ROLE OF THE SOUTHERN PINE BEETLE IN THE MANAGEMENT OF CONIFER FOREST OF HONDURAS

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TABLE OF CONTENTS

Page

I. INTRODUCTION

A. Economic Importance of Pine to Honduras 1
B. Influence of Beetle - Endemic and Epidemic. 2

II. LIFE HISTORY AND HABITS

A. Life Cycle. 4
B. Attack Behavior 6
C. Mating. 8

III. TREE AND STAND SUSCEPTIBILITY 9

IV. DAMAGE EVALUATION 11

V. CONTROL

A. Silvicultural 12
B. Chemical. 14
C. Biological. 15

VI. INFLUENCE OF DENDROCTONUS FRONTALIS ON ECONOMIC DEVELOPMENT AND PROTECTION

A. Road Net. 17
B. Watershed 18
C. Timber Productivity 19
D. Forest Regulation Plan of Aqua Fria 20

VII. LITERATURE CITED. 26

ROLE OF THE SOUTHERN PINE BEETLE IN THE MANAGEMENT OF CONIFER FOREST OF HONDURAS

I. INTRODUCTION

Honduras, the largest of the Central American republics, has more than 15,000 square miles of conifers, as well as extensive stands of tropical hardwoods. Forest products constitute the primary wealth for that portion of the country which has land too mountainous and soil too shallow for modern intensive agriculture. Already, forest products account for one-tenth of the foreign trade, surpassed only by bananas and coffee.

A. Economic Importance of Pine to Honduras

Ocote pine (Pinus oocarpa) constitutes the primary species and has excellent potential for industrialization. It is estimated that under full stocking, the pine forests as a whole are capable of a growth rate of about $6m^3/ha$[1] per year on a regular (medium) site. On good sites, however, growth rates of 8.5 to $11m^3/ha$[2] per year can be expected. These are considered to be conservative

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[1] 1020 bd. ft./acre

[2] 1445 to 1870 bd. ft./acre

estimates since it is expected that good forest management could increase the growth. On the other hand, if regeneration is not established and if the damage to the forest from fire, exploitative or illegal cutting, and pests increases, even the present average growth yield cannot persist, and the forests themselves could finally disappear.

It is estimated that it takes about 35 years for a Honduran pine to reach a height of 75 to 100 feet and a diameter (at breast height) of at least 14 inches.

Honduras is fortunate in that a great part of the land that is unfit for agriculture is suitable for the continued production of timber, so that it has the potential to support an industry that can provide work and wages for the growing population.

B. Influence of Beetle - Endemic and Epidemic

The pine bark beetle is a natural inhabitant of tropical pine forests, but under normal conditions the beetles do not attack healthy trees or, if they do, the trees are strong enough to withstand the attack. Toward the end of 1962, an increase in the population of the pine bark beetle (Dendroctonus frontalis Zimmerman) was noticed in the eastern part of the county of Olaucho. It is not clear what caused the increase in the first place, nor what turned it from a relatively slowly increasing infestation into a genuine epidemic in June, 1963. It is suspected that the almost yearly forest fires had weakened the trees over the last few decades, and that the lack of rain during the usual rainy season contributed to the vulnerability of the stand.

By January, 1964, the epidemic had reached the eastern boundaries of the counties of Yoro and Francisco Morazan, and estimates were that more than 3000 square miles were affected. The area of infestation continued to spread westward, and the epidemic had long since become so virulent that even healthy trees could not withstand it. The government moved into action early in 1964. The government passed a law declaring emergency status for the most seriously infected regions, and established a special organization - the Campaña pora la Defensa del Pino - to combat the plague. At the request of the Coordinating Committee of the project, the United Nations Special Fund agreed to make the project team available to aid the government in fighting the bark beetle. For several months the Forest Service, together with technical advisors from the U. S. Agency for International Development (USAID), the Expanded Program of Technical Assistance (EPTA), and AFTAH, the bilateral German forestry assistance program in Honduras, participated in the campaign. The World Food Program assisted with food aid.

By April of 1964, it had become apparent that the extent and virulence of the epidemic had gone far beyond any control measures by any means within the economic or logistical resources of Honduras.

The epidemic continued to spread and to increase in severity. Within the central pine region of the country, more than 2000 square miles of additional pine forest had been affected by September, 1964.

It was not until August, 1964, when reconnaissance flights over most of the country revealed only a few small new outbreaks in the west (around Lago de Yojoa, La Esperauza, and Morcala Counties), that it could finally be said that the bark beetle infestation had lost its epidemic character (Fig. 1).

