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GLOBAL FIRE INITIATIVE

Technical Report

Fire Management Overview of the Caribbean Pine (*Pinus caribaea*) Savannas of the Mosquitia, Honduras

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Cover Photo: Wildfire in the Caribbean pinelands of the Rio Platano Biosphere Reserve, Honduras.

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1 introduction

Objectives & Focus

During 2-10 March 2005, a three-person team of fire ecologists with expertise in fire applications—assembled by The Nature Conservancy's (TNC's) Global Fire Initiative—visited key locations within the Caribbean pine savannas of eastern Honduras. The purpose of the visit was to gain insight into the fire management issues facing the conservation of the Caribbean pine savannas that are located in and around the Rio Platano Biosphere Reserve and other conservation areas in the Department of Gracias Adios—an area long known as the Mosquitia or Miskito Coast. The trip was coordinated by The Nature Conservancy's Honduras/ Nicaragua Country Program and MOPAWI (Mosquitia Pawisa Apiska), an NGO focused on the development and conservation of the Mosquitia.

The objectives of the assessment were to:

(1) Gather information on the fire management needs and issues within the Caribbean pine ecosystem and related savannas.

(2) Assess current fire regimes and discuss whether they are significantly altered from what is believed to be appropriate to maintain the integrity of the pine savanna ecosystem.

(3) Develop a list of research needs and information gaps.

(4) Evaluate fire management planning and training needs.

(5) Assess how local communities and peoples might be integrated into fire management strategies.

(6) Identify key individuals who might participate in training courses, exchanges and mentoring programs.

(7) Propose fire workshops that could be held in the region to further address fire-related issues.

Team Members

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- Steven Morrison, Central Florida Preserves Manager, The Nature Conservancy, Lake Wales, Florida, USA

The team was accompanied by representatives from MOPAWI, in particular, Carlos Molinero, and COHDEFOR (the Honduran Forest Service), and met with a number of representatives from the local communities in Puerto Lempira, Mocorón, Laguna de Brus, and Laguna de Ibans.

(8) Provide TNC Honduras and MOPAWI with recommendations and next steps.

On this trip, we were unable to assess fire management threats and issues affecting the tropical broadleaved forests of the Rio Platano Biosphere Reserve, although current problems with land tenure and agricultural colonization in and around the reserve suggest that there will be an increasing fire problem in these areas from land clearing burns and escaped agricultural fires.

This assessment was conducted as part of the Latin American & Caribbean Fire Learning Network funded through The Nature Conservancy, with financial assistance from the U.S. Forest Service International Programs.

The information in this report is based on observations by, and discussions among, the members of the Assessment Team and their Honduran hosts during two days of meetings in Tegucigalpa and six days in the field in the Mosquitia. The Team's observations were limited to the following areas: 1) along the road from Puerto Lempira to the community of Mocorón, and from Mocorón to the community of Pranza, which is located on the Honduran side of the Rio Coco; 2) commercial air flights from La Ceiba to Puerto Lempira and from Puerto Lempira to Laguna de Brus, which gave a broad overview of vegetation distribution and recent fires; 3) the savannas west and north of the village of Laguna de Brus accessed by boat and by foot; 4) the inland waterway from Laguna de Brus to Laguna de Ibans and Plaplaya; and 5) a chartered over-flight inland from Laguna de Ibans over the Rio Platano Biosphere Reserve then east toward Laguna de Brus.

This assessment builds on, and draws information from, The Nature Conservancy's years of experience working in the pine savannas of Florida, USA, which are ecologically similar to Caribbean pine savannas, and its current work in the Caribbean pine forests of the Bahamas (Myers et al. 2004) and the Caribbean pine savannas of Belize. Much in this report is based on inferences made about the dynamics of the Honduran pine savannas from the extensive knowledge about the dynamics and fire regimes of the ecologically equivalent slash pine (*Pinus elliottii* var. *densa*) and longleaf pine (*Pinus palustris*) savannas in Florida, and supported by recent observations, management actions and monitoring in the Caribbean pine forests and savannas of Belize and the Bahamas.

