

SOME INTERRELATIONS BETWEEN AGRICULTURE AND FORESTRY
PARTICULARLY IN THAILAND.

Illustrated with Photographs by the Author

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This paper is an attempt to briefly call attention to some of the less well-known facts and relationships between forests, climate, and agriculture. In the humid tropics agriculture and forestry are very closely related, as contrasted with conditions in temperate regions where, at least in some respects horticultural, agronomic, and forestry methods and practices are relatively distinct. Inasmuch as "forestry" methods are being increasingly important in the conservation and management of the soil in tropical regions, and inasmuch as the methods of producing certain "upland" crops are not generally understood, it seems worth while to briefly consider some of these methods. Certain misconceptions regarding the interrelationships of forests and climate are also mentioned, because of their intimate relation to some of our agricultural problems. A rather different emphasis regarding these interrelationships may be noted, hence some of the statements may seem radical. This emphasis is not by chance; its purpose is to attempt to "debunk" certain conceptions regarding the effects of forests which, tho generally held, are still far from being definitely proved.

DENDROPHOBIA.

The pioneer in the forested regions of the world must fight the forest back and clear the land in order to plant food crops and to get open land whereon he may pasture his animals. Trees are thus the pioneer's enemy, or at least the pioneer considers them such. This is particularly true in tropical rain forest regions, and especially is it true in southern Thailand. Often the value of forest trees to the farmer is appreciated only after it is too late to conserve any of the natural forest resources. Then only after much effort in reforestation can worth while trees be had. Incidentally, one wonders how the peculiar relationship between the baynan or strangling fig (*Ficus* spp;

ton sai) and ghosts arose; in the Philippines there is the same reluctance to cut down trees of this sort.

Dendrophobia, with which the pioneer is so strongly afflicted, seems to persist even in the minds of many engineers; it is a characteristic especially manifest when improvements are under way, such as those made in the modernizing of towns. While it must be admitted that tree roots do play havoc with pavements and sidewalks, and the shade of trees does prevent macadam roads from drying out rapidly, too often the first step in town "improvement" is to clear away all the shade trees, no matter how beautiful they are.

While to the resident of Bangkok teak forestry and logging as contrasted with rice farming on the central plain here may seem as far apart as can be, and still be related to the soil, there are close relationships for the country as a whole between agriculture and forestry. In this and in other countries farmers are learning that it pays to plant and utilize trees as well as the more short-lived crops.

FORESTS AND CLIMATE.

Can climate be affected by forests? There is a very general belief that such is the case, that cutting off the forests decreases the rainfall over the cut-off region, and that planting forests in a previously unforested region increases the rainfall. There is, as yet, however, insufficient proof that forests have any such effects. In the first place, the important air movements which cause rain, and which determine other features of the climate are the result of air movements extending to great heights and over great distances. Masses of cold air coming from polar regions, enormous depressions (typhoons) many hundreds of miles across coming in from equatorial regions to the southeast and east of Thailand, and the monsoon winds which are due to the high summer heating and the intense winter cooling of central Asia are the important factors in the determination of the climate of this country. Changes in the forest cover have little or no effect upon air movements of such far-reaching extent. As yet, for Thailand all the relationships are not well understood, but we may say, in general, that the forests have no proved effects on climate, nor on the total precipitation in particular.

On the other hand, forests and other vegetation do have an important effect upon the hydrologic relationships of any region, and particularly on those of Thailand. Some of the reasons for this effect are as follows: Roughly 20% of the total rainfall which falls upon a dense tropical forest never reaches the ground at all.⁽¹⁾ Of the 80% of the rainfall, which does reach the ground, a part runs off over the surface of the ground, a part evaporates directly into the air, and a part percolates into the soil. The proportion of the water which percolates into the soil is increased by the leaf litter and other organic matter on the surface of the soil which has come from the forest trees; this covering prevents the soil from being stirred up by the raindrops and so prevents the soil pores from being clogged; the organic matter on the surface also retards the speed of such water as runs off over the surface. Of the water which percolates into the soil, a considerable part is taken up by the roots of the forest trees, for, in order to carry on its life processes the average tree cannot prevent losing through its leaves from 200 to 1,000 times as much water, by weight, as the gain in plant substance by growth. For example, a single tree weighing a ton, in order to have been able to have grown to that size, must have transpired between 200 and 1,000 tons of water. On the other hand, the dense shade under the forest keeps the soil cool and so prevents excessive evaporation by the sun; the forest also retards wind movement over the surface of the soil, and thus also reduces evaporation. Even a brief consideration of all these effects will make one realize the ways in which forest trees help and hinder the dissipation of the rainfall. Probably the most important single effect of the forests is to materially retard excessively rapid runoff, and, through encouraging perennial streams, to make a larger proportion of the total rainfall available throughout the year. In other words, a perfectly bare mountain slope may deliver in the course of the year a much larger percentage of the rainfall into the river draining the region than will a similar but well forested mountain slope. In the first case, the terrific speed with which the rain water rushes off the slope causes severe soil erosion and other

(1) Mohr, E. C. J., Soils of the tropics in general and those of the Netherlands Indies in particular. (Translated by Robert L. Pendleton).

damage; in the course of the year the forested slope may supply only half as many cubic meters of water to the stream but the flow of this water is so much more nearly uniform that this water is very much more useful, and its flow is seldom destructive. In short, *while forests neither increase the rainfall nor increase the total runoff, the water which does flow off from forested slopes in the streams is much more useful to man, and is very much less destructive.*

Moreover, particularly in regions of heavy rainfall, forests play an important part in the conservation of plant food. This effect is closely tied up with a very general and important misconception regarding tropical soils and dense tropical forests. In the popular mind, a dense tropical forest, particularly if there are tall trees in it, is a certain index of a rich soil. Though there are some grounds for such a belief, Vageler sounds a warning⁽¹⁾:

“The ‘inexhaustable richness of tropical soils’ is but seldom found in nature if ever appearances are deceptive they are so in the tropics and subtropics, and only thorough training in the study of the soil can save the planter from grave errors which cause him or his backers to lose their money.”

