Biodiversity

The Convention on Biological Diversity of 1992 defines biological diversity, or biodiversity, as the variability among living organisms from all sources including, among others, terrestrial, marine, and other aquatic ecosystems and the ecological complexes of which they are part; the term includes diversity with species, between species, and of ecosystems.

Maintaining the biodiversity of plants and animals, which entails keeping enough habitat for their sustained existence, is important: we depend on many animals and plants for our own existence, not only as food but also as sources of enzymes, genes, chemicals, resins, and fibers that we can exploit to cure disease, provide substance, and create economic wealth. If we are to continue to enjoy these and other benefits—such as aesthetic and recreational—we must also conserve the ecosystems, that is, the animals and plants and the habitats on which they depend.

The subregion has a rich biological diversity. Its varied land forms and climate have given rise to unique land species, including many rare animals that have only been discovered recently. The Mekong River system holds 1,400–1,800 species of fish; freshwater fisheries catches in the lower Mekong are estimated to be more than 3 million tons a year. These fish are the protein staple for most of the 55 million people who live within the basin. The forest ecosystems are composed of a rich and varied assemblage of plants and animals. These range from wet, evergreen, high and deciduous forests to swamp, mangrove, and dry coastal forests. Their innumerable plant species represent a rich mosaic of biological diversity and provide a vital habitat for animal life. They are home to elephants, tigers, primates, and other large mammals. And they support an abundance of insects, amphibians, reptiles, and birds.

Biodiversity defined

Biodiversity is of three general kinds: habitat diversity, species diversity, and genetic diversity. Each depends on the health of the other two.

• Habitat diversity refers to the variety of places where life exists—coral reefs, old-growth tropical forests, grasslands, coastal wetlands, and many others. As the habitat disappears, many of the species it harbors also disappear. However, as has happened in the old-growth forests and coastal wetlands throughout the Greater Mekong Subregion, a habitat often does not disappear completely but dwindles to scattered patches.

• Species diversity is what most people commonly understand as biodiversity. The species is the basic classification of living things that share common characteristics. The earth has about 1.5 million named and many more unnamed species. All in all, probably about 5–15 million species exist.

• Genetic diversity is the varied mix of genes within species that allows plant and animal populations to adapt to changes in their environment. Genetic homogeneity, which occurs when a species—be it elephant, tiger, or dolphin—population size becomes small, makes the species far less adaptable, and less likely to survive.

Douc langur. Habitat loss and hunting have left only small populations, some endangered.
Ecoregions of the Greater Mekong Subregion

The boundaries are not necessarily authoritative.

Source: ADB and UNEP RRCAP based on Oben et al. 2001.
An Ecological View

The surface of our planet is composed of ecosystems—areas of land or bodies of water, or a combination of both, and the complex webs of life they support. The subregion is made up of many montane, forest, river, wetland, and marine ecosystems.

The concept of ecoregions—natural ecological communities with shared species, dynamics, and environmental conditions—offers a useful way of understanding the biodiversity of the ecosystems of the subregion and planning for their protection. To represent the original distribution of plants and animals on earth, the World Wide Fund for Nature (WWF) has divided the entire planet into 867 terrestrial ecoregions, of which 40 are in the subregion.

In its Global 200 project, WWF selected approximately 200 ecoregions that are outstanding examples of biodiversity (see Box below). Six terrestrial ecoregions fully within the subregion are in the Global 200 list: (i) Northern Indochina Subtropical Moist Forests, (ii) Annamite Range Rain Forests, (iii) Cardamom Mountains Rain Forests, (iv) Indochina Dry Forests, (v) Peninsular Malaysian Lowland and Montane Forests, and (vi) Kayah-Karen Montane Rain Forests. A seventh WWF-selected ecoregion, Eastern Himalayan Broadleaf and Conifer Forests, overlaps with the northwestern corner of Myanmar.

The 6 outstanding ecoregions are described and illustrated in the following pages. Images from all 40 ecoregions of the subregion are presented on p. 135–174.

Selecting the Global 200 Ecoregions

The Global 200 ecoregions are the results of regional analyses of biodiversity across the continents and oceans of the world, completed in collaboration with hundreds of regional experts worldwide and by conducting extensive literature reviews.

The Global 200 ecoregions were chosen from outstanding examples of each terrestrial, freshwater, and marine major habitat type. Ecoregions that represent the most distinctive examples of biodiversity for a given major habitat type were chosen, based on the following parameters:

- species richness;
- endemism;
- higher taxonomic uniqueness (e.g., unique genera or families, relict species or communities, primitive lineages);
- extraordinary ecological or evolutionary phenomena (e.g., extraordinary adaptive radiations, intact large vertebrate assemblages, migrations of large vertebrates); and
- global rarity of the major habitat type.

Only the biodiversity values of ecoregions sharing the same major habitat type were compared because the relative magnitude of parameters such as richness and endemism varies widely among them.
Ecoregions of Outstanding Biodiversity Value in the Greater Mekong Subregion

The boundaries are not necessarily authoritative.

Source: AOB, and UNEP RRC/AF, based on FAO 2001.

LEGEND:
- River
- Protected Areas
- International Boundaries

Region of Outstanding Biodiversity
- Annamite Range Rain Forests
- Cao Bang Mountains Rain Forests
- Indochina Dry Forests
- Kayah-Khmué Montane Rain Forests
- Northern Indochina Subtropical Forests
- Peninsular Malaysian Rain Forests

Forest Cover
- Closed Forest
- Open and Fragmented Forest
- Other Land Cover
- Other Woodland
The Northern Indochina Subtropical Forests are globally exceptional for their biological diversity. This ecoregion has the second highest species richness of mammals in Asia and has a diversity of tree species comparable to the humid tropical forests of Malaysia. The highest level of endemism of some plants, mammals, and birds can be found in this ecoregion. It has the richest and most intact subtropical forest in Asia.

The ecoregion extends across the northern Myanmar highlands, the southern part of Yunnan Province, PRC where the tropical forests of Xishuangbanna are found, Thailand, Lao PDR, and Viet Nam. An intricate system of hills and rivers stretches south of the Yunnan Plateau to include the middle catchment areas of the Red, Mekong, and Thanlwin rivers.

The whole of the northern subregion has a summer monsoonal climate and a yearly precipitation of 1,200–2,500 mm on average. Mean temperatures differ depending on elevation, but the hottest time of the year occurs before the rainy season, and the coldest in January. Frost forms at higher elevations, although infrequently. The cool winters and high elevation support the growth of montane plants. Well-developed montane deciduous forests are found on the Shan Plateau in northern Myanmar. About 183 mammal species, 4 of them endemic and 5 near-endemic, and 707 species of birds including the near-endemic short-tailed scimitar babbler (*Jabouilleia danjoui*) occur in this ecoregion.

Twenty-seven protected areas, totaling 15,948 km², make up 5% of the ecoregion. Most protected areas are small (590 km² on average) and are found in northern Viet Nam. They do not significantly support the conservation of the vulnerable species. The biggest areas are mostly in the Lao PDR.

Land clearing for shifting cultivation, poppy farming, logging, and extensive illegal hunting for food and income pose the greatest threats to the biodiversity of this ecoregion.
Greater Mekong Subregion Atlas of the Environment

Annamite Range Rain Forests

This ecoregion is composed of two of the WWF ecoregions—the Northern Annamites Rain Forests and Southern Annamites Montane Rain Forests. These forests, insulated by their unique geography from major climatic changes worldwide, sustain one of the world’s rarest and most diverse ecosystems of plants and animals. The forests are situated along the border between Lao PDR and Viet Nam. In these relatively intact rain forests are several endemic species of mammals and birds and some endangered and threatened species. Four large mammal species discovered only in the last 10 years can be found in the area. The saola ($Pseudoryx nghetinhensis$), which belongs to a distinctive branch of the cattle and antelope family, was discovered in 1992; the giant muntjac ($Muntiacus giganteus$), a new deer species, in 1994; and another, smaller muntjac ($Muntiacus truongsonensis$) and the Annamite striped rabbit ($Nesolagus timminsi$), in 1997. These are the only new species of large mammals discovered in the world in the past 50 years. The forests are home to threatened species like the Indochinese tiger ($Panthera tigris corbetti$), the Javan rhinoceros ($Rhinoceros sondaicus$), the Asian elephant ($Elephas maximus$), and the douc langur ($Pygathrix nemaeus$). Some bird species, such as Edward’s pheasant ($Lophura edwardsii$) and the orange-necked partridge ($Arborophila davidi$), both endangered, are found only in this ecoregion.

Threats to the biodiversity of the ecoregion come from increased legal and illegal logging, the construction of dams, shifting cultivation, and intensive illegal hunting.
The Cardamom Mountains Rain Forests lie across the Cardamom Mountains and the Elephant Range, extending from southwestern Cambodia into southeastern Thailand. They are separated from other rain forests by the Khorat Plateau in Thailand to the north and east and by the Gulf of Thailand to the west. Although largely unexplored, this ecoregion is considered one of the most species-rich and undisturbed natural habitats in the subregion.