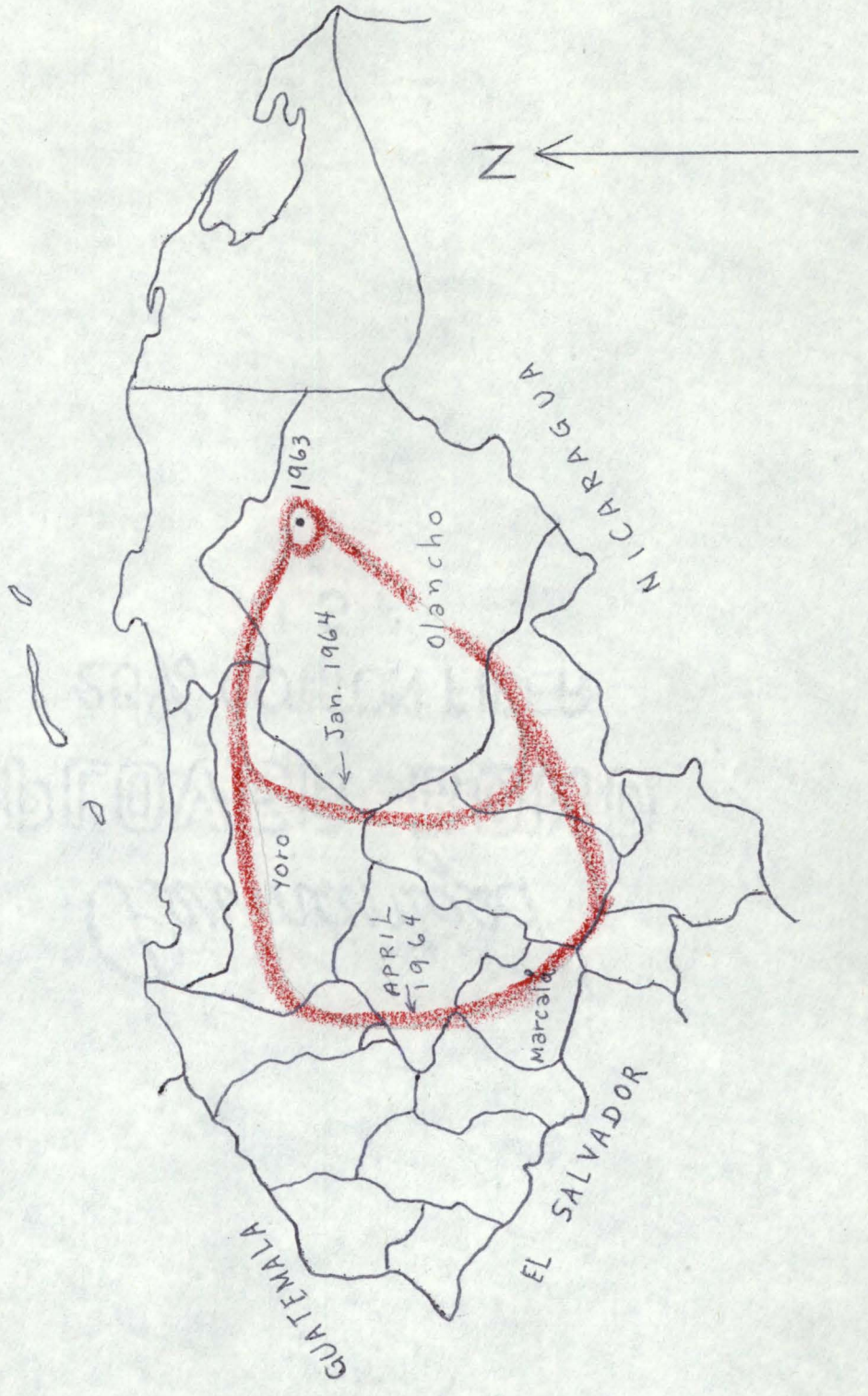
II. LIFE HISTORY AND HABITS

A. Life Cycle

The development of the southern pine beetle (Dendroctonus frontalis Zimmerman) varies by season and location. The beetle completes seven (and a partial eighth) consecutive development periods each year under favorable forest conditions. During the warmer months, fewer eggs are deposited, larval veines are often longer (20 to 60 mm) and less protected from arthropod attackers and environmental influence on the inner bark surface.

Brood development is more rapid from mid-February to late July, when temperatures rarely drop below 70° and often exceed 95°F in the north coast of the country. The delightful climate of Honduras provides the perfect setting for rapid and continuous growth of fungus and the propogation of the bark beetle. The following table shows the mean rainfall (Period 1956-63) and mean temperature (Period 1960-63) in the central part of Honduras.

