# Man, Fire and Wild Cattle in Southeast Asia

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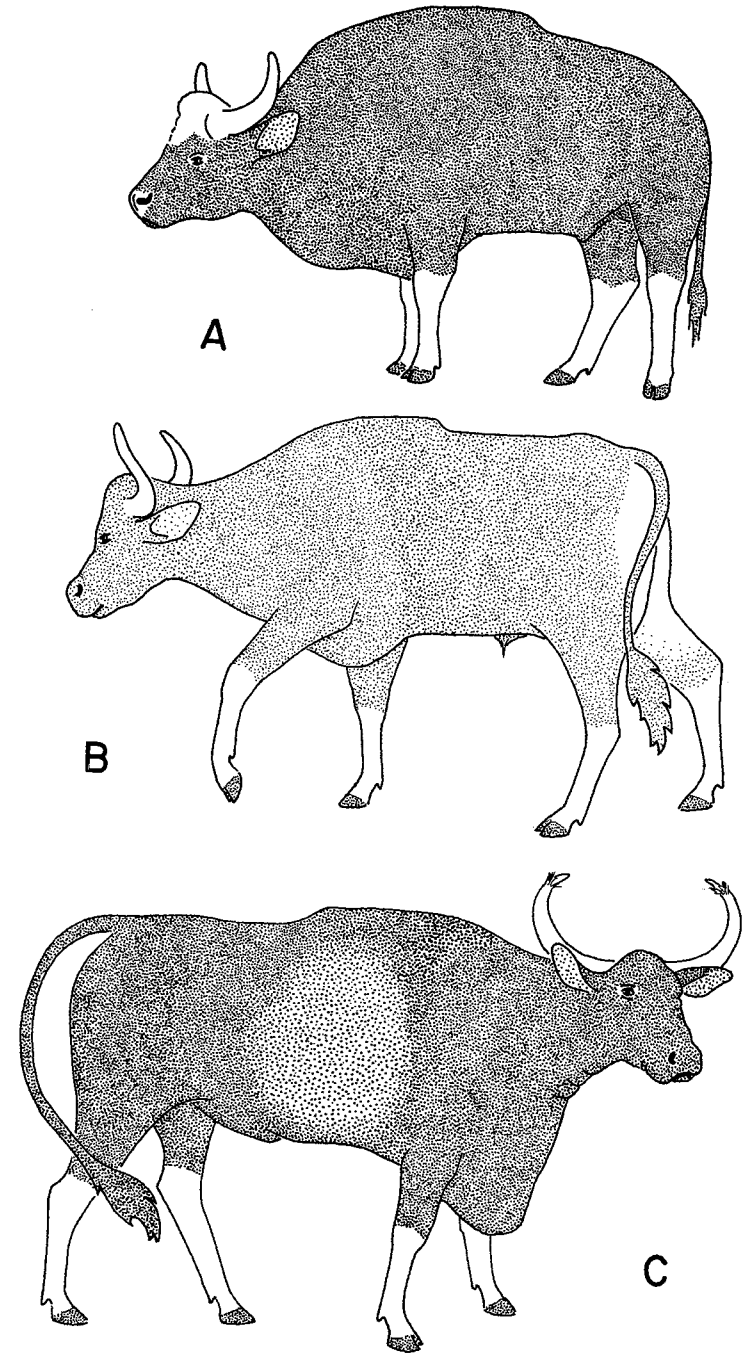
EVIDENCE was presented by Wharton (1966) that the savanna forests of northern and eastern Cambodia may have originated from, and are maintained by, the activities of man and fire, and that Cambodians and wild cattle in this area had apparently achieved a cooperative way of life, each benefiting the other. This paper seeks to document the activities of man which have altered or created the habitat of wild cattle throughout southeast Asia. For each country, the habitat of the wild cattle is discussed, based on published reports as well as information from correspondents. Evidence for the impact of man and fire on the vegetation has been gleaned from published accounts, and in some cases, from personal observation. Maps are presented with the known range of wild cattle superimposed on maps of human population, cultivation and general forest type.

Figure 1 pictures the three species of wild cattle involved. One of these, the kouprey (*Novibos sauvelli* = *Bos* (*Bibos*) *sauveli*) is principally confined to Cambodia. Coolidge (1940) has indicated that this rare ox may be ancestral to some domestic oxen. Field observations by Wharton (1957) lent credence to the belief that it is indeed a distinct species of wild cattle. A comparative osteo-


A
B
C

logical study by Bohlken (1961) failed to determine whether it is truly a relict population of an ancient wild stock or whether it is a feral domestic ox. The distribution and habits of the two widespread species of wild cattle, the banteng, *Bos (Bibos) sondaicus*, and the gaur, *Bos (Bibos) gaurus*, are treated in detail and their distribution is mapped, Figs. 19 and 20. While Harper (1945) listed the Bornean banteng, *Bibos sondaicus lowi*, and the Malay banteng, (*Bibos sondaicus butleri*), as separate races, there appears to be no significant differences in habits or habitat. There are some obvious anomalies: Why are there gaur but no banteng in the great bulk of India west of the Bramaputra River? Why are there gaur and no banteng in Malaya while in Borneo and Java there are banteng but no gaur?

Man's major alteration of the monsoon and rainforests of southeast Asia is through the means of shifting cultivation, sometimes called "slash and burn" agriculture. Essentially it involves cutting the virgin forest by either stone or iron tools, burning it and planting seeds in the ash-covered clearing. Usually cultivation is only for one or two seasons, the cultivator returning in some rotational fashion when the secondary forest has eliminated ground cover, fertility has returned, or necessity dictates.

Spencer (1966) feels that clearing the fields by fire and discontinuous cropping are the key elements in a definition of shifting agriculture. Geertz (1963) sees ideal shifting cultivation as a "canny imitation" of the natural ecosystem. The high diversity index of the tropical forest is taken advantage of in some cases by as many as 40 cultivated plants growing simultaneously—while in

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FIG. 1. Three species of Asiatic wild cattle. A, Gaur; B, Banteng; C, Kouprey. The gaur is the largest; a bull may measure over six feet at the shoulder and weigh over 2,000 pounds; both sexes are black. Both sexes of banteng are red, with white rump patch; old males may turn grey, brown or black. Kouprey cows are grey; bulls, characterized by a highly developed dewlap and horns frayed into tassels near the tips, begin with a grey coat, but eventually turn entirely black. All three species possess white stockings and the calves are colored a reddish bay.

higher elevations of the ranges of Burma and Assam only one or two plants are grown. Since decomposition is extremely rapid, the very large amount of organic material which would normally accumulate on the forest floor in temperate regimes is decomposed and readsorbed so rapidly that it led Geertz to claim that the tropical forest maintains most of its energy in living things, thus circumventing "the problem of impoverished soil conditions by feeding largely upon itself." Loss of nutrients due to heavy rain is apparently remedied by nitrogen fixation in "leguminous trees and adsorption of minerals released by rock decomposition." Firing the vegetation cut from a clearing is extremely important and effects the transfer of the nutrients locked in the tropical forest to more direct energy sources for man. Much efficiency is lost in burning, however. Gourou (1953) indicated that 600–900 pounds of nitrogen alone are lost in burning a single acre of forest, and much ash is inevitably washed away. Gourou and others see properly performed shifting cultivation as one of the least harmful means of exploiting areas where poor soils and heavy rainfall defeat conventional farming methods. The key to success seems to lie not only in a sufficiently long fallow period but in the speed and manner in which secondary seral stages are allowed to progress. Pelzer (1945) sees no reason to change to more intensive forms of agriculture as long as the population remains less than 50 people/$Km^2$. Ooi (1958) noted reasons why most shifting cultivation avoids low ground: the need for free drainage, ease of drying cut vegetation, better updrafts on slopes, and better exposure to light.

Wherever possible figures of human density per $Km^2$ are cited. Spencer (1966) indicates that land in shifting cultivation or fallow may reach 250–275 million acres in southeast Asia. His acreage estimates for the countries covered in this paper are: India 85 million; Burma 22 million; Thailand 10 million; Laos 8 million; Cambodia 50 thousand; South Vietnam 650 thousand; Indonesia 85 million; British Borneo 5.5 million. His studies suggest that the shifting cultivator often selects well-grown forest plots when given a choice and he doubts the existence of much virgin forest in southeast Asia. "It is likely . . . that most of the mature forests of the Orient

today are not virgin forest in the proper sense, but merely old forest that have reached a fairly stable equilibrium of ecological succession after some earlier clearing by human or natural means." The fallow process allows wild plant growth to accumulate new nutrients from depth, and to physically recondition the density and permeability of the soil. Spencer indicates the damage of combined firing and grazing, burning of parkland in hunting, and the careless use of fire in burning off clearings in certain plant associations. Apparently fires in secondary or climax forest in humid zones with no marked dry season do little damage. "Escapes in parkland including both humid climatic areas and those with a prolonged seasonal dry period, are more common and more damaging."

Remarking on the history of shifting cultivation, Spencer (1966) says that the areas involved would have been far larger 1,000 years ago. Spencer feels that 11,000-12,000 B.C. is the best date for the first domestication of plants and agrees with Sauer (1956) that lowland freshwater areas in southeast Asia were the probable beginning sites.

The reaction of writers to shifting cultivation has been varied and vivid. It has been called "fire-farming" or "soil mining" by Wickizer and Bennett (1941), and "forest eating" by Condominas (1957). FAO (1957) considered that 14 million $mi^2$ (36 million $km^2$) were involved, and that an expanding world cannot tolerate 6 people/$km^2$ operating in a Neolithic culture stage. They summarize the modifications suffered by the soil: low adsorption capacity for exchangeable bases of the clay fraction, tendency of these clays to immobilize phosphates, the leaching of plant nutrients by heavy percolation, and the rapid destruction of organic matter by high temperatures. Garnier (1873) wrote, "Everywhere they burn, to cultivate forest rice, corn and cotton, to clean the ground for getting about, to hunt animals, and for distraction. This barbarious custom is general . . . each year half of the total forest of Indochina . . . are ravaged by fire . . . on rich soil . . . one finds only more or less recent forest and on poor soil, one finds fire-controlled forests. Among the plants stimulated are spiny bamboos and *L'Imperata arundinacia*."

While Spencer, FAO and others cite acreages involved, there are few maps showing distribution of shifting cultivation. Since many difficulties would attend the preparation of reliable and precise maps, my approach has been to list the tribes and geographic regions involved in each country.

India is more fully discussed, relative to fire and shifting cultivation, but it should be understood that whenever shifting cultivation is mentioned, the reader may assume that fire is being used to remove and ash the vegetation from the cleared land. Special instances, such as where fire contributes to the formation of savanna forest, are cited.

## INDIA

### Wild Cattle Habitat

According to E. P. Gee (pers. comm.) there are no records of banteng in India. He states "there used to be a few in the Kabaw valley; . . . part of Manipur which is India, but the Kabaw valley was transferred to Burma."

Gaur, however, are found throughout India where the habitat is suitable. Figure 2 indicates that gaur are found in or adjacent to most of the major forest types, except thorn forest. Thompson (1852) met them in the Western Ghats, " . . . a succession of . . . rugged hills and . . . wild, deep ravines . . . here and there a bare ridge of hill, covered with a dense mat of bushes, brushwood, tall ferns and flowering plants. . . . Occasionally . . . on the borders of this country . . . [they] do great damage to the small fields of corn which the natives cultivate. . . ." Wood (1937) stated that "The gaur is found in the plains as well as in the hills and mountainous and rocky country and I have seen their tracks at an elevation of 8,000 feet . . . in Manipur. . . . At the height of the gadfly season . . . they will be found in open jungle. . . . Gaur prefer hilly country with grassy valleys intervening and clumps of thick forest interspersed . . . impossible to track . . . when the jungle is unburnt. After the jungle fires they feed on the green grass that sprouts up. . . ." In the Khasi hills near the Kipili River, Col. Wood found gaur com-

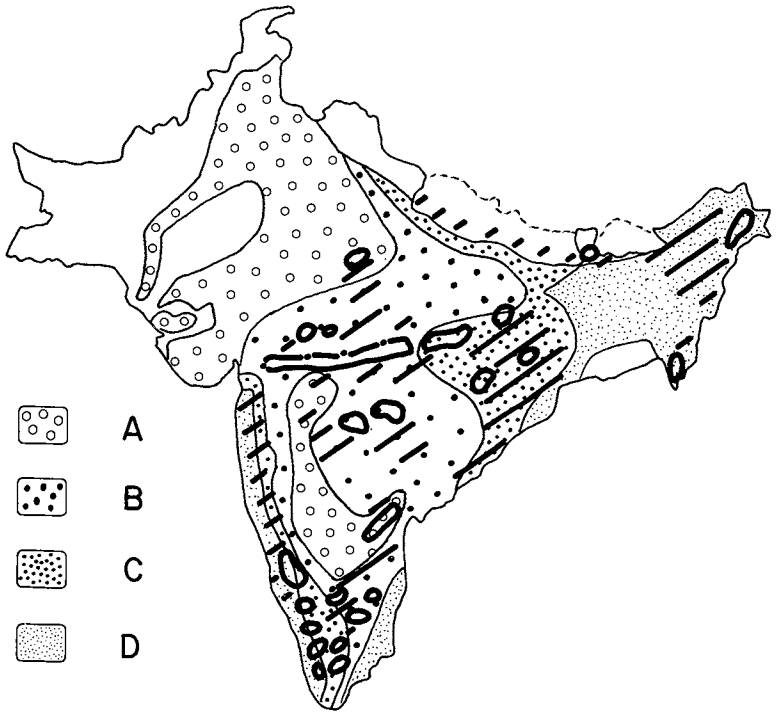


FIG. 2. Vegetation and gaur distribution in India. A. Tropical thorn forest; B. Tropical dry deciduous forest; C. Tropical moist deciduous forest; D. Tropical wet, semi-wet and dry evergreen forest. Ringed areas, known gaur localities; diagonal lines, probable gaur range.

mon stating, "The jungles had fortunately been fired some time prior to our visit, and the green grass sprouted up everywhere and there were patches of thick forest in the ravines." In Darrang he states that gaur ". . . used to come down from the hills after the annual jungle fires." Wood describes the Jagar Valley in Mysore as ideal gaur habitat. He describes clumps of bamboo and large open spaces of grass with the 2,000 ft hills having grassy plateaus on the summits.

