Mangrove ecosystems: some economic and natural benefits

D. Evan Mercer and Lawrence S. Hamilton

In recent years scientists and planners have come to appreciate that conservation need not be incompatible with development. On the contrary, countries have much to gain from the sustained use of their living resources, both economically and otherwise. If development is production, then conservation is the maintenance of the means of production. Both are necessary for human survival and well-being. In this article the authors look at the range of products, benefits and services provided by the world's mangrove resources. Unfortunately, the overexploitation of these tropical environments, and the tendency to convert them to other forms of use assumed to be of greater value, mean that mangroves are threatened or, at the very least, that their renewability is being lost. During September 1983 Hamilton and Mercer joined other scientists and coastal-zone management specialists at a workshop held at the East-West Center in Hawaii, to prepare a mangrove-management handbook. Unesco, in the framework of its Major Interregional Project on Coastal Systems, was one of the sponsors. The article presents some of the workshop conclusions about economic and societal benefits from mangrove ecosystems stressing in particular the many uses of one of the plants commonly found in mangroves, the nipa palm.

Mangrove forests are the characteristic forest ecosystems of tropical and subtropical intertidal regions. Mangroves exist in tropical areas of all continents and in subtropical areas in Asia, North America, Africa, Australia, and New Zealand (see Fig. 1). Although typically occurring on flatlands between high and low tide levels in areas with high annual precipitation, mangroves are also found in arid areas in the Middle East along the Arabian peninsula and in West Africa.

The term 'mangrove' is used in two different contexts: first, to describe a group of salt-tolerant plant species in twelve genera and eight families, and, second, to describe an ecosystem found along tropical and subtropical coasts. IUCN's *Global Status of Mangrove Ecosystems* lists sixty species of trees and shrubs exclusive to the mangrove ecosystem and twenty-three additional species that may be important in the mangrove habitat but are not restricted to it. Two distinct occurrences of mangrove forests can be identified, based on species assemblage. One occurs on the west coast of Africa and on both coasts of tropical and subtropical America (often referred to as the New World Mangroves), and the other is found in the Indo-Pacific region and along the east coast of Africa (the Old World Mangroves).

Mangrove ecosystems constitute a reservoir, refuge, feeding ground and nursery for many useful and unusual plants and animals. Through the export of decomposable organic matter (mostly in the form of plant detritus) into adjacent coastal waters, mangroves provide an important nutrient input and primary energy source for many tropical estuaries. Figure 2 illustrates the pattern of nutrient cycling within mangrove ecosystems and the importance of mangrove organic matter exports to many important human food sources.

Like the terrestrial tropical rain forests, mangroves have played a significant role in the economies of tropical societies for thousands of years, providing a wide variety of goods and services including wood production, support for commercial and subsistence fisheries, aquaculture, salt production, and shoreline and coastal

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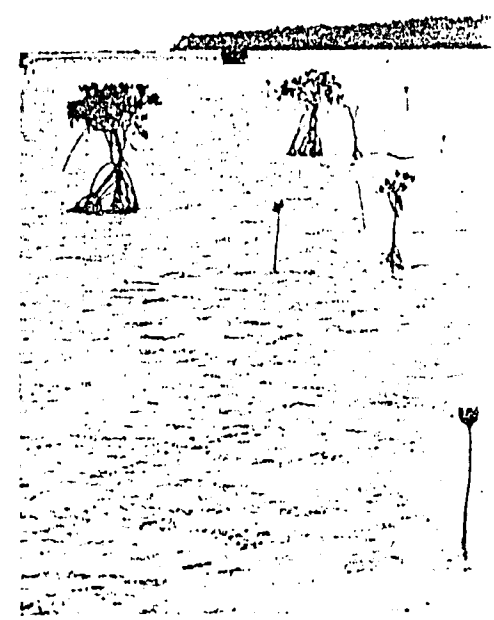

Mangroves are easily recognized by their vivaparous seeds and their tangle of prop roots. The roots allow the passage of water and nutrients into the plant while acting as filters against the salt.
[Photo: *D. Troost*]

erosion control. Also, especially in the developed world (e.g. the Florida Everglades) and increasingly in the developing world (e.g. the Caroni Swamp in Trinidad and the Mangrove Research Center in the Philippines), tourists and local people are utilizing mangroves and their secluded waterways for recreation (e.g. boating, fishing, and nature study).