The mountains are very wet and rise from sea level to more than 1,500 m, collecting moisture from the monsoon winds. Average annual rainfall can reach around 5,000 mm in some areas, resulting in a rain forest dense with plant life. At lower elevations, trees grow as high as 30 m, allowing light to pass through to support a mid-canopy of palms and rattans. Shrubs, climbers, and lianas are abundant in the dense understory. The upper montane forests are less rich but sustain dwarf rain forest trees half as tall as those found at lower elevations.

More than 100 mammal species, none of them known to be endemic, thrive in the ecoregion. There are threatened species, including the Indochinese tiger, the Asian elephant, the clouded leopard (Pardofelis nebulosa), the wild dog or dhole (Cuon alpinus), the gaur (Bos gaurus), the banteng (Bos javanicus), the khting vor (Pseudonovibos spiralis), the pileated gibbon (Hylabates pileatus), and the serow (Capricornis sumatraensis). Large mammals like the Sumatran (Dicerorhinus sumatrensis) and the Javan rhinoceros, which have disappeared from most Indochina forests, are believed to still exist in the Cardamom Mountains. Two bird species found nowhere else in the world are among the 450 bird species in the ecoregion.

Sixteen protected areas covering about 14,500 km², or 33% of the whole ecoregion, have been identified. Six of these areas—Aural, Phnom Bokor, Botum-Sakor, Roniem Daun Sam, Khao Ang Ru Nai (in Thailand), and Phnom Samkos—exceed 1,000 km². Phnom Samkos National Park is larger than 3,000 km². Phnom Kirirom in Cambodia is also in the Cardamom ecoregion.

The sparsely peopled forests of the Elephant Range and the Cardamom Mountains in Cambodia are still relatively intact, but forest areas in southeastern Thailand have been greatly reduced and exist in only a few protected areas. Illegal logging, even in the protected areas, threatens the ecoregion’s biodiversity. Wildlife trade has also caused excessive capture of animals throughout Cambodia and Thailand.
Indochina Dry Forests

This ecoregion is composed of two WWF ecoregions, the Central Indochina Dry Forests and Southeastern Indochina Dry Evergreen Forests. The dry forests are interspersed with evergreen forests in the wetter parts of the ecoregion. Significant to some large mammals and waterbirds are ponds and wet pastures of varying sizes.

The Central Indochina Dry Forests cover most of the center of the subregion, with its flat to slightly undulating terrain and hills generally no higher than 200 m. The ecoregion stretches widely in Thailand, from the dry lower slopes in the northern part and the foothills of the Tenasserim Range to uplands of the Chao Phraya Basin and across the Khorat Plateau. It extends along the broad valley of the Mekong River and its tributaries in central and southern Lao PDR and over the arid plains of northern, eastern, and south-central Cambodia.

These forests support about 167 kinds of mammals, of which two species of Vespertilionidae bats (Myotis altarium and Pipistrellus pulveratus) are endemic. Moreover, there are threatened large vertebrates characteristic of the Indo-Pacific region as a whole. These include the kouprey, Eld’s deer, tiger, Asian elephant, gaur, banteng, wild water buffalo, serow, and other species like the pilated gibbon, two leaf monkey species (Semnopithecus cristatus and S. phayrei), dhole, Malayan sun bear, clouded leopard, and common leopard.

The more than 500 bird species in the ecoregion include threatened species, such as the white-eyed river-martin (Pseudochelidon sirintarae), the Bengal florican (Eupodotis bengalensis), the adjutant (Leptoptilos dubius), and the white-shouldered ibis (Pseudibis davisoni).

Sixteen protected areas, which cover more than 15,000 km², compose 6% of the ecoregion. Four (Phu Kao-Phu Phan Kham, Xe Piane, Phnom Prich, and Yok Don) exceed 1,000 km², and two (Kulen Promtep and Lomphat) exceed 2,000 km². Most of these protected areas are in Cambodia and the Lao PDR and are protected areas with intact natural habitation.

Under increased population pressure, forests in this ecoregion have been converted to farms and settlements. Forest fires are often set to clear land for cultivation or for livestock pasture, and to make wildlife hunting easier. Parts of the ecoregion in Cambodia, Lao PDR, and Thailand are threatened by hydropower development and growing tourism.
The Peninsular Malaysian Lowland and Montane Forests include two WWF ecoregions—the Peninsular Malaysian Rain Forests and Peninsular Malaysian Montane Rain Forests. They cover the montane forests in Peninsular Malaysia and the extreme southern part of Thailand. The ecoregion is warm and has abundant rainfall all year round. It is composed of many distinct montane habitats where the trees are smaller than those in the lowlands. Oaks and chestnuts dominate the lower elevations and rhododendrons can be found in the upper montane areas.

Most remaining forests of the ecoregion are found only in high, steep areas and only two thirds are still intact. Four protected areas compose 5,120 km², or 30% of the whole ecoregion.

The ecoregion contains more than 200 mammal species, including nearly 100 bats and an endemic rodent species (Maxomys inas). There is also a small tiger population consisting of 300-450 Indochinese tigers (Panthera tigris corbetti) on the brink of extinction. The smallest rhinoceros, the Sumatran rhinoceros, is also found in these forests. This species was once scattered all over Southeast Asia but now the 500 or so of them that remain are believed to be found only in Borneo, Peninsular Malaysia, and Sumatra. Other endangered species living in these forests include the Malayan tapir (Tapirus indicus), the Asian elephant, and the gaur.

More than 250 bird species, five of them near-endemic, subsist in this ecoregion. Seventy-five of these bird species are found only in montane forests and two are classified as threatened: the mountain peacock-pheasant (Polyplectron imputatum) and the crested argus (Rheinardia ocellata).

Intensive logging in both uplands and lowlands, despite the rugged terrain, endangers biodiversity in the area. Other threats are the conversion of lowland forest to farms and cities, tourism, and roads.
Kayah-Karen Montane Rain Forests

The Kayah-Karen Montane Rain Forests cradle a rich diversity of plants, birds, mammals, and amphibians. The ecoregion is one of the richest in forest animal life in the subregion, second richest in bird species, and fourth in mammal species. Even greater biological variety is expected when more of the ecoregion is surveyed.

This ecoregion lies in the northern part of the Tenasserim Mountain Range, on the border between Myanmar and Thailand. Most of it is rugged, folded, and composed of Paleozoic limestone with overhanging cliffs, sinkholes, and caverns. Plants and animals living in these forests have distinct characteristics and some are unique to the area.

The region has an average annual rainfall of 1,500-2,000 mm and a monsoonal climate with a warm, moist summer and a mild, dry winter. The Myanmar side (west-facing slopes) receives more rain than the Thailand side (east-facing slopes), and the difference between these areas is reflected in their vegetation. Forests in the west are abundant with deciduous and evergreen species while dry deciduous trees dominate the east side.

The ecoregion harbors 168 species of mammals, one of which, the tiny Kitti’s hog-nosed bat (Craseonycteris thonglongyai), is endemic in the area, particularly in the limestone caves of western Thailand. This bat, weighing about 2 grams with an 8-cm wingspan, is the smallest mammal in the world.

The relatively intact and contiguous habitat in these forests makes them a potential area for the conservation of threatened species like the tiger. Most of Thailand’s biggest wildlife reserves and several protected areas are in this ecoregion. Thailand’s Huai Kha Khaeng Wildlife Sanctuary, which has an area of 2,575 km², is endowed with a high diversity of cat species, intact vertebrate communities, and intact lowland dipterocarp forests.

With 568 bird species, the ecoregion ranks high in avian diversity. Two species, the Deignan’s babbler (Stachyris rodolphei) and the Burmese yuhina (Yuhina humilis), are endemic in the area.

Almost one third of the forests have been cleared or degraded because of shifting cultivation and settlement. However, 20% of the ecoregion (23,500 km²) is given over to 28 protected areas. These have an average size of 725 km², although some, like Thailand’s Huay Kha Khaeng-Thung Yai Naresuan Reserve complex and Omgoy-Mae Ping-Mae Tuen Reserve complex, are much more extensive.
Fauna

Recent discoveries of new species (such as the saola, a forest dwelling ox, found in the Annamites in 1993) and the dedicated search for the elusive kouprey have captured the imagination of conservationists worldwide and heightened global awareness of the need to conserve the biodiversity of the subregion. Biological surveys continue to turn up new discoveries, emphasizing the region’s high concentration of unique plants and animals. These surveys also highlight the fact that the subregion is home to some of the world’s most threatened species. While a few have become extinct (such as Schromburbk’s deer, the pink-headed duck, and the white-eyed river-martin), most species are still relatively widespread in the subregion. However, wildlife populations are coming under increasing pressure from growing human populations, infrastructure development, and extraction for international markets. Many species of large mammals are close to extinction in several countries. These include the tiger, banteng, wild water buffalo, Eld’s deer, and Javan and Sumatran rhinoceroses. Other threatened groups include large water birds (such as cranes, storks, ibises, and pelicans), pheasants, large foragers (hornbills, imperial pigeons), freshwater turtles, and large migratory fish.

