a ban. Traditionally, the taking of crocodiles by natives for food was minimal and confined to young crocodiles and eggs, but harvesting increased when the international skin trade developed (National Research Council 1983).

The national plan culminated with the enactment of the 1969 Crocodile Trade Protection Act which was aimed at controlling the export trade, eliminating pressure on breeding adults, and

developing a nationwide program to rear crocodiles to marketable size. The government set up a three-tiered system of farms with loans, training, and informational booklets and guides. In addition, the government began establishing training centers and research farms in 1969. By 1975, there were eight such operations.

The Three-Tiered System: The program went into operation in 1972 with the creation of a first tier of small village farms, essentially holding pens for the young crocodiles captured by the natives. Each village had a holding capacity of 300-500 animals. Since the young have a high natural mortality rate, it was expected that taking young would have a minimal impact on the size of the wild population. The natives soon discovered, however, that they could not keep hatchlings alive. They gave up taking hatchlings, and concentrated instead on juveniles (1-4 year olds, 18-48 inches long). Juveniles have a good chance of surviving in the wild, and taking them in sufficient numbers has a distinctly negative impact on the wild population.

The second level of small business farms held up to 3000 animals, was located near bush airstrips, and had some ready source of animal protein for feed (generally trash fish or offal). This second level of farms supplied a third level of larger company farms, which had a holding capacity of up to 20,000 animals. These last were substantial operations, requiring about \$250,000 to establish; were located adjacent to major population centers; and had a reliable supply of food (generally offal from nearby poultry farms) and fresh water.

Each tier sold stock to the higher level as the crocodiles grew to market size and moved toward the export facilities. Each higher level was better financed and better equipped, and was expected to absorb the stock of the lower levels in case of food shortages, droughts, or periods of depressed market prices (National Research Council 1983). However, often when such pressures occurred, the crocodiles in village farms were in such a deteriorated condition that the company farms would not accept them, and the crocodiles perished (Ross 1985).

In 1981, the nationwide farming system held a total of about 30,000 crocodiles. The ultimate goal was to maintain a population of 100,000 crocodiles, producing about 30,000 skins per year for export. At full operation the government expected to be able to provide all its exports from captive-reared stock. By 1981, however, the system was performing far below expectations: 10,000 skins worth \$1-2 million were exported, but

only about 1,000 of these came from farm-reared stock. The rest were culled from the wild (Rose 1983).

The Election of 1980 and the Restructuring of the System: With the election of 1980, the entire wildlife program sustained a severe body blow. A development-oriented, conservative government interested primarily in promoting PNG's timber and mineral resources came to power. In 1981, the budget for the Department of Environment and Conservation was cut from three million (kina) to half a million and the staff from 300 to 50. Extension services were severely curtailed, and UN financial and manpower support was terminated.

The crocodile program underwent a completely restructuring. Village farms were largely abandoned in PNG in 1982. With only one or two exceptions the village farms reverted to being collection centers, holding hatchlings and juvenile crocodiles for a brief time for the large commercial rearing operations.

The restructuring was due only in part to the change in regime. As early as 1979 and 1980, UN/FAO advisors and observers indicated that very few of the 180 village farms were operating successfully. There were reports of shortages of food and water; a lack of hygienic conditions; crowded stocking conditions, leading to stress and disease; general neglect of the stock; and a decline in the number of animals being raised. All of this suggests that there was waning interest and ineptitude on behalf of the villagers in the farming program (Rose 1983).

This is particularly discouraging in light of the extent to which the government initially promoted and subsidized the program. The entire operation required sizeable start up costs, financed by the central government with development bank and UN backing. Subsidies were provided in the form of loans, training, frequent extension services, and centrally organized and controlled marketing.

Much of the deterioration in the village farm system was undoubtedly due to the technical difficulties associated with attempting to impose a rearing operation on villagers who were used to harvesting wild crocodiles for the skin trade. The villagers are primarily hunter-gatherers, unfamiliar with the requirements of operating a farm that is a supply source for an integrated commercial industry. Establishing a rearing operation in a primitive culture undoubtedly requires much more time, supervision, and funding than PNG and UN/FAO were able to provide.

