The Fire Ecology of Caribbean Pine in Nicaragua

NEIL MUNRO

THE FIRE ECOLOGY of Caribbean pine (*Pinus caribaea*), with special reference to the northeast coast of Nicaragua, will be discussed in this article. The fire history of this area is not documented and therefore direct references to dates and known fires, even in the recent past, is not possible. To overcome this lack of data it has been necessary to fit together an apparent sequence of events based on field observations, of the present stands, over a two year period when the author worked in the area. Fortunately the pine stands on the northeast coast of Nicaragua are spread over an area of approximately 10,000 square kilometers and most stages of stand successions and fire conditions are present. In addition, Caribbean pine stands in Belize (British Hondurus) and Hondurus were inspected and in certain cases it has been necessary to draw on observations from these countries to make a complete picture. This approach is not uncommon in ecology and it is basically the only method available in countries where historical records are not present. The major pitfalls in this method are that it is subjective, that is based on the experience of the observer, and that no documented proof, at least over a long period, can be supplied to substantiate the observations presented.

It must also be remembered that fire ecology is a finely balanced natural science, which depends on local factors such as microclimate to a great extent, and can vary greatly in a small geographical area. The reader is requested to remember the last two sentences when

reading this report and it is anticipated that he will be able to add to or correct this article on the basis of his own experiences.

The main sections of this paper are designed to give sufficient information on all phases of Caribbean pine ecology to lead up to, in a logical manner, the conclusions and predictions presented in the final section. These sections are:

1. General geographical, climatical, edaphical and fire conditions in the Caribbean pine stands on the northeast coast of Nicaragua.
2. Silvicultural characteristics of Caribbean pine with special reference to fire influence.
3. The effect of fire on the distribution, establishment and growth patterns of Caribbean pine. This section will include an explanation of Caribbean pine succession, from tropical hardwoods, to pines and back to tropical hardwoods, with reference to fire frequency.
4. How fire can be used in the management of Caribbean pine. This section will be concerned mainly with natural stands but it is anticipated that in many cases fire can be used in plantations of this species successfully with a reduction of management costs.

1. General Geographical, Climatical, Edaphical and Fire Conditions on the Northeast Coast of Nicaragua.

The geographical location of the pine stands on the northeast coast of Nicaragua are on the lowlands between the Rio Coco, or the Hondurus Border, and the Rio Grande. The most southern known range of Caribbean pine is just south of the Rio Grande near Bluefields. Generally these stands are between a coastal swamp and a tropical rainforest on the inland side. In some instances, for example just north of Puerto Cabezas, the pine stands reach right down to the beach and in other instances they are completely surrounded by tropical hardwoods. In the latter situation the hardwoods, at least on one side, are usually in the form of gallery forests or the pine stands are in a late successional stage.

The altitudinal range of the area is between sea level and 500 feet

elevation. The topography is flat to undulating although occasionally small hills with rather steep sides may be encountered.

The climate of the area falls in Holdridge's tropical humid classification. That is there is between 80-160″ of rain per year and the mean temperature is more than 24° C. (approximately 75° F.). The main feature of the climate is a 2 to 3 month dry season in which there is generally 1″ or less rainfall per month. This amount of rain in a colder climate would not necessarily have a drastic effect on plant growth but in a tropical country where the temperature is so much greater the results are close to a drought. The dry season, in March, April and May, can also be considered the period of greatest fire danger and it is not unusual for all of the unprotected pine savannas to be completely burned over in this season. The dry season is followed immediately by the wet season, locally referred to as winter, in June, July and August, and floods, not fires, are common over much of the low lying areas.

The edaphic conditions of the pine stands are generally characterized by very poor soils. The well drained soils, common in the northern half of the area, have no humus layer but only a topsoil, 4-10″ deep, of coarse pebbles mixed with sand and clay. Underlaying this topsoil is a deep bed of iron mottled clay. The poorly drained soils, common in the southern half of the area, differ only in the topsoil which in this case is a layer, up to 12″ thick, of poorly decomposed organic material. Although the above soils could be considered typical of the pine stands there are also considerable areas of pine on alluvial soils near the Rio Coco and elsewhere. The alluvial soils are the best pine sites, as far as growth rate goes, but it is difficult for pine to overcome the competition from hardwoods on these areas unless assisted by fire. More will be said about this in Section 3.