Mangrove destruction on a large scale

However, like the tropical rain forests, the mangroves are being degraded and destroyed on a large scale in many parts of the world due mainly to overexploitation of their potentially renewable resources and to conversion to single-use systems such as agriculture, aquaculture, salt evaporation ponds, housing developments, etc. In South and South-East Asia and tropical America, mangroves are under severe pressure through conversion to agriculture and aquaculture. For example, in the Philippines, mangrove areas converted to fish ponds have increased from 88,681 ha in the early 1950s to 244,401 ha in 1981. In Ecuador, 42,000 ha of mangroves have

View of a typical mangrove wood in a tropical coastal environment. Mangroves have a high tolerance for salt resulting from various specific physiological mechanisms.
[Photo: *D. Troost*]

been converted to fishponds, and in the Indian Sunderbans at least 1,300 to 1,500 km^2 of mangrove forests have been reclaimed for agriculture. Destruction of mangroves for housing developments is a major problem in high-income countries (e.g. Australia, New Zealand, the United States) and is beginning to become a problem in some developing countries. In southern Queensland, nine of the fifteen major estuaries within 130 km of the capital have been substantially modified by construction of residential canal estates, and in Singapore the areal extent of mangroves decreased from 10-12 per cent of the land surface in 1922 to only 2.96 per cent in 1979. Logging operations are affecting large areas of mangrove forest in South-East Asia, where large tracts of land are being systematically cut, primarily for woodchip production for pulp and rayon manufacturing in Japan. In Indochina, logging operations are claiming 200,000 ha of mangrove forest each year. In South Asia and Africa, diversion of waterways is severely disturbing mangrove ecosystems by disrupting freshwater inflow, increasing soil salinities, and interfering with nutrient supply.

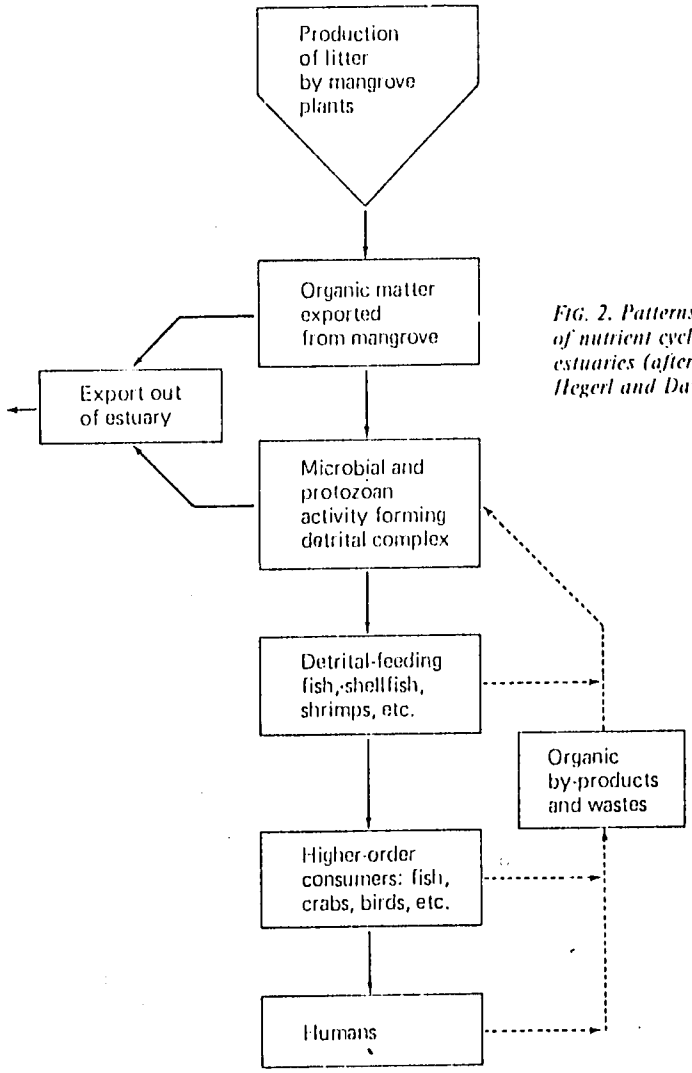

FIG. 2. Patterns of nutrient cycling in tropical estuaries (after Saenger, Hegerl and Davie, 1983).