It seems to be particularly the case that in the tropics a relatively luxuriant vegetation can maintain itself on a relatively poor soil, for in an undisturbed tropical forest a small supply of nutrients is used over and over in a cycle, comparatively rapidly. There is usually a mass of tree roots just under the surface of the soil, ready and lying in wait to grab the mineral nutrients just as soon as they are carried into the soil by the rainwater. The relatively small amounts of nutrients which may be lost from the cycle by escaping down past the roots, or as the result of material being washed off from the surface of the forest soil can often be compensated for by materials brought up by deep rooting trees from the very deep weathering zones of the soil. Once the land is cleared of the forest, however, and the deep tree roots are killed, and the brush and timber of the forest burned just where they grew, the concentrated nutrients from the ash are available for the crop which may be planted. It is likely that with the first rains a considerable portion of the ash may

(1) Vageler, P., *Tropical soils* (translated by H. Greene) p. 10.

be washed off from the land or, even if a considerable proportion is washed into the soil, much of the ash is apt to be carried down too deep to be within the reach of the crop plants, whether these be annual or perennial crops, for at first even tree crops have fairly shallow and limited root systems. The final result is that the nutrient capital which was sufficient for the continued life of a dense stand of tropical forest is dissipated in 2 or 3 years, and by this time most of the organic matter in the soil has decomposed and its nutrients are released. Since there has not yet been time for the development of fresh roots, deep to the weathering zone where more nutrients may be available, the true poverty of the soil then shows itself and the crops are often a great disappointment.

DIFFERENCES BETWEEN TROPICAL AND TEMPERATE ZONE AGRICULTURE.

In the temperate zones the plow and other cultivating tools, operated by animal or mechanical power, are used both for the plains and the hill cultivation; there is no sharp division into padi⁽¹⁾ and upland agriculture. While intensive cultivation thru deep and thoro stirring of the soil has been popular for a long time in the European regions of gentle rainfall and only shallow weathering of the soil material, and the weeds have been kept under control, on the other hand such intensive cultivation is not only expensive, but the soil fertility is reduced, in the end the soil structure is worsened, and the plant food supplies are cut off for annual crops. In regions of deeper weathering, and so of greater erodability, as is the case in the southeastern United States, if the cultivation is continued until erosion has removed all the useful, easily handled surface soil, forestation of the land is then the only possible solution for the prevention of the complete destruction of the land surface and damage lower down the slopes and along the streams. It is, therefore, a very real question as to whether or not it is advisable to encourage the cultivation of the more fertile, steeper slopes in tropical countries using the intensive temperate zone horticultural methods. In the tropics the most

(1) A padi (paddy) is a leveled field for planting lowland rice surrounded by a low dike to retain the flooding water on the land during the preparation of the soil and the growth of the crop.

generally used method of soil management is the use of puddled soil for transplanted rice, and the land is usually flooded. The padi farmer modifies his soil for the production of "upland" crops on the rice plain (vegetable and fruit gardening about Bangkok depend entirely upon the *Yok rong* or broad, elevated bank system, with broad, deep drains between each elevated bed), but the padi farmer cannot take his padi methods to the hill unless he uses extensive and extremely costly terracing, as is being done in the Philippines and Java.

TYPES OF AGRICULTURE IN THE HUMID TROPICS.

There are several types and subdivisions of agriculture in the humid tropics namely: (1) "lowland," or wet rice culture, which may be divided into (A) extensive, broadcasting methods with some varieties of rice suited to shallow and others to deep water, where the normally nearly level land is plowed but not puddled; and (B) intensive, padi or transplanting methods, with the seeding rice raised in seed beds, later transplanted to carefully leveled fields "padies" of puddled soil, which are flooded to only a shallow depth with water. The flooded soil is commonly puddled with an animal-drawn country plow, followed by a comb harrow, but an animal-drawn heavy wooden roller, corrugated or provided with iron chisels may be used. Sometimes, particularly in small padies in the mountains, where plowing is difficult, the farmers themselves tread the soil to puddle it, or they drive the cattle round and round on the wet soil. (2) "Upland" or *caiñgin* (*tam rai*) cultivation, is "cultivation" without cultivation, for the soil in the forest clearings is not plowed, but the seed is planted in very small holes made with a stick or similar tool. After one, or at most 2 or 3 crops, the land is left to revert to forest, and is not again cleared for some years, when the productivity of the soil is more or less restored. Since this general type of agriculture is employed so extensively, and the results of this method are so far reaching, hence of such great importance, we shall give some further consideration to it.

CAIÑGIN OR TAM RAI AGRICULTURE.