It is interesting to note that many of the low lying pine areas are flooded annually, in certain areas with a weakly saline water, and the pines withstand this although obviously they are not on their best site.

Fire conditions in the Caribbean pine stands vary considerably with the season. In the dry seasons the grass, which forms the herbaceous layer, is tinder dry and is burned annually, in most areas, by the local inhabitants who are mainly Miskito Indians. This burning is

carried out to provide fresh grass for livestock, for hunting purposes and to remove pests such as ticks, chiggers and snakes. Unfortunately the fires generally spread over a far greater area than necessary and are not stopped until put out by rain or halted by a natural firebreak. Dry season fires can be very severe and crowning frequently occurs and it is only the high resistance of Caribbean pine to fire that permits the establishment and maintainance of a tree layer in these conditions. Even the low lying areas, mentioned in the previous paragraph, are burned over in this dry season when the waters recede. In some instances fires do travel through these areas in the grass layer even though water still covers the ground.

In the wet season, and the months immediately following, it is more difficult to light fires but nevertheless fires do occur and cause considerable damage. Generally these fires are less severe than dry season fires and cause less damage in mature Caribbean pine stands. They do, however, kill seedlings extensively and prevent the establishment of good regeneration. Natural regeneration is easily obtained if fires are prevented.

The Nicaraguan Government initiated a reforestation project in 1959 and this project has proved that good natural regeneration can be obtained if fires are prevented. The project is based on a fire protection scheme and the major difficulty to date has been putting out man made fires which can occur at the rate of over 15 a day in the dry season. When it is considered that only approximately 100,000 hectares are under protection the number of fires is considerable. Until man made fires can be prevented it is improbable that this project can be successfully managed. To date, the fires encountered are basically grass fires which can be handled relatively easily at a low cost per fire but in the future when dense stands of young regeneration are available the problems encountered will be much more difficult. Irrespective of the above comments the Nicaraguan Government deserves high praise in having the initiative to start such a project and to continue to carry it out under such adverse conditions.

As it can be seen, the fire conditions in the pine stands on the northeast coast of Nicaragua are as bad as they could possibly be and in general this is true of most pine areas in Central America with the possible exception of Belize. It is suggested that the conditions pres-

ently existing in Central America are similiar to those which existed in the Southern Pine Region in the last century.

2. Silvicultural Characteristics of Caribbean Pine with Special Reference to Fire Influence.

The nomenclature of Caribbean pine has been confused in the past and at one time it was known as slash pine, (*Pinus elliottii*), to which it is undoubtedly closely related. At the present time it is classified as a different species which could possibly be divided into two separate species or at least into two separate varieties. The two varieties are a lowland form, tolerant of a tropical humid climate, and an inland form tolerant of a tropical dry climate. In the natural range of Caribbean pine there is one major characteristic, a definite annual dry season, the above two climatical classifications share. This definite annual dry season is favorable to burning and therefore to the establishment of Caribbean pine as a fire climax species.

The natural distribution of Caribbean pine is confined to the Atlantic drainages of Central America and to some islands of the West Indies. The inland form occurs in Nicaragua, Hondurus, Belize, and possibly Guatemala up to an elevation of about 3,000 ft. The lowland form occurs in Nicaragua, Hondurus, Belize, Guatemala, Cuba, Isle of Pines, Bay Islands and the Bahamas. In Hondurus and elsewhere the lowland form is also tolerant of low rainfalls down to 50 inches per annum. Caribbean is not resistant to frost and therefore can be considered a true tropical pine. This characteristic is shared with another Central American pine known as ocote (*Pinus oocarpa*) to which Caribbean pine is related. Ocote occurs in the highlands and at its lower elevational range it can be associated with Caribbean pine and the possibilities of hybridization between these two species are good. Until recently it has been thought that altitude controlled the ranges of these two pine species but recent plantation work in Central America has indicated this is not necessarily true. In Belize, the Department of Forests, and in Hondurus, P. J. Shank, have both established ocote plantations at low elevations in a tropical humid climate with very good results.