FIGURE 1. Sketch Map of Honduras



Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	YEAR
					A) RAINFALL IN INCHES							
7	3	1	1	3	10	15	8	11	14	11	8	92
				B)	TEMPERATURE IN FAHRENHEIT							
72.6	71.1	72.2	73.8	75.4	75.2	75.8	76.7	74.3	74.2	73.9	73.2	74

TABLE 1

Lower phloem temperatures and higher moistures are more favorable to egg survival and early eclosion. Combination of excessively high phloem moisture and adverse temperature, if maintained beyond a certain point in the early development of a brood, is detrimental. The best rearing environment for beetles in bolts would be at temperatures ranging from 20° to 22° C and R.H. of 50 to 60 per cent. (Gara 1967)

B. Attack Behavior

With the growing recognition of the fact that our future timber supplies are to be had, not alone by conserving present stands, but by growing future crops, it is time to determine what consideration must be given to insects in the application of silvicultural methods, particularly with the object of preventing rather than of controlling outbreaks.

Dispersal pattern and host selection of southern pine beetle populations is an excellent preventive control of the D. frontalis,

which periodically threatens the forest with severe outbreaks. Very few of the dispersing beetles land immediately after starting their initial flight period.

Two phases of colonization follow the initial host selection. First, a progressively increasing attack narrowly focuses, by olfactory response, on a tree and to that portion which is initially affected. Second, mass aggregation occurs on vertical objects near established sources of attraction, regardless of whether or not the objects are suitable as host materials. Apparently, visual orientation supplements olfactory response in aggregating the population. Differences in the resistance of host trees to southern pine beetle infestation seem to be limited to warding off initial attacks.

Emerging populations of D. frontalis will continue to attack new hosts near their brood trees. When sources of attractants are unavailable in the vicinity of the outbreak, the population disperses and may concentrate elsewhere.

Under field conditions a number of factors may affect loss of synchrony of emergence and attraction which, in turn, lead to dispersal. Local weather conditions may speed or delay beetle emergence, flight, or attack; adverse weather may lower the production of attractants; or, conceivably, rain may wash off or dilute attractive residues adhering to frass or bark. Indirectly, weather conditions may also influence synchronization by retarding larval development or affecting the quality of host material. Unsuitable

host material may foster a lowered level of pheromone production or even inferior populations with an increased proportion of individuals with a lessened ability for response. Under such circumstances, a spot population appears to collapse and the spot may be termed inactive.

Interruptions in the synchrony of emergence and attraction are an essential, perhaps not fully appreciated, part of chemical control procedures. Chemical control of infestations during summer are only possible when the most recently attacked trees are cut and treated first.

The fact that no further trees become attacked is usually mistaken as a result of the chemical control, when actually it is due to removal of the attractive material.

Colonization of Pinus spp. by the pine beetle is largely governed by chemical messengers, originating from both host and insect. Dendroctonus species share a number of insect-generated volatiles. Trans-verbenol, verbenone, brevicomin, and frontalin have been isolated from Dendroctonus species.

C. Mating

When a male was placed in the entrance of a gallery made by a female, it entered the gallery immediately. After reaching the female, which often was found at the end of the gallery, it jostled the posterior end of the female many times and then started to remove the frass made by the female.

Both males and females were found to mate more than once. In one observation, one female mated six times in four hours with different males. In another observation, one male copulated three times with the same female in a three-hour period. The copulation lasted an average of only 30 seconds.

When a beetle was introduced into a gallery, it seemed to differentiate the sexes olfactorily.

The predator Thanasimus dubius follows aggregations of the southern pine beetle, in response to pheromones released by its prey. Male and female T. dubius respond rapidly, in large numbers, and with a balanced sex ratio to frontalin, the major component of the population-aggregating principle of its prey.

III. TREE AND STAND SUSCEPTIBILITY

Knowledge of host selection by bark beetles is important both in the control of these insects and in research on the resistance of pines to beetle attack.

The incidence of attack per category of trees is about 20 times greater on previously-attacked trees than on those previously unattacked. Thus, this beetle is highly attracted by other attacks and exhibits, somewhat, the "mass attack" habit noted for other Scalytids, particularly Dendroctonus and Ips.

Mass aggregation of populations on new host trees are largely caused by olfactory responses to attractants created by the attracting females.

The attractant is apparently composed of host defacation and insect components, which interact in some unknown manner in orienting the population to new hosts. The only known components of bark beetle attractants are terpene alcohol.

D. ponderosae, D. frontalis, and D. brevicomis produce substantial amounts of trans-verbenol as a characteristic material of the hind gut.