Caribbean Pine Distribution

Pinus caribaea var. *hondurensis*, the Central American variety of Caribbean pine, ranges from the coastal plains of Belize and portions of the Mountain Pine Ridge, through the eastern lowlands of Honduras, and northeastern Nicaragua. Outlying populations of the species occur in Quintana Roo, Mexico, eastern Guatemala, and the Bay Islands (Honduras). As elevation increases it is found to intermix with, and be replaced by, *Pinus oocarpa*. Two other varieties of Caribbean pine exist: *Pinus caribaea* var. *bahamenis* in the Bahamas and the Turks & Caicos, and *Pinus caribaea* var. *caribaea* found in western Cuba and on the Isle of Youth (Farjon & Styles 1997). Ecologically and taxonomically, *Pinus elliottii* var. *densa* (South Florida slash pine) in central and southern Florida is very similar to *P. caribaea* in terms of morphology, habitat and response to fire. At one time they were considered the same species (Little & Dorman 1952).

General Ecology of the Pine Savannas

The lowland Caribbean pine savannas cover approximately 6,000 sq km in eastern Honduras and 10,000 sq km in Nicaragua (Figure 1). The topography is flat to gently undulating, less than 200 m above msl. Closer to the coast, drainage is poor and pines are restricted to ridges and mounds derived from ancient sand bars imbedded in a matrix of seasonally flooded or waterlogged grassland and/or palm thickets. Broadleaved tropical forests extend along water courses as narrow riparian zones and may form islands in areas protected from fire. Soils are nutrient poor sands, gravels and clays overlying heavy clays, with the clays predominating in poorly drained areas. Larger tracts of broadleaved forest occur on alluvial soils. Soils, however, are not limiting to either vegetation type. In the absence of fire, hardwoods can invade the pinelands, while repeated burning of the broadleaved forest can favor pines and associated fire-dependent species (Taylor 1963). In many places the boundary between broadleaved forest and pine savanna is abrupt; in other places a dense monte or brushline separates the two vegetation types (Parsons 1955).

These boundaries are a function of the differences in flammability between pine savanna vegetation and the fuels it creates and the moister, less flammable broadleaved vegetation. Virtually all fires originate in the pinelands. Most of these fires go out when they reach the moister, shaded fuels found in the forest. In the few places along these boundaries that escape

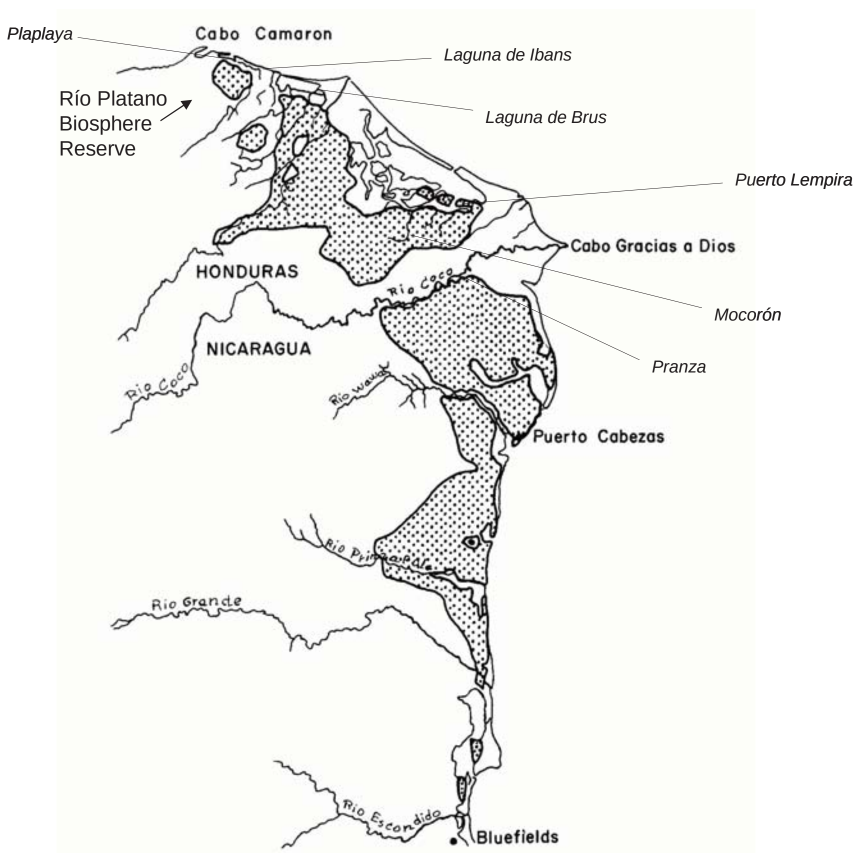

Figure 1. General location of Caribbean pine in eastern Honduras and Nicaragua (from Howell 1971), and approximate locations of places mentioned in this report.

fire for several years, broadleaved trees intermingle with pine. During severe droughts fires may cross the boundary and damage the tropical hardwood forest. The forest will recover if it remains fire-free, but fire-caused changes in fuel characteristics make these areas more flammable and susceptible to future burns.