Williams (1936) observed gaur between Coimbatore and the Kodaikanal Hills in Madura District, along the Taenar River. He described the country as having stunted trees, with much bamboo in ravines, and with typical grass hill land above 5,000 ft. He also

reported many prehistoric stone dwellings or graves which were "common throughout the deciduous forests in these hills." Walter Auffenberg (pers. comm.) observed gaur habitat in the Palni Hills and at Periyar in Kerala where the tops of the western Ghats are rolling savanna grasslands with *shola* or ravine forests in the valleys. He stated that these hilltops had been burned for thousands of years by the inhabitants, and that, while gaur resorted to *shola* forest they apparently did not frequent temperate forests (7–8,000 ft). M. Krishnan (pers. comm.) who observed gaur for over 30 years in Karwar, Mysore, Madras and Kerala States and has done intensive study of them in the Mudumalai Sanctuary in the Nilgiri Mountains (Madras) states that gaur do not inhabit true evergreen forests but are found in montane deciduous forests where there is an admixture of evergreen trees (*shola* forests), i.e., in moist, mixed deciduous forest. He states that they are also found in drier deciduous forests along the Madras-Mysore border. Krishnan notes that gaur like hilly terrain, "but do not inhabit high grounds." He associates them with wild elephant and sambur habitat. Krishnan gives the following details of the hill and foothill forest habitats in which gaur are found: tall grasses such as *Imperata* and *Saccharum* in belts and patches, as ground cover where the forests have been worked or opened up; belts and brakes of giant bamboo *Bambusa arundinacea*, and, in drier and lower forests the bamboo; *Dendrocalamus strictus;* brakes of screwpine and *Ardisia* along streams; short grasses and herbs and shrubs in clearings and swampy flats; tree forests characterized by a low ground flora of grasses, "wild arrow root", *Hibiscus* and *Sida*, creeping Papilionates, etc.; deciduous tree forests with *Anogeissus latifolia*, teak, rosewood, *Terminalia* spp. (especially *T. bellerica*, *T. tomentosa*, and *T. chebula*), *Gmelina arborea*, *Grewia tilliaefolia*, *Zizyphus* spp., *Kydia calycina*, *Acacia* and *Albizzia* spp.; *Emblica* spp.; shrubs such as *Lantana* (exotic), *Helicteres isora* and *Cerodendron* spp. This author states that gaur are as much given to browsing as grazing; they apparently browse bamboo broken down by elephants. Figure 3 indicates that gaur occur chiefly in areas of moderately low human density (176/mi$^2$) but may be found near areas of high density as well as adjacent to cities of moderate size (100,000 to 500,000). Figure 4 suggests that gaur are nearly always associated

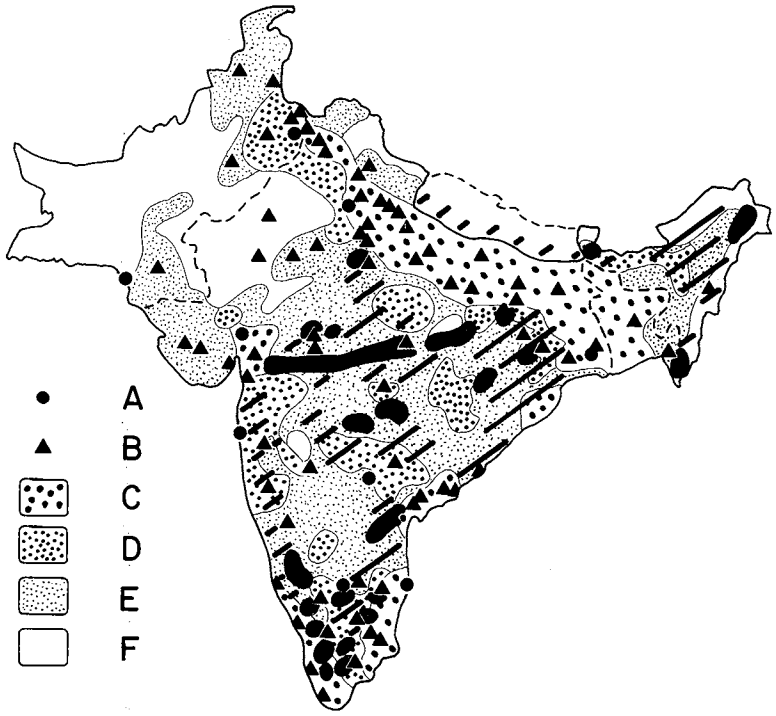


FIG. 3. Human population (1951 census) and gaur distribution in India. A. 500,000 to over one million (city); B. over 100,000 to 500,000 (city); C. 672/mi²; D. 320/mi²; E. 176/mi²; F. 32/mi². Irregular solid areas, gaur localities; diagonal lines, probable gaur range.

with woodland and forest; in peninsular India such forests are often adjacent to arable land mixed with scrub.

## EFFECT OF MAN AND FIRE

While paleolithic man is documented from northwest, southeast and central India in mid-Pleistocene, Piggott (1950), it is probable that agricultural man began seriously modifying Indian environments in an organized way about 3,000 B.C. By 2,000 B.C. there were both urban (containing a high proportion of proto-Australoids) and rural communities in northern India. Piggott indicates that the Aryan

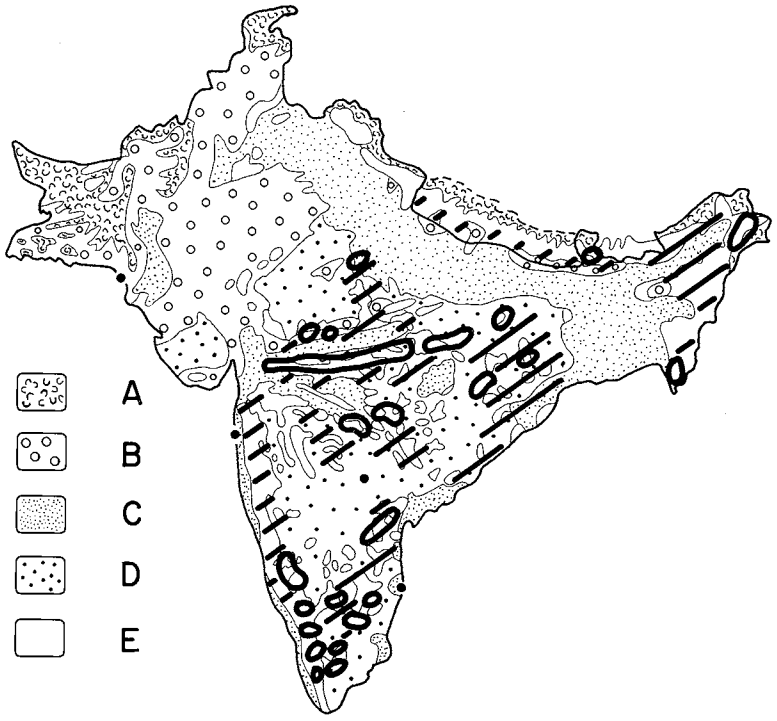


FIG. 4. Land use and distribution of gaur in India. A. Mountain vegetation; B. Arid wasteland or scrub and rough grazing; C. Non-flooding arable "dry" land or seasonally flooded wet (rice) land; D. Arable land mixed with scrub; E. Woodland and forest. Ringed areas, known gaur localities; diagonal lines, probable gaur range.

people invaded India from the West about 2,000 B.C.—these were semi-nomadic agricultural-pastoral people from the area between southern Russia and Turkestan. The Aryans were organized into simple agricultural communities, with grains (barley) but also with horses, cattle, sheep and goats. By 500 B.C. northern India was occupied by a literate, urban and organized people. Apparently peninsular India was already occupied by aboriginal tribes represented by the living Chenchus. According to Forsyth (1919) the Aryans interbred with the aboriginals to produce the Gond peoples of Central India. Piggott makes it clear that the Aryans destroyed the civilization of Harappa in northwest and north India but it is

not clear whether the proto-Australoids forming the bulk of the population were slaves or not. Just when the aboriginal population adopted agriculture is not clear; presumably the Gonds learned the raising of grains from the Aryans, or the Gondid race was originally an early agricultural population as indicated by Wissman (1956). In the 14–15th century in northern peninsular India a Mohammedan invasion forced many Hindus into remote areas; the Gond then retired to plateaus and slopes. Although the more extensive plateaus were invaded by the Hindus, the surrounding rugged, uncultivatable country remained in aboriginal hands. According to Stebbing (1923) the heavy valley lands such as those of the Narbada River were apparently beyond the means of aboriginals, but not the Hindus in the 14th and 15th centuries. "The Gonds retired before this invasion to the higher plateau, where their hunting instincts and rude system of raising coarse grains by the method of shifting cultivation . . . could still find scope." As late as 1853 the Gondwana highlands were apparently unexplored terrain. A great development of central India began early in the 17th century under the Mohammedan Akbar. The great valleys and plateaus were opened to wheat and cotton. In the late 18th century following the invasion of the Maratha hoards from the Deccan and their decline, the hill chiefs became brigands and great areas of country were abandoned and reverted to jungle. Forsyth, in 1919, estimated the aboriginal population at 40,000 in 3,000 $mi^2$ of the central highlands of peninsular India. Of 44,000 $mi^2$ in the Highland Region, 11,000 were under cultivation. He stated that one could stand on any high range of the Highlands of central India and for every acre of original jungle remaining, thousands had been "leveled by the axe of the Gond and Korku . . . No teak forest ever escaped this treatment." Forsyth states that the best gaur range is the Mahadeo hills, which he describes as the teak region, an area of volcanic rocks. Apparently most of this area burns during the dry season ". . . at this season the whole country appears at night ringed with these lines of fire; here thin and scarcely visible where the grass is scanty on a bare hill top; there flaring through tracts of long elephant grass . . . When the fires are burnt out, the spectacle is a dismal one indeed. Hill-side after hill-side of blackness, relieved only here and there by a long streak of white ashes

where a prostrate trunk has been consumed . . . Yet . . . there are few tracts where . . . some oasis will not be found. The larger ravines are often filled with clumps of bamboo . . . and here and there a sheltered valley will be met—where there is either a pool of water, or moisture not far below the surface with its fringe of verdure, and a few Mhowa or Mango trees, perhaps marking the site of some old village, deserted long ago beyond the memory of living man." The hill people of central India were aboriginies: Gonds, Kols, Korkus, Bygas and Bheels. Forsyth (1919) wrote "Though large tracts of splendid level land lie untilled on the Puchmari Plateau and in the valleys below, the Korku has no cattle or ploughs with which to break it up. He has nothing . . . but his axe. . . . This is enough. . . . He prefers a place where young straight teak poles grow thick and strong, as they are easiest to cut, and produce most ashes when burnt . . . by . . . May . . . he then sets fire to it . . . at the end of a week he will . . . contemplate with satisfaction the three or four acres of valuable teak forest he has reduced to a heap of ashes." Forsyth continues, "The abandoned *dhya* clearings are speedily covered . . . with . . . low . . . bamboo, and of certain thorny bushes . . . I have aften been obliged to turn back . . . after vainly endeavoring to force through it a powerful elephant . . . the *dhya* cutter . . . never again returns to an old clearing while untouched forest land is to be had." A great portion of the non-volcanic region of central India is covered with forests of sal (*Shorea robusta*), a truly fire-adapted species since the seeds appear to germinate better after fire. Many tribes have practiced shifting cultivation in sal forests. Forsyth writes "The Byga (predecessor of the Gonds) is the most terrible enemy of the forests we have anywhere in these hills (near Manola). Thousands of square miles of sal forest have been clean destroyed by them . . ." Apparently most of the Central Province country of India was devastated by shifting cultivators, Forsyth (1919), Stebbing (1923). Stebbing indicates that the Mahabharata tells of burning the great Khundava forest between the Ganges and Jumna River, and that in the time of the invasion by Alexander the Great (327 B.C.) the northern Punjab forests were still dense. The Mohammedan philosophy (their rule extended 750 years) considered that the forest was a free gift of nature, and

it was lavishly used. This war against the forests thus lasted 3,500 years. Stebbing says ". . . the wholesale destruction of forests has had a serious deteriorating effect on the climate of India. . . . The disappearance of the people of these old densely populated areas was mainly brought about by the reckless, continuous and wholesale burning of the forests which led to the gradual decrease of water in the larger rivers, to the drying up of springs, small streams and rivers and to a decrease in the rainfall of the country." Randhawa (1945) documents a progressive desiccation over northern India beginning 2,000–3,000 years ago. Banerjee (1942) wrote of changes wrought by shifting agriculture in the eastern Ghats, "In 1854 the rainfall was . . . between 80–90 inches yearly, due to the existance of forest covered hills, whereas the rainfall had decreased to 48 inches in 1900, by which time most of the forest vegetation was cleared away. In 1834 the Maliah tract was reported to abound in springs . . . whereas now only a few of the streams are perennial. . . ." He further states, "the Savaras . . . were gradually driven up the hills due partly to the lower slopes becoming sterile and unfit for shifting cultivation . . . at the tops of Singaraj, Devagiri and Mahendra hills there is no growth except grasses. . . . With the emigration of the Savaras . . . the once famous forests of Parlakimidi Division had disappeared due to shifting cultivation and indiscriminate revenue fellings . . . they prefer shifting cultivation to wet or dry cultivation as two or three showers of rain are enough for the hill crops to ripen, whereas wet or dry crops depend entirely on rains." Hewetson (1950) studied a 73 square mile tract in Madhya Pradesh, Central Provinces. Man's influence was noted in broken earth dams, hills under shifting cultivation, the whole of the country burnt annually. He found that grasslands were produced by light grazing and hot fires; heavy grazing and light fires let trees and shrubs get a foothold. He found savanna forest reduced to open savanna woodland by fierce fires if fuel accumulated for several years. Hewetson (1954) later concluded that runoff from burnt areas was as great a from bare ground; the cushioning effect of leaf litter was valuable, unburned grass acting as a soil stabilizer; therefore early burning in drier savanna forests promotes erosion. Gorrie (1954) wrote that open deciduous sal (*Shorea robusta*), teak and

pine are all burnt annually, filling reservoirs with silt—fire being used to make gathering of the edible Mahow (*Bassia latifolia*) flower easier. Spate (1954) writing of soils and the 12 percent of India under forests: "Three millenia of clearing for agriculture and of unregulated grazing (both often promoted by burning the jungle) have stripped the forest from nearly all the plains and much of the lower hills and plateaus, or turned it into scrub. . . ." Speaking of shifting cultivation he says. "The more valuable deciduous monsoon forests are more affected than the fire-resistant evergreen. . . . Throughout central and southern India forest control is rendered extremely difficult by shifting cultivation. . . . Much land once wooded has now become a mere waste of acacias, euphorbias, very poor grass and even bare rocks, while in the southern Deccan the water table has in places been lowered by deforestation and erosion. . . . Even in the terai (foothills of Himalayas) and the wetter areas (with over 80 in.) pressure of population has led to clearing and the spread of a savannah-like cover. . . ."