This shifting type of cultivation, known under various names in the different tropical countries (*caiñgin*, Philippines; *taungya*, Burma;

jhum, Assam; *cheena*, Ceylon; *ladang*, Netherlands Indies; *tam rai*, Thailand; *milpa*, Central America, etc.) is carried on for the most part in the following way: Toward the close of the rainy season a suitable piece of land, not too steeply sloping and covered with a good growth of forest, is selected and the claim indicated by blazes on the trees, or by short poles stuck into the ground and carrying distinctive marks. About January or February, when in most of Thailand the dry season has commenced, the undergrowth is cut, after which the larger trees are either cut, or are severely trimmed up.⁽¹⁾ Toward the end of the dry season, in April or May, by which time the brush has thoroughly dried, the clearing is fired; all the smaller branches and brush are completely consumed, and frequently almost all of the big timber is killed if not entirely burned up. (Figure 1). To a forester, or lover of trees, this destruction of forests and timber is frequently very distressing, and when these trees are teak or other good timber, the loss is even more serious. While much of the ash is probably washed off in the first rains, along with some of the looser surface soil, a part undoubtedly remains to fertilize the soil. As soon as the land is well moistened, and the rainy season is believed to be well started, a sharpened stick or a light bamboo pole several meters long, and shod with an iron chisel tip, is used to peck very small holes, about a decimeter apart and perhaps a couple of centimeters deep and 2 to 3 cm across, all over the clearing. While the men usually handle the planting stick, the women drop a few seeds into each hole, and, using their feet, cover the seed with a little loose earth. Since the clearing may be some kilometers from the permanent village, and the field is seldom fenced securely, the farmer (*caiñginero*)⁽²⁾ usually erects a small hut to shelter himself or some member of his family against the weather (Figure 3) as he watches the

(1) As described by Mr. Roy D. Bennett, the Illengot tribe of the Philippines employs a very ingenious method of crossing from one high tree to another, cutting off all the smaller branches of each, and working aloft all day. Then when the brush is burned the heat is so intense that the trees are killed, without the necessity of having to cut the trees.

(2) A *caiñginero* is one who makes a *caiñgin* and raises crops in this manner, i. e. of shifting cultivation. *Caiñginero* is a term generally used in the Philippines where this sort of agriculture is practiced extensively and has also been studied in some detail.

crop; here he will live until the crop is harvested and the grain taken back to the village. Once or twice during the growing season of the crop the field may be weeded, but the soil is never stirred. Perhaps some of the sprouting stumps are cut back, but by the time the rice, maize, or other crop is ready to be harvested, the long stubble and the wild growth already protect the unstirred soil very effectively, so that, considering the slope of the land, erosion is not nearly so serious as might be expected. If the native vegetation, particularly the cogon (*Imperata* spp.) does not invade the field too swiftly, sometimes toward the end of the rainy season, after clearing away the weeds and young brush a second crop is planted. But usually after only one crop the wild growth of weeds and forest trees gets too vigorous, the field is abandoned and the forest allowed to grow up as it will. Only in the case of certain tribes in the north of Burma have I heard (1) of caiñgineros of their own accord in any way assisting the forest cover to return to the abandoned clearings. (2) Usually the influence of the caiñginero is just the opposite. If the forest growth returns quickly on the abandoned caiñgin, it kills out the weeds, and improves the fertility of the soil, both chemically and physically. This is particularly true where the roots of the forest trees extend down deep into the zone of active rock weathering, so that they can take in the elements liberated in the weathering processes.

One of the strongest growing weeds in the tropics is the cogon or lalang grass (*yaka*, *Imperata* spp.). This plant is among the first

(1) In a personal conversation Major Green, of the 20th Burma Rifles, told me that in the course of more than 20 years duty with his organization, which had taken him to all parts of Burma he had noted: Near Bhamo on the hilltops the Lissü tribe has very thoroughly and extensively deforested the land. Much farther north, north of Michanau, in the Triangle, the Kaku tribe plants seed of the *myba pun* peach after harvesting upland rice. After allowing the peach trees to grow for 8 years the land is again cleared for upland rice. Still farther north, on the Tibetan border, the Yaw Yin (Black Lissü) tribe effectively reforest their clearings by planting out small trees following the harvesting of the food plants. From these and other observations Major Green is not at all in agreement with many who unreservedly condemn caiñgin cultivation.

(2) Foresters in India and the Philippines have found that the employment of the caiñgin system in the clearing of the land, getting a food crop from it, and then planting up the field with the desired forest trees is a very economical and practical method of converting certain worthless types of forest into commercial stands of valuable forest trees.



Figure 1. Destruction of timber to allow the growing of food crops. Maize being grown in the Yaw Ka Dong Settlement, about 55 kms south of Yala, Southern Thailand. July 2, 1936. Photo No. 635—3.



Figure 2. A forest clearing (*caiñgin*) from which the crop of upland rice had just been harvested. January 2, 1939. Km 88 northeast of Prae, on the highway to Nan. Note the threshing floor in the lower right corner. Photo No. 1101—12.

which comes into the clearings, and, while at first it is not conspicuous, it has one characteristic which makes it an important, and a serious enemy of the forest. When still quite green this grass burns very rapidly, and with a hot flame. Once this grass is well established on the land, almost without exception it burns off annually. (Figure 4). The natives burn it off to get rid of the old, tough grass, and to enable the cattle to pasture off the resulting young leaves and shoots; they also burn it to get rid of the wild animals, or to facilitate hunting, etc. The burning is particularly destructive of whatever other natural forest vegetation there may be starting on the land, so that once the cogon is well established, the natural forest can rarely come back. While the normal humid tropical forest seldom is liable to forest fires, the fierce annual cogon grass fires gradually force back the adjoining forest so that the cogonal steadily increases in area, particularly up the hill. Fortunately there is as yet very little cogonal in Thailand; some of the largest areas may be seen along the railway between Chumporn and Prachuap Girikan, but the through trains, always pass there at night so that the average traveller down the peninsula does not see them, nor hears the exclamations over the beauty of the country—exclamations which only could be uttered by one afflicted with dendrophobia.

