Fire in Tropical American Lowland Areas

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THERE ARE many incognitas and misconceptions about the exact role of fires in tropical areas. How old is fire? Is lightning fire possible or a factor of importance in the tropics? Does the tropical rain forest ever burn? How does fire affect the vegetation, the soil, the distribution of certain types of vegetation or species? And finally, what are the possibilities of harnessing fires in the tropical lowlands?

There is no pretense here to answer definitely all of these questions, but rather to define some of the problems and to explain our present knowledge in the light of literature published. Emphasis is laid on an area with which the author has been familiar for the last 18 years, namely, Venezuela, Colombia and especially Central America, the latter meant to include all countries from Panama to the border of Mexico.

THE OCCURENCES OF FIRES NOWADAYS

Fire is widespread in all tropical countries, usually connected with primitive agriculture and grazing (Bartlett, 1955, 1956). Surface fires constitute the great majority although they may vary considerably in intensity and frequency. Occasionally crown fires have been reported in Central American pine areas but they have never been seen by the author. Fire is most predominant in grass areas and usually spreads from there into the adjoining forests if conditions are favorable. In all tropical countries fire is presently used—or misused—in pasture management and clearing of forest vegetation as part of the so called "slash and burn" type of agriculture. Wildfires

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are considered a very important forest problem in many tropical American countries, especially Brazil, Venezuela, Colombia and Honduras, where at times great efforts and expenditures have been made towards their control.

ANTIQUITY OF FIRE AND LIGHTNING

There is no doubt as to the antiquity of fires associated with early man. The real question here is connected with lightning. Was it possible that before man's arrival large areas of forest and savannas burned periodically? Man's influence is suspected to date back between 10,000 to over 50,000 years ago according to the source used. The answer lies probably in the study of lightning today but even this requires a good amount of speculation.

In this connection there is a current belief that while lightning strikes, it does not produce forest fires because it does not occur at a time when the forest or savanna is flammable. However, there are definite proofs that lightning does sometimes produce fires as has been stated in the Annual Report of the British Honduras Forest Department, (1955) where a lookout tower and other expenditures towards presuppression and suppression were undertaken, partly because of lightning fires. Isolated mountain peaks with no indication of human encroachment have been burned in southern Venezuela and this must also be attributed to lightning. A forest fire produced by a combination of lightning and an exceptionally dry spell is theoretically possible, although probably very rare. Still it is sufficient to produce a fierce fire even if it occurs only every 5 or 10 years. If there are no more fires of that type reported in literature, it may be because there has been little scientific reporting; knowledge of lightning and its effects is scarce. On the other hand, most areas have already been previously burnt by man when lightning strikes and could have originated a fire. Frequent fires on an annual basis as practiced today considerably reduce the hazards of potential lightning fires.

THE CLIMATIC LIMITATIONS OF FOREST FIRES

In tropical American lowlands a generally high temperature, above 24° C or 75° F is the rule but rainfall may vary enormously from

less than 16 inches a year as in northern Venezuela to more than 200 inches as in northwest Colombia and some areas in Central America. Within this range fire varies its activity in every possible respect. The greatest frequency and intensity of fires, however, occurs where there is a strong alternation between dry and wet season. It is here that fire finds its greatest expansion since fuel has accumulated during the dry period, principally leaves. Towards the drier regions with less rainfall, fire is widespread although usually limited to areas covered partially or wholly with grasses. Rarely is intensity a factor.

FIRE IN WET ENVIRONMENTS

Towards the wetter areas, fire is possible and common especially when grasses are present or when secondary brush has developed. Generally speaking, when rainfall exceeds 80 inches which usually means a dry season of less than 4 months, the natural high forest is sufficiently resistant to any fire, although there are exceptions. One is the case of vegetation developing on extremely poor soils either naturally or by action of man. Here a much drier vegetation than indicated by rainfall is present and may become flammable after only a short dry season. Also, when a type of monsoon climate prevails, that is, when there is plenty of rainfall concentrated in a few months with still a relatively long dry season, the total annual rainfall means little, and the vegetation behaves like a normal deciduous forest with less rainfall and does become vulnerable.

As said before, in areas of heavy rainfall, the high forests will rarely burn, but secondary woody vegetation and grass may often burn because only a short dry spell is needed to produce that possibility. The reason for this behavior may be found in the adaptations of the secondary plants themselves and the small water holding capacity of the soils. Secondary woody species of the pioneer type, implying those that colonize areas devoid of vegetation are often adapted to drought by shedding leaves which provide enough fuel. Grasses react very quickly to drought and can become flammable after only 3 rainless weeks, a phenomenon not uncommon in many areas with over 100 inches of rainfall. The effect of drought can of course, be accentuated by poor soils with a reduced water holding capacity.