Caribbean pine is a well known tropical coniferous plantation spe-

cies and has been planted widely throughout the tropical parts of the world with generally good results. Plantations of this species exist in such widely spread countries as Australia, Africa, and South America. It is suggested that because of the variability of Caribbean pine's natural range more attention should be given to seed source than is presently being applied. With careful selection of seed sources it is very probable that plantations of Caribbean pine can be established over a much larger range of sites than is presently being done. This statement is also true for ocote.

In natural stands of Caribbean pine the greatest problem at the present moment is preventing fires which kill most of the natural regeneration and damage the existing stems. Once natural regeneration is established fire prevention is still the most important problem but is closely followed by thinning and hardwood invasion problems. In Nicaragua where 5 year old natural regeneration is established the major problem, other than fires of course, is how to thin the dense natural regeneration which will stagnate if not thinned quickly. Hardwood invasion occurs later in the rotation but is predicted to be a serious problem if it is desired to maintain a pine forest on the area concerned.

3. The Effect of Fire on the Distribution, Establishment and Growth Patterns of Caribbean Pine.

The effect of fire on the distribution, establishment and growth patterns of Caribbean pine is profund and it can be said there are no natural stands of this species in Central America which, even though there is no apparent relationship, have not been effected by fire at least once, if not numerous times, in their life times. This section will be discussed in detail and a diagrammatical description is given on the following page. This description is divided into 7 phases, or seres, which follow the evolution of an area from hardwood, to pine, and back to hardwood. Each phase represents the frequency of fires and the forest type encountered on the northeast coast of Nicaragua for an area burned over as prescribed in the phase concerned.

Phase 1 is a climatical climax tropical hardwood stand which has probably never been burned over in the last 500 years or more. This stand is probably over 40 meters high and could contain 100 or more

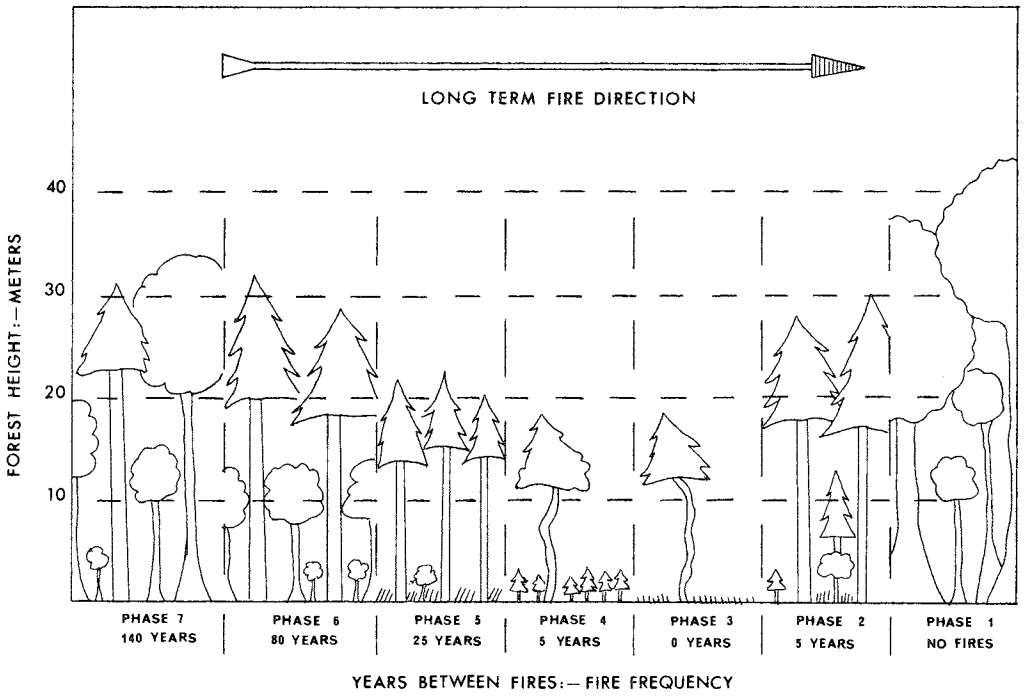

FIG. 1. Diagram of fire frequency and Caribbean pine succession relationships.

species which reach 50 centimeters dbh. The understory is composed of small hardwoods, generally of a different species than the overstory, palms and rattans.