Once the land is covered with cogon grass (has become a cogonal) it can no longer be cultivated by the *tam rai* (caiñgin) method, so that, in so far as the local methods of food production are concerned, the land has become a grassy desert. It should be noted that the local cultivator never attempts to plow his forest clearing, for this would not only be quite unnecessary but also impossible, since all the stumps and roots of the trees are left in the ground. When the land has become a cogonal, and this is particularly likely to happen when there is not enough land for the inhabitants and they have to again clear the land try to plant it before the forest has had adequate time to completely kill out the weeds, then the villagers cannot cultivate the land at all. Even if they wished, they could not use their native and relatively weak plows on this grass, though the modern iron plows when properly used are quite effective in breaking up the cogonal and making the soil suitable for the growth of maize, upland rice, or other food crops. It should be noted that the *tam rai* or caiñgin

system of cultivation is really nothing more than a long term rotation, with the natural forest as the cover crop. When there is enough good land for the inhabitants the system is not bad, though it does require much more land per unit of food produced and about three times as much labor as do the more intensive lowland methods of food production. In fact, in Sumatra, a modified caiñgin method has been found practically imperative for the production of the highest quality wrapper tobacco. In this case the long time under the forest growth not only improves the fertility of the soil but also gives time for the serious tobacco diseases to die out.

ADVANTAGES AND DISADVANTAGES OF CAIÑGIN CULTIVATION.

The following are among the advantages of caiñgin cultivation: (1) There is little soil erosion, even though the slopes are steep; (2) steep land can be cultivated which otherwise would not be crop-producing; (3) the fertility extracted from the soil by the forest cover is concentrated at the surface through the burning of the slash, while the tree roots, when they are not killed, will soon function again, and bring more nutrients to the surface; (4) no work animals and practically no farm tools are needed; (5) there is control of crop diseases and pests; and (6) crops of improved quality may be raised, such as Sumatra wrapper tobacco, and upland rice in the Philippines.

Among the disadvantages, the following may be mentioned: (1) About 3 times as much labor is required for the same quantity of crop as is needed in the lowland padi cultivation; (2) 5 to 10 times as much land is needed to produce the same quantity of product annually; (3) there is a very serious destruction of timber and other forest resources, particularly where the practice is extended into previously untouched forests; and (b) cogonals are developed; and once well established, except for a little poor pasture and some thatching grass, these are not only unproductive but prevent the natural development of the forest.

SOIL EROSION IN THAILAND.

In the United States and certain other countries soil erosion is at last receiving the attention which such a serious enemy of man-



Figure 3. A caiñgin of a Müsser dam farmer, from which he had recently harvested rice and melons. November 30, 1939. Note the temporary hut in the lower left part of the field. Ban Ma Ang Kang, in the hills near the Burma Border, southwest of Muang Fang, Chiengrai province. Photo No. 1047—7.



Figure 4. A cogonal or *yaka* (*Imperata* spp.) slope which had been burned over annually. Once a rubber plantation, the forest trees are gradually being killed by the burning. Klong Tjong, 10 kms north of Tung Son Junction. Nakorn Sritamarat province. July 10, 1936. Photo No. 646—9.

kind deserves. In Thailand the erosion of river banks, particularly as the result of power boat wash and of cultivation of the inner banks during the low water season is serious in places. In many other places, particularly between the hills and the productive lowlands, however, *there has not been sufficient normal, geological erosion in this country to remove the weathered-out residual material left after the decomposition of the rocks into soil.* Such regions are to be seen along the road between Sukotai and Raheng, between Krabin and Aran Pratet; and vast expanses in the northeast, such as those south of Udorn, and south of Ubon. (Figures 5, 6). Farmers will cross from 5 to 10 kilometers or more of such poor, infertile soil if they can plant upland crops such as peppers and cotton on the hill slopes which are less infertile because the soil has gradually eroded from them before it had had a chance to form a thick, leached-out covering over the weathered rocks. (Figure 7) An additional indication of an old, weathered out soil is the presence of a laterite horizon or layer in the subsoil.

Where these weathered out, old soils are located in depressions so that rain water or that from the surrounding slopes will collect and stand on them, lowland rice is the one crop which can be grown, even tho these soils are far from rich. Parenthetically, the appalling poverty of some tropical soils would be much more apparent if rice were not our main crop.

TERMITE EFFECTS.

In these regions of poor soil termite heaps are conspicuous and important because of heavier texture and higher fertility of the soil composing the heaps; this is because of the action of the termites in moving and concentrating clay and calcium carbonate. Consequently other sorts of forest trees are associated with the heaps, and the farmers use the heaps either in their natural state, or more or less truncated, to grow vegetables and other crops which cannot be grown in the usual soils of the locality.

POTENTIALITIES OF NORTHEASTERN THAILAND.