Adult females of Dendroctonus frontalis Zimmerman and D. brevicomis (LeC.), upon contact with new host material of Pinus spp., strongly attract other members of their species to initially infested trees. The aggregations that result are largely due to olfactory responses of the bark beetles to attractive principles of chemical composition.

Females of both species produce the same major volatile compound, identified as trans-verbenol. Trans-verbenol is known to be a product of auto-oxidation of a pinene, but its presence in the hind gut of D. frontalis and D. brevicomis females would suggest that it is being produced by the beetles.

Aggregation of destructive populations of Dendroctonus and Ips in pure forests consists of three phases: first, detection and selection of suitable host trees; second, mass attack and colonization; and third, a possible mass attack of adjacent trees. Host finding is believed to be random or guided by host odors. The mass attack of selected trees is caused by attractants or pheromones generated by the insects, and which are effective over considerable

distances. The attractants are produced by the host-selecting sex, and released only in contact with fresh host material.

IV. DAMAGE EVALUATION

The bark beetle infestation running rampant in Honduras has vividly called attention to the tremendous wealth represented in pine forests and the pressing need for roads, fire control, reliable information, maps, better communications, trained personnel, and a forest management system.

The Honduran government is interested in forestry for the first time since 1954. Our forests are in urgent need of immediate recognition and management. A forest management program will not come easy. This program will need support by enforcement of forest management regulations, that may first have to be enacted into law.

Surveys subsequent to the epidemic showed that the average loss of pine volume to the bark beetle had been 20 per cent, although losses differed widely from stand to stand and varied somewhat from one region to another. At 1964 prices, Honduran pine lumber brought an average of U.S. $36.00 per 300 ~~board~~ cubic feet on the export market. If all the volume of pine lost in the epidemic had been cut and sawed into lumber, the exportable portion would have brought Honduras more than U.S. $300 million. This is nearly 75 per cent of the gross national product for the entire country in 1964. In addition, further revenue would have been received for domestic sales. This was indeed a great loss.

There are 111 sawmills, which produce approximately 575,000 cubic meters of 20,309,000 cubic feet of lumber annually. It would take the present mills of Honduras about five years to saw the timber that is dead.

V. CONTROL

It is well known that Dendroctonus cause an annual drain on timber in Honduras, and that periodically they increase to an epidemic status which results in extremely heavy losses. It is believed that the damage done by bark beetles far exceeds any beneficial effect which they may exert on the forests of the country. So, it is time to determine the silvicultural, chemical, and biological control.

A. Silvicultural

The first symptoms of bark beetle attacks are usually the appearance of pitch tubes, the small globs of gum that accumulate around the entrance hole. In two to three weeks after attacks, the needles begin to droop and turn yellow. Later, they become red as the trees die. By the time the needles turn red, the beetle broods will usually have left the tree.

The fact that bark beetles require weakened trees in which to breed provides a means of preventing serious outbreaks. Losses are minimized, even in drought periods, in well-managed timber stands.

Pine stands should be thinned at frequent intervals to reduce the competition between trees. Timber that has reached maturity and worked-out turpentine trees should be removed. Competition from hardwood and brush should be kept to a minimum. These practices eliminate the breeding places of the beetles and increase the amount of water available to the remaining trees.

In logging operations, precautions should be taken to prevent the build-up of large bark beetle populations. Tops should be lopped and left in the sun to dry out. The larger tops left after sawtimber cutting should be utilized promptly for pulpwood. During severe drought periods, material larger than three inches in diameter that is to be left in the woods should be sprayed with one-fourth per cent gamma isomer of BHC (benzene hexachloride).

Every effort should be made to prevent injuries to the trunk and roots. Pruning and cutting should be done in rainy seasons. Under extreme endemic conditions, the emerging beetle population disperses and survives in the absence of specific breeding material in trees damaged by lightning or logging or infested by other insects. Injured trees may represent the only suitable material for successful attack. As soon as a host has been invaded, a pheromone is released by the female beetle, insuring the attraction of a male.

Mixed vs. pure stands by
Mixing by species and/or age classes

B. Chemical

Bark beetle infestations can be controlled if they are found early. Serious losses may result if control measures are delayed. Infested trees should be sprayed with a solution of BHC containing one per cent of the gamma isomer. On large, thick-barked trees it may be necessary to scrape the heavy, loose bark plates off the base of the tree to allow better penetration of the insecticide.

Benzene hexachloride is a chemical compound made up of five closely related chemicals called isomers. Of these five isomers, only the gamma isomer (lindane) is important for killing insects. Therefore, the insecticidal value of BHC solutions are dependent upon the content of the gamma isomer.