The annual rainfall in eastern Honduras is 2,600 to 3,500 mm with a marked dry season starting in February and extending to May. This rainfall amount is more than enough to maintain tropical forest vegetation, thus pointing to fire interacting with soils as the primary factor maintaining savannas in the region rather than climate. In fact, it has been noted that the Miskito Coast of Honduras and Nicaragua is probably the rainiest place in the neotropics with savanna vegetation (Parsons 1955).

Fires in the pine savannas can probably occur at any time of the year as long as there are several sunny days without rain. Fires during wetter periods are invariably of low intensity, are patchy and go out at night as humidity rises; nevertheless, they can cause considerable mortality of pine seedlings (Munro 1966). In the early dry season, grasses are still green and fire intensities are still relatively low. Most fires in the early dry season probably also go out at night. As the dry season progresses, the grass fuels and pine needle litter become progressively drier and fires are likely to carry through the night. They may burn for many days.

Fire Regime

The Honduran Caribbean pine savannas and forests are fire-dependent, i.e. the ecosystem depends on fire for its persistence (Hardesty et al. 2005). Without repeated fire, the pinelands would change to something dominated by tropical hardwood trees, palms and shrubs—ecosystems without significant adaptations to fire—i.e. fire-sensitive ecosystems. The pines, grasses and herbaceous species would disappear (Munro 1966). There are likely many vertebrate and invertebrate species that depend on the open, frequently burned pine savanna for habitat and food. The dominant species in the overstory, midstory and ground cover of the pine ecosystem have adaptations to both survive fire and to respond positively to it. Their flammability also facilitates the spread of fire.

A specific fire regime is required to maintain the pine savanna ecosystem. A fire regime is defined as a set of recurring conditions of fire that characterize a given ecosystem. This set of conditions includes fire frequency, fire intensity, burn severity, seasonality of burning, and pattern of burning. The fire regime required to maintain the biodiversity of the Honduran Caribbean pine savanna ecosystem can be generally described as frequent (i.e. fire recurring within a range one to ten years), low intensity, surface fires (i.e. the fuels that carry the fire are on or just above the ground surface). The fires have little impact on either the overstory species or on the soil substrate. The fuel is probably capable of burning at any time of the year provided that there is a day or two of drying after rainfall, but there is a predictable protracted dry season that generally starts in late January and continues through May. Most of those areas that do burn probably burn in April and May. The fire season may extend into June if the rains arrive late. This assessment took place at the early- to mid-dry season when humidity is low but grasses are still green. The fuels that carry the fires are grasses and pine needle litter. When present, scattered-to-dense shrubs and palms contribute to fire intensity, and when they burn they may locally affect the overstory pines.

Although the appropriate fire return interval probably varies between one and ten years, the operative word is "varies," i.e. variability in the fire frequency and other fire regime factors may be more important ecologically than average or repeated properties. Although a pine savanna that supports mixed-age or even-aged stands of pine can readily withstand fires every year for a number of years, even for decades, repeated annual fires will gradually reduce the density of the pines until they disappear because the pines are not able to reproduce under a regime of annual fires. Similarly, fires recurring only every ten years would be burning through very heavy fuels, increasing the likelihood of mortality of larger trees. The greater the fuel loads the greater the fire intensity, all other factors being equal. Fires recurring only every ten years may allow the persistence of hardwood shrubs and trees, which as they burn intensely, could eventually tilt the pine forest towards broadleaved forest or shrubland.

There are two ignition sources: 1) lightning, particularly at the end of the dry season, even though lightning fires are routinely grossly under-reported in many areas and this is likely true of the Mosquitia pine savannas; and 2) humans, who have been an important part of the savanna ecosystem for millennia, and whose ignitions have likely been key, if not paramount, in shaping the structure, species composition, pine stand dynamics, and extent of the savannas. That is, biologically diverse pine ecosystems invariably have had an important human influence.