Casual management practices on behalf of the government probably contributed to the problems at the village level, as well. During the years when the skin trade flourished, the expatriate traders maintained a regular schedule of visits to the villages. Under the integrated Federal system, visits by purchasing agents were much more erratic (Ross 1985). Villagers became discouraged once they realized that they were involved in a project which did not generate cash or barter rewards at reliable intervals (Rose 1983).

Assessment of the Original Design: Although there were a number of things which led to the decline in the morale of the village crocodile farmers and the deterioration of the farms, the structure of farm property rights was definitely not one of them. In a society which is primarily communal (such basic activities as food gathering and distribution are conducted collectively, for example), the crocodile farms were organized so as to provide every incentive to operate them efficiently. Village farmers were responsible for harvesting their own crocodiles (or purchasing them from other hunters) and for maintaining their captive stock in salable condition. In return, any revenues from sales accrued to the pen operators. Since a stock pen is a fairly simple thing to construct, and since the government guaranteed the farmers a market, there was no lack of incentives. Indeed, in any one village there were as many as a dozen crocodile farms (Ross 1985). What the private property rights structure did not do was create an incentive to conserve wild crocodiles or their habitat. That role was left largely to government regulation and the fortuitous location of the habitat relative to developmental pressures.

In PNG, each tribe owns the nearby forest (including any crocodile habitat) communally; no portion of the forest goes unclaimed. This territory is actively protected. Territorial boundaries have been established and are regularly defended through inter-tribal conflicts (King 1985). Although a tribe will defend its territory against raids by alien hunters, ordinarily it does nothing to restrict taking of wildlife by tribal members.⁶

This system extended to crocodiles. Subject to the 20 inch belly-width, limit, crocodiles and their nests belonged to the

⁶There are some exceptions, e.g., paradise birds which are considered to be the reembodiment of their ancestors.

individual who located them. This is precisely the recipe for a commons: multiple, unregulated entities all trying to capture and sell as much of the commonly owned crocodile population as is privately profitable. Although the central government encouraged the tribes to manage the harvesting by rotating harvesting areas, few tribes initiated management practices.

Three things limited the pressure on the wild populations:

- o The government successfully monopolized the trade in crocodiles. Illegal trade was controlled, and as a monopsonist, the government only provided a market for juveniles and hatchlings.
- o As extensive as the harvest of juveniles and hatchlings was, it evidently was not so efficient as to prevent recruitment to the breeding stock.
- o The native population was small enough that the impact of any taking of crocodiles (adults, juveniles, and hatchlings) or eggs for self-consumption had de minimis impact on the wild populations.

Remoteness was the primary savior of the habitat. The crocodile habitat is located in the swampy lowlands, and most of the development (lumbering, mineral extraction, and monoculture) occurs elsewhere. Thus, although some increase in the pace of development occurred under the conservative government, it probably had little impact on the crocodiles and their habitat. Further, it would be misleading to imply that only the conservative government promoted the development of extractive industries. With the change in regimes there was merely a change in emphasis. Timbering and mining have been conducted for some time in PNG. They represent an important source of revenue and employment, and the returns are such that this type of activity will continue no matter which government is in power (Bruning 1985). If economically exploitable mineral reserves are ever discovered in the lowlands, the crocodile habitat will be threatened.

Since the habitat is communally owned, individual, private property rights cannot play a role in conserving the habitat. But the manner in which communal property rights are structured in PNG certainly will play a role in protecting the habitat from conversion and development. Under the constitution, unanimous consent of tribal members is required for a change in land use (King 1990). Given the native peoples' preference for their

traditional lifestyle, this legal structure stands as a formidable obstacle to development. Of course, if the mineral or timber resources are valuable enough, the legal structure may become vulnerable, or the development decision may be made in an extra legal manner. Such things have been known to happen in developing countries.

The Election of 1983 and the Revival of the Conservation Program:

In 1983, the conservation-oriented government was reinstated and began trying to resuscitate the wildlife projects. Many of the projects had already been closed or drastically reduced in size. Emphasis was placed on the insect and crocodile projects. Plans to extend farming to other species were abandoned, and have never been revived.