Asian Elephant (Elephas maximus)

The Asian elephant is the largest land mammal species in the subregion, growing to about 6.5 m long and 3 m high. Adult males weigh about 5,000 kilograms (kg); females, 3,000 kg. They live for about 40 years. While an estimated 30,000–50,000 Asian elephants are believed to survive, the species is nearing extinction in the wild in many areas. The animals need space, preferring tropical grassy plain and rainforest habitats. Deforestation and human encroachment have led to widespread habitat loss. Calves of Asian elephants are also kidnapped for use as beasts of burden, especially in the logging trade.

Banteng (Bos javanicus)

Considered one of the most beautiful kinds of wild cattle, the banteng is an endangered species found mostly in Myanmar and Thailand. It looks similar to an ox, only larger. It has white “stockings” on its legs, a white rump, a white muzzle, and white spots above the eyes. The banteng prefers to live in open, dry, deciduous forest, although in Borneo, some dwell within evergreen forests. This huge animal is very timid and retiring and feeds at night in areas where humans encroach. Bantengs usually roam in herds of one bull and several cows and calves. Some bulls stay alone and join the herds only during the breeding season. Bantengs are known to be grazers but they also consume available leaves and fruits. They live up to 20–25 years.

A rapid decline in their population was observed in the early 1990s. According to IUCN (2000), they number no more than 5,000. Hunting and loss of habitat endanger their existence. Interbreeding with domestic and other cattle threatens the genetic integrity of the banteng.

Douc Langur (Pygathrix)

Douc langurs of the genus Pygathrix are native to Southeast Asia. Up until only a few years ago, two distinct taxa were recognized—the red-shanked and the black-shanked douc langur. Between August 1995 and January 1998, however, six male specimens of the new and distinctive Pygathrix cinereus were found, some confiscated by Vietnamese wildlife authorities and the others donated by private individuals and placed in Cuc Phuong National Park. The animals had evidently originated in the southeastern part of Viet Nam’s Central Highlands,
where field primatologists had also identified wild populations of the same description in a region occupied by red- and black-shanked monkeys. Wild populations of the three doucs have been reduced to small numbers by habitat loss and hunting. While Cambodia and the Lao PDR may have more sizeable populations of the red-shanked and black-shanked douc, the newly discovered *Pygathrix cinereus* is known only from Viet Nam and is considered the most critically endangered species.

**Indochinese Tiger (Panthera tigris corbetti)**

The Indochinese tiger is found in Cambodia, southern PRC, Lao PDR, Myanmar, Thailand, and Viet Nam. It is one of only five surviving tiger subspecies in the world, all of which are endangered. Only about 1,200–1,800 Indochinese tigers are left in the wild. Tigers thrive in remote forests and hilly, mountainous terrain. As predators, tigers also depend on other animals like wild pigs, cattle, and deer to survive. Habitat destruction, along with the loss of these prey species, threatens the tiger’s survival. Another big threat comes from the ancient belief that a tiger’s body parts can give humans the potency of this animal.

**Kouprey (Bos sauveli)**

Its name literally means “forest bull” in Khmer, but the kouprey is more commonly known as the Cambodian forest ox. First discovered in 1937, the kouprey is a gray forest ox with frayed horns and a long dewlap. Koupreys are found in small numbers in northern and eastern Cambodia, and have also been known to exist in southern Lao PDR, eastern Thailand, and western Viet Nam, although sightings anywhere are rare. Koupreys habit low, rolling hills with patches of dry forest, near denser monsoon forests. They live in herds of up to 20, grazing in open areas by day and entering the forest for shelter from predators and sunlight.

The kouprey has always been rare. However, the destruction of its habitat by slash-and-burn agriculture, logging, and warfare, along with hunting and disease, has severely affected it. By 1970, there were fears that the species might have become extinct. But the kouprey has been observed since in several places. Although the animal itself has not been seen since 1988, its tracks and skeletal remains have been spotted, leading many to believe that koupreys still exist, but probably only about 100–300 of them.

**Saola (Pseudoryx nghetinhensis)**

The saola, also known as the Vu Quong ox, is an endangered, nocturnal forest-dwelling ox weighing about 100 kg. Its habitat is the dense montane forests in the Annamite Mountains, which run through the Lao PDR and Viet Nam. It is thought to be restricted to a 4,000-km² area along the border between Viet Nam and the Lao PDR. The saola is generally considered the greatest animal discovery of recent times. First documented in Viet Nam in 1992, it is so different from any other known species that a separate genus had to be created for it. The classification of the saola has generated some controversy; different physiological and genetic studies classify it with goats, antelope, or cattle. Only 11 saolas have ever been caught. Much of what is known about them comes from villagers’ tales and unearthed skeletons. The saola seems to prefer the edges of wet lowland and montane evergreen forests. Villagers say that it eats the leaves of fig trees and other bushes along riverbanks. The saola stays at higher elevations during the wetter summer season, when streams at these altitudes have plenty of water, and moves down to the lowlands in winter, when the mountains, streams dry up. They are said to travel in groups of two or three animals, rarely up to six or seven. The animal has been classified as endangered by IUCN. Hunting and the loss of forest habitat due to logging and conversion to farmland threaten its survival.
Siamese Crocodile
(*Crocodylus siamensis*)

The Siamese crocodile, also known as the soft-belly crocodile, is an endangered species found in Cambodia, Lao PDR, Thailand, and Viet Nam. It prefers to move in groups in slow-moving areas of freshwater, feeding on fish, amphibians, reptiles, birds, small mammals, and carrion. It grows to about 3 m. The Siamese crocodile is not considered dangerous to humans, although it has been mistaken for its far more threatening cousin, the saltwater crocodile, which is larger and has a narrower snout. The Siamese crocodile has all but disappeared from many countries in the subregion, although a new population has been discovered in the Cardamom Mountains. Expectations for its survival are poor because it is under significant threat from poaching and habitat destruction.

Fish of the Major River Systems

About 1,200 species of fish have been identified in the Mekong River system, and the number is expected to increase as more field studies are done and the system of classification improves. The discovery of new species is especially likely in the mountain tributaries of the Lao PDR and Yunnan Province, PRC, where little or no research has been done. Only the Amazon River system of South America has greater fish diversity—about 2,000 fish species—while its volume is more than nine times that of the Mekong. Many fish species found in the Mekong are also found in other rivers of the subregion. The Ayeyarwady, Thanlwin, and Red rivers, however, have endemic fish species not found in the Mekong. In fact, the Ayeyarwady River is more like the Ganges River in its fish species composition. Yunnan Province, PRC, through which all four rivers run, probably has the highest fish diversity of any region in the PRC.

Several fish species in the subregion’s rivers are already endangered and, if protective measures are not taken soon, many more could become endangered. Perhaps the most famous endangered fish are the giant Mekong catfish (Pangasianodon gigas) and the giant barb (Catlocarpio siamensis), both of which can grow up to 3 m long. The giant Mekong catfish is an important species endemic to the Mekong River system. One of the largest freshwater fish in the world, it grows up to 3 m long and can weigh more than 300 kg. The catfish migrate along the rivers to spawn in lakes and tributaries. The species has recently gained recognition because of the increasing threat posed to it by humans. Although listed as endangered, the fish are still caught and sold for meat in Cambodia, Lao PDR, and Thailand. Because of its size, it is increasingly sought after by sport fishers.

The giant catfish and barb qualify for protection under the Convention on Biological Diversity (CBD) and the Convention on the Conservation of Migratory Species of Wild Animals (CMS). While all six countries represented in the subregion have signed the CBD, Cambodia, Lao PDR, and Thailand have yet to ratify it, and none of the six have signed the CMS.

Another famous endangered “fish” in the subregion is the Irrawaddy or Mekong River dolphin (*Orcaella brevirostris*), whose numbers have fallen drastically over the past 3 decades. The Irrawaddy dolphin prefers to live near the coast and at the mouths of rivers. It also lives upstream in some tropical rivers. In Myanmar, Irrawaddy dolphins have been reported at Bhamo, 2,300 km upstream from the mouth of the Ayeyarwady River. Fish populations are also found in the Mekong and Se Kong. A few years ago, Irrawaddy dolphins were a relatively common sight in rivers and waterways of the Lower Mekong and in Tonle Sap Lake. Little is known about the dolphins, which grow up to 2.8 m long and can weigh as much 150 kg. A recent survey discovered a small population of dolphins, growing in the stretch of the Mekong River from Cambodia’s northeastern Kratie Province to the far northern border with the Lao PDR. These dolphins and their prey are seriously threatened by entanglement in gill nets, blast fishing, and the potential barrier effects and habitat degradation from planned dams. Although fishing, hunting, and increased river traffic have wreaked havoc on the dolphin’s habitat, in some areas dolphins are considered sacred. And they are said to have a special relationship with fishers on the Ayeyarwady and Mekong rivers, helping fishers drive fish into their nets.