The current fire regime in most of the savanna is probably too frequent to maintain the pines long term, with many areas burning every year or two, There is a notable lack of pine regeneration and smaller pines over extensive areas. This situation in eastern Honduras and Nicaragua was noted over five decades ago when Parsons (1955) stated such fires have not only suppressed the encroachment of broadleaved trees, but have also sharply restricted the regeneration of the pines themselves. With the added pressures from logging operations, there is a very real concern for the perpetuation of the pines as an element in the savanna association. The near lack of pines in the savannas near Puerto Lempira probably reflects the effects of logging and very frequent burning.

Figure 2 is a conceptual ecological fire regime model showing the relationship between fire regime and vegetation type. The actual density, stature and species composition of the pine stands and their understory will depend on the specific mean fire return interval and variance for a particular area. This will be determined by ignition frequency (proximity to human activities and communities) and the landscape pattern (i.e. soils, topography and vegetation mosaic of any given area).

Although fire frequency and fire intensity are important fire regime components that influence vegetation structure and composition, equally important, and often overlooked, is the effect of season of burn on maintaining biodiversity (Robbins & Myers 1992). Some species will only flower and produce seeds if they burn during a specific season of the year. Also, repeated burning during a particular time of the year may favor some species at the expense of others.

Adaptations & Responses to Fire

Species in predictable fire environments like the pine savannas of eastern Honduras tend to express three characteristics: 1) Resistance to damage by fire, 2) Adaptation to respond positively to fire, and 3) Modification of the fire environment in which they occur. This applies to the ground cover and understory species as well as the pines.

Caribbean Pine

The adaptations and responses of Caribbean pine to fire have not been well studied, but we can make a number of inferences from 1) observations of fire effects we have made after fires within the range of Caribbean pine, 2) the pine's morphological characteristics (e.g. thick bark, high open crown, seedling characteristics), and 3) knowledge about the adaptations of similar pine species.

Caribbean pine regenerates most readily on sunlit mineral soils, which naturally occur after fire. Fire removes grass cover and organic matter. Fire may also kill older trees, reducing the density of the stand thus allowing more sunlight. Seedlings are intolerant to shade and do not survive under closed canopies, so for successful regeneration some agent is needed to open stands to sunlight. That agent can be fire, insect and disease damage, wind (most notably hurricanes) or harvesting. At times fire may interact with insect, wind or harvesting damage to allow regeneration.

Pine seedlings are sensitive to fire, but young regeneration (> 100 cm) can survive low-intensity surface fires as long as fuel loads are kept low by relatively frequent burning, and/or the stand burns under moderate conditions with a backing fire (i.e. burns into the wind). In Belize, we have found that the majority of Caribbean pine saplings between 50- to 100-cm survive backing fires early in the dry season (December) and the majority of those greater than 150 cm can survive backing