BHC may be purchased as technical grade, wettable powder, oil concentrate, or emulsifiable concentrate. The concentrates are easier to use and are commonly sold containing 12-½ per cent of gamma or one pound of gamma per gallon. The oil concentrate diluted with oil is recommended for woods use and the emulsifiable diluted with water for shade trees.

A spray of one per cent gamma benzene hexachloride in water equals the standard 0.5 per cent oil solution as a summer control for the southern pine beetle. Substitution of water for diesel oil reduces the cost of components by about five cents per gallon and, in addition, permits substantial savings in transportation, since water is generally available in the field. The risks of fire and dermatitis are also eliminated.

Spray is applied over the entire bark surface to the point of runoff. Fast-acting herbicides containing cacodylic acid (dimethylarsenic acid) significantly reduce broods of Dendroctonus adjunctus (Hopkins), D. obesus (Mannerheim), D. ponderosae (Hopkins), and D. pseudotsugae (Hopkins) in naturally infested trees. The chemical is injected directly into the sap stream near ground level. Application is made soon after the attack, before most of the eggs have hatched.

Control of bark beetles by injection of herbicides looks promising. It appears that this method is well-suited for use on large-scale control operations. Advantages: (1) ease of application, (2) low cost of treatment, (3) safe for both applicator and environment, and (4) lower hazard to non-target insects.

C. Biological

Forty-two families and 83 species of insects were found associated with the southern pine beetle. Eight known hymenopterous parasites and seven known predators of southern pine beetle were identified. A torymid, Roptrocerus eccoptogastri, was the most prevalent of the wasps found parasitizing the southern pine beetle. The life history of R. eccoptogastri is apparently more closely synchronized with that of the southern pine beetle than any of the other parasitic wasps. Emergence of this insect occurred simultaneously with emergence of the southern pine beetle brood adults. Dendrosoter sulcatus and Heydenia unica were the next most abundant of the parasitic wasps. Cecidostiba dendroctoni,

a known parasite of the southern pine beetle, was recorded relatively abundant.

Of the Diptera, Medetera maura, a dolichopodid, was recovered from infested trees. Thanasimus dubius (Coleoptera:Cleridae), Scoloposcelis mississippenis (Homoptera:Anthocoridae), and Temnochila virescens (Coleoptera:Ostomidae) were among the most prevalent predators collected. Of the remaining associated insects, some were predators, hyperparasites, or parasites of other insects, and some were scavengers or competitors for phloem food supply. The combination of all species of predators, parasites, and competitors of southern pine beetle probably had an effect in lessening the intensity or causing the decline of its outbreaks.

A clerid beetle, Thanasimus dubius, is highly predaceous on the southern pine beetle and on Ips calligraphus Germar. A T. dubius adult, during a life span of 5 to 10 weeks, can destroy at least 75 southern pine beetles. As the southern pine beetles and Ips beetles land on the bark, the adult of T. dubius moves about rapidly catching and feeding upon them, and mating and laying eggs. Females deposited from zero to 44 eggs daily (average 2.4). Eggs were laid singly or in clusters of two to 10. The incubation period ranged from seven to 14 days.

T. dubius larvae fed on all stages of the host beneath the bark, but mainly on the larvae and pupae of the southern pine beetle.

T. dubius may be capable of reducing epidemic populations of the southern pine beetle to tolerable levels.

VI. INFLUENCE OF DENDROCTONUS FRONTALIS ON ECONOMIC DEVELOPMENT AND PROTECTION

The republic of Honduras is presently at the stage of management where there are four important problems that need to be solved. These problems are: road net and protection, watershed, timber productivity, and regulation.

A. Road Net

It is reasonable to assume that there will not be good forest management and a healthy lumber industry until there are good arterial highways running directly from timber areas to seaports. High transportation costs are now the cause of about 20 per cent of each tree being left in the woods.

Honduras is roughly the size of Georgia, which had over 95,000 miles of rural roads. This is in direct contrast to the less than 2,000 miles of comparable roads in Honduras. The existing poor roads and the resulting high transportation costs are the greatest contributing factors to the poor logging practices now used. Lack of roads is causing the timber stands adjacent to roads to be overcut. No change can be expected in these practices until good roads are available. A transportation system suitably located, adequately constructed, and properly maintained is essential to protect our forest from injurious insects and forest fires.

Fire control will be difficult to sell, since it will mean changing a well-established way of life. Repeated burning is a

way of life in Honduras. Practically the entire pine forested area is burned over once every three to five years. This has resulted in a thin, even-aged stand of pine.