Before progressing to Phase 2 the long arrow above the diagram will be described. This arrow indicates the long term fire direction or fire movement over an area. In other words it could be described as the direction of savanna movement, or savanna development, over centuries of time. Caribbean pine savannas are not permanently fixed in one place but are expanding or contracting their boundaries according to fire frequency. Fire frequency is again controlled by any of a multitude of factors which include climatic, edaphic, biotic, geologic and human influences. Which of these influences are most important depends on the specific case being studied and in the Carib-

FIG. 2. British Honduras: Forest fire in hurricane damaged mature tropical rainforest:—Phase 1.

bean pine savannas of Central America the two most important of these factors are human and climatical.

Phase 2 is the most complex stage of the 7 given and can be considered the buffer or transitional stage between the hardwood stands and the true savanna. This zone is usually narrow and is composed of an overstory of mature pine and an understory, often present in several layers, of pine and hardwood. The composition of the hardwood portion of this phase is most interesting because the hardwood trees are often quite old and, what is more important, are fire resistant species such as nancite (*Byrsonima crassifolia*), lengua de vaca (*Curtella americana*), and roble (*Quercus oleoides*). The composition of this phase is often the only way it can be separated from phases 5 and 6 in the field. This area is not burned over annually and in many cases the fires are only light grass fires sufficient to kill fire susceptible species only. It is through this zone that fires penetrate in exceptionally dry years to the tropical hardwood and old garden areas to expand the pine area. The penetration of fires into a tropical hardwood

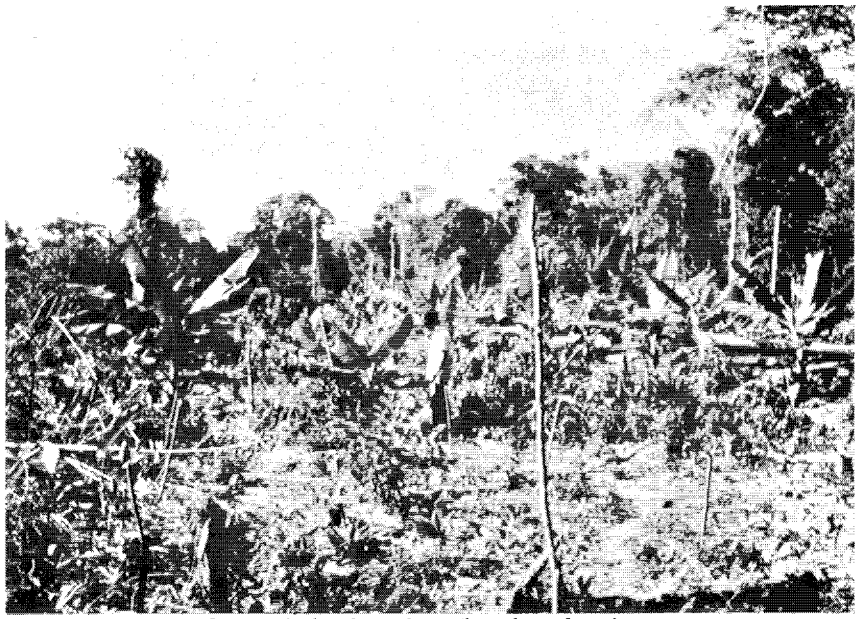

FIG. 3. Nicaragua: Garden in hardwoods at the edge of a pine savanna:—Phase 2.

stand, even in the driest of years, cannot be expected to be very great unless this forest type is severely damaged by natural causes, such as hurricanes, or man. Hurricanes are consistently damaging or destroying hardwood stands in the Caribbean Region and have no doubt assisted greatly in the development of pine stands in the area. A case of this was seen in Belize by the author in April 1963 when fires starting in pine savanna areas spread into hardwood stands damaged by Hurricane Hattie. As important as natural factors may be there is without much doubt that man has been the main influence in controlling the distribution, movement, and maintainance of pine savannas in tropical America. Man, even primitive man, has destroyed the native vegetation with his tools, especially fire, to create an environment most suited for himself and in this case most suited for Caribbean pine.