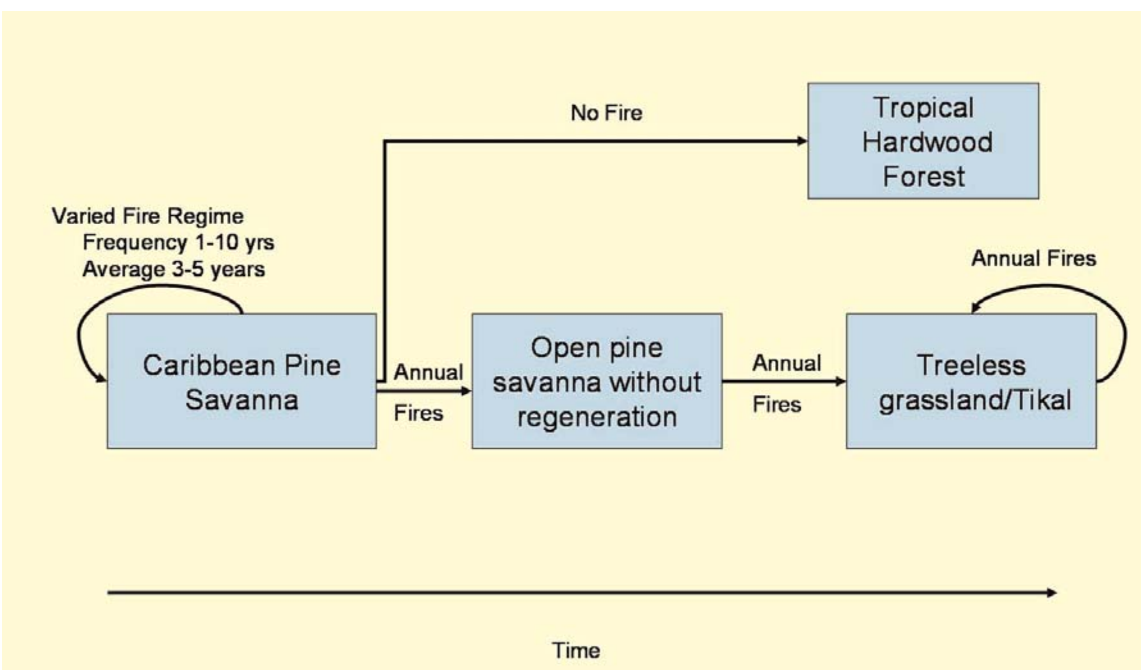

Figure 2. Ecological fire regime model showing the relationship between fire frequency and changes in vegetation. The current regime of nearly annual burns will eventually lead to the loss of the pines. Complete fire suppression will convert the pine savannas into tropical hardwood forest.

fires during mid-dry season (February) prescribed burns on sites that have not burned for 10 years (Figure 3). In December, January and early February the live fuel (green fuel) component of the grasses is high and soils are moist. As the dry season progresses, the proportion of live fuels decreases relative to dead fuels. By the late dry season, virtually all surface fuels are dead, significantly increasing the potential fire intensity, burn severity, and negative impacts on small trees.

In general, Caribbean pine seedlings (i.e. less than one year old) cannot withstand even low-intensity fire, but some saplings ranging from 0.5 m to 1.0 m in height do survive surface fires, particularly if the burning conditions are moderate and the flaming front is backing or flanking into the wind. The majority of Caribbean pine saplings over 1.5 m in height can survive moderate burn conditions and/or backing and flanking fires (Figure 4). Late dry season wildfires would be fatal to most saplings less than 1.5 m (Figure 4).

Larger trees are very resistant to fire. The thick bark protects the cambium, while the high, open canopy allows for heat dissipation

Figure 3. Backing fire as part of a prescribed burn in a Caribbean pine savanna in the Rio Bravo Conservation & Management Area, Belize. The burn took place in January (early dry season) in fuels that had accumulated for eight years. Caribbean pine over 1 m in height has a good probably of surviving fires with this flame length. Photo by R. Myers.

Figure 4. Upper photo: Caribbean pine saplings immediately after a prescribed burn, Rio Bravo, Belize, December 2003. Lower photo: Survival of saplings in the same view, December 2004. Virtually all saplings >0.5 m survived the backing fire that occurred under moderate burn conditions. Fireline intensity was less than in Figure 3. Photos by S. Morrison & R. Myers.

Figure 5. Pine stand along the road between Mocorón and Pranza. Thick bark and high, open canopy protect Caribbean pine from the heat of frequent low-intensity surface fires. Photo by R. Myers.

Figure 6. Grass species blooming after a wildfire in late March (mid-dry season) in a Caribbean pine savanna in Belize. A similar flowering response has not been observed in savanna grasses prescribed burned in the early dry season (December-February). This suggests that there may be a season of burn or burn intensity response to fire. Photo by R. Myers.

before lethal temperatures are reached (Figure 5). The crowns can withstand a considerable amount of needle scorch, in some instances up to 100 percent as the buds are protected by a dense rosette of needles.

Ground Cover Species

The species that make up the ground cover of pine savannas are frequently overlooked in the characterization and management of pine savannas, but it is the ground cover where most of the biodiversity in these ecosystems lies. The number of plant species in the ground cover of frequently burned pine savannas similar to those in the Mosquitia can be very high, in some cases 30 or more species per square meter (Walker & Peet 1983.). Although we know of no year-long, pre-burn/post-burn floristic studies of the ground cover in Caribbean pine savannas, we surmise that ground cover plant species diversity will prove to be as high as or higher than in ecologically equivalent pine savannas elsewhere. Common species are *Rhynchospora barbata, Bulbostylis paradoxus*, and bunch grasses in the genera *Trachypogon, Andropogon, Paspalum, Aristida* and *Leptocoryphium*, and the fire-stimulated bracken fern, *Pteridium aquilinum*.

The vast majority of ground cover species are able to resist fire. Nearly all are perennials and possess the ability to re-sprout from underground roots, rhizomes or lignotubers. Many of the grasses and other herbs are adapted to flower after fire, especially if the fires occur late in the dry season and/or are intense (Figures 6 & 7). It is likely that some of the ground cover species will not flower and produce seeds without the influence of fire. It is also likely that there are a number of species that are rarely seen except after a fire.