Even grassy swamps will burn since their phenology is related to climatic patterns, especially rainfall. In Venezuela for example, large marshy areas of the Orinoco Delta are burned every year when there is a dry season, even if there is plenty of moisture available to the roots. The same is the case of Laguna Arenal in northern Costa Rica, almost wholly covered by grasses and sedges. Burning takes place during the small dry season. In both areas, rainfall exceeds 90 inches. Nearby forest will not burn, mainly because the environment, especially the soil surface, remains sufficiently moist. The water holding capacity is at its maximum capacity and the shade tolerant undergrowth vegetation will prevent the drying out of the soil. Once cleared, however, the upper few inches of soil dry out with great facility. There is often a deterioration of structure due in part to the dismembering of soil aggregates resulting in clogging of the porous space. This process is of course stimulated by the loss of organic matter and may be accentuated by grazing. The end result is often compaction and a formation of a hard or indurated pan, meaning a great diminution of the water holding capacity (Budowski, 1956). Only plants adapted to the resulting drought can survive. These are often plants that normally live in a much drier habitat. When succession takes place on degraded soils, it may require from 10 to over 100 years to reestablish some of the favorable former soil characteristics, depending on the stage of degradation. As a result, the successional stages may remain potentially flammable for some period before a vegetation and an environment resistant to fires, is reestablished.

SAVANNA AND FORESTS

Over decades ecologists have discussed the relationships between these types of vegetation so widespread in tropical areas. There is usually a sharp boundary between both vegetation types and discussions usually center around the principal factors that determine each type of vegetation. A savanna-forestry boundary symposium was held in May, 1964 in the Venezuelan llanos with assistance of prominent specialists of the tropics from all the continents. Fire was of course a central theme, being present in all savannas (Fig. 1). The following statement made 30 years ago by Myers

(1936) is still completely true: "I have never seen in South America a savanna however small or isolated or distant from settlement which did not show signs of more or less frequent burning." The same applies of course to Central America. Another noteworthy ecologist Aubréville (1965 b) summarizes his views on the origin of the Venezuelan llanos, explaining that fires have produced these savannas at the expense of forests poorly adapted to resist repeated burnings.

The process may proceed as follows: At the end of the dry season the deciduous forest becomes flammable. Fire, generally started in nearby savannas, penetrates the forest where it burns the leaves, small twigs and branches while seedlings and small poles are scorched, most of them deadly so. The larger trees resist. The greater penetration of light allows the establishment of some grasses especially in opening and edges. These in turn burn easier the following year. Wounds are inflicted to older trees which suffer more intensely during subsequent fires (Fig. 2). In the course of year, many trees eventually fall down, the forest becomes more and more open, and there

FIG. 1. Passage of fire in tall grass in the southern llanos of Venezuela.

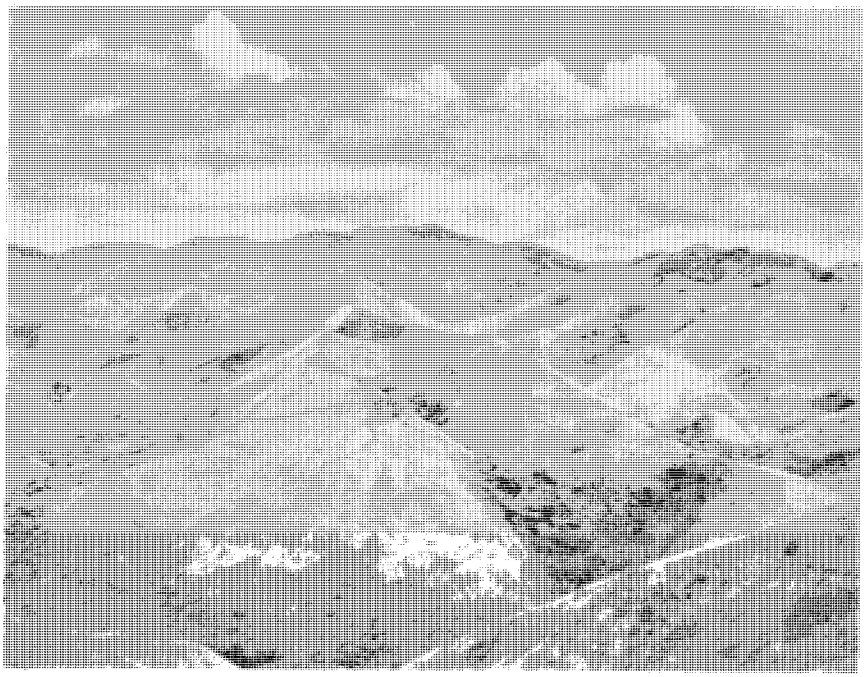
FIG. 2. Fire within a large *Anacardium exelsum* tree. Although the forest is close to the river and the roots of the larger trees reach the water table and are evergreen, the undergrowth dries out sufficiently to allow fire to penetrate.