Dutta (1955) states that in the hilly areas of Madhya Pradesh the Korwa, Pando, Kodaku, Baiga, Bhumia, Mudia, Korku and other tribes practiced shifting cultivation prior to 1860. "The extent . . . is not accurately surveyed . . . the total area is quite large."

Furer—Haimendorf (1943) studied the aboriginal Chenchus of Hyderabad, who form the oldest surviving racial stratum in India (a fusion of veddids and early Indo-negrids called proto-australoid). These peoples ranged from Madras across the Kistna River into Hyderabad. Their habitat is savanna forest with the ruins of many Shiva temples scattered about. "As the temperature rose . . . fires, partly accidental but more frequently started by the Chenchus themselves, rapidly destroyed the dense, high grass . . . by . . . March the forest presented a scene of complete desolation." It is important to note that even in this hunting and gathering society which cultivates no plants, firing the forest appears to be practiced.

Breeks (1873) noted jungle clearings constructed by some Nilgiri mountain tribes such as the Badaga, Kurumbas and Irulas. In 1948 Furer-Haimendorf (1952) found the Jen-Kurumba and the Bette-Kurumba tribes practicing shifting cultivation in the Wynad region on the border of Madras and western Mysore. The International

between the Brahmaputra and the Burmese border. All the tribes, the Garos, Khasis, Mikirs, Cacharis, Nagas and Lushais practice shifting cultivation. The area and population of the major regions were given; Khasi and Jainta Hills (5,533 $mi^2$, pop. 66/$mi^2$); Naga Hills (4,203 $mi^2$, 49/$mi^2$); Lushai Hills (8,150 $mi^2$, 24/$mi^2$); Garo Hills (3,141 $mi^2$, 6/$mi^2$). Bor (1942) was intrigued with the fact that most of the Shillong plateau of the Khasi and Jainta hills (alt. 4,000–6,400 ft) was rolling grassland with some pine (*Pinus insularis*) where one would expect evergreen forest. Cherrapunji, on the southern edge of this plateau has the world's highest rainfall, 45 feet annually not being unusual. The entire plateau is apparently fired yearly. Bor states, "These hill grasslands are extremely interesting and are comparable to the grasslands of the Nilgiris which have been in more or less the same condition for 300 years at least. In the Khasi Hills they have not changed for at least 100 years but are obviously very much older. Similar hill grassland is to be found in the Naga Hills and in Manipur and are of comparable age. . . . A combination of burning and grazing destroys. . . . The tall grasses disappear, the shrubby and herbaceous Leguminosae give up the unequal struggle and are replaced by . . . *Chrysopogon aciculatus* and *Imperata cylindrica*." If grazing is stopped, *Imperata* apparently becomes dominant. In every case known to Bor the presence of pine was due to human action. "Fire alone is capable of maintaining the stability of the grassland in a forest climate . . . but the number (of grasses) which can tolerate fire and grazing is surprisingly few. *Pinus insularis*, is one the pioneers. . . . It takes possession of abandoned cultivation . . . it maintains itself in secondary jungle over a wide area in India and Burma. . . ." Amid this savanna, Bor found relict climax evergreen vegetation only in sacred groves protected by the Khasi peoples. Griffith (1847) wrote that the Khasi Hills appeared wooded only half way up, with grassy tops, and at Churra "the only wooded vegetation is found in ravines." He likewise reported the Naga Hills clothed with grass. Other studies by Hodson (1911) on the Kabuis, Marring, Quoireng and Chirus indicated shifting cultivation in Manipur; Hunter (1879) observed similar habits in the Miri, Padam, Garo, Naga, Khasi and Jainta tribes.

Godwin-Austin (1873) found that most spurs in the Garo Hills were cleared for cultivation. Furer-Heimendorf (1938) found shifting cultivation common to all northern and eastern Naga tribes. He stated that the Konyak-Naga are one of southeast Asia's most ancient civilizations—they use taro as a carbohydrate source (alt. 2,500–5,000 ft). Other tribes such as the Changs, Yinsangr and Kalo-Kengyus live largely on Job's tears (*Croix lachryma*) and some millet, and their clearings are at somewhat higher elevations. He found the Kalo-Kengyu Naga country cultivated to the point of exhaustion. Farther north in Assam, near the Tibetan frontier, Dalton (1845) reported shifting cultivation in use by the Meri tribes.

Gohain (1954) surveyed the Padams, Pasi, Minyongs and Pangi tribes of the Siang Frontier Division and found their economy based on shifting cultivation. Verma (1956) listed eight Naga tribes, the Khasi, Garo, Purum, Thadous and four tribes of the Abor group using shifting cultivation. Closer to the Burmese border Das (1945) discussed the Kukis (pop. 78,346) and Carey and Tuck (1896) indicated that the Chins similarly clear the jungle—"in March when grass is dry, all the jungle is systematically burnt and game driven into 'nullahs.' " In the Chittagong hill tracts of eastern Bengal and Assam, Hutchinson (1909) observed that the Mongoloid Kuki tribe increased its population from 9 to 33/mi$^2$ in one decade. He found elephant, gaya (*Bos frontalis*, supposedly feral) and rhino still commonly coexistant with this large nomadic tribe. The population lived in 296 villages in 1872 and was not spread through the forest. Das (1937) surveyed the Old Kuki group (includes 11 or 12 tribes) and the New Kuki group, (Thadous). He found, that although plains land was available, their culture patterns were based on shifting cultivation, and this stood in the way of valley settlement.

## BURMA

### Wild Cattle Habitat

Figure 5 indicates that banteng occur chiefly in the dry and moist tropical deciduous forests in river bottoms along the Tenasserim coast.

Vernay (1924) seeking specimens for the American Museum in

1923, pictured (p. 200) banteng habitat as "bamboo jungle". He considered this animal more elusive and difficult of pursuit than the gaur and other big game. He stated "The *tsine* . . . shows a greater preference for the grass plains and the flatter bamboo jungles than the gaur, and although an extraordinarily good climber, is not quite as adept as the latter."

Peacock (1934) photographed Burmese banteng at a salt lick and in glades in what appears to be typical savanna forest, similar to their haunts in Cambodia and Thailand, and annually burned. He writes, "When the annual ground fires of March and April have cleared the heavy undergrowth from the woods and burnt the long rank grass in the clearings, it is pure delight to "still hunt" for *saing*." Prater (1965) states, "The banteng, unlike the gaur, prefers flat or undulating ground covered with light deciduous or mixed deciduous and evergreen forest, where there are glades of grass and bamboo." He notes "that they have retreated with the advance of cultivation and deserted their favoured grounds for the seclusion of denser hill forests. . . . In April, the undergrowth of grass, a feature of the low level forests is usually burnt away by forest fires and the herds visit these areas. . . ." Peacock (1933) listed the habitats as "light forest", "*indaing* forests". In the heavy evergreen forests of the Tenasserim coast of peninsular Burma he found banteng in isolated *phongo* forest defined by U Tun Yin (pers. comm.) as "dense secondary growth on the sites of abandoned forest-clearings." Hundley (1958) described typical banteng habitat as ". . . flat or undulating country lightly covered with dry forest, particularly *Indaing* (*Indaing* closely resembles Cambodian savanna forest, Wharton, p. 25, 1957) but interspersed with strips and patches of bamboo and evergreen forest. Salt licks commonly found in these *indaing* forests are an attraction to *Saing*." He states that banteng have been heavily decimated by disease from domestic cattle and that civilization's advance has forced them into hilly and denser forests. Hundley states that banteng keep to the lower slopes in hilly country, that their habits "are very nearly identical with those of bison (gaur)", and that during hot weather they seek shade in heavy jungle and cane brakes.

Yin (pers. comm.) reveals that the last six annual censuses of wild

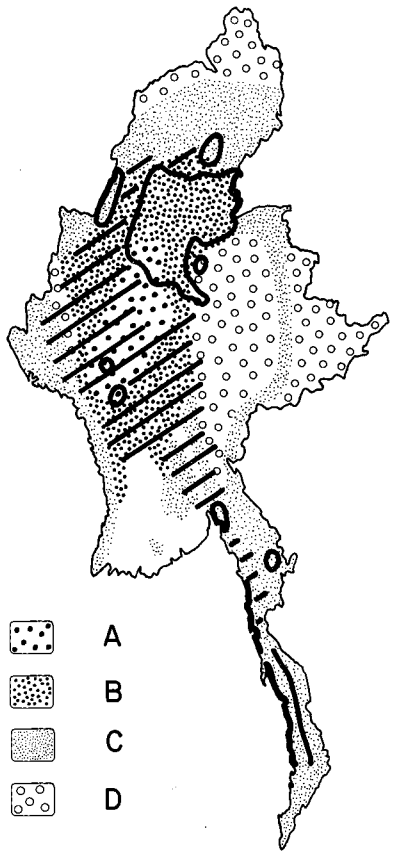


FIG. 5. Vegetation and banteng distribution in Burma. A. Tropical dry deciduous forest; B. Tropical moist deciduous forest; C. Tropical wet evergreen forest and tropical semi-evergreen forest; D. Wet temperate forest, sub-tropical mixed and sub-tropical wet forest, mountain forest. Ringed areas, known banteng localities; diagonal lines, probable distribution.

cattle in the Pidaung sanctuary at Myitkyina found the gaur population up from 88 to 141, but banteng down from 34 to 8. In his recent "Wild Animals of Burma" Yin (1968) reviews observations that banteng have better senses and are more difficult to hunt than the gaur. Unlike the gaur, they may move into crop areas and occasionally consort and interbreed with domestic cattle. He states

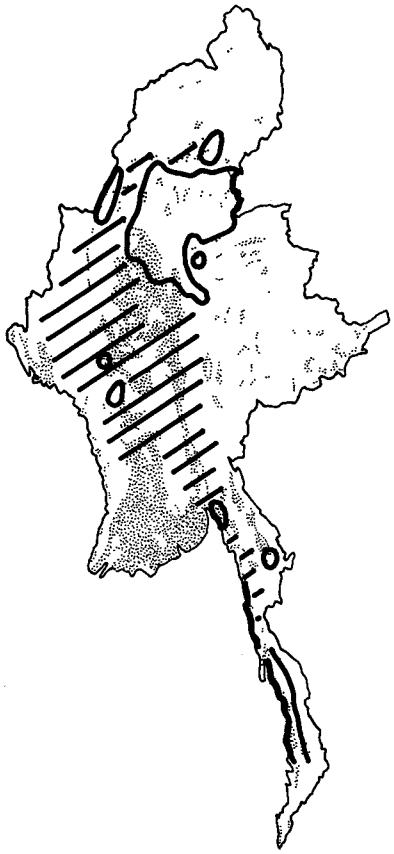

FIG. 6. Permanent cultivation (stippled area) and banteng distribution in Burma. Ringed areas, known banteng localities; diagonal lines, probable distribution.

that "*Indaing* is the natural habitat of *tsaine*," but that some banteng under human pressure, have sought seclusion of denser hill forests, adopting gaur habits. They frequently sleep and feed in Burmese *lwins* (open grassy plains). Yin states, "They normally avoid evergreen forests and hilly country" and in Tenasserim (normally dense humid forest), "*tsaine* occur in a few isolated places where the forest is comparatively dry and open."

Figure 6 shows that banteng do not, in general, range near per-

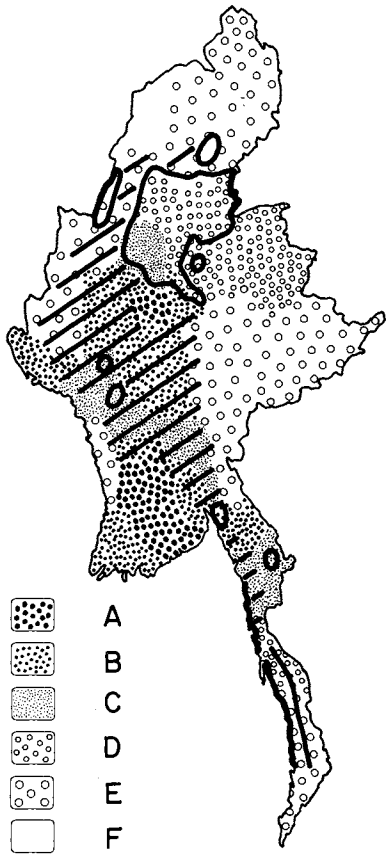


FIG. 7. Population (per mi²) and banteng distribution in Burma. A. over 200; B. 100–200; C. 50–100; D. 25–50; E. 10–25; F. 0–10. Ringed areas, known banteng localities; diagonal lines, probable distribution.

manent cultivation, while Figure 7 indicates that banteng avoid areas of highest human density, but range in or near areas of low (10–25 mi²) to high (100–200 mi²) density.