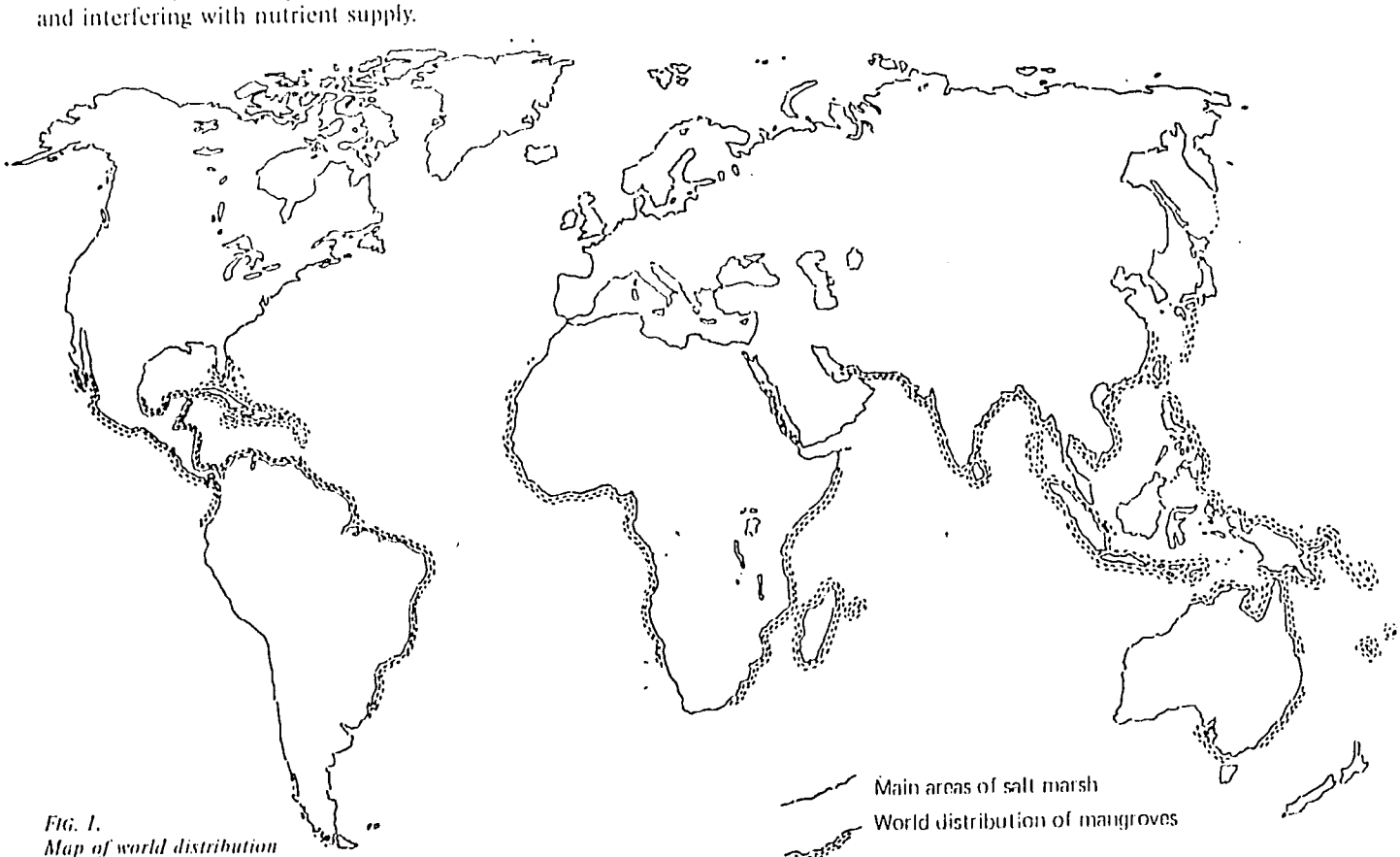

FIG. 1. Map of world distribution of mangrove forests.