is practically no regeneration of the canopy trees. Gradually grasses take over and may produce fires with greater intensity. The soil deteriorates and an indurated pan is formed. The process has been called "savannization" and is commonly used to explain the origin of most of the savannas today.

The process is of course accelerated when clearing for agriculture is the initial step. Here, after the land is abandoned, succession takes place beginning with grasses and shrubs which burn easily in the dry season (Figs. 3, 4, 5). Further proof to the man made origin of savannas is the lack of an endemic vegetation (Lasser, 1955; Aristiguieta, 1959), the absence of a specialized herbivore fauna (Bates, 1948) and of course, observations on natural succession on protected areas.

FIG. 3. Shifting agriculture through slash and burning.

FIG. 4. The original forest was not flammable but the secondary grasslands are.



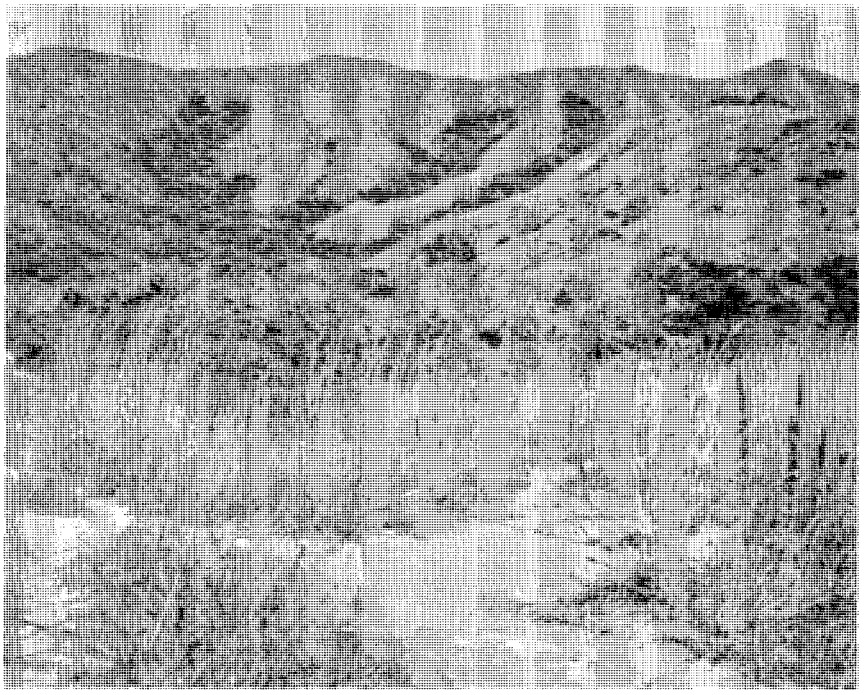


FIG. 5. Savanna with remnants of forest in the moister depressions.

An important feature of savannas induced by fires is the presence of some characteristic trees forming a kind of "orchard savanna" (Figs. 6, 7, 8, 9). These trees are always invaders not remnants of former arboreal vegetation. Most typical are *Curatella americana*, *Byrsonima crassifolia* and to a lesser extent *Bowditchia virgilioides*, *Xylopia grandifolia*, *Apeiba aspera* and some palms, notably *Acrocomia* spp., *Copernicia tectorum* (on clayey soils) *Scheelia* spp. (in wetter places).

The first two have an extremely wide distribution. They are very fire resistant with a thick bark and a well protected terminal bud. Moreover, they can sprout with great facility. They are able to germinate and grow on extremely poor and often barren soil, hence getting a respite, at least for a few years, from fire. Many other adaptations to fire have been described (Lasser, 1955; Tamayo 1962).