Action is being taken in some areas to protect critical fish habitats and, thus, fish production in the Ayeyarwady and Mekong rivers. Some Buddhist temples in Thailand and elsewhere provide protection to small stretches of river habitat or wetlands, to ensure that some fish will survive each dry season to spawn and repopulate the river. Over the past decade, several local communities in Champassak Province, Lao PDR have also established fish protection areas in the Mekong River, typically around the deep pools where many fish species seek refuge during the dry season.

Ultimately, the future of many fishes in the subregion’s rivers will depend on regional cooperation and strong national and local support to (i) protect the integrity of key fish habitats from deforestation, land reclamation, and other destructive actions; (ii) maintain water quality by providing municipal, industrial, and domestic sewage facilities, and by minimizing the use of chemical pesticides and fertilizers in agriculture; (iii) maintain open migration routes and provide appropriate fish passes at dams, weirs, and other obstructions to natural water flow and flood patterns; and (iv) regulate fishing pressure so that fish stocks remain healthy and productive, and enforce bans on destructive fishing.
Flora

The subregion is home to an enormous number of plant species, at least 20,000 and possibly many more. Thailand has about 12,600, Viet Nam 10,500, and Myanmar 7,000 species of higher plants. About 20% of the plant species in Thailand and Viet Nam occur only in those countries. The flora of Yunnan Province, PRC is estimated to contain 14,000 species. There is undoubtedly great overlap between the countries and considerable overlap with the more temperate Yunnan Province, PRC. Numbers recorded depend not only on the actual numbers that occur, but also on the nature of the country, and efforts taken to survey and collect data. The more intensively an area is studied, the greater the number of plants and animals likely to be discovered.

The flora in the subregion includes many rare ornamental flowers and trees that beautify the entire region and support a thriving horticulture industry in most of the countries. The flora also includes highly valued hardwood tree species like teak that generate a major share of the forestry income and are currently the focus of major conservation efforts to stop illegal logging and cross-border trade.

Significant numbers of plant species are threatened with extinction within the subregion, nearly 400 species in Thailand and more than 300 in Viet Nam, although only a handful in Cambodia, Lao PDR, and Myanmar. Around 300 species are threatened in the entire PRC; presumably those in Yunnan Province are far fewer.

The Three Parallel Rivers of Yunnan Protected Areas (see p. 83), a newly affirmed World Heritage Site, contains the richest diversity of higher plants in the PRC and a wide spectrum of fungi and lichens. The protected area is one of the world’s least disturbed ecological areas. It has 22 vegetation subtypes and harbors 6,000 plant species. This represents more than 20% of the PRC’s higher plants, 10% of which are endemic to the area.

Botanical explorations in the subregion continue to yield new plant species. In 1999, a new genus and species of conifer, Xanthocyparis vietnamensis, was discovered on steep limestone ridges in a mountainous area in northern Viet Nam. In 2002, a new genus and species of fern, Caobangia squamata, was found in a collection made by a National Geographic Society expedition.

Human activities such as deforestation, illegal trade of endangered species, and agricultural encroachment, however, threaten the richness of plant species in the subregion. Nevertheless, the flora continues to be a resource to be conserved and a beauty to be appreciated.

Flowers of Yunnan

Because of the unusual natural conditions in Yunnan Province, PRC—no extreme cold in winter and no intense heat in summer—the province is home to 2,500 kinds of ornamental rare flowers and uncommon trees. Yunnan Province, PRC is said to produce the best quality and cheapest flowers in the world. Flowers are grown on a vast scale and are produced with very minimal requirements.

The province has a long history of growing flowers. One thousand years ago, people from the area cultivated flowers to uplift their spirits, decorate their gardens, and enhance their environment. In Kunming, breeding of flowers began as early as in the Tang and Song dynasties. Camellias became popular and were widely grown during the Yuan Dynasty. In the Ming Dynasty, there were about 70 famous types of ornamental flowers and the number grew to more than 180 during the Qing Dynasty and the rise of the Republic. The province presently identifies “eight famous flowers of Yunnan.” They are camellia, rhododendron, indigo, primrose, lily, orchid, rough gentian, and meconopsis. Camellia was chosen as the city flower of Kunming.

In the late 1980s, Yunnan Province, PRC started to develop a flower industry and the Government of Yunnan decided to support this as a way to boost the local economy. By 1994, Yunnan Province had replaced Shanghai as the flower center of the PRC.
The province now contributes more than 50% of the total sales volume of cut flowers in the PRC. The industry produces around 1.1 billion stems each year, worth about $57 million. In 2000, Yunnan Province, PRC was the biggest producer of cut flowers in the PRC with total sales volume of $5.28 million.

Orchids of Thailand

Thailand is well known for its many beautiful orchids, locally known as "Gluay Mai." There are around 1,300 species of orchids in the country. They come in many gorgeous colors and shapes and vary from common to rare. Although they are most prolific in the north, orchids are found in all parts of Thailand, from the low plains of the central region to the highest mountains of the north, from the forests of the south to the dry northeastern plateau.

The most beautiful of Thailand's orchids are the white, the bright yellow Oncidium, and the brick red orchids. The white orchid commands a high price because of its scarcity in the wild. Other orchid varieties are easy to grow and are abundant year round, such as the violet bloom, which is usually offered to visitors. There are many orchid farms in northern Thailand; Chiang Mai is considered the center for cultivation and exhibition of these exotic flowers.

Interest in orchid cultivation in Thailand can be traced back in 1913 when some exotic plants were brought to the attention of Prince Kromprana-kornsawanvorapinit. He became interested in growing orchids, both as a hobby and for commercial purposes. In 1957, the Orchid Society of Thailand was formed under royal patronage.

The most important orchid study center in the north of Thailand is found in Doi Inthanon National Park. This park is an abode to more than 25% of the orchid species in Thailand. Orchids are found in the deciduous forests from the foothills to the forests at the top of the mountain within the park. The most common species is Dendrobium infundibulum. Also, many rare montane orchids can be found along the Keo Mae Pan Nature Trail near the summit of the park.

Orchid production is an important source of export earnings in Thailand. Ninety-five percent of the production is for export. Total orchid production in 1999 was estimated at 25,200 tons, with a production value of about $300 million.

Vanishing Teak

Teak (Tectona grandis (Linn)) is a highly-valued wood because of its elegance, and high resistance to weathering. Teak trees grow in groups among other tropical species and are oily to the touch. The oil makes the trees extremely durable against water, rust, and termites, and the wood can last for more than a thousand years. Teak plantations are abundant in the subregion, particularly in Myanmar and Thailand. Myanmar is now one of the world’s biggest suppliers of teak. Teak production there is the biggest source of forestry sector earnings and provides significant foreign exchange to the country. In 1995, teak exports reached 200,000 m³, with a value of $200 million. If managed properly, teak production could become one of the pillars of Myanmar’s economy in the future.

Before the Second World War, teak was the third most important export commodity of Myanmar. In the early 1970s, teak exports accounted for 25% of total export earnings. With the decline in rice exports, Myanmar identified the forestry sector as a primary source of foreign exchange to boost the economy. Increased investment led to an increase in annual teak production from 291,000 tons in 1971 to 440,000 tons in 1991. A major cause for the increase was the ban by Thailand in 1989 on cutting timber from its forests. To ensure supplies of wood, Thailand signed a series of logging contracts with Myanmar. The increased rate of timber extraction in Myanmar caused growing concern about Myanmar’s forest resources. At 1990 felling rates, it was estimated that the teak stock would be depleted within 15 years.

Because of the unsustainable cutting of teak, Myanmar has now focused its forest management on the sustainable management of natural teak-bearing forests. The annual allowable felling of teak trees was lowered from 609,000 to 409,060 m³. Myanmar has also programmed the planting of trees on 40,500 ha per year, of which teak plantations cover 8,100 ha, on a 40-year rotation. The country has also established two model forests in which natural teak forests are prominent, namely Oktwin and Pauk Khaung model forests in Bago Yoma Region.

Myanmar is the headquarters of the Asia-Pacific regional network TEAKNET, the objective of which is “to strengthen interaction among all those concerned with the conservation and sustainable management of teak-bearing forests and plantations through sharing of information and promoting collaborative efforts to deal with common problems.”

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Terrestrial Protected Areas in the Greater Mekong Subregion

The boundaries are not necessarily authoritative.

Protected Areas

Protected areas are the primary means of protecting biodiversity. The World Conservation Union (IUCN) defines a protected area as an area of land and/or sea especially dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means.

As defined by IUCN, protection must maintain biodiversity and natural resources. And it must have an explicit legal or social basis. Sites that combine attraction, recreation, and nature conservation uses can also qualify if at least 75% of the area is managed primarily for conservation. Nonconsumptive and low-intensity uses are compatible with some categories within the IUCN scheme, but such sites as forest plantations managed primarily for timber production do not qualify.