It must have been the failure to appreciate fully these soil conditions which led Dr. Zimmerman recently to forecast for the

northeast a great increase in agricultural production, an estimate which our studies do not thus far seem to substantiate. But Thailand is no different from most others in that it has some lands which, for some reason or other, cannot be used for the production of crops. Other countries have vast areas of land which are too dry, or too saline, or too rough and mountainous, for agriculture. Fortunately for this country, most of the lands unsuited to agriculture are forested, and do produce considerable quantities of hard woods valuable for timber and for fuel. (Figure 5). In fact, care must be taken to conserve these valuable forests, that they may continue to produce these and other important products.

Ubon changwat is perhaps the most extreme in its contrasts between the various sorts of soils and in its distribution of the large total population: Apart from the town, which is important as a commercial center, there are cultivation of the river banks and lower, more or less well watered plains and depression of moderate fertility. Then there are many kilometers of open, poor forest, on land which for the most part is not worth clearing and, except for the termite heaps, is practically uncultivated. Out near the southern and eastern edges of the province, on the lower slopes of the hills and mountains, however, there is a zone of agricultural villages, for the farmers find these hill soils with their normal erosion more responsive to cultivation, and here can be grown cotton, peppers, and other crops in addition to upland rice.

FORESTRY & AGRICULTURE IN THE CENTRAL OR BANGKOK PLAIN.

The most effective continuous use of the land and the best interests and comfort of the population require that a considerable proportion of any land be under forest in order to supply fuel, timber, fruit, shade, tanning materials, protection against the wind, etc. Many supposedly advanced portions of the world, such as the United States, are just beginning to realize this. Here in our central plain there are vast opportunities of forestry development, or at least for the growing of many more trees around the farmers' houses and on the canal banks. It is true that particularly in certain portions of the plain *Mai sakae* (*Combretum quadrangulare*) and sugar palm (*Borassus flabillifer*) are grown on the padi dikes, while other trees



Figure 5. Typical forest on a light sandy laterite soil. Along the Mahasarakam road, about 40 kms east of Ban Pai, northeastern Thailand, March 25, 1936. Photo No. 602—11.

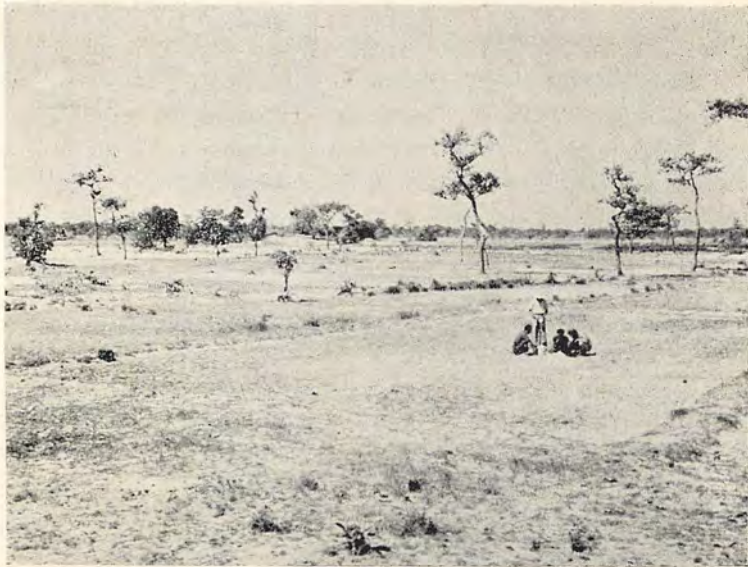


Figure 6. Unproductive "lowland" rice fields on a light fine sandy laterite soil. About 22 kms northwest of Ubon, in Ampur Muang Sam Sip. Northeastern Thailand. Photo No. 1009—10.

and bamboo are planted along the stream banks and about the farmsteads. *Mekamtet* (*Pithecolobium dulce*) grows particularly well on canal banks in the central plain, and experiments in the Philippines indicate that, when eight years of age, the bark of this tree contains 25% extractives of the best quality for tanning leather.

CAIÑGIN AGRICULTURE AND THE DISAPPEARANCE OF EARLIER CIVILIZATIONS.

According to Bishop ⁽¹⁾ the plow was introduced into Annam and the plains of the Mekong river about the time of Christ, the plow having been brought from India to China 3 centuries earlier. Thus, as Bishop says, the Khmers at the height of the development of Angkor were certainly using plows. But without doubt the plows were used only for the preparation of the soil for lowland rice, as is still the case to-day in Thailand and the rest of the Indo-China Peninsula. The native plows never have been strong enough to contend with the grasses of the upland fields.

The traveller thru Cambodia notes that there is but a moderate proportion of the land which is so situated that it receives enough,

(1) Bishop, C. W. 1936. The Origin and Early Diffusion of the Traction Plough. *Antiquity*. September. pp. 261—281. And in a personal letter to me under date of 21 May 1938 he continues: "...I pointed out that we have evidence for the use of the plough, drawn by oxen or buffaloes, in the Ganges valley at quite an early date; and that there is explicit mention in the Chinese records that it came into use...in northern China about the 3rd century B. C. The Chinese records further state that when the Chinese got down into what is now French Indo-China, roughly around the beginning of our Era, they found the people using a hoe culture, and that the Chinese introduced ploughs. This takes us back to at least a millenium before the time you mention, for the introduction of the plough in Annam. Surely it shouldn't have taken a thousand years for it to travel the relatively short distance down into the Khmer country; and then too we mustn't forget that many cultural elements reached Cambodia from India during the early centuries of our Era, and that the Hindus and Buddhists of the Ganges valleys had already long had the plough. I know of no explicit reference in any literature to the Khmers having had ploughs; nor have any examples of its representation on carvings come my way; but then I have not particularly looked for them, and wouldn't say that such did not exist. But even if they did have ploughs, they would almost certainly just scratch the ground, not turn a furrow or break up a sod, and I shouldn't think they'd have much more effect in that direction than the primitive hoes and digging sticks which seem to have preceded them."