Indiscriminate burning is done to kill insects, clear land in a shifting agricultural economy, and to provide grass for cattle. The bark beetle epidemic would be due to an over-aged stand of timber continually weakened by fire.

The Forest Service has provided fire control for the last ten years. Elsewhere, fire sweeps from 20 to 50 per cent of the forest area every year, and regeneration is destroyed before it can reach survival size.

If the rural population can see the forest as a source of wealth and a source of future jobs, they will better understand the need to conserve it, to control fires, and to control illegal cuttings. Making forest information available to people would help in the task of gaining their cooperation to improve the productivity of the forest as a whole.

B. Watershed

Forest have other values besides their importance as a source of primary wealth. In many areas where they have been destroyed, soil has been washed away, floods have become more frequent in the rainy season, and droughts have become more severe in the summer. In the parts of Honduras where the soil is very shallow, the loss of the forest could result in the loss of the soil itself, leaving only the barren underlying rock. The potential for soil erosion and sediment damage to water quality increases in rugged mountainous terrain.

All land uses are potential precursors of floods, soil erosion, and sediment production. Abusive use or insect damage, if allowed to proceed sufficiently far, result in these conditions. These damage agents must be guarded against, because natural recovery of hydrologic characteristics and soil stability by damaged watersheds frequently proceeds so slowly. Corrective action must be taken to hasten recovery to a level of satisfactory watershed conditions. A significant part of watershed management in Honduras should be devoted to the development and application of appropriate watershed rehabilitation treatments and restoring protective watershed conditions.

C. Timber Productivity

Honduras has an estimated 79 million cubic meters of timber concentrated on an area of about 2 million hectares.[3] With good forest management the pine lands are capable of growing 18 million cubic meters [4] of roundwood annually. Yet, due to repeated burning, insects, shifting agriculture, etc. the annual growth is about one third of capability.

Good forest management practices are completely lacking and proper silviculture practices are ignored. The poor logging practices contribute to an unbelievable waste of timber.

Present milling practices are on the average quite bad. The logs, 16 feet in length, have been hand chopped square.

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[3] 2,790,280,000 cubic feet on 4,942,000 acres.

[4] 635,760,000 cubic feet.

Lumber is hand-dipped to kill insects and prevent blue stain.

It now appears that with sound forest management, the danger to the Honduran pine resource should be no greater than the risk that is faced anywhere in the world where large areas have pure stands of individual species.

Forest management that increases the vigor of a forest reduces its vulnerability to attack. More important, however, with an existing staff of trained forest personnel it is possible to find and quarantine any small outbreak that might form the nucleus of a new epidemic.

The forests of Honduras are capable of producing a high yield of good quality wood. However, they cannot reach their potential yield unless forest management planning and regulation of industrial forests are applied and are protected from damage agents.

D. Forest Regulation Plan of Aqua Fria

The Forestry Project in Aqua Fria will stimulate economic growth and provide effective development of 20,000 acres of pine forest. This project will benefit 200 rural families who now live in a minimum subsistance economy, with the typical family income averaging less than $150.00 a year. Income will increase according to the amount of lumber processed and sold by the cooperative.

The inventory in Aqua Fria region indicated that we should cut about seven million board feet of timber annually. This amount

of timber will provide a base for forest industry development and management of these previously unmanaged stands (Fig. 2).

Three main sections make up the project area with each main section divided into three subsections for a total of nine subsections (Fig. 3). The high quality saw logs mature in about 60 years; therefore, a 6-2/3 years cutting cycle for each subsection might yield the greatest returns from rapid growing Honduran pine. This implies a selective cutting of the entire area every 60 years.

The stand structure indicates no serious reproduction problem. To assist regeneration on cut-over subsections, we will build three-strand barbed wire fences around each subsection following the cut. Free grazing rights enjoyed by cattle owners make a fence necessary.

We must employ all the necessary methods ~~as much to prevent~~ as to control the southern pine beetle and the forest fires which occur and which, given the traditional customs of the country, could constitute a serious danger for the quantity and quality of the timber. The danger of man-caused fires increases as more people work in the forest. This necessitates building three forest fire lookout towers for rapid detection and reporting of ~~potential~~ forest fires.

Rational management of this region will not allow private ownership of forest lands. Instead, the family units of the region will organize into a cooperative to grow and harvest the timber and to manage the sawmill. A government official will appoint the general manager of the cooperative who has two

Figure 2. Agua Fria Region.