IUCN categories

The IUCN system of classifying protected areas was designed to standardize and facilitate the collection and dissemination of data and to improve communication among countries. Standardization of parks and protected areas in differing ecosystems and in different political, legal, and cultural contexts is achieved by using management objectives as the basis for comparison. This provides enough flexibility to account for a range of possible combinations of management objectives, socioeconomic contexts, and ecosystems. Definitions of the categories, and examples of each, are provided in Guidelines for Protected Area Management Categories (IUCN 1994).

- CATEGORY Ib. Wilderness Area: protected area managed mainly for wilderness protection.
- CATEGORY II. National Park: protected area managed mainly for ecosystem protection and recreation.
- CATEGORY III. Natural Monument: protected area managed mainly for conservation of specific natural features.
- CATEGORY IV. Habitat/Species Management Area: protected area managed mainly for conservation through management intervention.
- CATEGORY V. Managed Resource Protected Area: protected area managed mainly for the sustainable use of natural ecosystems.
- CATEGORY VI. Protected Landscape/Seascape: protected area managed mainly for landscape/seascape conservation and recreation.

Three Parallel Rivers of Yunnan Protected Areas—Inscribed as a World Heritage Site in 2003

This World Heritage Site consists of eight geographical clusters of protected areas within the boundaries of the Three Parallel Rivers National Park in the mountainous northwest of Yunnan Province, PRC. The 1.7-million ha site features sections of the upper reaches of three of the great rivers of Asia: Thanlwin, Mekong, and Yangtze (Jinsha). These rivers run roughly parallel, north to south, through steep gorges that, in places, are 3,000 m deep and are bordered by glaciated peaks more than 6,000 m high. Its special features are:

- outstanding value for displaying the geological history of the last 50 million years associated with the collision of the Indian Plate with the Eurasian Plate, the closure of the ancient Tethys Sea, and the uplifting of the Himalaya Range and the Tibetan Plateau;
- dramatic expression of ecological processes—a mix of geological, climatic, and topographical effects;
- outstanding natural features—the deep, parallel gorges of the Jinsha, Lancang (Mekong), and Nu Jiang (Thanlwin) are the dominant scenic elements in the area, and high mountains are everywhere, with the glaciated peaks of the Meili, Baima, and Haba Snow Mountains providing a spectacular scenic skyline; and
- location in northwestern Yunnan Province, the area of richest biodiversity in the PRC and possibly the most biologically diverse temperate region on earth, encompassing most of the natural habitats in the Hengduan Mountains, one of the most important remaining areas for conservation of the earth’s biodiversity.

History of Protected Area Management

Cambodia was the first country in Southeast Asia to establish a national park: the 10,800-ha forest around the Angkor Temple complex, in 1925. Twenty-three protected areas were designated in 1993, covering about 19% of the total land area and representing a diversity of habitats.

In Yunnan Province, PRC, there are two major categories of protected area: nature reserves and forest parks. The Yunnan Provincial Forest Department exercises overall authority for protected areas, which are managed at four levels: nation, province, prefecture, and county. There are 111 nature reserves that cover in total about 5% of the province.

The Lao PDR has one of the youngest and most comprehensive protected area systems in the world. Established in 1993, the system of national biodiversity conservation areas was based upon sound scientific principles and now covers 12–14% of the land area.

The Protection of Wildlife, Wild Plants and Natural Areas Law was promulgated in Myanmar in June 1994 in order to carry out biodiversity and environmental conservation more effectively. Currently, about 5% of the land area of Myanmar are protected areas including 23 wildlife sanctuaries and 5 national parks, with plans to increase this eventually to 10% of the land area.

Protected areas in Thailand were given a legislative basis in the early 1960s with technical assistance from IUCN through promulgation of the Wildlife Act (1960) and National Park Act (1961). Khao Yai was the first National Park, established in 1961, followed by Salak Pra Wildlife Sanctuary in 1965. Currently, more than 15% of the country is covered by protected areas, with a target of 25% by the year 2005.

Viet Nam established an extensive national network of protected areas in the 1990s. This has succeeded in slowing the rate of destruction of the country’s forests. The network is now being expanded to include wetlands and marine areas. Currently, more than 6% of the country is covered by protected areas.

Conservation Coverage

There are now 550 protected areas in the subregion, of which 380 are judged to have biodiversity conservation as a major function. Their classification varies from country to country and there are 14 different classes of protected areas around the subregion (see Table). Not all classes appear to fulfill major roles in conserving biodiversity. For example, the forest parks of Thailand and Yunnan Province, PRC, Thailand’s nonhunting areas, and the protected landscapes of Cambodia and Viet Nam may have limited value for biodiversity conservation.

Cambodia, Lao PDR, and Thailand have relatively large protected area systems. Thailand’s system is long established, although several areas have been added in recent years. Those in Cambodia and the Lao PDR are of recent origin, designed specifically with biodiversity conservation and representation in mind. In these larger systems, cover of biotic communities and their species is very good

## Legally Designated Protected Areas (km²)

<table>
<thead>
<tr>
<th>PROTECTED AREA TYPE</th>
<th>IUCN CATEGORY</th>
<th>CAMBODIA</th>
<th>YUNNAN PROVINCE, PRC</th>
<th>LAO PDR</th>
<th>MYANMAR</th>
<th>THAILAND</th>
<th>VIET NAM</th>
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<tbody>
<tr>
<td>Bird sanctuaries</td>
<td>IV</td>
<td>894</td>
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<td>Mountain parks</td>
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<td>29,030</td>
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<td>2,547</td>
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<tr>
<td>Nonhunting areas</td>
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<td>Wildlife sanctuaries</td>
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<td>Totals of all protected areas</td>
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<td></td>
<td>19,142</td>
<td>29,030</td>
<td>14,031</td>
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<tr>
<td>Proportion of total land area (%)</td>
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<td>15.2</td>
<td></td>
<td>14.2</td>
<td>2.1</td>
<td>14.2</td>
<td>6.5</td>
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<table>
<thead>
<tr>
<th>Areas having biodiversity protection as a major function (km²)</th>
<th>29,030</th>
<th>19,142</th>
<th>29,030</th>
<th>14,031</th>
<th>72,943</th>
<th>21,511</th>
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<tbody>
<tr>
<td>Proportion of total land area covered by protected areas having biodiversity protection as a major function (%)</td>
<td>16</td>
<td>4.8</td>
<td>12.3</td>
<td>2.1</td>
<td>14.2</td>
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</table>

although there is a paucity of lowland dry evergreen forest. Forests of this type, where they occur inland, have been extensively destroyed throughout Southeast Asia.

In Cambodia, 12 out of 17 protected areas are larger than 500 km² and comprise 95% of the total system. The figures for the Lao PDR are even higher: 19 out of 20 and 98%, respectively. The average size of Thailand’s protected areas is less than half those for Cambodia and the Lao PDR, only 50 out of 124 areas being larger than 500 km², covering 73% of the total protected area.

Yunnan Province’s and Myanmar’s protected area systems have the smallest average sizes in the subregion. In Yunnan Province, PRC, only 8 out of the 111 protected areas exceed 500 km² although, because five areas are larger than 1,000 km², they include 67% of the total system by area.

The protected area system in Myanmar has scope for enlargement. The ultimate target of 10% cover, according to the Myanmar National Forest Policy of 1995, is believed to be a realistic target because large, well-forested, and sparsely populated tracts of country exist in the north. At present, Myanmar has the lowest proportion of cover in the subregion (2.1%), and most of its protected areas are in the 101–500 km² range (average 494 km²). Nine of its 29 protected areas are larger than 500 km² and 4 exceed 1,000 km².

Viet Nam’s system has good biodiversity representation but individual protected areas are relatively small. Only 11 out of the 80 protected areas are larger than 500 km—covering 49% of the total protected area.

Legal instruments for biodiversity conservation and protected area management vary from country to country. Thailand has the most sophisticated set of laws and regulations while the Lao PDR has the least developed. Viet Nam is thinking of revising its national wildlife laws, while Cambodia and the Lao PDR plan to do so soon. In many cases, the broad umbrella of laws and policies is in place but the implementing regulations are still to come.

Thailand, Viet Nam, and Yunnan Province, PRC have already used up a large proportion of their forests. The remaining forests are now mostly within protected areas. However, in many cases, this has not stopped the continuing unsustainable and illegal extraction of timber. To safeguard the biodiversity of the subregion for future generations, this issue must be tackled. In Cambodia, Lao PDR, and Myanmar, governments at the highest levels must support the protected area system while committing the human resources necessary to ensure that the areas are managed appropriately. In the short run, the much-needed support is likely to continue to come from international and nongovernment organizations.