but not too much water, to be planted to lowland rice. Observing Cambodia and particularly Angkor from the air during several flights, Dr. H. N. Whitford, a forester with long experience in the tropics spoke ⁽¹⁾ of the large bodies of dipterocarp forest especially about Angkor. And tho there could be seen little evidence of ancient or present day padi cultivation about the large lake, Tale Sap, to the south of Angkor, in some place he noted large areas of old, long abandoned padis, while here and there some new padis were being made in the grass or *parang* areas (*parang* is a fire-maintained grassy plain with scattering specimens of the few small sorts of trees which can withstand the annual burnings). Whitford agreed that the extensive savannas in the Angkor region and west toward the Thailand boundary are the result of the increasing demands of the population upon the shifting cultivation for food, so that the clearings were made increasingly frequently until the grass fires which became more and more frequent maintained the artificial savannas. Dr. Whitford added that after studying the conditions in Central America he believed that the Malays disappeared for the same reason—a lack of food because of the grassy deserts which are an inevitable result of endeavoring to increase the production from the land by the *cañgin* or shifting cultivation system. A tropical soil under heavy rainfall, he continued, cannot remain permanently productive with only annual upland crops even if the cogon and other grasses can be controlled; forest crops are essential for maintenance of permanently productive upland soils.

While a good deal of food may have been brought in by boat or cart to Angkor, much of the food consumed by the population in the Angkor region must have been produced from upland soil by the *cañgin* method, and that as the demands upon the land increased with the increase of the population there was no longer sufficient opportunity for the forests on these relatively poor soils to kill out the coarse grasses and to restore the fertility of the soil. The land under grass increased more and more, while the plantable area decreased so that the total available quantity of food was greatly decreased.

While the actual fall of Angkor is ascribed to the superior military power of invaders, the resistance of the inhabitants was

(1) Dr. H. N. Whitford, in a personal conversation with me in July, 1937.

doubtless much less than it would have been had the lands been productive and they had had adequate supplies of food. Dr. Bishop ⁽¹⁾ adds ...When you made your interesting and I think very plausible suggestion that the Khmer civilization foundered as a result of the application of the law of diminishing agricultural returns even before you mentioned what Dr. Witford said, I had already thot of the Mayas. I worked down there one season, you know, and it used to strike me as curious—almost inexplicable—that we should find those great stone edifices, literally buried in the “bush,” deserted, with no indications of ever having been fortified or of having been assaulted, and nothing to show why they were abandoned. Many, perhaps most, of them were more in the nature of “civic centers,” and for miles around, in the “bush” (as they call the tropical forest down there), are small mounds, representing in all probability the dwelling sites of the people in general. I think the failure of agriculture, almost certainly the reason for the abandonment of given sites. And that the same thing occurred among the Khmers I think equally likely. And I am told that Dr. O. F. Cook, botanist of the U. S. Dept. of Agriculture, had similarly explained the dying out of the Maya civilization.

One cannot but wonder whether the development of cogonals might not have been an important contributing factor in the dying out of some of the other civilizations of the tropics, notably that of Anuradapura, in Ceylon.

Possibly some of you who have visited Angkor will recall the relatively luxurious vegetation about the ruins, particularly the dense forests of the locality, and wonder how this fits in with the above explanation of soil impoverishment and the development of grassy plains. Two important points should be kept in mind: (1) as a result of the dense population that inhabited the region for centuries there is doubtless still a higher concentration of phosphorus and some other plant foods in these soils close to the center of the old city than there is in the average soils of the region; and (2) since the locality has been abandoned for a long time and the soils are now hardly suited to cultivation, the forest has had a chance to grow up again, and in fact is now protected. In several places in the Korat region

(1) Dr. C. W. Bishop, in a personal letter dated 21 May 1938.

of Thailand I have noted village sites⁽¹⁾ where as the result of ancient settlements the soil is obviously still different and more fertile than that of the surrounding country.

HILL TRIBES IN THE NORTH VERY DESTRUCTIVE OF FORESTS.

One of the important factors in the racial complexity and culture of Thailand has been the continued infiltration of peoples from southwestern China and adjacent regions. One wonders to what degree Sawankolok and Sukotai as well as the older more northerly settlements in what is now Thailand were overthrown by such groups, and to what degree the inhabitants were weakened because of insufficient food supplies. Be that as it may, some infiltration from the north continues, the newer groups coming down on the mountain ridges and keeping to the mountain tops. While it is said that these groups, such as the Miao, farther north are padi farmers in the higher valley floors, and in China closely related tribes plant and raise trees for timber, in Thailand they raise their food by some form of shifting agriculture. They have agricultural methods suited to the circumstances: upland rice grown for food in cañgins usually on the lower slopes of the hills, often many kms below their villages, while the maize, grown in the summer rainy season for their animals is rotated continuously with opium grown in the winter, *often for 8 to 10 years on the same land*. Not being willing to live in the lowlands these folk have been especially destructive of the forests.