No attempt was made to return the village crocodile farms to a nursery status. Instead, the village farms continued to be maintained merely as collection centers and short-term holding operations for hatchlings and juveniles. The second level rearing farms were consolidated into three large entities. It was clear that the erratic nature of the visits to the villages by the rearing farm purchasing agents had played a pivotal role in the deterioration of the system. Managers at the rearing farms focussed on developing reliable schedules, and today, purchasing agents make regular monthly pickups at the villages.

After the UN/FAO terminated its support, the government abandoned census taking. Arguing that a wild population cannot be managed without a census, UN/FAO officials threatened to petition CITES to transfer PNG crocodiles from Appendix II to Appendix I. Trade in Appendix I species is much more restricted. The rearing farm operators came forward, offered to finance the census taking, and contracted with UN/FAO to conduct the work from helicopters.

The government became increasingly concerned that the village farms, even in their altered role as collection centers and even with regularly scheduled pickups, were having an unacceptable and unnecessarily large impact on the population, of hatchlings. It was decided that the survival rate, both in captivity and in the wild, could be improved if the rearing farms expanded into hatcheries. As a result, an entirely different collection and incentive system has been instituted at the village level.

After locating nests from the air, UN/FAO census-taking staff return to the villages, and travel with the village farm operators into the bush to retrieve eggs from the nests. The rearing farms pay the village chiefs \$1.50 plus one chicken egg

for each crocodile egg, and the funds and eggs are distributed communally. The chicken eggs replace crocodile eggs in the natives' diet and eliminate any incentive to collect the crocodile eggs for consumption.

The entire system seems to be functioning well. The wild population is healthy and growing, and rearing farm revenues are up. Although villagers still take juveniles and small adults for the hide trade, most skins come from the farm-reared stock, exactly the reverse of the situation in the early 1980s.

It is not apparent that a more systematic management arrangement has been applied to the commons. The 20-inch, belly-width prohibition serves as the major regulatory constraint, but with the rearing farms willing to purchase all legal specimens, the real constraint on the extent of the take appears to be the inability of the natives to capture so many young crocodiles as to jeopardize the breeding population.

As a conservationist, I am happy for the crocodiles. As an economist, however, I am disappointed that private incentives do not seem to have played a greater role in the transformation of the system. The entire incentive system at the village level has been replaced with a system in which gains are distributed communally. Albeit, the original design lacked a feature to induce conservation of the wild, and needed to be supplemented with a strategy for managing the commons. But, now a system has been adopted which shares all gains communally, makes very little use of private incentives, and still lacks a satisfying strategy for managing the commons. Perhaps in societies which are used to functioning communally, such arrangements will work just fine. And perhaps economists need to be less orthodox in their consideration of management mechanisms and incentive systems.

BUTTERFLIES

Habitat modification has taken its toll on butterflies throughout the world. Deforestation in the tropics and wetland conversion and environmental degradation in more developed areas have resulted in threats to a number of species and extinction for several others.

Although PNG has been spared these by-products of development and remains largely an undisturbed rain forest populated by forest farmers, its butterflies have still come under stress from collectors, commercial hunters, and traders. By the mid-1960s,

butterfly collecting and commercial harvesting, which had been going on since the turn of the century, had reached such proportions that several of the most exotic species (the birdwings) were endangered.

PNG moved to protect its butterflies, going so far as to stipulate in its constitution that insect conservation is a national objective. The government took its first protective steps toward butterflies in 1966: collecting and trading in seven species of birdwing butterflies were prohibited, large fines were instituted, and penalties ranging to deportation were implemented. Soon thereafter, preserves were established, and research undertaken to promote the recovery of depleted species. In 1974, it initiated its butterfly farming program. In 1975, in an effort to retain a monopoly in PNG's unique varieties of butterflies and to reserve any economic returns for PNG natives, the government prohibited foreigners from engaging in commercial trade in butterflies, and forbade the export of live specimens (National Research Council 1983).

The Nature of the Butterfly Trade: Although butterflies pollinate crops and flowers and serve an important role in the food chain, commercially they are valued only for their aesthetic qualities. Taiwan, Korea, and Malaysia maintain factory-like operations where specimens are mounted in plastic and glass, on trays, coasters, tabletops, decorative screens, and even on items of such questionable taste as clear plastic toilet seats. Similar but somewhat smaller enterprises flourish in Honduras, Hong Kong, the Philippines, and several African nations.