The palms mentioned are naturally fire resistant because of the

anatomy of the extremely hard outer wooden layers protecting circulation tissues inside. Their buds too are well protected. Not all palms do of course display such behavior. The palms and most of the savanna trees are propagated by animals, usually with seeds going through their digestive tracts. In some, the germination process is favored by fire.

As has been pointed out by Aubréville (1965 a) among others the balance between savanna and forest in the presence of fire can be considered as falling into three groups.

The first is very favorable to forest, that is, the forest will return agressively after being burned or sometimes even when clearcut and burned. Hence it will never yield to savannas. Many of the deciduous forests will display this behavior. In spite of being burned from time to time the natural forest will not disappear because it will regenerate. When cut, this is much less frequent but occasionally the trees will readily sprout or re-invade the area, except of course, if the woody vegetation is continuously cut back in subsequent years. These forests occur mostly on good soils or on areas with a relatively short dry season.

The reverse case applies to forests that are in a state of unfavorable balance with savannas. They may be remnants of a climatically more favorable past and will have little resistance to fires. In a few years after being subjected to fire they will completely disappear leaving the area open to grassland. Soils will degrade very quickly. If these grasslands were eventually protected they would probably produce a kind of shrubland which very slowly will revert to forest but quite certainly of a different nature (Fig. 10). These forests occur mostly on poor soils, exposed and erodable slopes, and the dry season may be unusually long.

The third case shows a delicate balance where during some exceptionally dry years, especially when fuel has accumulated, the trend will be towards "savannization" while wet years will produce encroachment of trees over the savannas. Both cases are shown to occur in nature.

This picture is probably a little too simple since another factor, namely time, intervenes. An area not burnt for several years may accumulate so much fuel that a very fierce surface fire will cause much

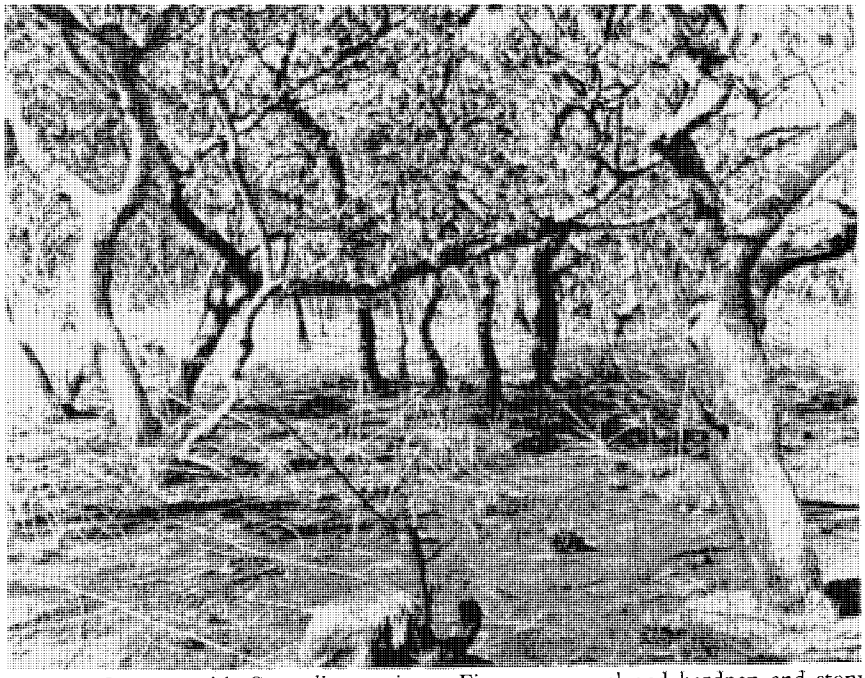


FIG. 6. Savanna with *Curatella americana*. Fires are annual and hardpan and stony outcrops are common.

FIG. 7. Sandy savanna with *Bowditchia virgilioides* in Central Venezuela.