It is probable that much of the area presently covered by pine stands was originally covered by hardwoods and man by destroying the hardwoods to plant agricultural crops and to supply feed for his

FIG. 4. Nicaragua: A few large pine, heavy grass, pine regeneration, and fire resistant hardwoods typical of Phase 2.

FIG. 5. Nicaragua: An uncontrolled fire in Phase 2.

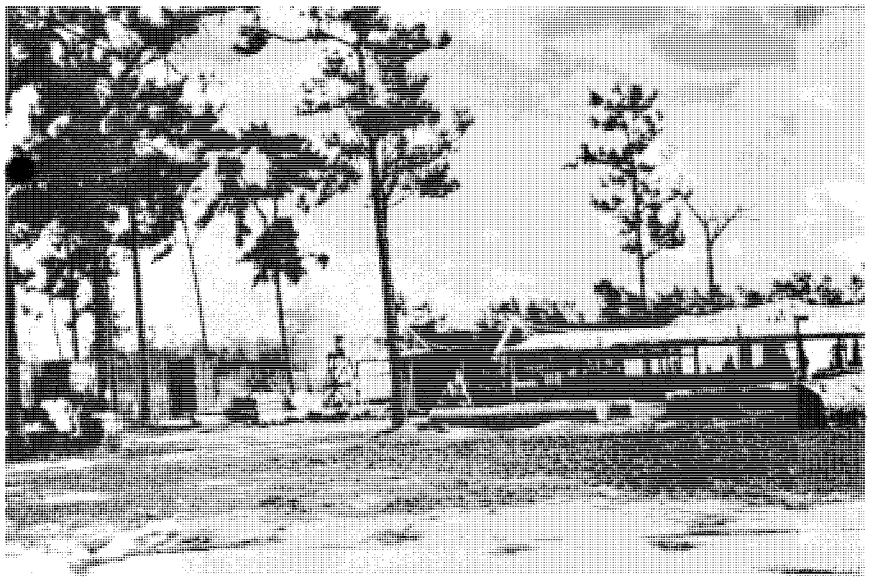

FIG. 6. British Honduras: A small portable sawmill cutting over-mature pine in Phase 3.

livestock has allowed pine to become established. Man then maintains the pine stands by continually re-burning the area he has claimed from the hardwoods. The area claimed consistently becomes larger with time and over a period of say 100 years, can be quite large for even a small group of people who use shifting agriculture to provide their living. Shifting agriculture has been and is still being used by many primitive farmers in Central America.

Phase 3 is the most common phase presently existing in Nicaragua and is characterized by crooked, fire scarred, over mature pine trees. These trees are usually quite short, less than 20 meters high, and very scattered. The stocking can go down to one or two trees per hectare but is usually slightly better. This phase is burned annually, often twice a year, and generally has no understory or regeneration. The herbaceous layer is grass and sedges. On the northeast coast of Nicaragua heavy exploitation of these stands often results with there being no seed trees left and the chances of reclaiming these areas by

FIG. 7. Nicaragua: An overstory of over-mature pine and an understory of dense pine regeneration—Phase 4.

natural regeneration are poor and therefore planting will be necessary.

Phase 4 represents an area which was phase 3 but has not been burned for the last five years. This type is typical of some of the area which the Nicaraguan Government has protected from fire for 5 years and remarkably good regeneration has been obtained from very poor seed sources. This phase can be considered the immediate objective of any forester working with natural stands of Caribbean pine.

Phase 5 is an old pine savanna area which has not been burned for 25-30 years. The regeneration from phase 4 is now 15-20 meters tall and forms a complete crown cover which prevents the development of more pine regeneration because Caribbean pine is not tolerant of heavy shade. It will be noticed that small hardwoods are now coming up through the heavy herbaceous layer and unless halted will eventually take over the site. The herbaceous layer usually consists of tall grasses and bracken fern which present a high fire hazard in the dry seasons.