The trade is divided between collector-exotics and common ornamental varieties, and is extensive. Taiwan alone sells an estimated 15-500 million specimens annually; the take of blue Morphos from the South American tropics is roughly 50 million per year (National Research Council 1983). Despite the magnitude of the harvest, wild population levels in Taiwan seem to have been unaffected, and biologists estimate that reproduction rates are such that the harvest from South America could be doubled without detriment.

Although the vast majority of the specimens in trade are collected directly from the wild, increasing numbers are being supplied by breeding farms. A limited amount of farming is done in Australia, Malaysia, and the American tropics, but in PNG butterfly farming is conducted on an ambitious scale. There were 500 farms operating in 1978, and although I do not know the current number, there are significantly more than that now.

Farming in PNG: The farms are operated by villagers who plant flowering hibiscus to attract adult butterflies and leafy plants for caterpillars to feed on. After mating, the females lay their eggs on the plants which support the larvae. In turn, the larvae attach chrysalises to the undersides of the leaves. Harvesting, preserving, and packaging the specimens for shipment to the government marketing agency, IFTA (Insect Farming and Trading Agency) in Bulolo are delicate matters, and timing is critical. That some technical skill is required is apparent from the fact that in 1978, only 50 of PNG's 500 farmers were consistently able to supply marketable specimens.

Although the farms are run independently, the government maintains control over all other aspects of butterfly conservation and trafficking. IFTA trains village farmers, does research designed to increase productivity, and operates a marketing co-op, taking and filling all orders and maintaining quality control, for which it retains 25 percent of the profits.

•Despite the scale of the farming program, cultivated butterflies account for a relatively small proportion (roughly a third) of the specimens marketed, the rest being collected directly from the field (Orsak 1990). Farmed specimens generate about half of the revenue, however, reflecting the fact that given the costs involved, it is only economical to raise the most valuable species.

In its early years the program was pretty modest as a revenue raiser: \$180,000 was distributed to the villages during the first seven years of operation (1974-81). There was significant potential for growth, however, since IFTA was able to fill less than 10 percent of the orders it received. In 1981, PNG's aspirations were to export 5,000-10,000 specimens a month and generate \$120,000 income per year for the villagers. Currently, the program grosses roughly \$300,000 per year, which even in 1981 dollars is almost twice expectations (Orsak 1990).

Assessment: There are several reasons for PNG's success in stopping the depletion of wild butterfly populations, but none of them has to do with the establishment of private property rights over what was formerly a common property resource. The farms are satellite entities, dependent upon the wild. They take from the wild and may, by augmenting habitat, stimulating reproduction,

and releasing unharvested specimens, even add to the wild.⁷ In and of themselves, however, the farms do nothing to prevent overharvesting of wild butterflies (which except for birdwings remain an unregulated, common property resource) or create a private incentive for the preservation of wild habitat where no incentive existed previously. Rather, it is the underlying conditions...economic, environmental, and anthropological... together with government regulation which account for the replacement of an over-exploited commons with a commercial structure consistent with conservation.

The tragedy of the commons was circumvented largely because the government moved to exercise control over the wild. The most vulnerable species (the birdwings) were protected. Although other species remained common property and harvesting of them from the wild continued apace, they seemed able to sustain the pressure, and extension of protective controls was unnecessary.

Government management of the commons was crucial for the conservation of the butterflies, but equally as important is the remoteness of the habitat and the absence of any immediate threat from development. Although PNG's butterfly industry is successful beyond the authorities expectations, it generates too little revenue to stave off deforestation if it were imminent.⁸ It is the combination of significant development (lumbering, monoculture, mineral exploitation, or shifting agriculture) not being imminent together with government restrictions on butterfly harvesting and trade that accounts for PNG's successful substitution of a butterfly industry in harmony with the environment for one which promised not to be.

The natives are primarily gatherers not cultivators, and hence, they put little pressure on the forest;⁹ much of the country's timber and mineral resources are too remote and inaccessible to

⁷Even if no overharvesting occurs, the farms may not be neutral in their impact on the wild. Because they are managed for production of the most profitable species, released specimens may change the relative population levels in the wild. Most experts consider this a remote possibility, however.

⁸Coffee growing is an alternative for some of the butterfly habitat, and Orsak believes that the revenue generated by butterfly farming is sufficient to prevent conversion to coffee (Orsak 1990).