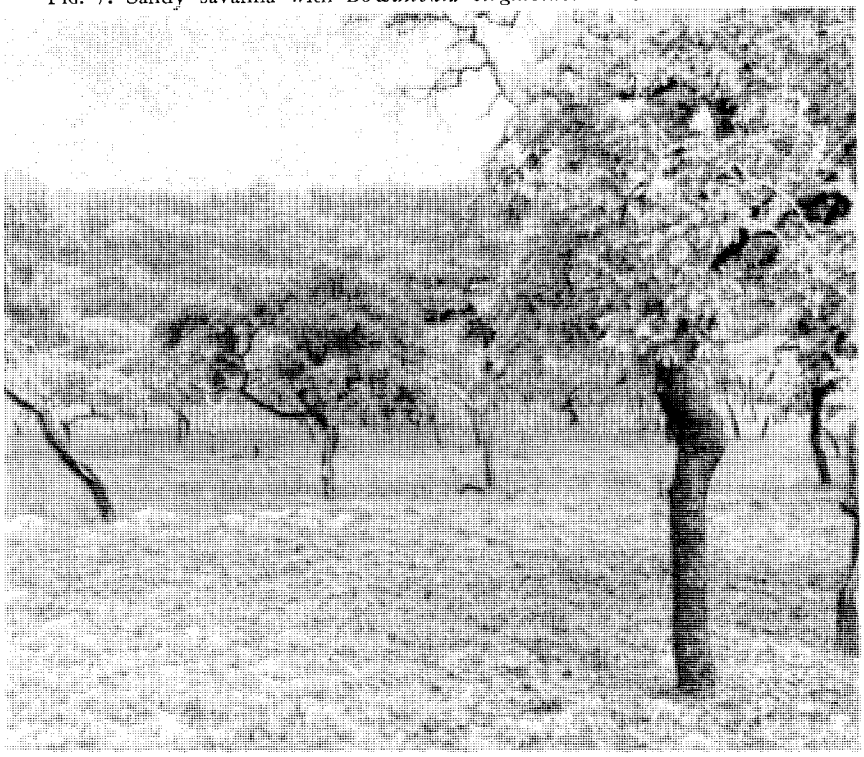
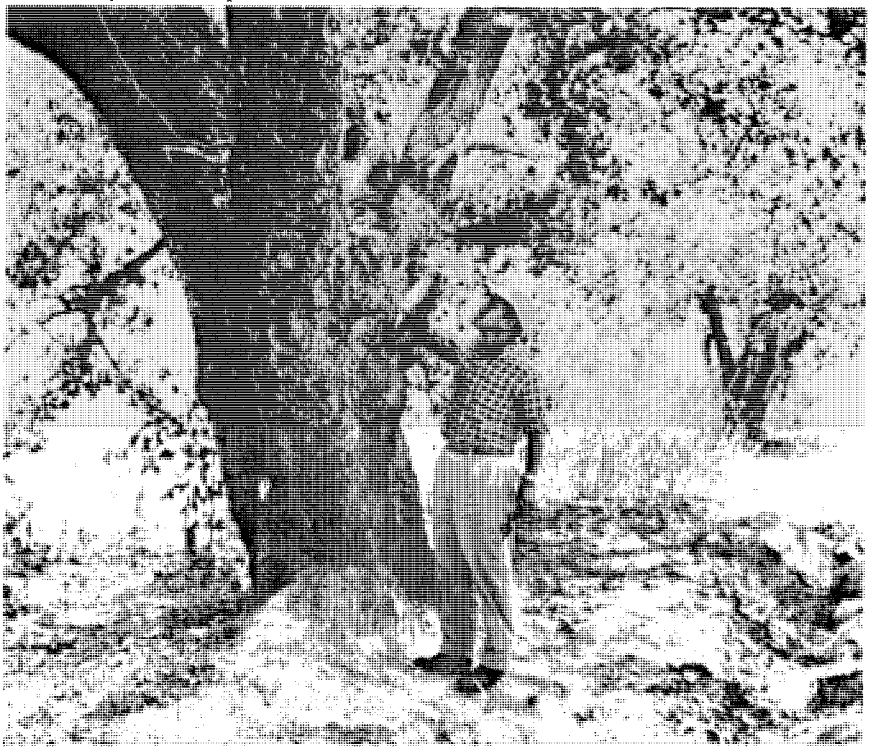


FIG. 8. Fire resistant palms, *Corozo oleifera* in savannas of the Guanacaste area in Costa Rica.

FIG. 9. *Quercus oleoides*, an oak growing close to sea level in Costa Rica and favored by fire and poor soils.