Gaur are frequently discussed as denizens of dense hill country, though frequenting glades. Mustill (1939) documents several instances of gaur-banteng and gaur-elephant associations in Burma, citing instances of 50 gaur resting in "open country", and 100 animals "in open scrub forest".

It is often stated [Evans quoted by Yin (1968), Mustill (1939), Thom (1934)] that the gaur avoids the proximity of man, though not as wary an animal as the banteng. His eyesight is reputedly poor. On the other hand, Thom (1934) states that "Solitary bull bison in the Arakan Hill tracts of Lower Burma frequently enter the cultivations and villages of the hill people to consort with the herds of mithun kept by them." This author saw a bull gaur spend the night within 20–30 yards of a village. The experience of having Malayan gaur feed within 50 meters of a noisy village is well documented by Hubback (1938), and a similar situation was described by Kinlock (1927) for India.

Yin says that gaur are shy and "Generally inhabit forests undisturbed by man. . . .They . . . frequent high ridges in the rains and stay along the banks of streams during the dry weather." In hot weather he notes that gaur are often found in abandoned forest-clearings, and that gaur occur throughout Burma where the jungle is moist and the country hilly.

## Effect of Man and Fire

Helfer (1839) wrote specifically that the Karens in Tenasserim cleared the inland forests and forests on the banks of rivers or in secluded valleys, the habitat where the banteng is now found. As early as 1866, Bigandet (1866) noted that the Khakien tribe of the Bhamo region of upper Burma cleared and cut the forests as typical shifting cultivators. Ferrar and Ferrar (1900) estimated the Karen population at 633,600 and noted that shifting cultivation was practiced by the Chins on steeper slopes and by the hill Kachin of upper Burma. Furer-Heimendorf (1938) noted that shifting cultivation was common to all north and east Naga tribes (discussed more fully under the Assam region of India). Atkinson (1948) states that Burma has almost the same area of actual forest as India. Chapman (1950) discusses fires set by natives to benefit grazing. Griffith (1847) wrote that from the Mogoung River to the Irrawaddy the country is open and grassy with plains and patches of dry jungle, the 3000 ft. hills being quite naked in places.

Allsop (1953) classifies Burmese forests affected by shifting culti-

vation as evergreen forest (*Dipterocarpus* spp., *Shorea*, *Parashora* spp., etc.); moist upper mixed deciduous with teak (*Tectona* with *Xylia*, *Terminalia*) and vigorous bamboo growth; lower mixed deciduous (bamboo absent); hill evergreen forest (*Castanopsis*, *Quercus* spp.); and pine (*Pinus insularis*) forest (not used but damaged by neighboring fires). He states that the largest incidence of shifting cultivation falls in the hill evergreen forests covering northwest, northern and eastern Burma. "*Quercus and Castanopsis* . . . will not tolerate too frequent cutting and burning. . . . Many square miles of certain districts of northern Burma have been reduced by the shifting cultivator to a waste of *Imperata* or *Lantana*." Allsop indicates that the *Xylia dolabriformis* forest of the Arakan Yoma of western Burma has an undergrowth of the bamboo, *Melocanna bambusoides*. "As a result of shifting cultivation, vast areas now contain no *Xylia* but are covered with *Melocanna* bamboo, which grows from rhizomes . . . to the exclusion of all other vegetation. . . ." Atkinson(1948) states that this bamboo is nearly impenetrable and covers many hundreds of square miles. In the Kachin state of Northern Burma the 300,000 Kachin people avoid 2½ million acres of level, fertile valley land and live on mountain slopes or in narrow mountain valleys, subsisting by shifting agriculture. They have apparently become experts in judging soil for their *taungya* plots, considering in detail such factors as slope exposure, moisture holding capacity, structure, acidity and types of natural plant indicators. Roy (1960) found that the Padam-Minyong inhabited mountains up to 6000 ft in altitude.

Stamp (1925) states that "there appears to be no true grassland in Burma below 3,000 ft. though large areas of the Shan Plateau above 3,000 ft and the Arakan Yomas are grass-covered." Both of these areas have been frequently cut and burned by man. Stamp indicates that the fire-adaptive *in* (*Dipterocarpus tuberculatus*) is replacing *ingyin* (*Pentacme suavis*). The seedlings of *in* "with their ring of dominant buds, recover very easily from fire. . . ." The *in* tree can grow on nearly poor sands (25 inches rain), dry ridges of Pegu Yoma (60–80 inches rain), and on poor gneissic soil (100 inches of rain).

Stevenson (1944) gave populations of Burmese hill peoples as:

Chins (250,000), Naga (75,000), Kachin (400,000), Shan (1,000,-000), Karen (1,367,673), all occupying about 40 percent of Burma.

## THAILAND

### Wild Cattle Habitat

Figure 8 indicates that banteng distribution conforms to an area of mixed deciduous dipterocarp forest and to areas of open savanna. Boonsong Lekagul (pers. comm.) indicates that the habitat of banteng in Thailand is very similar to that in northern Cambodia, being deciduous forests and open savannas. There are no banteng in the lower part of the peninsula; the rain forest is too dense, Lekagul states, and he also gives this as the reason for its absence in Malaya. The distribution of the banteng conforms to areas of reasonably moderate population, (Fig. 9), largely where the rainfall ranges between 40–60 inches and where savanna forest dominates, which Dobby (1967) says is "much subject to fires in the dry season . . . becoming savannah or scrub in type after frequent burnings, whether caused naturally or by shifting cultivators." While the vegetation of the Korat Plateau is similar to the excellent wild cattle lands of northern Cambodia, human population is much higher, 50 to 100/mi$^2$ according to Dobby (1967). In addition there are 5 million domestic cattle and 7 million domestic buffalo on the plateau. Figure 10 indicates that banteng are not found in areas of heavy wet-rice cultivation but can be found in areas with a combination wet and dry rice agriculture in northern and eastern Thailand.

### Effect of Man and Fire

Like Burma, Thailand is notorious for shifting cultivation. Although Mouhot (1864) found a low density of about 6,000 people for the entire Korat Plateau, Aymonier (1897) found there cleared plains alternating with savanna forest, with tree species similar to those of Cambodia's northern plains, along with large dug basins and other evidence of an older civilization. In one circuit south into Cambodia from Mu'ong Souren, Aymonier, who crossed the Dangrek Escarpment by two different routes, passed three sets of ruins in Thailand and five in Cambodia. According to Bartlett (1961),

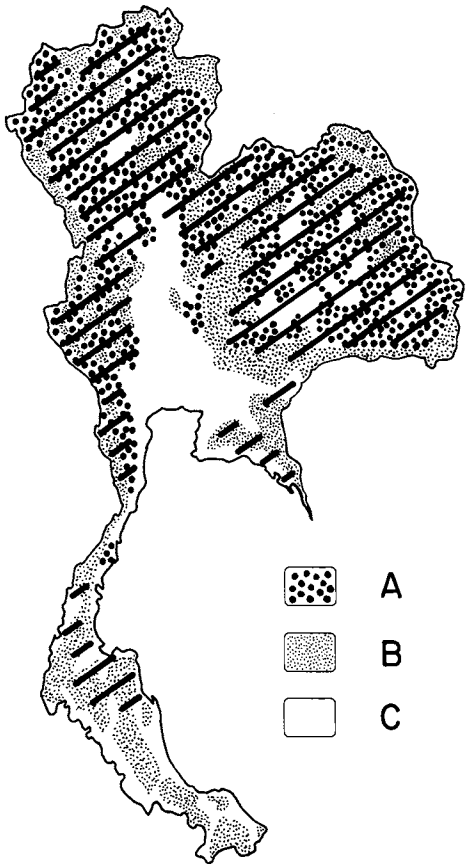


FIG. 8. Vegetation and banteng distribution in Thailand. A. Mixed deciduous forest, deciduous dipterocarp forest, savanna; B. Tropical evergreen forest; C. Permanent cultivation. Diagonal lines, probable banteng distribution.

Aymonier gave the "impression that most of northern Siam had been swept over by shifting cultivation, probably by several successive populations." Harmand (1877) passed from Cambodia into Thailand and remarked on the "desperate monotony" of the savanna forests of northern Cambodia, with the fires adding to the sadness of his trip. He remarked on the movement of villages in the open forest. In their study of Thailand vegetation Ogawa, Yoda and Kira

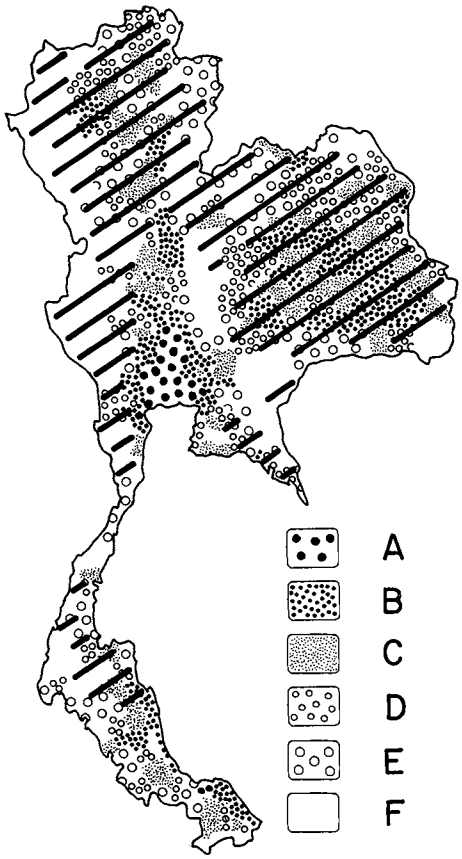


FIG. 9. Human population (per mi²) and banteng distribution in Thailand. A. 270 to over 520; B. 140–270; C. 90–140; D. 50–90; E. 25–50; F. 0–25. Diagonal lines, probable banteng distribution.

(1961) state that "ground fire in the dry season, either accidentally or intentionally induced by the inhabitants, is the most important biotic factor in the foundation and maintenance of savanna forests."

While no map is presented on the distribution of the gaur in Thailand, Harper (1945) indicates that their range includes northern and northwestern Siam and the Siam-Tenasserim border. In the northern provinces, Ogawa, Yoda and Kira indicate that hill tribes

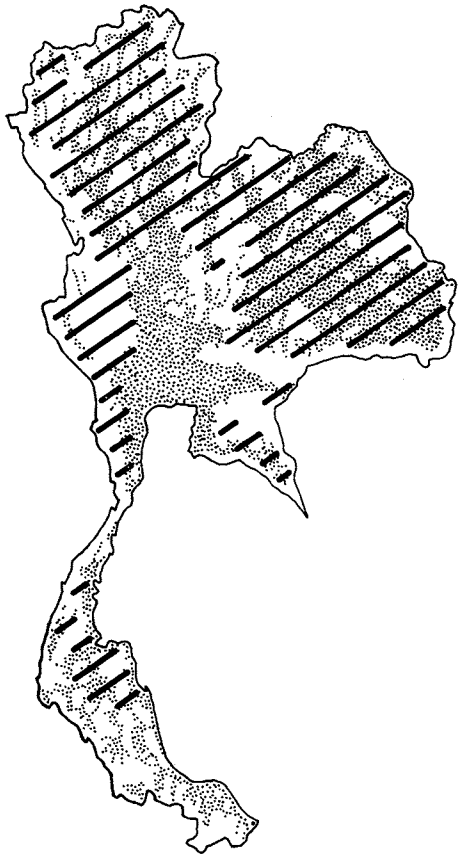

FIG. 10. Cultivation (stippled area) and banteng distribution in Thailand. Diagonal lines, probable banteng distribution.

such as Miao, Yao, Karen, and Musso inhabit temperate evergreen forest "and live mainly on crops obtained by shifting cultivation, by which large areas of virgin forest are burned and turned into secondary grasslands after a few years cultivation and subsequent fallow." They picture a Miao village at 1400 m. at Doi Suthep. They indicate that bamboo, a common vegetation over large areas of southeast Asia, usually results from human disturbance and state that "most bamboos . . . are deciduous . . . fires sweep over the latter in the dry season . . . but rarely damage living shoots."

## CAMBODIA

### Wild Cattle Habitat

Figure 11 indicates that banteng distribution generally conforms to areas of dry forest, savanna forest and savanna; their distribution in sub-humid and humid forest areas is associated with shifting cultivation.