⁹Slash and burn agriculture is practiced in some parts of PNG.

make exploitation attractive; and overharvesting is restricted by government prohibitions, made easier by natives interested in preserving their traditional lifestyle and sympathetic with the objectives of the conservation programs. If these conditions could be duplicated elsewhere, there would not be much need to establish economic incentives to conserve the wild.

Conceivably, the joint revenues from multiple commercial wildlife programs could be sufficient to make deforestation and traditional development uneconomic, but I doubt it. As we have seen, the wildlife programs are a precarious arrangement, vulnerable to the whims of political change. If traditional development is stalled, it is much more likely to be due to the magnitude of the direct costs associated with achieving it than to the magnitude of the returns from marketing wildlife.

CONCLUSIONS

It became fashionable during the last decade, at least in certain circles, to maintain that the market can solve virtually every allocation problem, even those involving environmental resources. In its purest form, this, is fanciful. Markets function best when values are well-captured by market signals; when resources move easily in small increments from one activity to the next; when actions are reversible; and when the consequences of actions are well-known and close at hand rather than uncertain and distant in time. These conditions are frequently not met for environmental considerations.

If the concept of property rights is broadened to include the exercise of government authority over the environmental commons, the opportunities for utilizing economic incentives for conservation are greatly expanded. With no claim to either their necessity or sufficiency, the following conditions are listed as favoring the replacement of a commons with commercialization consistent with conservation:

- o Habitat has relatively low value in alternative uses;
- o Government is stable and committed to conservation and management of the commons;
- o Property rights can be established that are not prohibitively expensive to enforce;

- o Species and their habitat can be insulated from the effects of contiguous development; and
- o Owners of wildlife resources can compete effectively with either poachers or manufacturers of synthetic substitutes.

The analysis of the case studies suggests that although it is often difficult to realize such conditions, there are opportunities for conserving wildlife by substituting property rights structures for uncontrolled commons. Such structures will not necessarily be self-enforcing, however. They will require varying degrees of government support, management, and regulation to be successful.

Of the cases considered, the management arrangements for the seabirds in Iceland come closest to the pure property rights paradigm. Most of the breeding grounds for eiders are privately owned and farmed. Government protection is extended to eiders on lands that are not farmed. For the other seabirds, local authorities (and, in some cases, private owners) lease the harvesting rights, but the government regulates hunting methods, so as to avoid taking of breeding adults. The birds have fared far better than under a commons.

The system for harvesting crocodiles in PNG still retains important aspects of a commons. Although the natives cannot take specimens which are larger than a specified size, there is no limit on the magnitude of the harvest of eggs and hatchlings or of juveniles and adults within the size constraint. The system of village farms has evolved from one which made a great deal of use of private incentives, but needed a strategy for managing the commons to one which distributes gains communally, and continues to lack a completely satisfactory strategy for managing the wild. Dramatic improvement in the status of the crocodiles since the days when the international skin trade brought them to the brink of extinction is due largely to: government restrictions on the taking of adult breeders and virtual elimination of any illegal commerce; the remoteness of the habitat relative to developmental pressures; and the ability of the crocodile population to sustain the harvest of young and still grow.

Similarly, the depletion of PNG's threatened butterfly populations was interrupted, not because private property rights replaced the commons, but because the government exerted control over the harvest and protected the most vulnerable species. The farms are satellite entities on the periphery of the commons, and remain dependent upon the commons for their breeding stock. The

habitat itself remains largely undisturbed because of its remoteness and the absence of pressure for traditional development, the interest of the natives in preserving their traditional lifestyle, and a constitution which requires unanimous consent by tribal members for conversion to occur. Clearly, the butterfly revenue helps to sustain the natives, but it is probably not sufficiently lucrative to displace traditional development if it were a threat.

Although there are opportunities for utilizing market mechanisms for conserving wildlife and substituting property rights for unmanaged commons, one cannot be too optimistic that this strategy can be widely applied and sustained. It takes careful planning to design the appropriate economic incentives and support from government authorities to implement them and enforce the property rights. LDCs have immediate and overwhelming economic and political problems, and the likelihood that future ecological consequences will be heavily discounted in favor of short-run benefits from development remains strong.

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