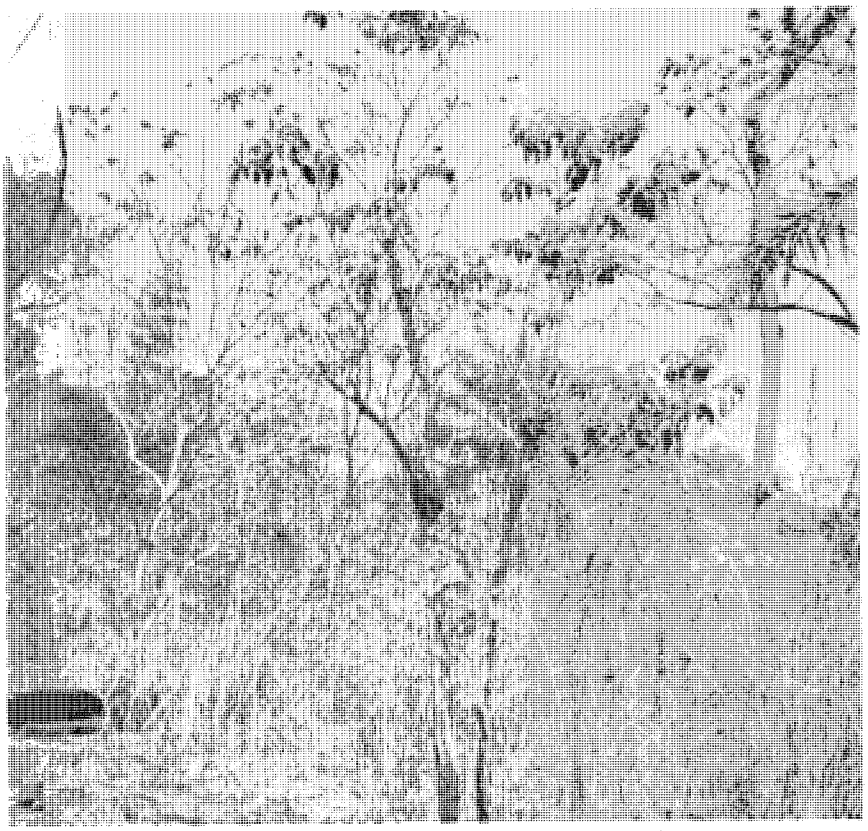


FIG. 10. Fire after passing through a secondary forest.

damage when it finally takes place during an exceptionally dry year. It is not well established for how long in the course of succession of natural grasslands the fire danger increases until a woody vegetation is eventually established, weeding out grasses and decreasing from then on the danger of a severe fire. Letourneux (1957) working in African savannas with 52 inches of annual rainfall and a 6-8 months dry season showed that absolute protection produced a change to seed production by grasses formerly propagated vegetatively, accumulation of organic residues and diminution of vigor. This accumulation increased the fire danger for the next 3 years but in subsequent years the fire danger decreased again as a result of invasion of other less flammable species, particularly shrubs and trees.

Actually, when grasslands are not periodically burnt the occurrence of a subsequent very fierce fire may definitely prevent the encroachment of arboreal species. This amounts to saying that woody species may often best get established with light annual fires which reduce the fuel, as has been pointed out as early as 1909 by Cook (p. 11). If grazing is also added, resulting in the reduction of fuel, the result will often be the invasion by trees especially those species not affected by cattle, as has been eloquently shown in Honduras by Johannessen (1963). The general rule is that these species originate from much drier areas and become invaders. This has often lead to the erroneous belief that climate has changed. Actually, a vegetation adapted to drought has invaded the area because of the combination of fire and grazing.

CAUSES OF FIRE

Almost all fires are intentionally set by man, usually with a definite initial purpose. There have been many studies made on reasons to kindle fires, including recommendations towards a campaign for presuppression (Budowski, 1951; Valenzuela, 1957). The origin of fires range from such common causes as renewal of pastures and cleaning of land for agricultural purposes—by far the two most important factors—to some other very specific causes such as releasing of balloons with a kind of home made candle inside, as practiced in Brazil on certain religious holidays, land turtle hunting especially during the Holy Week period, at the peak of the dry season when turtle meat is very much in demand, campfires and hunting purposes. A variation of hunting is practiced by Indians in southern Venezuela, where selective patches of savannas are burned during the dry season. The new grass that develops a few weeks later attracts game, especially deer which is then collected (Budowski, 1959).

Whatever the causes, fire is a deeply entrenched custom with rural people everywhere. Legal measures to prevent fires have usually failed even if they may be very drastic. Their enforcement besides being very unpopular, has usually proven to be very difficult, except close to cities. It is likely that fires will remain a great force in influencing vegetation and animal life for years to come.