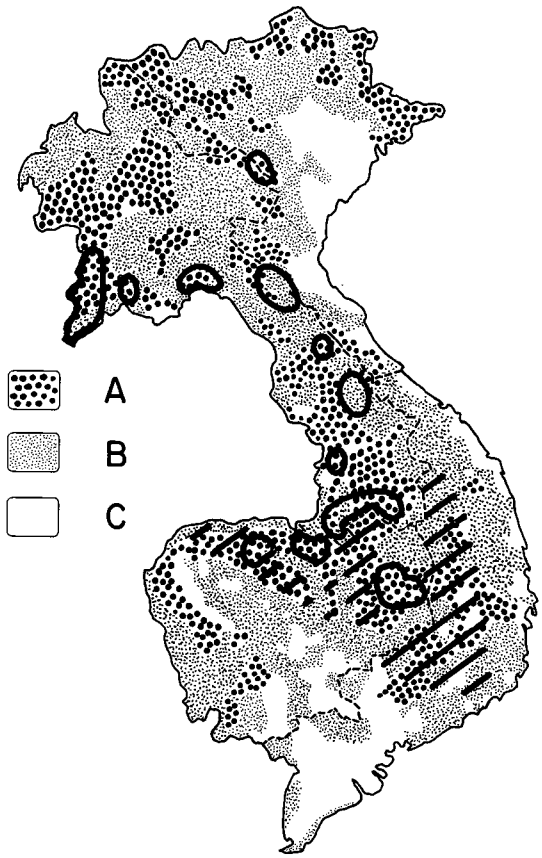


Fig. 11. Vegetation and banteng distribution in Cambodia, Laos, and Vietnam. A. Tropical deciduous forest, wooded savanna, grass savanna; B. Humid and sub-humid tropical evergreen forest; C. Permanent cultivation (wet rice). Ringed areas, known banteng localities; diagonal lines, probable distribution.

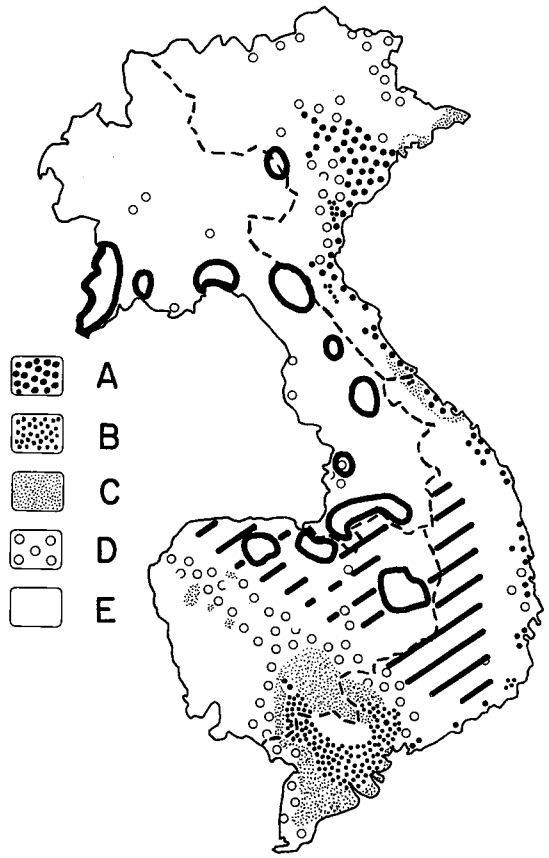


FIG. 12. Human population (per mi²) and banteng distribution in Cambodia, Laos and Vietnam. A. Over 520; B. 260–520; C. 130–260; D. 25–130; E. 0–25. Ringed areas, known banteng localities; diagonal lines, probable distribution.

The specific habitat requirements of banteng, and kouprey as well, were summarized by Wharton (1966) to include natural open areas (savanna forests and glades) with salt licks and permanent waterholes; a total range large enough to provide suitable refuge from disturbance, and patches of sub-humid forest offering cover, shade and higher humidity. The distribution of wild cattle in Cambodia lies within an area of fire climax savanna forest and arid savanna forest, Wharton (1957, 1966), with remnants of sub-humid decid-

uous forest. Wharton cited evidence for the regression of sub-humid forest and noted that by the agency of fire, savanna forest is still encroaching and destroying the original climatic climax in many places.

Dumas (1941) stated that banteng live in all the dry terrain of Cambodia, including sandy plains and rocky hills and that they rarely entered sub-humid forest. He noted that gaur, inhabiting the Chaine des Cardamomes and the Annamite Chain, were found in all the provinces of Cambodia, especially around forested mountains or hills surrounded by herbaceous savannas. Hoeur (1963) describes "incomparable" gaur habitat between the Mekong and Vietnam on the west side of the "Piste Richomme," an area of "tormented" physiography; hills, marshes and ravines near extensive savanna forest areas. Figure 12 shows that banteng do not occur in areas of permanent (wet rice) agriculture, and are primarily found in areas of very low (0–25 $mi^2$) human density.

## Effect of Man and Fire

Little is known of man in Cambodia prior to the early bronze-age Dong-Son civilization about 500 B.C.

The major impact upon northern Cambodia's soil and forests probably came from the Khmer. From the 2nd to the 6th century A.D. the Khmer and the Indonesian Fou-nanese began to clear the forest in Cambodia's Mekong Valley, going up the feeder streams, Bernard Groslier (pers. comm.). Angkor became the geographical center of a vast empire which included southern Thailand and Laos. According to Groslier, the entire area from southern Thailand to the Mekong was systematically occupied, cleared and irrigated around provincial cities, linked by canals. Rivers were controlled by a dam system, and road systems appeared in the 12th century. By the 12th century over-deforestation, soil exhaustion and perhaps climatic change had weakened the empire. Climate reached a warm "high" between 1000–1300 A.D., then began cooling rapidly, Dorf (1959). Following the collapse of the Khmer empire in the 15th century the survivors apparently turned to shifting cultivation which Groslier thinks must have aggravated the problems of deforestation, erosion and ferrolization of the soils between the 14th and 19th

centuries. Wharton (1966) maps the distribution of the ancient and present Khmer, indicating that withdrawal from, and abandonment of, much of the present wild cattle habitat has taken place. He was able to show that the few remaining inhabitants are dependant on hunting-gathering and the agency of fire to survive the long dry season, appearing to be in a state of coincidental cooperation with wild cattle.

Early travelers recognized the tremendous impact of man on northern Cambodia. Harmand (1876) found areas away from the main river entirely deforested and states that this "indicates forest devastation to which this ancient land was subjected through many centuries." Harmand (1877) later crossed the Dangrek range on the Thailand border and noted the frequent movement of villages, and the burned aspect of the country. Brien (1885) discussed fire-setting for the security of travelers and hunting. Bertrand (1952) entered Cambodia from the east and found dry-rice fields dispersed in a 5–10 km circle around villages—these *chamcars* differing from typical clearings in more humid jungle in that all the trees had not been cut down, although many incompletely burned stumps were observed. Traveling westward toward the Mekong he observed that these clearings gradually coalesced to form the familiar savanna forest landscape. Bertrand observed that the soil of new clearings was permeable to great depths. Dry rice culture is, he stated, possible solely on new ground; after repeated cultivations, an impermeable layer forms and the fertility diminishes, the yield dropping from 3 to 1 ton per year as the field passes from dry to wet rice.

In a well-mapped trip across eastern Cambodia from Kratié, Cupet (1900), crossed mostly savanna forest along the Prekté River. He emphasized that the entire route was on fire and offered no shade. He encountered the first readily identifiable clearings near Ban Don in Vietnam. On reaching the red earth of the Vietnamese plateau he found shifting cultivation in humid forest. He cites bandit activity at Lomphat and along the Srepok river which is quite near the Kouprey locality investigated by Paul Pierret on the 1964 expedition. Coincidentally, this same country was insecure in 1952 and 1964. These limited observations suggest that this part of Cambodia may have been a zone of conflict or perhaps a no-mans-land between the

Vietnamese tribes and the Khmers. That this buffer zone could have served as a refuge for banteng and kouprey during the Khmer era is an intriguing question. Additional habitat could have been found (in eastern Cambodia and southern Laos) in the foothills of the Annamite Mountains where shifting cultivation and fire had been employed by the aboriginal inhabitants long before the rise of the Fou-nan, Khmer, and Cham civilizations. Today these Mnong hill tribes have spread westward all the way to the Mekong, numbering about 68,000 in Cambodia, Wharton (1966).

Gourou (1940) indicates that 78 percent of Cambodia's rural Khmer population now lives on 18 percent of the land, a narrow band lying between flood stage of the Mekong (and Grand Lac) and the savanna forests. He noted the low (0.40/km$^2$) population of the savanna forests of eastern Cambodia. Today banteng and gaur occur in Vietnam, and along the headwaters of the Srepok River there appears to be a continuous band of savanna forest between eastern Cambodia and the Kontum plateau of Vietnam. Kouprey have been seen (Wharton, 1957) in this area in Vietnam.

## LAOS

### Wild Cattle Habitat

The present-day distribution of banteng in relation to vegetation is shown on Fig. 11. Chanthepha (pers. comm.) indicates the habitat of banteng in Laos to be "open savanna grasslands with scattered trees. . . . They are not found in more humid deciduous forests, nor in dense rain forests. . . . During the day they prefer to sleep in the bamboo area. . . ." According to the maps of Vidal (1960) and others, Laos along the Mekong appears to be a much more complex mosaic of vegetation types than does Cambodia. The vegetation map, Fig. 11, is only approximate. In general, Fig. 12 shows that banteng distribution roughly conforms to areas of low to moderate human population (areas modified by the agency of man and fire). Izikowitz (1951) cites data that the whole of Laos had, at that time, only 4 people/km$^2$.

## Effect of Man and Fire

The history of Laos is similar to that of Cambodia. Harmand (1879) spoke of the blackened, sandy plains, alternating with stunted forests and savanna forests. On mounting the volcanic plateau of Bolevens he found huge clearings with blackened stumps. Aymonier (1895–1897) noted in the region south of Attopeu that the Thekhuet and Brao tribes lived on "denuded mountains." Barthelemy (1899), who crossed southern Laos from Bassac to Attopeu spoke of the savanna forests as "the desert of Indochina," having only an illusion of shade and water. Cupet (1900) wrote that the presence of the Laotian Meo was indicated by immense treeless tracts; all summits of hills around 1400 m were nude of vegetation. Gourou (1940) pointed out the basis for the limited population in the mountains of Laos and Vietnam, indicating that in the Tonkin Delta 80 percent of the soil was cultivated against 5 percent in the mountains (4 percent in shifting cultivation and 1 percent in wet rice). He says shifting cultivation, as practiced by the Indochinese Montagnards, is a prudent-enough technique for soil utilization; far greater soil destruction results from annual fires in the grassy clearings so that their water buffalo may have young grass. The Meo cultivate "par le fer er par le feu" on the North Vietnamese Mountains. South of Tran Ninh the mountains are inhabited by Thi Moi (*Kha* in Laotian) numbering 800,000 people on the heights of the Annamite chain. Apparently (Gourou, p. 361) forests never exploited or modified by man are rare in Indochina. Gourou (1940) says savanna forests are due to climate, soil (poor sand or laterite) and always by the action of men. He indicates that man has taken a preponderant part in the formation and maintenance of the savanna forest and suggests the following procedure: a clearing fired at the end of the dry season, then in 3, 2, or sometimes 1 year the field is abandoned and another area cut. The burning of new clearings often fires the old and prevents denser forests from regrowth. Also, better pastures are provided by fire. The regression of the forest constitutes a national peril, according to Gourou. Repeated fire apparently destroys important bacteria indispensable for fertility, so that even *Imperata* will not grow, with inedible ferns or laterization following. Vidal (1960) stated that the

prime motive for burning was to obtain pasture for domestic cattle, and discussed the adaptations of the xerophilic trees of the savanna forests. Succession is summarized by Vidal: dense forest—(fire)—semi-dense forest—(fire)—savanna forest or savanna forest peniclimatic—(fire)—open savanna. From an ecologic viewpoint Vidal recognizes two types of savanna forest in Laos, a stable pseudoclimatic savanna forest of edaphic origin and an unstable peniclimatic savanna forest of anthropogenic origin. He says the savanna forest and open savanna are affected most by the ancient custom of burning; the fundamental objection is that fire stops soil evolution.

## VIETNAM

### Wild Cattle Habitat

Banteng in South Vietnam chiefly inhabit savanna grasslands on plateaus in the southern part of the Annamite Chain, Fig. 11. Vu Ngoc Tan (pers. comm.) indicates that banteng inhabit these areas in the rainy season but may be found in more humid deciduous forests from March to mid-May, which is the hottest part of the dry season. Some of the Vietnamese savannas are large: Bazé (1950) states that the Lagna savanna covered 65,000 ha. Huard and Maurice (1939) wrote of the eastern end of a 200 by 5 km band of savanna forest terminating at Ban Me Thout in the Annamite Mountains, occupied by Biat, Bouneur, Preh, Puthung and Ti-Pri tribes numbering about 7,000. They spoke of the undergrowth of bamboo grass (similar to that found in Cambodian savanna forest). Their map (p. 37) shows a zone of elephant capture, including this savanna forest region, which extends from Ban Don in Vietnam down the Srepok River and its tributary, the Dak Dam, well into Cambodia.

The Darlac Plateau of South Vietnam is a famous hunting area. Ngo Van Chi (pers. comm.) told me in 1963 that there were approximately 2,000 banteng in one valley alone, and estimated the population of gaur on the Plateau de Cannes at 500.

Mochi and Carter (1953) mention gaur in "Indochina" which "came down from the hills shortly after the natives had burned off the grass and canes of the lowlands. . . . If disturbed, they took

refuge in the eight-foot stands of elephant grass from where it was impossible to dislodge them without the aid of elephants."

As Fig. 11 suggests, banteng are not found in areas of permanent agriculture and Fig. 12 shows that banteng occur in an area of low (0–25 $mi^2$) human density (where shifting cultivation is prevalent).

## Effect of Man and Fire

The tribes occupying the Annamite chain are generally lumped by most authors into the category of *Moi* stated by Gourou (1951) to number about 800,000. Four-fifths of Indochinese live on coastal slopes or 1/10th of surface area, Izikowitz (1951). Dobby (1967) refers most Moi to the Nesiot tribe and states that "some (Ho, Yau, Meo, Lao, Neua, Dam, Deng, and Lu) are related to the woolly-haired Negritos."