Protected Areas Highlighted in the Atlas

<table>
<thead>
<tr>
<th>PROTECTED AREA</th>
<th>DESIGNATION</th>
<th>COUNTRY</th>
<th>ATLAS FEATURE</th>
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<td>Aural</td>
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<td>Botum-Saakor</td>
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<td>Biosphere Reserve</td>
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<td>Cao Gai Wetland</td>
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<td>Cang Shah, Er Hai Hu</td>
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<td>Don Chai Hu</td>
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<td>Don Chai Lake</td>
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<td>Hue Kha Khoang</td>
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<td>Kayah-Karen Montane Rain Forests</td>
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<td>Inle Lake</td>
<td>Bird Sanctuary</td>
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<td>Inle Lake</td>
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<td>Laos FDR</td>
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<td>National Park</td>
<td>Thailand</td>
<td>Sam Roi Yod Wetlands</td>
<td>57</td>
</tr>
<tr>
<td>Si Nakarin</td>
<td>Wildlife Sanctuary</td>
<td>Thailand</td>
<td>Kayah-Karen Montane Rain Forests</td>
<td>76</td>
</tr>
<tr>
<td>Thung Ya Naresuan</td>
<td>Multiple Use Area</td>
<td>Thailand</td>
<td>Kayah-Karen Montane Rain Forests</td>
<td>76</td>
</tr>
<tr>
<td>Tonle Sap Lake</td>
<td>Biosphere Reserve</td>
<td>Cambodia</td>
<td>Tonle Sap Lake</td>
<td>55</td>
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<td>Umphang</td>
<td>National Park</td>
<td>Laos FDR</td>
<td>Indochina Dry Forests</td>
<td>74</td>
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<tr>
<td>Xe Piane</td>
<td>Conservation Area</td>
<td>Laos FDR</td>
<td>Luzshaihe Watershed; Northern Indochina Subtropical Forests</td>
<td>44, 71</td>
</tr>
<tr>
<td>Xo Nhuang Banna</td>
<td>State Nature Reserve</td>
<td>Yunnan Province, PRC</td>
<td>Indochina Dry Forests</td>
<td>74</td>
</tr>
<tr>
<td>Yek Don</td>
<td>National Park</td>
<td>Viet Nam</td>
<td>Indochina Dry Forests</td>
<td>74</td>
</tr>
</tbody>
</table>

Note: Only those protected areas with areas of 1,000 km² or more are included in the above list.
The subregional countries, except Thailand, have primarily agrarian economies. Agriculture provides the main source of livelihood for most of the poor, as well as of GDP and export earnings. Agriculture involves about 70% of the population in the Lao PDR and 53% in Viet Nam, accounting for about 51% of GDP in the Lao PDR, 57% in Myanmar (including livestock and fisheries), and 24% in Viet Nam. Rapid economic growth in nonagricultural sectors has in recent years reduced the relative importance of agriculture in Thailand, where agriculture provides employment to about half of the labor force, but only about 9% of GDP. Despite rapid industrialization, much of the population of Thailand is still rural.
Agricultural Land

More than 21% of the subregion’s land, or 49 million ha, is classified as agricultural (2000 data). This includes arable land and land for permanent crops and permanent pastures. Thailand has the most agricultural land (about 19 million ha) and proportion of agricultural land in total land (about 37%), making 38% of the subregional total. Agricultural land ranges from 8% to 30% of the total area in the other countries. The Lao PDR has the least amount of agricultural land.

From 1990 to 2000, agricultural land increased in most of the subregion—by 19% in Viet Nam and 11% in the Lao PDR. Thailand and Cambodia were exceptions. More than 12% of agricultural land in Thailand was converted to other uses during this period.
Importance of Rice

Rice is critical to subregional economies. Most poor subsist on a diet of rice and fish. Myanmar, Thailand, and Viet Nam earn foreign exchange by exporting their surplus production. The subregion contains the important rice-growing areas (the “rice bowls”) of the Ayeyarwady, Chao Phraya, Mekong, and Red River deltas.

Viet Nam is the subregion’s biggest rice producer. Rice is planted on 6.3 million ha, 82% of the total farm area, and accounts for more than 85% of food grain output. The major rice-growing areas are the Mekong and Red River deltas. Higher-yielding modern varieties are planted. The country became a net rice exporter in 1989 and produced about 34 million tons in 2002. Viet Nam exported 4.6 million tons of rice in 1999, making it the second largest rice exporter in the world, next to Thailand.

Thailand’s rice exports have been growing steadily and were 6.5 million tons in 1999. Total rice production has consequently continued to grow, despite a declining trend in domestic demand. The country is well known for its high-quality, long-grain white rice, which usually commands a much higher price than lower grades. At present, Thailand is the region’s second largest rice producer, with nearly 26 million tons in 2002. Although rice is declining in relative importance, it is still grown on more than half of the cultivated land and is the staple food of Thais regardless of income. Most rice farmers, including those in the richly alluvial Chao Phraya Delta, are subsistence farmers, who sell only their excess production. Much surplus is from the intensively cultivated central region. The area planted to rice grew from 6.9 million ha in 1968 to 9.8 million ha in 1988 and has since been fluctuating around 9–10 million ha, depending on the relative price of rice in the world market.

In Myanmar, rice is virtually the only food grain produced. Rice production employs 40% of the labor force. Myanmar’s rain-fed lowland and deepwater rice fields are confined to the Ayeyarwady Delta region and the coastal strip of Rakhine State. Rice is grown in irrigated lowland areas mainly in Mandalay, Sagaing, and Bago divisions, and upland mostly in Mandalay, Sagaing, and Shan states. In 2002, Myanmar produced 2.2 million tons of rice on 6.5 million ha. Exports are constrained by low rice quality, inadequate processing and marketing infrastructure, and an underdeveloped trading system.

Rice is by far the most important staple food in Cambodia, which has a rice-growing area of about 1.8 million ha. Cambodia was a net importer of rice until 1995. Since then, the country has become self-sufficient in rice production and now exports small amounts. In 2002, it produced about 3.7 million tons. Most rice is grown on the extremely flat, poorly drained areas of infertile soil around the Tonle Sap Lake Basin and the upper reaches of the Mekong Delta.

In 2002, the Lao PDR produced 2.4 million tons of rice on an area of about 747,000 ha. That amount would be enough for domestic needs if distribution could be improved. Because of the high cost of marketing and underdeveloped infrastructure, only a small amount of the total production is traded within the country.

In the following pages are descriptions and images of the four main rice bowls of the subregion.
Ayeyarwady Delta, Myanmar

The Ayeyarwady Delta is a large basin 300-km long and 250-km wide lying southwest of Yangon and extending from the shoreline of the Bay of Bengal across the Bago Range. It collects water from Ayeyarwady, Bago, Yangon, and Pathein rivers, which irrigate millions of ha of agricultural land. Most agricultural processing in Myanmar takes place in the Ayeyarwady Delta.

The rainfed lowlands of the Delta account for 52% of the country’s rice land. Deep-water rice, planted in Delta floodlands, accounts for a further 24% of the rice area. There are two cropping seasons, with harvests in November to January (main season) and April to May (dry season), respectively. Yields are relatively low, averaging 3.3 tons/ha. There is room for yield increases. For example, modern varieties are planted with little fertilizer use, resulting in declining soil fertility. Several rice varieties have been developed expressly for the delta conditions, but inadequate supply of and high cost of chemical fertilizers prevent their potential from being realized. Excessive flooding in low areas is another problem associated with the Delta.

Chao Phraya Delta, Thailand

The Chao Phraya Delta is a fertile plain in the lower part of the Chao Phraya River Basin with a vast agricultural land area for intensive rice cultivation. It has a total area of 1.4 million ha. Although the Delta makes up only 7% of the area planted to rice in Thailand, it contributes 20% of the country’s rice production.

The relatively high production in this area is the result of several factors: there are many large farms that are mechanized and irrigation facilities are widespread, allowing many farmers to grow two rice crops each year. Each season lasts nearly 6 months, with harvests in November–December (main season) and May–June (minor season), respectively. Nevertheless, rice yields nationwide average only 2.3 tons/ha, the lowest in the world. This is because farmers tend to grow high-quality but low-yielding rice varieties that fetch top prices both domestically and internationally.
The Red River Delta is a flat surface of about 1.5 million ha leaning toward the sea in a northwest-southeast direction. The climate favors the growing of vegetables and fruit crops of high economic value. About 18% of the rice produced in Viet Nam is grown here. With a population of almost 17 million, more than 20% of the population of Viet Nam, the Delta is one of the most densely populated areas in the world. The average farm size of 0.25 ha is the lowest in the country. A rice surplus, although smaller than that of the Mekong Delta, is therefore possible.

Farmers in the delta area have long been growing two crops of rice each year, using methods that are highly labor intensive. Unlike the Mekong Delta, the rice seasons in the Red River Delta are similar. The area planted is the same in each season, about 0.5 million ha, and the yields are similar, at 5.2–5.7 tons/ha for each crop.
Other Crops

While rice is the staple food across the subregion, many other crops are grown, which reflect national preferences as well as the nature of available farmland.