For many years educational campaigns were limited to leaflets, road signs and radio programs, all advocating for the suppression of fires but rarely suggesting substitutes for the benefitial effects achieved by fires. Cigarettes especially were frequently the object of this educational campaign. It should be said in passing that the experimental work carried out by Vareschi (1962) in Venezuela has shown that cigarettes rarely if ever could be held responsible for fires because the initial ignition temperature is too low. However, matches thrown into the grass and still burning, do reach the necessary temperature.

FIRE AND PINES IN CENTRAL AMERICA

Fires are found everywhere in pines which cover considerable areas from Nicaragua to Mexico. Two of the pines, *Pinus caribaea* and *P. oocarpa* are found in areas below 3,000 feet although the latter is usually more common above that elevation. It is well known that pines are secondary species except on very poor sites such as for instance exposed ridges where they can meet successfully the competition of other species. They readily invade lands opened by natural factors such as landslides, hurricanes, and of course, man. When protected from fire, other species will enter and displace the pines. The best natural regeneration is usually found in areas previously burnt. However, subsequent fires will damage most, sometimes all, of the regeneration, often producing a park-like area (Fig. 11). Processes connected with pine and fire have been well described by Bartlett (1956) for the tropics in general and more specifically by Parsons (1955) and Taylor (1962, 1963) for northeastern Nicaragua and Denevan (1961) for the upland pine forests in this country. Cook (1909, p. 20-21) even suggests that prior to the arrival of the Spaniards to Central America, the area of pines in Central America was much more entensive as can be witnessed by the "pitchy roots found within more luxuriant vegetation . . . far away from any living pine forest." He attributes this decrease to the diminution of the Indian population after the arrival of the Spaniards. In recent years, however, because of the increase of population which probably has quadrupled since Cook (1909) wrote his excellent paper, it can be assumed that the area in pines has again increased even if the present

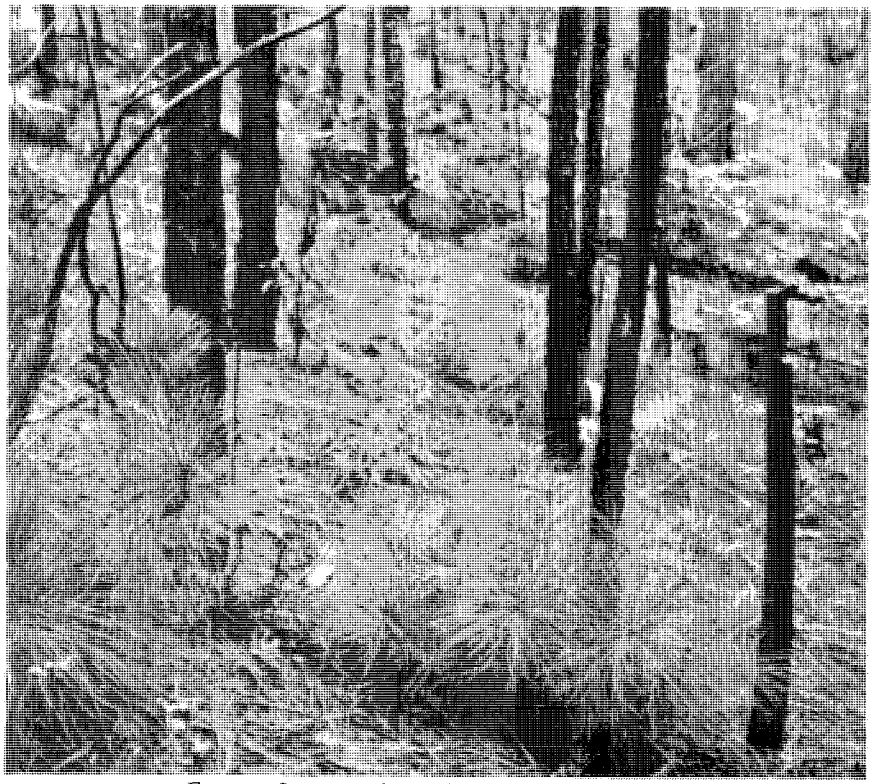


FIG. 11. *Oocarpa* pine poles sprouting after fire.

density of most stands has considerably decreased, a matter due to grazing and exploitation during the last 30 years.