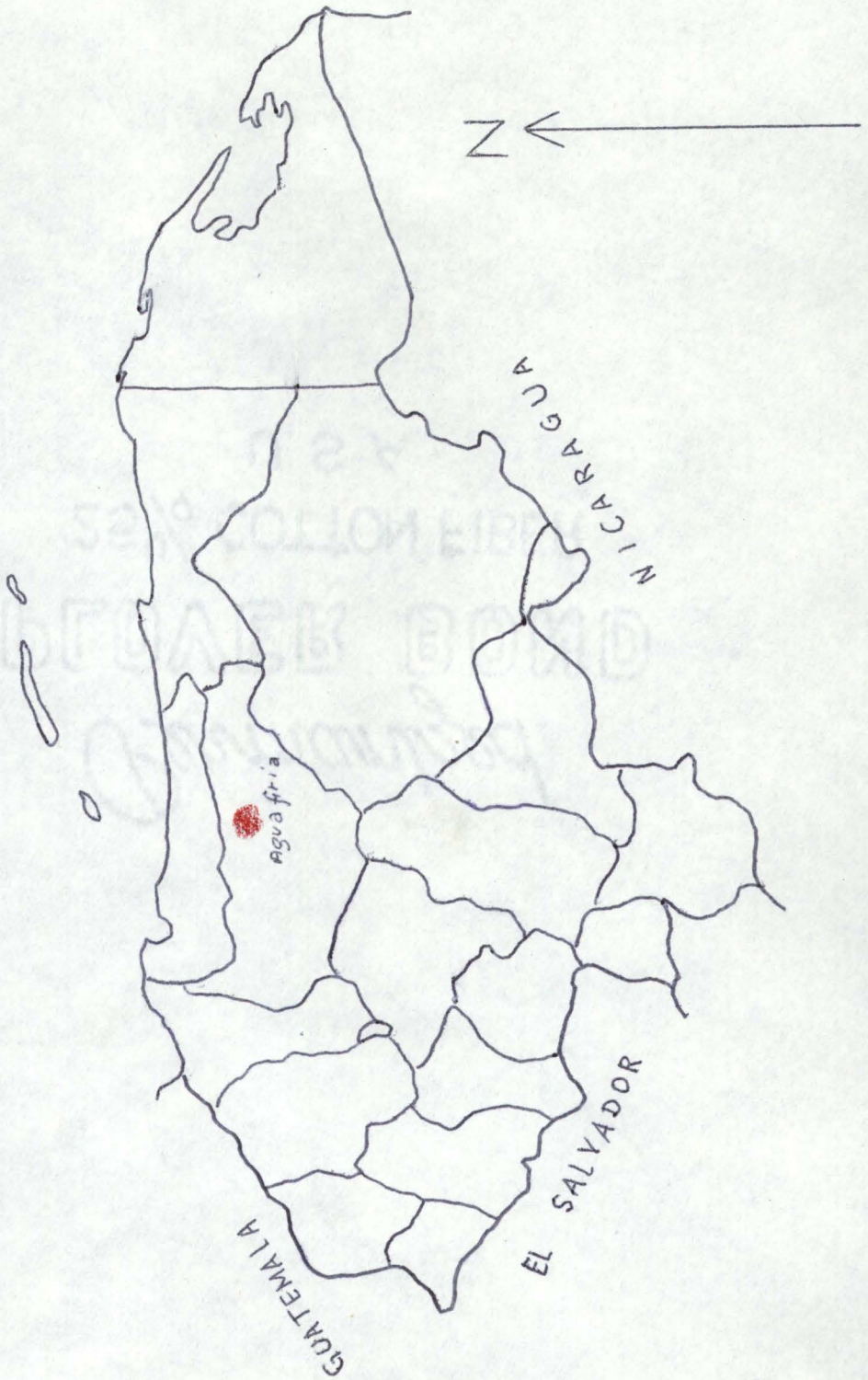
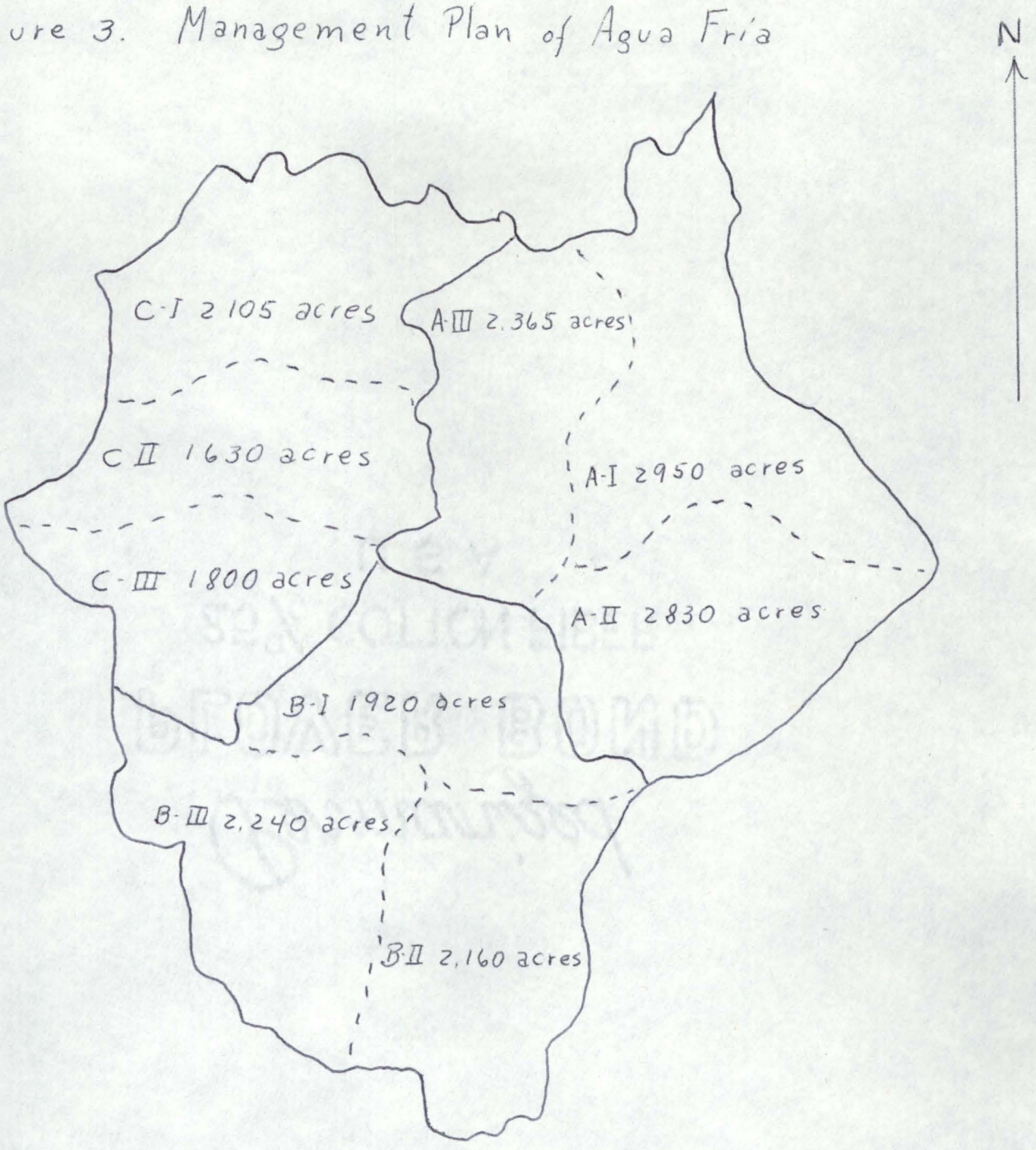