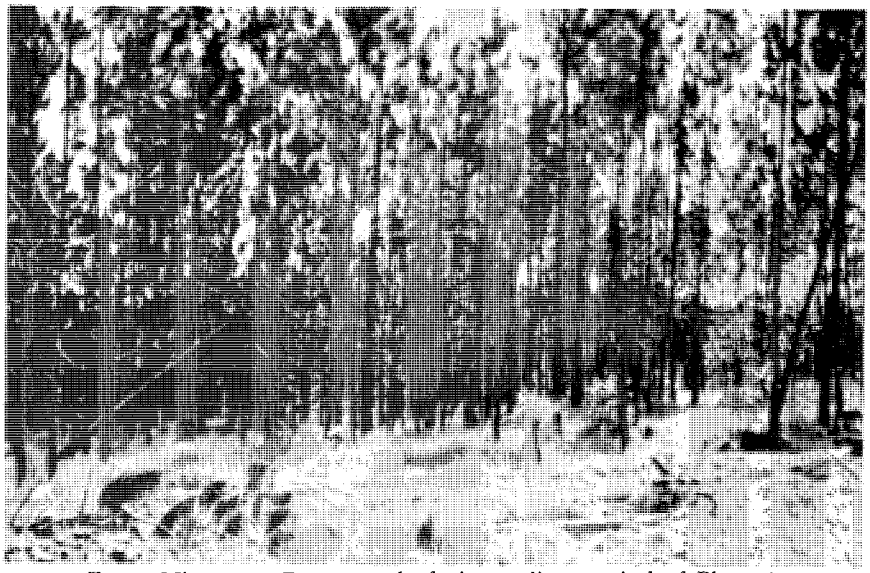

FIG. 8. Nicaragua: Dense stand of pine saplings typical of Phase 5.

Phase 6 is approximately 80 years after the last fire and the pine have now reached a height of 30 meters or more and the invading hardwoods have formed a well established second story up to 12 meters high. There is no pine regeneration and the life of the area as a pine site is limited. The hardwoods present are typical secondary and climatical climax species such as zopilote (*Vochysia ferruginea*, comenegro (*Dialium guianense*), cedro macho (*Carapa guianensis*) and santa maria (*Calophyllum brasiliense*). The short lived primary secondary species such as balsa (*Ochroma lagopus*) and guarumo (*Cecropia* spp.) are not present because they need more light to become established in the first place and do not have a long enough life span to be present at this stage. Zopilote can however be considered a true secondary species while the other three are true climax species. None of these trees are fire resistant and are absent from phase 2 which usually gets burned over every five years or less.

The final phase, phase 7, contains only the remnants of the pines and is almost completely taken over by the hardwoods. The pines are

FIG. 9. British Honduras: The results of an uncontrolled fire in Phase 5. Some of the taller trees will survive.

decadent and it is not unusual to find they have little commercial value because of decay and termite attack. It is not uncommon to find pine windfalls and old stumps in this type which is only one step away from phase 1 where we started. This type is also common on the northeast coast of Nicaragua and is locally known as bush pine. The biggest stands are in the Rio Kukulaya-Rio Prinzapolca area and it is safe to say that the pine savanna acreage of this area has recently decreased greatly. From this we could theorize that for some reason man has moved from the area, taking fire with him, but the actual reason for his leaving is unknown and will probably remain unknown because of the lack of historical records.

4. THE USE OF FIRE AS A TOOL IN MANAGING CARIBBEAN PINE.

To date fire has created and maintained vast stands of Caribbean pine which from a foresters viewpoint are very non-productive. The initial problem in many of these stands is to increase the productivity