Surprisingly, the major crop in Thailand is not rice, but sugarcane. More than twice as much sugarcane—62.4 million tons in 2002—as rice is produced each year. Sugar is important also in Viet Nam—where it is about half the size of the rice crop—and Myanmar.

After rice, the other major staple in Thailand and Viet Nam is cassava. In Thailand, the cassava crop is two thirds (16.9 million tons in 2002) the size of the annual rice crop. This fondness for cassava is unmatched elsewhere in the subregion. Viet Nam is the next largest cassava producer, at 4.2 million tons in 2002, a quarter the size of the Thailand crop. It is a relatively minor crop elsewhere in the subregion.

Falling a far third, maize is the next staple, followed by sweet potatoes.

Vegetables are important crops. Viet Nam is by far the leading producer at 7.6 million tons in 2002. Fruits are also important, particularly in Thailand, which produced some 7.7 million tons in 2002. Coconuts are a significant product in Thailand (1.4 million tons) and Viet Nam (0.8 million tons). Cambodia produces only 70,000 tons, but that makes coconuts the seventh largest crop in that country.

Some of the top 10 crops in each country are very minor in other countries. For example, Thailand alone produces large amounts of oil palm fruit and is the subregion’s leading rubber producer. Myanmar is the subregional coffee bean producer. Viet Nam produces far more dry beans, groundnuts, and is the next largest cassava producer, at 4.2 million tons in 2002) and associated hen eggs. Thailand’s egg production at 800,000 tons is four times that of Viet Nam, the second largest egg producer. Thailand not only produces the most hen eggs (500,000 tons) but also is the only big producer of duck eggs (300,000 tons).

Beef is relatively important in most countries, except Thailand. Milk production is correspondingly significant, especially in Myanmar, which produced not only 0.5 million tons of cows milk—nearly as much as Thailand and more than six times that of Viet Nam—but also more than 100,000 tons of buffalo milk in 2002.

Swidden Agriculture

Swidden cultivation, practiced for centuries in the highlands of the subregion, is the dominant farming system among traditional ethnic societies. Two forms of swidden cultivation can be distinguished: pioneering and established. Vietic groups, such as Arao, Maleng, and Malang in the Lao PDR, practice pioneering swidden cultivation, a simple slash-and-burn technique for monocropping mainly cereals and legumes. Other ethnic groups, such as the Brou of the Lao PDR, practice the more stable established form, in which trees, annual crops, short-term cereals, and legumes are grown together.

Swidden cultivation is understood differently by government, academic, and civil society groups. Some believe swidden cultivation causes deforestation and soil erosion. But, in reality it can

### Top 10 Primary Crops Production, 2002

<table>
<thead>
<tr>
<th>Crops</th>
<th>Cambodia</th>
<th>Yunnan, PRC</th>
<th>Laos PDR</th>
<th>Myanmar</th>
<th>Thailand</th>
<th>Viet Nam</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rice, Paddy</td>
<td>3,740,002</td>
<td>–</td>
<td>2,410,000</td>
<td>21,900,000</td>
<td>25,946,000</td>
<td>34,063,500</td>
</tr>
<tr>
<td>Vegetables and Melons, Total</td>
<td>473,000</td>
<td>–</td>
<td>3,525,010</td>
<td>1,365,000</td>
<td>7,670,022</td>
<td>4,274,800</td>
</tr>
<tr>
<td>Fruit excl. Melons, Total</td>
<td>322,000</td>
<td>–</td>
<td>3,002</td>
<td>660,000</td>
<td>4,170,000</td>
<td>2,314,700</td>
</tr>
<tr>
<td>Coconuts</td>
<td>186,800</td>
<td>–</td>
<td>2,750,000</td>
<td>1,396,000</td>
<td>838,000</td>
<td>331,400</td>
</tr>
<tr>
<td>Sugarcane</td>
<td>168,850</td>
<td>–</td>
<td>35,662</td>
<td>2,460,000</td>
<td>1,276,100</td>
<td>1,276,100</td>
</tr>
<tr>
<td>Maize</td>
<td>168,060</td>
<td>–</td>
<td>35,662</td>
<td>2,460,000</td>
<td>1,276,100</td>
<td>1,276,100</td>
</tr>
<tr>
<td>Coconuts</td>
<td>70,000</td>
<td>–</td>
<td>35,662</td>
<td>2,460,000</td>
<td>1,276,100</td>
<td>1,276,100</td>
</tr>
<tr>
<td>Natural Rubber</td>
<td>32,365</td>
<td>–</td>
<td>35,662</td>
<td>2,460,000</td>
<td>1,276,100</td>
<td>1,276,100</td>
</tr>
<tr>
<td>Sweet Potatoes</td>
<td>25,538</td>
<td>–</td>
<td>35,662</td>
<td>2,460,000</td>
<td>1,276,100</td>
<td>1,276,100</td>
</tr>
<tr>
<td>Tobacco Leaves</td>
<td>7,260</td>
<td>–</td>
<td>35,662</td>
<td>2,460,000</td>
<td>1,276,100</td>
<td>1,276,100</td>
</tr>
<tr>
<td>Coffee Green</td>
<td>2,4600</td>
<td>–</td>
<td>35,662</td>
<td>2,460,000</td>
<td>1,276,100</td>
<td>1,276,100</td>
</tr>
<tr>
<td>Beans Dry</td>
<td>19,600</td>
<td>–</td>
<td>35,662</td>
<td>2,460,000</td>
<td>1,276,100</td>
<td>1,276,100</td>
</tr>
<tr>
<td>Groundnuts in Shell</td>
<td>8,720</td>
<td>–</td>
<td>35,662</td>
<td>2,460,000</td>
<td>1,276,100</td>
<td>1,276,100</td>
</tr>
<tr>
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<td>1,276,100</td>
</tr>
</tbody>
</table>

Notes:
- Top 10 primary crops are shown in bold.
- Data not available.
Source: FAOStat.
contribute to biodiversity conservation and soil erosion control. Established rotational cultivation represents an important means of in situ conservation of traditional plant varieties. Especially important genetic resources are conserved. These endemic varieties are highly representative of the practices that are destructive to the environment.

Viet Nam Central Highlands

Ethnic minorities rely on swidden cultivation for their subsistence. For instance, in the Se San watershed of the Central Highlands of Viet Nam, the Gia Rai and Ba Na peoples plant upland rice in forest clearings. Most Gai Rai swiddens use few crop species, depending on the suitability of the soil. The common swidden cycle takes 5–7 years: 2 years of dry rice farming, followed by 3–5 years fallow. Some rice swiddens are almost pure monocultures. The rice seeds are mixed with the other seeds of rice, usually upland rice, are grown. These monocultures are grown for food security, including vegetables (sesame and legumes), root crops, gourds, fruit (bananas), and nonfood crops like tobacco and cotton. The rice seeds are mixed with the other seeds in order to cultivate crops of different heights. This method helps to maintain a complete cover of vegetation, which prevents soil erosion, retains moisture during dry periods, and discourages the growth of grasses.

The Hai System of the Lao PDR

In the Lao PDR, the swidden cultivation or hai system is relatively stable under ideal conditions and has minor environmental impact. Ideal conditions include low population density (less than 0.4 persons per ha) and low to moderate cropping intensity. Hai fallows should be long, 10–15 years, to ensure the system’s sustainability. When a fallow period of less than 6 years is used, the hai system becomes unsustainable, as indicated by such factors as poor fallow vegetation cover, rapid reduction of yield, high weeding requirements, acute rice deficit, and rapid depletion of forest resources and other communal resources.

Precarious Balance: Ecology and Development

Population pressure and lack of government support have generally undermined productivity and sustainability of swidden cultivation. Government campaigns of fixed settlement and cultivation have limited the mobility of ethnic minority communities. In Viet Nam, households practicing swidden agriculture have been allocated a fixed area for cultivation, with leasehold ownership of 20–30 years. As a result, the living space of these households that were formerly dependent on swidden farming has now been limited to the few hectares of land allocated to them.
Fisheries Production

The Mekong River Commission estimates the yearly freshwater fish production from the Lower Mekong River Basin, which makes up about a third of the subregion, at more than 3 million tons. This basin and its freshwater fisheries are probably the most productive in the world.

In terms of total (marine and freshwater) annual fisheries production, Thailand was leading the subregional countries (excluding Yunnan Province, for which disaggregated data are not readily available) in 1999, at around 3.5 million tons, much of it from a large offshore marine fishing fleet. FAO statistics show gradually increasing fish production in subregional countries; however, there has been clear underreporting, especially in the case of Cambodia, whose estimated annual production was raised to more than 400,000 tons following recent improvements in data collection and reporting. The large number of widely dispersed small-scale and subsistence fisheries around the subregion hinders accurate measurement.
People’s Dependence on Fish

The importance of fish to the people of the subregion has often been underestimated. In Cambodia, fish and rice production is the basis for food security, and in other subregional countries most poor people also rely heavily on fish for protein. Some fish are consumed fresh throughout the year, but preserved fish, fish paste, and fish sauce—which are processed at the end of the wet season when fish are abundant and cheap—are equally important. Recent data show that the 55 million or so people in the Lower Mekong River Basin consume an average of 56.6 kg of fish per person per year, and considerably more in the case of some groups living along riverbanks.