Travelers early noted the devastation produced by the *Moi.* Human (1884) said "the Moi devastates everything." Consigny (1936) stated that the Dalat pine forests are "without doubt secondary to old dense forest." Here fire has degraded the soil, leaving an arable layer only a few centimeters thick over a compact clay. Consigny passes on the often quoted, "pas de feux, pas de gibier" ("no fire, no game"). Huard and Maurice (1939) called the groups on the central Indochinese plateau (Cambodia's eastern border) *Mnong* (he excluded the Rhadé, Djarai and Stieng). The *Mnong* apparently occupy the basaltic "red earths" that can be cultivated as long as 4 years, supporting a density of 8/$km^2$. At that time 16,000 Mnong occupied 10,000 $km^2$ (1.6/$mi^2$). Basaltic regions encompass 30,000 $km^2$ in South Vietnam.

Open forest, partly in Cambodia and partly in Vietnam, was *Mnong* hunting territory, a no-man's-land between the *Mnong* called Biat in Cambodia, Huard (1938), and the hill Djarai, a country alternately dry and ravaged by fire or waterlogged. Earlier (Cupet's time, 1879–1895) the population was destroyed by bands of Laotian, Khmer and Rhadé slave raiders. In this area, now wild cattle range, Bartlett (1961) interprets Huard and Maurice as saying that this infertile region would only produce one crop of upland rice when cleared, and required 50 years for regeneration; as a conse-

quence the former population was almost truly nomadic over a large area.

Bertrand (1952) discusses the Cilis and Ma tribes who cut and burn in the Haut Donnai region at the extreme southern end of the Annamite chain near Djiring, and Dobby (1967) states that a million hill tribesmen exist in Indochina. Gourou (1951) redefined land use in the Indochinese uplands (population 2,000,000) as including 400,000 $km^2$ with an average human density of 5/$km^2$. The Annamite chain, however, supports only 3/$km^2$; about 23,200 $km^2$ are occupied annually. Since malaria is rampant from the lowest slopes to 1500 m owing to *Anopheles* which breed in mountain streams, Gourou (1951) feels this is an important factor in low populations. In some areas, such as the calcarious Don Hoi mountains, physiography is such that 6,000 $km^2$ is uninhabited by man.

Izikowitz (1951) studied the Lamet hill peasants in North Vietnam near the Burmese border (altitude 500 to 1500 m). The ridges are heavily used, malaria in the valleys being the chief reason given. Lamet population density is 2.9/$km^2$ over a 2000 $km^2$ area. Deer and gaur are abundant. The population was confined to 103 villages. This author states that the Lamet do not overcultivate like the Meo and other tribes who have degenerated their clearings into what he calls "steppe."

Lafont (1959), surveying slash and burn agriculture in central Vietnam indicates that the region contains 1,200,000 proto-Indochinese, the most important tribes being the Djarai, Rhadé, Bahnar, Mnong and Sedang. He states that many of these mountain peoples (unlike the Lamet), let yearly brush fires cause degeneration of clearings into savannas of *Imperata*, and states that lands described by explorers 60 years ago are now merely desert. He states that one-third of the land in Kontum district is abandoned. He cites general mass migration, such as the movement of Djarai towards Cambodia.

In his book on "forest-eaters," Condominas (1957) presents a study of the Mnong-gar, a semi-nomadic band of Moi on the middle fork of the Srepok (500 m altitude) in wild cattle country, stating that most forests between Dalat and Ban Methuot have been destroyed by man.

## MALAYA

### Wild Cattle Habitat

Harper (1945) cited Hubback's (1932) information that a herd of banteng repeatedly crossed from Siam to the Malayan states of Perlis and Kedah on the extreme northwestern border. It is perhaps more than coincidental that the forest habitats of this most northern part of Malaya differ from the rest of the peninsula. Dobby (1951) states "towards the north, the uplands suffer from a drier season and their climate represents an early transition from equatorial to monsoon type. There the shifting agriculture shows particularily prominently on the landscape, partly because the rate of vegetative regrowth on an abandoned clearing is slowed by the drier season, partly because the population of aboriginals is somewhat denser. . . . For these reasons the landscape of that bushy vegetation typical of secondary forest growth is commoner on north Malayan uplands than elsewhere. . . ."

According to Lord Medway (1965b) a few banteng (*Bos javanicus*) have been reported from northern Malaya and he states (pers. comm.) that its habits and the confirmation of its occurrence is not documented.

The gaur, however, is quite widespread in distribution. Figure 13 shows that, in general, gaur do not occur in areas of permanent agriculture, but in the tropical evergreen lowland forest or where this formation joins the hill forest. Distribution in this originally dense forest community is apparently made possible by shifting cultivators, borne out by the numerous small localities shown by Medway.

Ogilvie (1954), acting chief game warden of Malaya, observed gaur for over 7 years, and was able to repeatedly study a herd within 30 yards of his outbuilding in King George V National Park. He was the first to describe a mutualistic relationship between wild jungle fowl and these ponderous beasts. This author stated that ". . . chiefly due to our primitive people . . . they are able to enjoy rich grazing which would not otherwise be available. Primitive man with his shifting cultivation fells the forest, grows and takes off his crops, and moves further on to fell again. This leaves

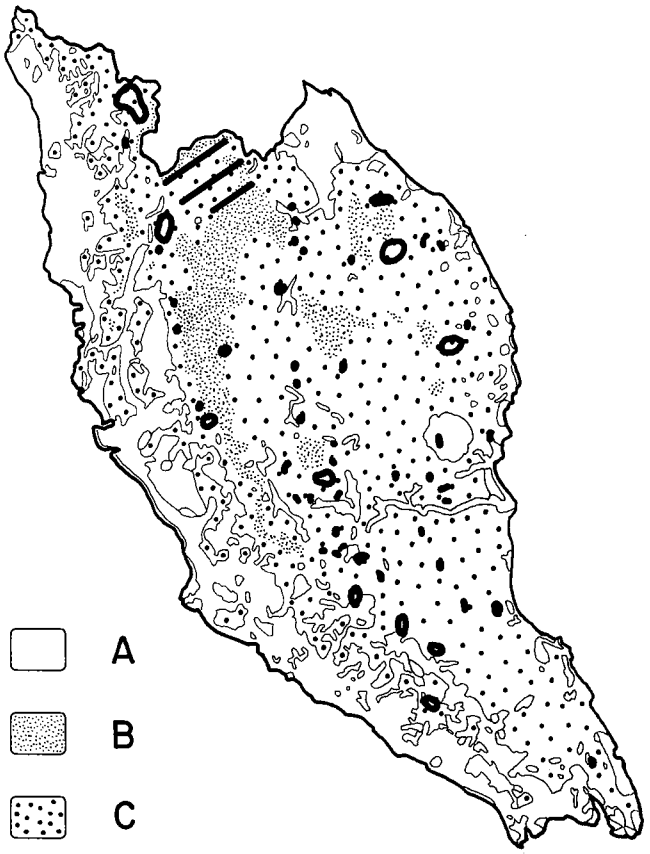


FIG. 13. Vegetation, cultivation and gaur distribution in Malaya. A. Permanent cultivation, mining, coastal littoral; B. Tropical evergreen hill forest; C. Tropical evergreen lowland forest. Ringed and irregular solid areas, gaur localities; diagonal lines, probable distribution.

abandoned areas which for some years produce luscious fodder for the *seladang* before reverting to secondary forest." Lord Medway (1965b) states that "*seladang* are not true forest mammals but favour the banks of large rivers, abandoned clearings of shifting cultivation, forest glades and other open situations where grazing is available." He states that there is no suitable habitat above ca. 1,000 ft "so that *seladang* are rare or absent in the remote hills of the interior." He

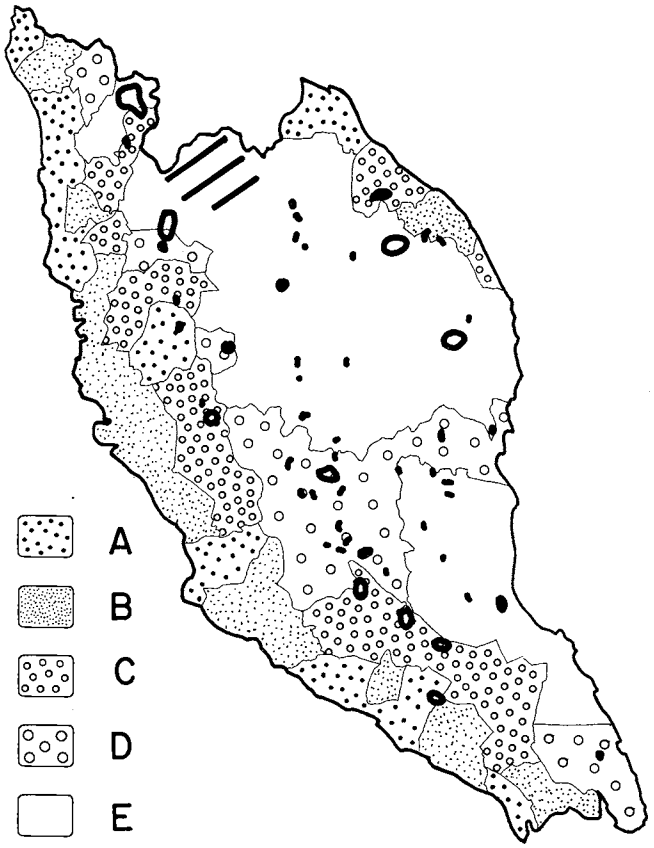


FIG. 14. Human population (per mi²) and gaur distribution in Malaya. A. 200 to over 300; B. 100–200; C. 50–100; D. 25–50; E. 0–25. Ringed and irregular solid areas, gaur localities; diagonal lines, probable distribution.

states further that ". . . it is unlikely that any significant portion of the *seladang* population of Malaya exists far beyond the limits of peripheral human settlement." The distribution of the gaur in Fig. 13 is taken from Medway (1965b). Pelandok (1938) states that gaur feed mostly on a variety of grasses, chiefly on young shoots in burnt fields of *Imperata cylindrica*, on grasses that grow luxuriantly in abandoned Sakai clearings, on the edges of swamps, on young bam-

boo and on wild ferns. He documents the almost daily presence of gaur in new plantations of oil palm in Pahang province. Theodore Hubback, formerly chief game warden for Malaya, is recognized as an authority on the Malayan gaur. Hubback (1939) states, "the *seladang* is a forest-edge animal and its habitat is not virgin forest, although it is often forced into heavy forest." He believes it unlikely that the gaur is indigenous to the Malay Peninsula and supposes that it "came down through Siam and Burma to the Malay Peninsula following the cleared spaces of the early settlers in Malaya." He also cites the bright bay color of the calves as evidence that the gaur is, basically, a grass-country animal. Hubback feels that the origin of the Malayan gaur is important in considering their habitat and reaction to civilization, for "we must consider carefully the artificiality . . . of their present existence." Grasses preferred by gaur are listed by Hubback as those associated with clearings and open areas, and he states that the leaves of at least two trees of the secondary jungle (*Trema amboinensis* and *Eugenia zeylanica*) are eagerly sought. Fig. 14 indicates that most gaur are found in areas with from 0 to 50 people/mi$^2$; some are shown near the boundaries of areas of higher population. The scale of the map shows uniformity whereas, in fact, the human population is clumped, so that Fig. 14 does not reflect the actual association of gaur and man in some cases. The 1957 census reported by Ooi (1963) calculated 41,360 aboriginals in Malaya, 65 percent of whom practice shifting cultivation with a direct bearing on gaur distribution.

## Effect of Man and Fire

The rolling terrain occupied by the gaur is essentially the country utilized by the shifting cultivator. Less than 1 percent of the Malayan population lives above 500 ft, Dobby (1951). Among these people 7 percent were Negritos of the Semang and Pangan tribes who do not damage their environment. These hunter-gatherers were estimated by Ooi (1963) to number about 1,000 in 1957. About 65 percent of the remaining aboriginal population, according to Williams-Hunt (1952), practices shifting cultivation. These are chiefly the caucasoid Senoi (Sakai) whom Dobby (1951) reported to clear 10,000 acres/year. Rice was a novelty to these primitive peoples—they traditionally

utilized clearings for root crops and bananas, although Annandale (1903) stated that some Sakai raised millet. The Senoi peoples are found in the foothills and valleys surrounding the central range of Malaya's mountains. The Jakun or aboriginal Malays, who inhabit the southern half of Malaya, also practice shifting cultivation. The distribution of the gaur appears to coincide with these two cultural groups. Although 78 percent of its land surface is under forest, according to Wyatt-Smith (1958), no figures are available as to what percent of this is secondary growth resulting from shifting cultivation.

## SUMATRA AND JAVA

Banteng are not presently know from Sumatra. There are opinions that they existed there in the past. While thinly populated (17.43/km$^2$ Mohr, 1938), Sumatra has felt the heavy hand of man, particularly in the areas which would have been optimum cattle habitat. The soils are apparently much older and less rich than those of Java, volcanism occurring only in three or four places. As early as 1928, Bartlett (1928) wrote of the fast disappearing flora of Sumatra due to clearing for tobacco, rubber, tea and oil-palm plantations. Ooi (1958) discusses the tremendous impact of shifting cultivation practiced by Dutch tobacco planters.

Banteng are present on Java, having been domesticated in certain areas—the herds on the island of Bali are renowned. Java is one of the densely populated countries of the world, some districts having extremely high *average* populations, in rural areas ranging from 75/km$^2$ to 1000/km$^2$, Mohr (1938), to 2000/km$^2$, Geertz (1963). Mohr relates this demographic phenomenon to juvenile volcanic ash-soils along with sufficient rainfall. Bartlett (1961) interpreted Herwerden as stating that "as a result of rob-agriculture (shifting cultivation) the primary forest that originally covered most of Java had been gradually replaced by second-growth and *alang-alang* grasslands . . . the western part of the Preanger region was still a forest about 1650. . . . Eventually circumstances forced the development of *sawahs* (wet rice fields) where irrigation was possible, and the utilization of the degraded irrigable grassland for grazing.