CONTROLLED FIRES

Little has been done so far in this aspect. In natural pine forests of British Honduras controlled fires were recommended some 20 years ago (British Honduras, 1946) and according to a later Annual Report (British Honduras, 1962), practiced with apparent success. Recommendations for early fires were also made for pine in Guatemala (Holdridge, Lamb and Mason, 1950) but at this stage none have been practiced in appreciable scale. Presently an FAO Mission in northeast Nicaragua has been experimenting with this technique in the pine

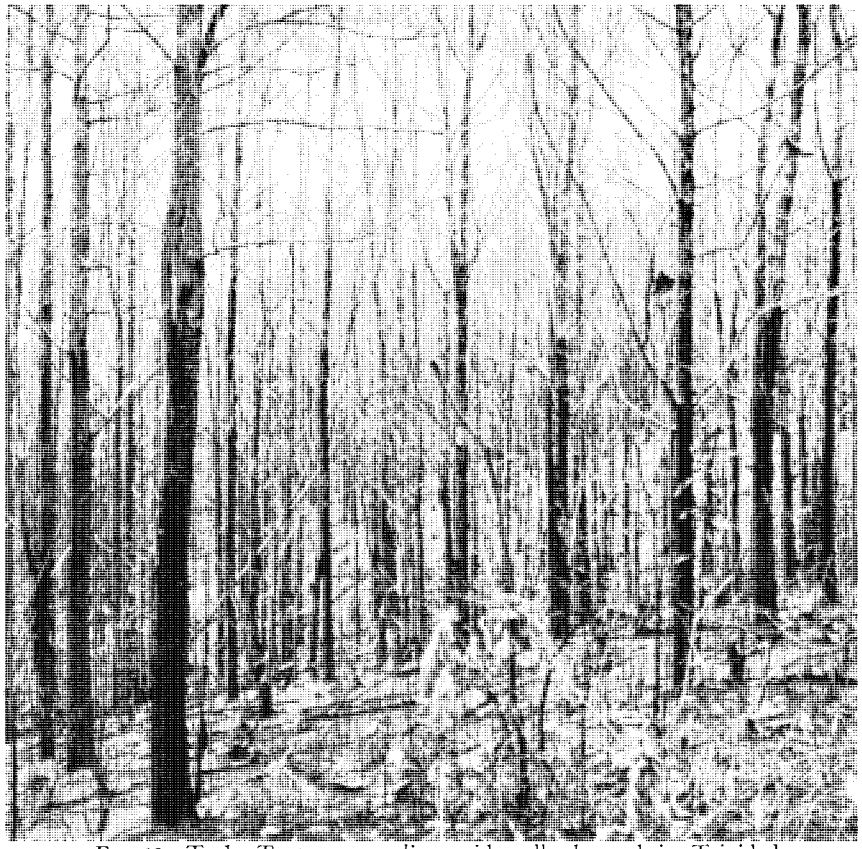


FIG. 12. Teak, *Tectona grandis*, accidentally burned in Trinidad.

forests but no results have been published to date. In natural savannas only some observations of short duration are found (Blydenstein, 1962, 1963).

Since forest plantations only cover small areas in tropical America—with the possible exception of teak in some of the Central American countries and Trinidad—controlled fires are of little importance presently but could well be considered in the future. Teak forests have often been accidentally burnt in Trinidad with apparently little damage (see Fig. 12). Management of fire in natural grassland is scientifically investigated only in Venezuela. The whole matter of controlled fire, however, needs much more research as has been shown in similar ecological regions in Africa. The timing and frequency of fires especially in relation to fuel removal, establishment and tending of regeneration, control of successional processes and relationship to wildlife are all subjects that offer very promising possibilities for research.

SUMMARY

Forest fires examined in the light of experience in northern South America and Central America are very widespread and of old origin. Presently, they are almost always associated with man's activities, principally grazing and slash burning. Lightning fires have been reported in British Honduras. Fires are more widespread in areas where a strong alternation between the rainy and dry seasons prevails. Fires are possible in areas of heavy precipitation but are restricted to grasslands, grassy swamps or some types of secondary vegetation all of which are liable to burn after only a few weeks of dry weather. The delicate balance between forest and savanna is discussed in the light of factors favoring the encroachment of each of these vegetation types, over the other. Arboreal components of savannas are typically invaders that are resistant to fire because of special adaptations. It appears that next to complete protection, light fires will favor the return of forest although the species composition may reflect a vegetation more adapted to drought. Causes of fires are numerous although almost always anthropogenic. Uncontrolled fires are likely to remain common for many years to come. Pines, naturally found on only few sites are favored by fire and opening of land and have considerably extended their range. Their distribution is likely to be linked with man's activities. Controlled fires offer a very interesting field for research.

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