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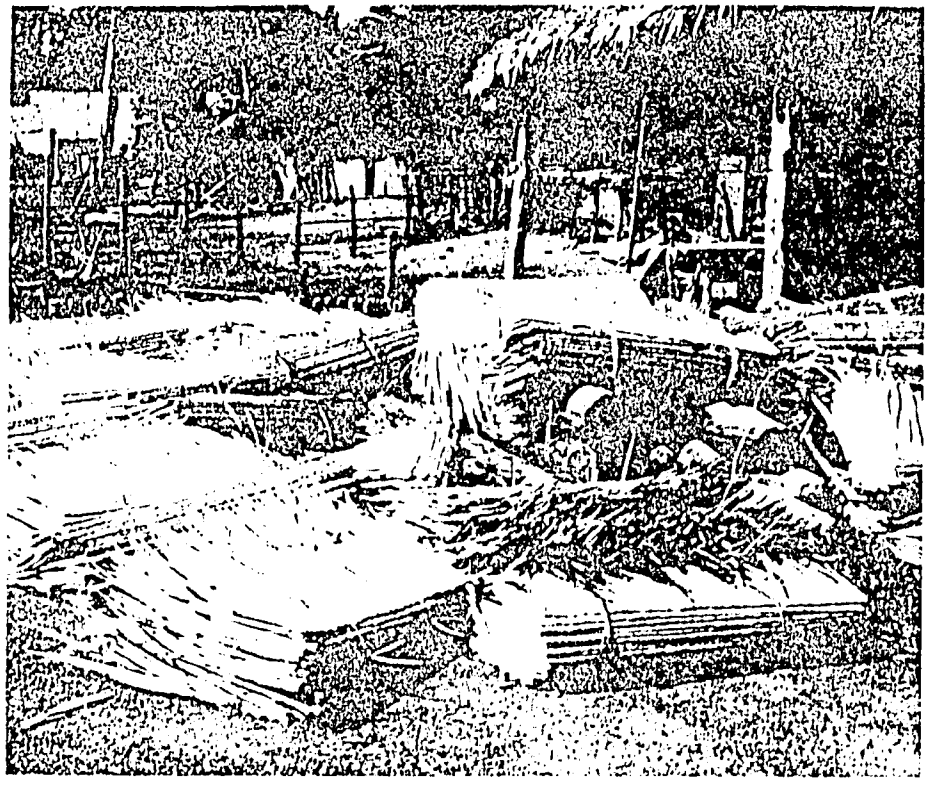
Unfortunately, in contrast to the tropical rain forests, which have received much recent attention from scientists, conservation groups and resource managers, many regional, national and international officials still view mangroves as 'wastelands' with little value unless 'developed' through conversion or direct exploitation for cash products. A recent workshop at the East-West Center emphasized the fallacy of such notions, stating that the global problem confronting mangrove management results from ad hoc utilization decisions that tend to ignore the broad range of multiple-use possibilities of mangrove ecosystems and frequently fail to utilize long-term sustained yield guidelines. Such decisions often result in the foreclosure of future opportunities for economic development and in the permanent loss of services beneficial to society that are provided at no cost by a functioning mangrove ecosystem.

Natural benefits

A mangrove forest can serve as a natural means of controlling coastal erosion and a buffer against the destructive forces of typhoons, hurricanes, and cyclones, as a nursery and feeding ground for many commercially important fish, shrimp and other marine organisms, and as an abundant source of wood and forest products (provided the logging operations are carried out in a sustainable and renewable manner). However, when the mangrove forest is destroyed (e.g. through conversion to aquaculture ponds, agriculture, housing developments, etc.), the natural services of the mangrove forest are reduced or lost completely and the economic benefits are transferred to private concerns at great cost to the public.

For example, the costs of building erosion control devices and storm buffers frequently exceeds the society's available financial resources and a fishery once destroyed is difficult and very costly to restore. In the Bay of Bengal, where cyclones are a major threat to human life, the loss of life and property is consistently lower in areas inland from the heavily forested mangrove areas of the Ganges-Brahmaputra delta than in similar areas devoid of mangroves. Furthermore, in southern Florida, where engineering alternatives to mangrove planting are prohibitively expensive and do not provide a suitable habitat for important fisheries, the government has mandated the planting and/or protection of mangroves to minimize shoreline erosion and to provide habitats for commercial and sport fisheries. If resource utilization, both economic and subsistence, is consistent with the conservation of the natural system, society can receive both direct economic benefits and a variety of natural services at little or no cost.

The mangrove experts attending the workshop were particularly concerned with outlining the potential and current sustainable uses of the many species occurring in mangrove ecosystems. A wide array of products, ranging from fuelwood, timber for construction, fishing materials, fibres for cloth, dyes, tannins for leather, pulp for paper, fodder for livestock, various foods and medicines, honey, and a variety of household items such as glue, soap, rope, cosmetics, pencils, matchsticks, tool handles, incense, and even Christmas trees can be derived from many of the species in a functioning mangrove ecosystem.