Figure 7a. Vegetative state of *Bulbostylus paradoxa* (Cyperaceae), a common ground cover species in the savannas of the Mosquitia and widespread in fire-maintained tropical savannas in the Americas.

Figure 7b. *Bulbostylus paradoxa* blooming within a few days after a fire. It is likely that this species never blooms unless it burns. The presence of species with such strong adaptations to fire is an indicator of a long history of frequent fire. Photos taken in the savannas between Mocorón and Pranza. Photos by R. Myers.

Species in frequently burned, fire-dependent ecosystems tend to be flammable by possessing a growth form, structure, and chemical composition that facilitates ignition and fire spread. Bunch or tussock grasses, as those found in the savannas of the Mosquitia, are typical of fire-maintained ecosystems, and they possess these flammable traits.

Mid-Story Species

Another highly flammable species in Caribbean pine savannas is the dominant palm species, *Acoelorraphe wrightii* (Figures 8a & b). Flammability ensures that fires will spread intensely and maintain conditions suitable for continued growth and reproduction of adapted species.

Acoelorraphe wrightii is common in the pine savannas of the Mosquitia, and clumps tend to dominate some areas, especially near the coast adjacent to the mangrove-fringed coastal lagoons. The local name for the palm is *tique* and the extensive patches of palms are called *tikales*. It may be that the palmetto is more tolerant to high water tables, seasonally saturated soils, and periodic flooding than the pines.

Other woody species are widely scattered throughout the savanna and pinelands. Their very low density is probably due to the history of very frequent fires. Virtually all of the woody species common in the savannas have some resistance to fire and possess the ability to resprout if damaged by fire. Common species are *Byrsonima crassifolia* (nance), *Curatella americana, Calliandra houstoniana, Miconia* spp., *Crescentia* sp., and the oak *Quercus oleoides*. All are common in fire-maintained, natural and derived savannas in Mesoamerica. *Curatella* extends into derived and natural savannas in South America.

Shrubs become more prominent in pine stands that have escaped fires for a number

Figure 8a. The palmetto *Acoelorraphe wrightii* burning intensely during a prescribed burn in February, 2005, Rio Bravo, Belize, illustrates the high flammability of this species.

Figure 8b. Same view taken five months post-burn. The palm, although highly flammable, readily recovers from the intense fire. Other species, such as pine, which are less tolerant to high fire intensities, would be killed if adjacent to the palm. Thus the palm's flammability gives it a competitive advantage over other species. Photos by R. Myers.

of years at the expense of the herbaceous ground cover. The fire response of two common shrub species in Caribbean pine savannas have been studied in Belize (Miyanishi & Kellman 1986). The reproduction of *Miconia albicans* and *Clidemia sericea* from seed were found to be stimulated by fire. Both of these species also resprout after being top-killed by fire.

2 observations

Puerto Lempira—Mocorón—Pranza

Observation 1: Savanna near Puerto Lempira. The savannas we observed between Puerto Lempira and Pranza are burning very frequently, in some cases every year. This may account for the lack of pines in the vicinity of Puerto Lempira, although a long history of local harvesting and some commercial logging likely has contributed to the scarcity of pines. Because the frequent fires are keeping fuel loads very low, pole-sized to mature pines that do exist are largely unaffected by the frequent fires. Regeneration, in contrast, is lacking (Figure 9).

Observation 2: Managed pine forests near Mocorón. Closer to the community of Mocorón, there is a mixture of pine plantations and fairly dense, natural pine stands that resulted from plantings and more intensive forest management that started in 1975 when COHDEFOR was more actively engaged in developing commercial pine forests and implementing forest protection in the area (Figure 10). These management activities were abandoned after about 15-20 years.

For the past several decades most of these stands have burned during relatively

Figure 9. Open savanna sparsely populated with pines near Puerto Lempira is likely an artifact of very frequent burning and a long history of local harvesting. Fires occur too frequently to allow for adequate pine regeneration. Under the current fire regimes the pines will eventually disappear. Photo by R. Myers.

frequent wildfires. Some fire control efforts continue to this day by an army garrison located near Mocorón.