About 10% of fish consumed in the Lower Mekong River Basin are produced by aquaculture, or fish farming. Most inland aquaculture is in northeast Thailand on the Khorat Plateau and in the Mekong Delta in Viet Nam, and production has been steadily increasing. Traditionally, tiny fry or fingerlings are caught in rivers and lakes and raised in enclosures but in recent years, the artificial rearing of fry of some species is making their production more reliable. Given the problems facing the fisheries in the subregion, discussed below, the aquaculture subsector will become more important in the future, but itself may be constrained by environmental problems, such as water shortages and pollution from agricultural run-off.

Annual Consumption of Freshwater Fisheries Products in the Lower Mekong River Basin, 2000

<table>
<thead>
<tr>
<th>LOWER MEKONG BASIN (LMB) COUNTRIES</th>
<th>POPULATION IN LMB (millions)</th>
<th>PER CAPITA CONSUMPTION (kg)</th>
<th>TOTAL FISH CONSUMPTION (tons)</th>
<th>CAPTURE FISHERIES (tons)</th>
<th>RESERVOIR FISHERIES (tons)</th>
<th>AQUACULTURE PRODUCTION (tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cambodia</td>
<td>11</td>
<td>65.5</td>
<td>719,000</td>
<td>682,150</td>
<td>22,750</td>
<td>14,100</td>
</tr>
<tr>
<td>Lao PDR</td>
<td>5</td>
<td>42.2</td>
<td>204,800</td>
<td>182,700</td>
<td>16,700</td>
<td>5,400</td>
</tr>
<tr>
<td>Thailand</td>
<td>23</td>
<td>52.7</td>
<td>1,387,900</td>
<td>932,300</td>
<td>187,000</td>
<td>68,100</td>
</tr>
<tr>
<td>Viet Nam</td>
<td>17</td>
<td>60.2</td>
<td>1,021,700</td>
<td>844,850</td>
<td>5,250</td>
<td>171,600</td>
</tr>
<tr>
<td>Total LMB</td>
<td>75</td>
<td>56.6</td>
<td>3,133,400</td>
<td>2,042,200</td>
<td>232,200</td>
<td>259,200</td>
</tr>
</tbody>
</table>

Fish Provide Much More than Protein

Fish provide as much as 70–80% of animal protein in the diet of the 13 million people of Cambodia. Although perhaps not such a dominant part of the diet elsewhere in the subregion, fish and other aquatic products are still very important, especially among millions of rural poor. Virtually all farm families in the Lower Mekong River Basin, and most other rural families as well, fish for subsistence and for extra cash income.

Fish also supply much of the calcium in the diet of rural people throughout the subregion. Calcium is essential not only for bone growth in infants and children and bone maintenance in adult, but also for proper brain development. The World Health Organization recommends a minimum daily intake of 500–700 milligrams (mg) for children, and 400–500 mg for adults. Studies show that 100 g of small fish eaten fresh contains about 1,000 mg of calcium and that the same amount of fish paste can contain more than 2,000 mg of calcium. Thus, fish compares very favorably in calcium content with other common foods such as tofu (250 mg of calcium for every 100 g) and Chinese kale (245 mg). Moreover, recent studies have debunked the long-held belief that the body does not readily absorb calcium from bones, the primary source in fish.

Protecting the exceptionally productive freshwater fisheries of the Mekong and other rivers should be a very high priority of the subregion’s countries. Should the fisheries begin to fail and the rate of fish consumption fall, public health, especially among the poor, could be very seriously affected. Most poor people would have no other sources of food. The loss of dietary calcium, for one, would be difficult to offset. Milk has been successfully introduced into the regular diet of many people in Thailand, but it is comparatively expensive and there is not enough of it to feed everyone in the subregion. Besides, lactose would be indigestible to many adults who rarely, if ever, drank milk in their childhood.

Potential Threats to Fisheries

Dams and Weirs

The Mekong River system has two general classes of fish: white fish, which migrate seasonally up and down the river and its tributaries; and black fish, which live in lakes, ponds, and swamps. Both classes of fish disperse seasonally across 70,000 km² of diverse habitats on the nutrient-rich floodplains to reproduce and grow. There are about 20,000 dams and weirs in the Lower Mekong River Basin alone. These structures have affected the fish, which are also under threat from current and planned dam projects on the Mekong River main stem.

The fishes of the Mekong River system have developed over many millennia in response to a flow regime that varies greatly from the wet to the dry season. The annual change includes not only a large seasonal floodplain, but also the important and unique reversing flow of the Tonle Sap River and the flood buffer system of Tonle Sap Lake itself. Fish reproduction is key to this hydrological cycle, as evidenced by the close correlation between the annual maximum flood level and the fish catch of the dai (large bag net) fishery in the Tonle Sap River.

Each dam built for hydropower generation, irrigation, flood control, or water supply stores water in the wet season and releases water in the dry season, thus reducing the flow of the river in the wet season and increasing it in the dry season. These modifications in the flow regime alter the natural dynamics of the river. These flow changes in the Mekong River system may also disrupt fish migration and spawning, and reduce the yield of fisheries.

Lancang Cascade

Of the planned cascade of eight dams in the Mekong main stem in Yunnan Province, PRC, two have been completed, a third is being built, and two others are scheduled to begin construction before 2010. The eight dams will have a combined active water storage capacity of more than 23 billion m³.
roughly 30% of Yunnan Province’s annual contribution to the Mekong River, and nearly 5% of the 475 billion m³ average annual discharge of the Mekong River into the South China Sea. The Lancang Cascade could have significant impact downstream on the river’s hydrology, annual flood pattern, fisheries, and navigation.

Aside from hydropower generation, the PRC plans to release water from the reservoirs to increase the dry-season flow downstream, enough to allow massive barge trains to navigate the river virtually year-round, once other channel alterations have been made (see below). Although the hydrological changes have not yet been accurately modeled, the effects may be felt far downstream of the dams, and maybe even in Tonle Sap Lake and the Mekong Delta in Viet Nam. The Yunnan cascade of dams may also significantly change the quality of the water downstream. Most importantly, sedimentation in the reservoirs will make the released water deficient in sediments and thus clearer than normal; reservoir stratification could also make the water devoid of oxygen at times.

**Navigational Improvements in the Upper Mekong River**

In 1993, the governments of PRC, Lao PDR, Myanmar, and Thailand began looking into how the Mekong River could be made more navigable for regional commerce. In its natural state, the river can be navigated year-round only by small vessels of less than 60 dead-weight tons (DWT) because of reefs, shoals, and rapids between the Yunnan Province, PRC border and Ban Houayxai in the Lao PDR, although some sections can be safely navigated by larger vessels in high water. In April 2000, the four countries agreed to make the river navigable 95% of the year, first for vessels up to 100 DWT, by removing 11 major rapids and shoals and 10 scattered reefs; then for vessels up to 300 DWT, by removing another 51 rapids and shoals; and finally for the 500-DWT barge trains, by “canalizing” the waterway. Other rapids, shoals, and reefs already have been removed from the river in Yunnan Province, PRC.

These rapids, shoals, and reefs regulate water flows and oxygenate the water. They are also important habitats and spawning grounds for fish, and in some cases are associated with deep pools where many fish shelter in the dry season. Removing them would destroy critical habitats and could disrupt fish migration and spawning, especially when dry-season flows increase with water released from the mainstream dams in Yunnan Province, PRC. Among the fish most at risk from such development is the endangered giant Mekong River catfish.
Pollution from Many Sources

Most arable land in the subregion is already cultivated. New technology and intensified farming to feed the growing population probably will mean increased fertilizer and pesticide use. Fertilizers speed up eutrophication (a process that reduces the amount of available oxygen) and reduce fish production in rivers and lakes that receive runoff from agricultural lands. High levels of pesticides are also toxic to fish, but even low concentrations of pesticides can reduce fecundity because their chemical structures mimic female hormones. The production, distribution, and application of agricultural chemicals must be better regulated to avoid misuse or overuse, and to protect very valuable fisheries.

Industrial, municipal, and domestic wastes will increase as the population grows. Like agricultural chemicals, these wastes hasten eutrophication and increase the toxicity of receiving waters. But because these pollution sources are more localized, appropriate centralized waste collection and treatment can often lessen their detrimental effects. Nevertheless, because factory wastes are often accumulated in storage ponds, breaches in the pond walls due to floods or other causes can release very large quantities of pollutants in a short time, causing massive fish kills. Better facilities for managing industrial wastes and controlling toxic spills are urgently needed. Cities, towns, and factories must build or upgrade sewage collection and treatment facilities, and treat their wastes before discharging them into nearby rivers.