Nipa shingles in Indonesia produced in 'cottage' industry.
[Photo: *Sanit Aksornkoe.*]

Nipa, the versatile palm

One of the most intriguing plants found in mangrove forests is that remarkably versatile palm, the nipa palm (Nypa fruticans). It is one of the most common, widely distributed, and useful palms found naturally in the mangrove forests of Asia and Oceania, and is also found in West Africa where it was introduced in 1906.

Nipa palms have historically provided many useful products to traditional peoples living near or in coastal and estuarine mangrove forests. The leaves, the juice or sap, and the fruit have been utilized for a wide variety of products, many of which have become the bases for cottage industries and commercial operations. Some large-scale commercial interest is also currently developing for nipa products in many countries.

Various parts of the nipa palm have been used by traditional healers throughout tropical Asia for a variety of ailments. The *Medical Book of Malayan Medicine* gives directions for the treatment of herpes with nipa. The juice from a young nipa shoot is mixed with coconut milk and drunk, while the pulp from which the juice was extracted is applied to the open sores. In Kalimantan, the decayed wood is reported to have medicinal properties and

TABLE 1. Direct products from mangrove forests

Uses	*Products*
Fuel	Firewood for cooking, heating; firewood for smoking fish; firewood for smoking sheet rubber; firewood for burning bricks; charcoal; alcohol
Construction	Timber for scaffolds; timber for heavy construction (e.g. bridges); railway ties; mining pit props; deck pilings; beams and poles for buildings; flooring, panelling; boat-building materials; fence posts; water pipes; chipboards; glues
Fishing	Poles for fish traps; fishing floats; fish poison; tannins for net preservation; fish-attracting shelters
Agriculture	Fodder; green manure
Paper production	Paper of various kinds
Foods, drugs, and beverages	Sugar; alcohol; cooking oil; vinegar; tea substitutes; fermented drinks; dessert topping; condiments from bark; sweetmeats from propagules; vegetables from propagules, fruits, or leaves; cigarette wrappers; medicines from bark, leaves, and fruits
Household items	Furniture; glue; hairdressing oil; tool handles; rice mortar; toys; matchsticks; incense
Textile and leather production	Synthetic fibres; dye for cloth; tannins for leather preservation
Other	Packing boxes

TABLE 2. Indirect products from mangrove forests

Source	*Products*
Finfish (many species)	Food; fertilizer
Crustaceans (prawns, shrimps, crabs)	Food
Molluscs (oysters, mussels, cockles)	Food
Bees	Honey; wax
Birds	Food; feathers; recreation (watching, hunting)
Mammals	Food; fur; recreation
Reptiles	Skins; food; Recreation
Other fauna (e.g. amphibians, insects)	Food; recreation

Nipa palm—one of the useful and interesting plants of the mangrove forest.
[Photo: *Lawrence Hamilton.*]

the ash, *garm nipah*, obtained by burning the roots or leaves, is used to treat both toothache and headache. Another book, *Malayan Poisons*, reports that the nipa stem-bud has been used in making a 'charmed preparation to counteract poison'. More common and important economically is the use of nipa palm for construction purposes. The leaves have traditionally been harvested throughout its range for thatching material for roof shingles and walls for dwellings, poultry and pig houses, and for rest houses and picnic huts in recreational and resort areas. In fact, in June 1978, the Filipino architect W. M. Tingcungco received, for his 'model house built with nipa', the Bahay Filipino Award for a 'truly Filipino architecture to fit our aesthetic values, our resources, and our pockets'.

Commercial potential

A commercial market for nipa shingles has developed in many parts of Asia, providing both employment opportunities and inexpensive construction materials within the reach of the masses. The Philippine Bureau of Forest Development Statistics reported a 1980 shingle production of 2,978,000 pieces, valued at $7.10 per hundred. In Thailand, a production of 15,300 shingles per hectare with a value of $230 per hectare per annum has been reported, and in Bangladesh, production of nipa for thatching was reported as 81,600 metric tonnes. Other traditional uses for nipa leaves include hats, mats, raincoats, brooms, floats for fish nets, fishing poles, ropes, and even cigarette wrappers.

The fruit of the nipa is also used for many purposes. The young seeds (gelatinous endosperm) are coated in sugar and eaten as sweetmeats. Although the mature seeds are very tough and not edible, they may be converted (i.e. by grinding) into animal feed. The mature, hardened seed has also traditionally been used as a vegetable ivory and for buttons.