This latter type of cultivation has, for obvious reasons in recent years been carried on only in relatively very inaccessible localities, such as hidden valleys high in the mountains. There is ample evidence in the character of the forest cover that in former years in some localities the areas planted by these hill peoples was very much greater than that planted more recently. In other localities, both near Chiengrai and near Nan, within the memory of observant residents, due to the increasing deforestation by hill tribes, the supply of water for irrigation from the smaller streams has seriously decreased, so much so there is no longer available the good supply of water needed for padi cultivation in regions northwest of Nan and south of Chiengrai.

(1) Ban Būng, Ubon province, site of a 12th century Mawn town.
Ban Pai—Mahasarakam highway, Kon Kaen province.

OTHER AGRICULTURAL AND FORESTRY RELATIONSHIPS
IN THE NORTH.

The valuable timber tree, *teak*, occurs principally as scattered groves and clumps of trees, usually on the better, well drained soils around the base of the hills and mountains and near the river banks. This scattered nature makes these forests very difficult to properly administer. Teak forest soil is also good upland rice or Virginia-type tobacco soil, so that unless the protection for the teak is very effective, the trees are very apt to be eliminated by the farmers who wish to use the better soils to grow crops which will give quick returns.

While *tung* and related sorts of trees, grown for their valuable paint and varnish oils, are not yet an important factor in Thailand, they are being grown more and more extensively by plantation methods in the Occident, for the most important source in south-western China is practically cut off. In northern Thailand there are already experimental plantings on land which has been logged off, and there promises to be a considerable extension of plantings. The one larger grower has demonstrated that he is able to eliminate the expenses and disadvantages of clean cultivation of these trees by using the plantations the first couple of years or so for planting papaya. More than 700 acres were handled this way last year. Papaya gives a quick return thru exporting the dried latex from the fruit. This enables the land to be kept free from weeds, and provides shade for the soil until the tung trees are at least partially able to shade the land.

For chewing with betel leaf and areca nut some form of tan-bark or tanning extract is generally used; this is known under the term *sisiat*. It may be extracted from the bark of various sorts of *Dipterocarpus* trees, or from the heartwood of *Acacia catechu*. In the Chiengkam ampur, in the upper Me Ing valley, the farmers plant these trees on good soil and let them grow 12 to 15 years then cut them and extract the heartwood with boiling water, evaporating the extract and casting little cakes of the material.

AGRICULTURE AND FORESTRY RELATIONSHIPS IN
SOUTHERN THAILAND.

Attention has already been called to the cogonals north of Chumporn; farther south, in Yala province, as in Figure 1, and

elsewhere, there continues serious destruction of the forest resources. In Pattani province and elsewhere, there are vast plains covered with grass; doubtless here, too, the forest would return if fire could be kept out. But whether these plains have developed as the result of caiñgin or *tam rai* cultivation is a question, for the soils seem to be too acid and deficient in certain nutrients to be worth cropping without fertilization. And this the caiñginero cannot do.

Horticultural versus "forestry" methods: The average Occidental, accustomed as he is, to clean cultivated orchards and vineyards in temperate zones, is inclined to keep a plantation in the tropics likewise cultivated. This is now quite generally recognised as a mistake. In southern Thailand the local planting methods are more sensible. Near Songkla are islands in the lagoon and on them there are considerable plantings of *fruit* trees, planted as if they were forest trees. See Fig. 8. Annually, before harvesting the fruit, the undergrowth is slashed and left on the ground, but there is no stirring of the soil or other cultivation. The results are excellent, and there is no soil deterioration, no catastrophic erosion, no expense for cultivation.

In this region *Hevea rubber* is grown very generally as rather dense plantings, on the better well drained types of soil; in this way this tree actually produces more per unit area than extensive plantings of the same stock on the more open, European plantation methods. Clean culture of the soil is avoided; at best there is selective weeding, to somewhat control the type of undergrowth. In this way soil erosion is prevented; the soil fertility is also conserved and the cost of maintenance is decreased.

While enormous numbers of *coco palms* are growing down the peninsula, they are seldom planted as extensive plantations. Usually planted close to habitations, the trees receive the household and village wastes which, on poor soils, make the difference between good crops of nuts, and practically none at all.

SUMMARY.