Figure 3. Management Plan of Agua Fria



Assignment of compartments To cycles

_____ 3 Sections A, B, C.

- - - - - - - - 3 Subsections I, II, III.

responsibilities: firstly, the financial structure of the enterprise, and secondly, the general field supervision.

The cooperative will establish an educational service to inform prospective members about the forest as a source of income and jobs. Members must understand the need to conserve the forest by controlling fire and preventing outbreaks of the southern pine beetle.

The Governmental Division of Roads and Highways will construct 35 miles of roads, needed in the execution of the project. These roads will facilitate the transportation of wood and also will serve as a means of access for forest protection and for public use.

To efficiently utilize the forest products, we will construct a sawmill in the locality of Aqua Fria, the most populous of the hamlets within easy reach of the timber. The Technical Department of the National Agrarian Institute will promote short courses to provide workers with training on the job. This sawmill will produce about 18,000 board feet of sawn lumber daily and will employ about 100 workers.

Until now, a large part of the high-quality wood exported to the European market has received a lower price than that paid by the North American market. The southwestern United States may become a larger market in the future. In this area there exists active interest in high grade Honduran pine. Markets for pulpwood will develop by 1972.

The National Agrarian Institute will keep a record of all production, will administer payment of outstanding debts, and

reinvestments into the cooperative. The Institute will also administer distribution of the profits to the local members during the first three years. The average annual family income of those living there will increase to approximately $575.00.

Since this represents a unique project in all Latin American countries, the Institute will closely observe all aspects. We will publish the necessary information of this Forest Development Project in a special momograph. The results would not be confined to our area, but would also contribute valuable knowledge toward management of the forest to the neighboring countries.

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