An important commercial prospect for nipa is the use of the sap as a source of sugar. The sap has traditionally been used to produce sugar, vinegar, alcohol, and a widely used fermented beverage called *tuba* in the Philippines, *nira* in Malaysia, *arak* in Indonesia, and *toddy* in India and Bangladesh. Currently, there are two factories in Sarawak manufacturing sugar from nipa to make alcohol, and vinegar from nipa is produced in Papua New Gui-

nea. In the Philippines, vinegar and alcohol production from nipa has a very long tradition. In fact, in 1919 some 2,225,000 gallons of alcohol were produced from nipa in the Philippines.

The recent escalations in fossil fuel and fertilizer prices have stimulated renewed interest in the fuel-alcohol potential of nipa. The Steering Committee on Canadian Liquid Renewable Fuels reports that nipa alcohol may be mixed with petrol at a 1:4 ratio and used directly in standard petrol engines without carburettor modification. Currently the Department of Primary Industry of Papua New Guinea is planning an alcohol-from-nipa project, and alco-gas from nipa as an energy source is under study in the Philippines.

With a sucrose content of 14-17 per cent, nipa sap compares favourably with other sugar crops such as sugar cane (15-20 per cent sucrose) and sugar beet (10-15 per cent sugar). However, on a per hectare basis, nipa is one of the highest alcohol producers of any plant. In Malaysian nipa estates managed for alcohol production, yields of up to 15,638 litres/hectare/year of 95 per cent alcohol (equivalent to 20.3 tonnes/hectare/year of recoverable sugar) have been reported. Sugar cane, in comparison, is estimated to produce only 3,350 to 6,700 litres/hectare/year, while cassava produces 3,240 to 8,640 l/ha/yr, sweet potato 6,750 to 18,000 l/ha/yr and coconut sap 5,000 l/ha/yr.

Sugar/alcohol production from nipa offers several advantages over sugar-cane production: (a) no expensive crushing mills are needed; (b) no bagasse (waste from crushing mills) disposal problems; (c) unlike sugar cane, nipa does not compete with other crops for prime agricultural land; and (d) continuous production (once planted nipa does not require replanting) means no displaced seasonal labour, which is a major problem in sugar-cane economies.

One of the interesting aspects of sap production and an important labour input is the activity of beating or kicking the tree at intervals, called 'gonchanging'. During the first month following flowering, the trees are kicked once a week in order to oscillate the flower stalk and prevent embolism formation that would block sap flow. The kicking frequency is gradually increased over the three- to four-month period of sap flow, until in the fourth month trees are kicked daily.

Resource conservation and sustained yield

As one may well see from this brief description, the potential of the nipa palm to benefit man is great, and this is but one of the many useful plants and animals found in mangrove ecosystems. From all the evidence, one conclusion is apparent: although the mangrove ecosystem may be considered to be a unique and, to some, a curious tropical habitat, it is by no means a worthless landscape, suitable only for reclamation or witless exploitation. Many ecological, sociological and long-term economic benefits can be achieved by promoting a policy of maximum retention and conservation of mangrove areas. Indeed, the maximum economic benefits are obtainable only if the resource is protected against misuse and abuse and if resource conservation is promoted through sound land-use management based on the principles of sustained yield.

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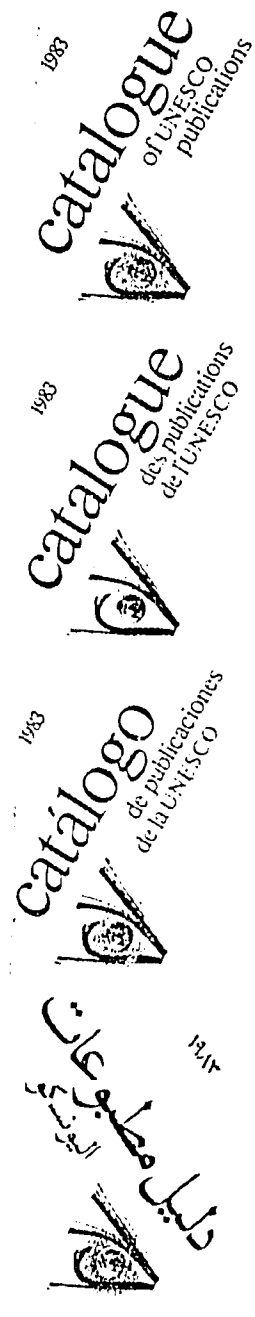

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