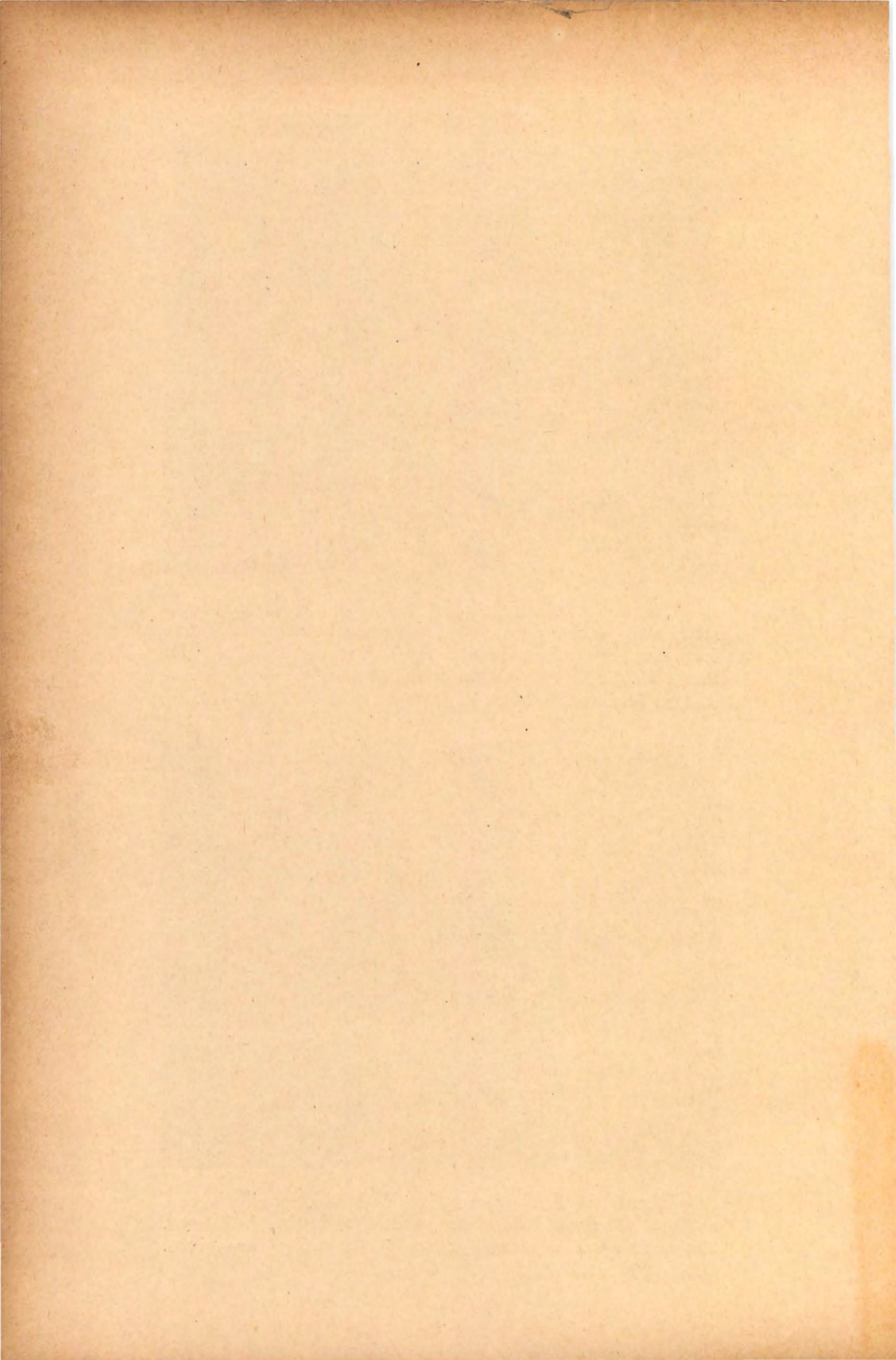
Forests, even tho they transpire much water from the soil, and may hold back even 20% of the rainfall from ever reaching the soil, facilitate, thru the production of organic matter, moisture per-



Figure 7. A caiñgin being prepared for planting on a stony slope, such soils as these being much more productive for upland crops than those shown in Figures 5 and 6. Pu Pan Yod, Ampur Sahaskhan, Mahasarakam province, north-eastern Thailand. March 23, 1936. Photo No. 599—10.



Figure 8. Fruit "foresty" on Ya Island, Songkla lagoon, southern Thailand. Rambutan, santol, and other fruit trees. The underbrush is slashed annually; no other care given. October 15, 1935. Photo No. 516—9.



colation into the soil so much more, and retard runoff to such a degree that they make more useful the water which actually does flow off, as compared with that from slopes without forest. This is because the forests make the flow of streams thruout the year more nearly uniform and keep the water clear, thus preserving the stream channels, and all the associated benefits.

Pioneers and primitive peoples have always had dendrophobia and have used caiñgin methods. Pushed too hard, caiñgin agriculture means the extinction of peoples thru the development of grassy deserts which persist because of annual burning. Such consequent grass lands cannot be cultivated with the primitive hand tools, the only kind which primitive peoples have had. The annual fires also prevent forest regeneration.

Caiñgins can be replaced by horticultural, intercultural or clean culture methods, such as are used in the Temperate west, thru the help of strong plows and powerful draft animals or tractors. But such types of cultivation encourage soil erosion and rapidly deplete the soil. Tropical rubber, tea, and coffee soils have suffered seriously thru the application of these types of cultivation.

Tropical soils are not usually nearly as rich as is supposed, the growth of the forest being misleading; the deterioration of tropical forest soils after clearing is more rapid than that of temperate zone soils.

Especially for Hevea rubber soils there is a marked trend toward the use of "forestry" methods, so that the soil has permanent cover crops to prevent erosion and to conserve fertility.

If the soil is to be conserved and if the best interests of the entire population are to be served, it is necessary to have a balanced development of forests and agriculture, for not only are tree products as well as annual grains and similar crops necessary for man, but both sorts of crops are dependent upon an extremely thin and easily damaged, and slowly repaired or regenerated soil.

While soil erosion, if excessive, is extremely serious, completely destroying the soil, yet there should be some erosion to remove slowly the completely weathered out and impoverished surface material.

Note: While this paper was in press the following interesting statement was discovered in Steiger-Beyer-Benitez's book, "A history of the

Orient." pp. 160-162—"About 1,300, however, Angkor suffered a terrible catastrophe: the mouth of the Mekong became so blocked by deposits of mud that the waters backed up and flooded the entire region around the city, turning the fertile fields into a great area of useless marsh lands. The population of the city and of the surrounding region were now compelled to migrate or starve."