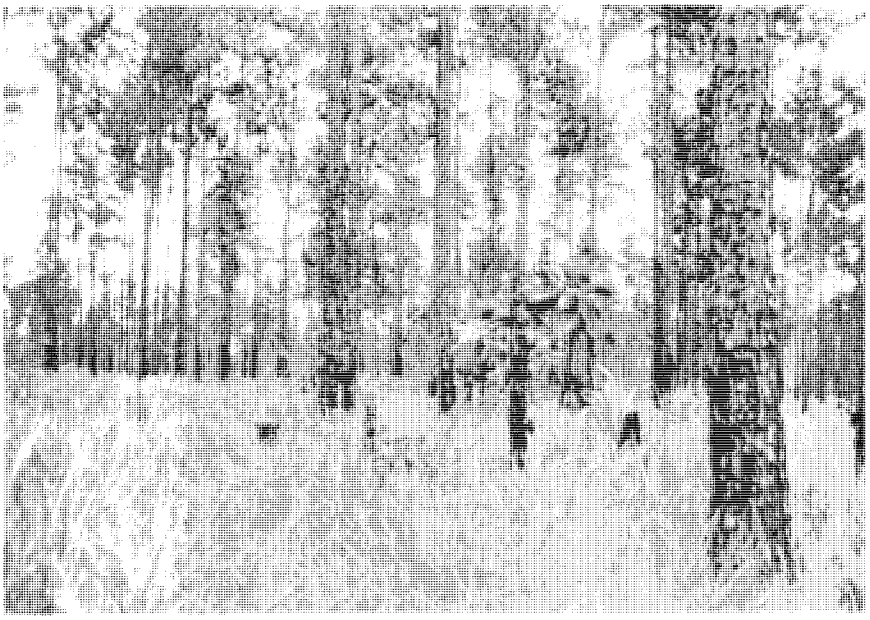

FIG. 10. Mature pine repeatedly burned and thus preventing the development of a hardwood understory. This could be described as natural prescribed burning in Phase 5.

as rapidly and as inexpensively as possible. To do this fires must be controlled and used.

Fires can be used in managing Caribbean pine stands as follows:

a. Preparing sites for planting and or natural regeneration.
b. Removal or lowering of fire hazard in established stands.
c. Preparing of stands for the removal of thinnings or for the final harvest.
d. Removal of slash.
e. Preventing or retarding the natural succession to hardwoods.
f. Silvicultural uses such as thinning or pruning.

Most of the above uses of fire are common in forest management but a few words will be said here about them to end this article. The first use, "a" above, is standard practice in forestry as far as planting goes but in many cases is not practiced in natural regeneration programs. If natural regeneration is to be obtained, it will be necessary in many areas to prepare the site by removing plant growth which will compete with the young seedlings. There are many areas in the

reforestation project where site preparation has been neglected and poor regeneration has been obtained. If these areas had been broadcast burned just before seed fall much better results would have been obtained.

The second use, "b" above, will probably be the most important use of fire in the management of Caribbean pine. Methods as used in the southern pine should be applicable without many modifications. Prescribed burning will not only lower fire hazard but also prevent the invasion of hardwoods.

The third use, "c" above, will assist greatly in the economical removal of material from stands which, because of dirty conditions, could be expensive to log or thin. This use of fire is common in some parts of Central America and because no control has been exerted over the methods used serious damage has resulted. If controlled properly there is no reason why it should not lower logging costs considerably in some stands.

The fourth use of fire is common in many parts of the world and can generally be considered as a part of "a" or "b".

The preventing of hardwood invasion, "e", of the pine stands is very important in Central America if forestry is to be practiced there on a natural basis. Pine stands must be maintained to supply the necessary timber requirements for export and domestic uses. Tropical hardwoods can never completely replace pine in many uses, and therefore the spread of hardwood into pine areas must be prevented. The most economical way to do this is by prescribed burning.

The last uses mentioned above, "f", are very controversial and could possibly never eventuate. By silvicultural uses I mean thinning and pruning with fire. Whether this can be done without causing excessive damage is debatable but in areas where money available for forestry use is next to nil, even worse than Canada or the U.S.A., it is necessary to consider these uses because eventually there might be a situation where no other means is available and the forester concerned might have to take the gamble. Lets hope more research can be done in these lines before it eventuates.

To conclude, fire in the proper hands is a useful tool in forestry and many of it uses can be applied to the management of Caribbean pine. However, it should be used by experienced hands and be based on a

sound scientific background. If used carelessly or by inexperienced persons it can quite easily do more damage than good. Fire is not the foresters best friend and it is doubtful if it ever will be.

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