. . . In less favored districts deforestation resulted in . . . degradation of forest to mostly waste grassland. . . ."

No communication was received from the Republic of Indonesia regarding the distribution of banteng in Java. Hoogerwerf (1938) made careful observations of banteng in the Oedjoeng-Koelon Reserve created in 1921 on the western tip of Java, where banteng are concentrated on the peninsula's northeast coast, "in an open terrain, savanna or park-like." He stated that the presence of banteng was probably due to the old man-made *ladangs* (clearings from shifting cultivation) which were burnt to prevent their reforestation. These clearings were, in 1938, becoming rapidly overgrown, with serious consequences for the survival of the banteng population. Apparently clandestine burning is keeping open what little suitable habitat remains in this essentially humid climate. Hoogerwerf attributed the poor condition of the animals to their limited grazing. He cited several comparisons of the condition of the Oedjeng-Koelon banteng with banteng in other parts of Java. He never saw tracks or evidence of banteng in the humid forests, "In the heavy forest that covers most of the peninsula and when the undergrowth is mainly bamboo, salak, rattan, etc., I did not find any tracks of banteng. . . . The entire life of the banteng is spent in the more open parts of the reserve and in the light forest which is nearby."

Hoogerwerf found comparatively large numbers of dead banteng over a period of 3 years and reported that, in his opinion, they had fallen victim to disease or parasitism because of undernourishment. He noted that they may be subject to parasitic infestation by *Fasciola hepatica* and *Paramphistomum cervi,* and the possibility that in wet weather they are forced, by the absence of fire-caused clearings on high ground, to utilize marshes where they probably acquire the infections.

## BORNEO

### Banteng Habitat

Figure 15 indicates that, for Kalimantan at least, banteng are largely found in secondary forest associated with shifting cultivation,

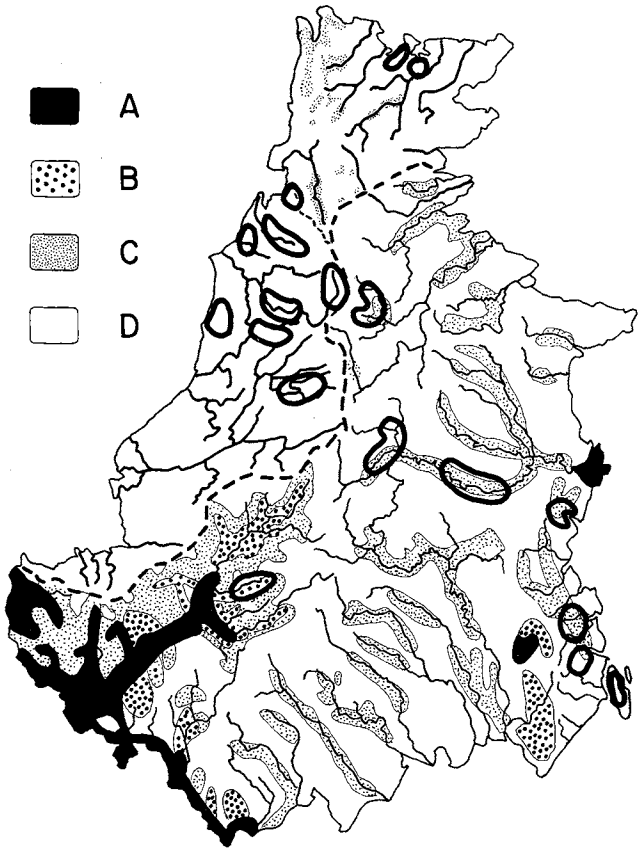


FIG. 15. Vegetation of Kalimantan, secondary forest with shifting cultivation in Sabah and Kalimantan, and Banteng distribution in Borneo. A. Cultivated (chiefly wet-rice); B. Savanna grasslands; C. Secondary forest with shifting cultivation; D. Tropical evergreen forest. Vegetation and cultivation omitted for Sarawak. Ringed areas, banteng localities.

and the general pattern of shifting cultivation can be seen to be along the rivers. Since most banteng localities in Sarawak lie on major rivers, the same probably holds true for this country.

Low (1848) indicated that in Sarawak banteng lived chiefly in bamboo forests along the Sangow and Baram Rivers. Beccari (1904) noted that the banteng is not scarce and "keeps to the jungle . . .

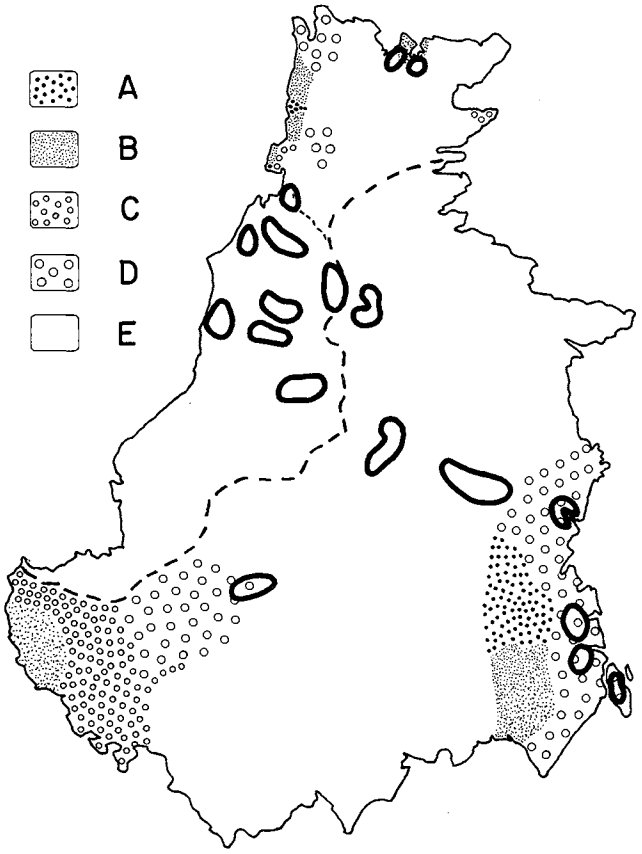


FIG. 16. Human population (per mi²) and banteng distribution in Sabah and Kalimantan, Borneo. A. 125–313; B. 63–125; C. 25–63; D. 13–25; E. 0–13. Ringed areas, banteng distribution.

especially to the forest of second growth, in the interior." He refers to the banteng's liking for bamboo shoots, indicating that it sought secondary forest for this reason ". . . it is rarely met with in the primeval forest." Beccari, a keen naturalist, describes secondary Bornean forest as characterized by trees of small size dominated by Euphorbiaceae such as *Mallotus* and *Macaranga*. The authority on Bornean mammals, Lord Medway (1965a), states that banteng were

"formerly at least widespread on the mainland of Borneo confined principally to riversides and areas of secondary growth succeeding shifting cultivation." Anderson (pers. comm.) indicates that in 1967 few banteng existed in Sarawak. He noted that they are found in secondary forest but may move through primary rain forest from one area to another, stating "it is also likely . . . to take shelter in primary forest on the margins of secondary forest or cultivation." No information is currently available from Sabah. Gaur do not occur in Borneo. According to Lord Medway (pers. comm.), banteng appear to replace it ecologically.

While there are no data from Sarawak for human population on Fig. 16, banteng distribution in Kalimantan coincides with areas of low population density. Banteng distribution in Sarawak, Fig. 16, coincides with areas of low human population as given by Hodder (1956, p. 75). Freeman (1955) gave the density of the Iban in Sarawak's interior region of Balok at two to three families/mi.$^2$; Hodder gives Sarawak's population at 13/mi$^2$, but most of these people live along the lower courses of the principal rivers. Harrison's (1964) 1960 census figures for inland and hinterland areas list 323,300 people in Sarawak and 24,000 in Sabah.

## Effect of Man and Fire

Extensive areas of Borneo have been converted to secondary forest or, with too frequent rotation and fire, grasslands of *Imperata cylindrica*. Poore (1964) quoted estimates that 20 percent of Sarawak is under shifting cultivation or degraded into grasslands. While the Iban of Sarawak do not appear to cultivate above 1,000 ft, the Dusun of Sabah may cultivate to 3,000 ft. In 1950 most of the terrain from 500 to 3,000 ft. appeared (Fig. 17) to be a mosaic of cultivated fields alternating with all stages of fallow brush and forest. If the banteng is indeed dependent on shifting cultivation for browse and pasture, the antiquity of such a practice is quite pertinent. Since the last submergence of the Sunda Shelf banteng have survived in an area composed of 75 to 85 percent rain forest. Prior to its association with man's shifting cultivation, banteng may have existed only on extensive alluvial plains extending as much as 100 miles inland in Sarawak. Hunt (1837) observed large grasslands on the Bornean plains

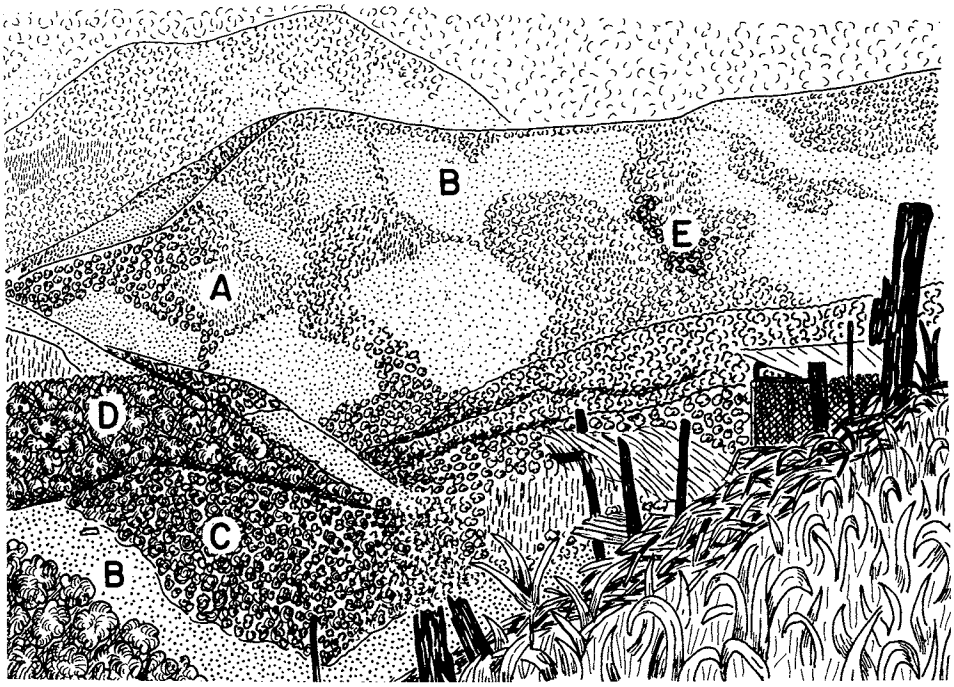


FIG. 17. Shifting cultivation in Sabah, Borneo. From a photo looking at the southwest flank of Mount Kina Balu. Generations of Dusuns have removed nearly all the original vegetation up to the 3000 ft level (about the top of the figure). When the field is in use the shelter is occupied to warn off hungry birds and mammals. The entire field of view is a mosaic of secondary succession in various seral stages: A. Recently cut and burned (bamboo stage); B. Shrub-height fallow, following abandonment; C. Older fallow (mixed shrub-young tree stage); D. Old fallow approaching a closed canopy; E. Relict mature trees, probably a ravine or rocky terrain.

and stated, "It is at this season that whole herds of wild cattle range down from the mountains in the interior to fatten on the plains, but during the wet season they ascend to their hills." Hunt thought these extensive grasslands along the lower rivers were of natural, not ruderal origin. Bartlett (1957, 1961) concurred but implicated post glacial silting as the reason, rather than flooding from the 12 foot differential between wet and dry season levels of the larger rivers as

postulated by Hunt. Following the discovery of the Nias skull, Harrison (1964) was able to document the presence of modern *Homo sapiens* in Borneo at 35,000 B.P. Negritos existed in Borneo in the late Stone Age but have since perished. Hunting and gathering cultures are today represented by some 15,000 Punans in Kalimantan and Sarawak. The Punans and the Ukits do not modify the forest, indeed they are markedly photophobic. According to Haddon (1901) all other Bornean interior tribes engage in shifting cultivation. He states that 1,000 years ago Borneo was occupied by a weak, agricultural people (land Dyaks, Murut, Dunsun, etc.) who were pushed out by the migration of Kenyah and Kayan, who in turn were forced into the headwater areas by the sea Dyaks (Iban). Burns (1849) estimated 17,000 Kayans on the Rejang and Baram watersheds, already skilled in smelting native iron ore. According to Freeman (1955) extensive destruction of large areas of virgin forest could not be followed by a neolithic people.

Mohr (1938), speaking of the South and East Division (with a human density of 1.4/km$^2$) states, "Extensive forests and fields of grass vegetation cover the mountains, hills and plains and marshes. All this country is uncultivated. The population lives only along the banks of rivers." Hahn (1950) wrote, "In West Borneo the original jungle has made way for rolling fields of yellow grass ("alang alang", *Imperata arundinacea*) extending over large areas."

Harrison (1964) presented evidence that the first Iban crossed the central Bornean mountain range and entered Sarawak 450 years ago. Freeman (1955) indicated that they became semi-nomadic in Sarawak about 1863, some families moving over 50 to 100 miles of territory. He found that each family required 4.6 acres of hillside for support and estimated that 241,000 Ibans were engaged in shifting cultivation. Hodder (1956) indicates that 500,000 acres of Sarawak's jungle and scrub are cleared each year.

The huge Bornean rivers (Beccari, 1904, found the Rejang to be 300 ft deep and possessing freshwater elasmobranchs) have long been major routes into the interior. It appears that the stronger groups of shifting cultivators moved up these streams farther and farther, sometimes under the impetus of more aggressive peoples leaving behind

extensive areas of secondary forest, and sometimes grassland. Grabowsky (1908) stated that the middle and upper Kapuas (Kalimantan) had extensive areas of deserted fields with grass and low brush, perhaps a reason for the migration of some Iban across into Sarawak as discussed by Harrison.

It seems likely that banteng followed in human footsteps, even crossing the high central range of Borneo. Lord Medway (1965a) quotes Harrison who observed that banteng cross the watershed divide from the headwaters of the Batang Kayan river in Kalimantan 50 miles to the Kalabit uplands of Sarawak. Lord Medway quotes Banks who states that domestic banteng were kept by the Kalabits. It is interesting that Harrison (1964) considers the Kalabits, who occupy the headwaters of the Baram River, as one of Borneo's few culturally and topographically stable groups.

## DISCUSSION AND SUMMARY

From the foregoing account of the relationship of wild cattle to climate, vegetation and human land use, it is now possible to more closely define their habitat and niche.

The gaur appears to avoid evergreen rainforest, preferring foothill tracts of sub-humid or deciduous forest adjacent to savanna forest, glades or other open terrain affected by man and fire thus co-existing with and exploiting low human populations in hill zones with moderate to heavy rainfall.

The banteng avoids evergreen rainforest and is confined to savanna forests within the drier deciduous forest zones of the continent. In more humid areas such as the Malayan Archipeligo, banteng live in secondary seral stages following the alteration of the original forest by man and fire, although they may enter tracts of sub-humid forest on occasion. Apparently the two animals are adapted to different niches. The color and larger size of the gaur would seem to support this assumption. In Cambodia I have observed gaur, when disturbed, to run directly for heavier forest, while banteng did not; there may be other behavioral differences. A careful study of the foods eaten by the two species is needed.

The absence of banteng in Malaya may be explained by the paucity of savanna forest, or clearings so contiguous as to provide the typical open canopy habitat. On the humid Tenasserim coast of Burma and to a great extent in Borneo, areas normally supporting evergreen forest, banteng are found only in riverside savannas and post-agricultural clearings.

If the gaur has truly followed shifting cultivation into Malaya perhaps its absence in the remainder of the archipelago can be explained by either the absence of, or lack of continuity in, the migration of shifting cultivation from the mainland out through the archipelago prior to the post-glacial rise of sea over Sundaland. Shifting cultivation is presumed to have begun not earlier than 12,000 B.P., Spencer (pers. comm.). Apparently hunter-gathering cultures were not able to seriously modify the forests of the present emergent parts of the archipelago even with fire, except in parts of Java, whereas in the monsoon regions these primitive peoples could have been serious modifiers since the Pleistocene.

The presence of the gaur in highly populous India is probably due to the concentration of human population in villages as well as to diverse microclimates and habitats wet enough to counteract fire, particularly in the Western Ghats and Assam. There were apparently enough unexploitable steep ravines and rocky terrain to have sheltered nuclear herds of gaur in spite of multiple waves of immigrant peoples. The aversion to beef eating must likewise be considered. Thus it is that gaur feed today among prehistoric stone dwellings in India as do kouprey, gaur and banteng in Indochina.

The movement of and differences between tribes and cultures in much of southeast Asia have tended to create buffer zones, as along the western fringe of the Vietnam highlands, which may have afforded refuge for grazing herbivores during the flowering of the Khmer civilization. Such large scale human movements and land use apparently did not take place in Malaya or the Islands of Sundaland.

It is more difficult to explain the absence of banteng in India, where extensive tracts of forests, notably sal, would seem to afford ideal habitat. The simplest solution is to postulate that banteng never existed west of the Arakan Hill Ranges dividing India and

Burma. Otherwise one must resort to stating that the intensive past use of Indian environments by successive groups of immigrants left insufficiently large buffer refuges to shelter a banteng population, particularly in the face of disease and competition from domestic stock introduced at least by 2000 B.C.

It is in Assam that one begins to encounter a long-existant division of the human population into savage hill tribes and peaceful wet land agriculturists. In the main, the inhabitants of the hill tracts of Assam and Burma and Indochina appear to be immigrants from the north who directly replaced the hunting-gathering groups. In India, on the other hand, it appears that successive cultures appeared to drive valley peoples into the hills. The long occupancy of the Assam-Burma mountain area enabled the peoples to domesticate the gaur, (Mithan or Gayal). Thus strong groups of hill tribes occupy the great highland land masses of Assam, Burma, Thailand and Vietnam; hardly comparable "land islands" exist in peninsular India.

The persistance of banteng in Java until recent years may be due to several factors. According to Batchelder (1967) Java possesses a dry deciduous forest in its easternmost sector which experiences a seven month dry season. Westward the dry season shortens markedly, until on the extreme northwest coast its duration is about one month. Eyre (1963) shows monsoon forest along the northern coastal rim of Java; it is also the dominant cover on the Lesser Sunda islands including Bali, Lombok and Sumbawa. Thus Java, and perhaps Bali, may have provided a natural refuge for banteng with the drowning of Sundaland, as neither Borneo, Sumatra or Malaya apparently offered any dry season or monsoon forest in the lowlands. Also, the rich, young volcanic soils of Java could support extensive shifting agriculture and a larger population than either Sumatra or Borneo, hence the availability to the wild cattle of extensive areas in rotational fallow in parts of the island too wet for the formation of savanna forest. Normally, shifting cultivation is associated with areas of low human density. That the banteng cannot continue to live in the Javan evergreen forest where the human population has withdrawn, is attested by Hoogerwerf's observations in Oedjoeng-Koelon.

Unless banteng were brought by man to Borneo, relict populations have apparently persisted there on edaphic and perhaps fired grasslands on the extensive alluvial plains, following man into the interior only along the routes of abandoned clearings bordering the major rivers.

Thus banteng occur in abandoned savanna forest where the soils are poor and degraded, or occasionally in areas with volcanic hill soils and a human population sufficient to keep evergreen forest in secondary successional change. Malaya, too wet to support extensive monsoon forests, could not offer the soil and resulting human density in the hill country that would culturally simulate a savanna forest as has come about in parts of Java.

No country in southeast Asia appears exempt from extensive modification of its forests by man and fire, from low alluvial plains fringing populous wet-rice areas to high altitudes in mountainous tracts. While the present-day modifications are attested to by both recent clearings and extensive savanna forest now abandoned by agricultural man, the pre-history of man and fire in the area is less well established.

The Chenchus of India, apparently living descendants of the primitive hunter-gatherer tribes, use fire for non-agricultural purposes today as their progenitors probably did. The primitive Byga tribe, who preceeded the Gond and Aryan in India, was intensely destructive to the forests. There are abundant sources cited by Stewart (1956) that aboriginal man has used fire since time immemorial. Van Steenis, in a discussion following Sauer's (1956) article, refers to the rapid rate of forest destruction by the stone age people of New Guinea today. Iverson (1956) proved that it would be possible for Neolithic man to clear large areas of forest using only crude flint axes and fire.

There are reasonable conclusions that tuber-planting agriculture originated along the coasts and river banks of southeast Asia ca. 13,000–9,000 B.C., Sauer (1952) and Wissman (1956). Wissman thought that these first agriculturalists then invaded the monsoon forests of the interior. There they must have encountered the nomadic collector-hunters, who, if their ways have not changed, had already been firing the forest for thousands of years. Stewart (1956) sug-

gests that the cultivation of millet and buckwheat, apparently adapted to the savanna margins, enabled man to complete the invasion of the drier zones of India and Burma. Presumbly, at or about this time, rice supplanted taro and higher populations became possible, particularly in the wetlands.

Owing to the much slower rate of recovery of monsoon or deciduous forest with extended dry seasons, Geertz (1963), Phillips (1963), fire was able to extend far beyond what might have been small, original clearings in the Asian hinterland. Since fire so materially aids hunting and gathering in the savanna forest areas today, Wharton (1966), there is no reason to assume that it was not equally useful during prehistoric times. Since fire was definitely used by Neolithic peoples and propably by Paleolithic man, it would appear that the savanna forests of southeast Asia may be ancient indeed, although the need to make better evaluation of an indigenous fauna, or lack of it, is obvious.

That shifting cultivation has been more extensive in southeast Asia in the past is made clear by Spencer (1966). His interesting map (p. 18) indicates that this form of agriculture is now remnental over most of peninsular India, Thailand's Korat Plateau, the southern Vietnamese highlands and Malaya. East of the Brahmaputra, shifting cultivation today involves the majority of humans living in mountain and hill tracts. In the rich sedimentary valleys enclosed by these mountains, shifting cultivators have invariably been assimilated into the more advanced wetland culture. According to Spencer's map, not a single remnant of shifting cultivation exists in Java, in marked contrast to Sumatra and Borneo.

Figure 18 is an attempt to diagram the relationship of man and wild cattle in southeast Asia east of India. Assuming that banteng habitat is typically zone B, gaur, originally perhaps a zone A-B inhabitant, could adapt to zone A with sufficient shifting cultivation by hill tribes. Zone B has been thoroughly inhabitated in places by great civilizations of the past, but fire and soil degradation defeated permanent occupancy. During this time, zone A-B may have acted as a buffer between these advanced cultures and the independent hill tribes, at the same time acting as a refuge for banteng and kouprey in the nature of the intertribal buffer zone between the

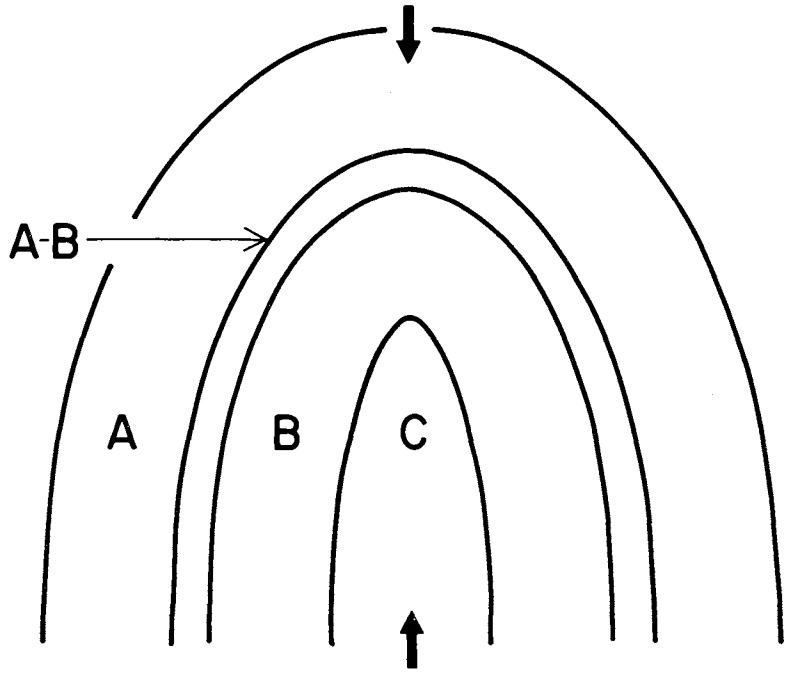


FIG. 18. Diagrammatic representation of the relationship of man and wild cattle in southeast Asia from Assam to Indochina. A. Zone of evergreen forests occupied by hill tribes with shifting cultivation; gaur characteristic; B. Drier zone of deciduous forest, now savanna and mixed deciduous forest largely abandoned by man; banteng characteristic; A-B. Buffer zone between peoples occupying A and, formerly B; original gaur habitat, refuge for all species; C. Zone of wet-land agriculture and dense population. Arrows indicate direction of human immigration.

North American Sioux and Chippewa Indians which acted as a refuge for the virginia deer, Hickerson (1965). Human withdrawal from zone B has resulted in its reoccupation by wild cattle.

The pattern of soils and human occupancy of India suggests departure from this schematic plan more characteristic of Burma, Thailand and Vietnam. Some soils, such as the 20,000 $mi^2$ of the Deccan trap are black and rich, Ammal (1956), and may have supported high populations so long that wild cattle not adaptable to heavy ravine forest and thick scrub jungle could no longer exist.

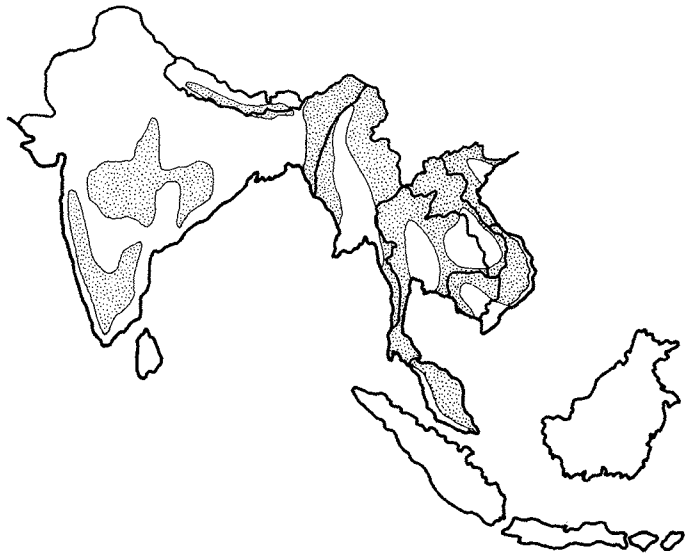

FIG. 19. Present general distribution of the gaur in southeast Asia. Where its distribution overlaps evergreen rainforest, the animal occurs in areas subject to shifting cultivation.

FIG. 20. Present general distribution of the banteng in southeast Asia. Presence of wild banteng in Java unconfirmed.

We may conclude that the living wild cattle of southeast Asia appear intimately dependent on an environment which is, if not entirely created by man and fire, certainly maintained by these agencies. Their survival has apparently been possible by the fortuitous combination of human activity and monsoon climate acting upon characteristic terrain and bedrock.

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