The fire suppression efforts in the Mocorón area may actually be increasing the probability of more damaging fires as fuels accumulate or as the dry season progresses. The fires that have been occurring seem to be producing positive results in the pine stands by reducing fuels and protecting the stands from damaging wildfires. During the early dry season these fires tend to go out at night as the relative humidity approaches 100 percent and dew accumulates on the vegetation surfaces.

These early season wildfires are effective in not only reducing fuels in the pine stands but also are creating a mosaic of burned patches that serve to constrain the size of later fires. Efforts to suppress these fires may be exposing the forests to more severe fires later in the dry season when suppression is more difficult. A better strategy may be to let most early season fires burn. Local communities could be encouraged to burn at this time of year and to focus on priority areas while avoiding burns in areas where regeneration in needed. Although these fires would be largely unmanaged, it is an activity that would direct the current level

Figure 10. Pine plantations near Mocorón. Most of these plantations and nearby natural stands are burning frequently with unmanaged fires. In the early dry season these fires are beneficial because they prevent fuel accumulation and reduce the probability of tree-damaging fires later in the dry season. These early dry season burns also create a mosaic of burned patches that limit the spread of damaging wildfires that occur later in the dry season. Photo by R. Myers.

of burning toward meeting forest management goals and community needs.

Most of this forest represented by Figure 10 consists of even-aged stands of 30- to 40-year-old trees. Some appear to support several age classes. From a silvicultural and forest management perspective, these stands are in good condition, being maintained and protected by frequent, unmanaged, anthropogenic fires. In a few places, we observed stands that had suffered from intense fires that had caused considerable tree mortality (Figure 11). In some cases, there was significant pine regeneration underneath the dead trees. Such damage likely occurred during intense heading fires (fires burning with the wind) during extremely dry periods. The fire intensity was due to higher fuel loads that resulted from past management by COHDEFOR and the current suppression activities of the military. The high density of pines in the affected area may also have contributed to the extent of the fire damage, as dense stands tend to trap heat below the canopy.

Observation 3: Effects of current burn regimes near Mocorón. We observed a number of recent burns (within the past few days and weeks) and a number of burns were in progress in the area south and west of Mocorón. We felt that the impact of these fires was largely beneficial. There were a number of recent understory burns in pine stands that could not have been conducted better by a professional prescribed burn crew. The fires may be too frequent to allow for pine regeneration, but these largely even-aged, previously

Figure 11. Extensive damage and tree mortality from what was probably a late-dry season wildfire burning under severe environmental conditions, i.e. high winds, low relative humidity, low fine fuel moisture, and possibly higher fuel accumulations. Photo by R. Myers.

managed stands are too dense for successful regeneration anyway. With a slightly longer interval between fires, regeneration would occur as the stands thin naturally and become more uneven-aged, or regeneration could be facilitated by using appropriate silvicultural techniques following harvest. The low fuel loads maintained by relatively frequent burning are effectively protecting the forest from damaging severe fires.

Closer to the military base south of Mocorón, some of the pine stands had dense shrub understories and heavy fine fuel loads indicating a number of years without fire. We assume that this situation is the result of effective fire suppression actions by the military. We feel that it would be better if the military would let most early dry season fires run their course if they are burning with moderate intensity or backing or flanking through a stand. Aggressive suppression of fires should occur only in areas in need of regeneration and/or where cultural features are threatened. The military fire crews could also be incorporated into a fire management program that included strategically placed prescribed burns to reduce fuel and to break up horizontal fuel continuity. Their current suppression efforts only allow for more severe and extensive fires later in the dry season.

Observation 4: Old fire breaks. There are a number of old fire breaks separating formerly managed pine stands. These have not been maintained for a number of years. If stands or management units need to be protected from fire for several years, these old fire breaks could be burned to create black lines. The use of black lines and burned areas as fire breaks has a much lower environmental impact than mechanically maintaining fire breaks that disturb the soil.

Observation 5: Along road from Mocorón to Pranza. Between Mocorón and Pranza there are extensive areas of natural stands of Caribbean pine (Figure 12). These apparently have never been commercially logged, though there is probably a long history of cutting trees for local use. The structure of these stands reflects the fire regime that they have been exposed to. There are scattered older trees, a greater abundance of widely spaced trees that may age from the 1970's when fire suppression was implemented for about a decade, and very few young trees. The limited regeneration is the result of very frequent burning.

Observation 6: Community of Mocorón. The assessment team met with leaders of the indigenous community of Mocorón. This community is located on the edge of a large tract of pine forest, savanna and plantations that were managed by COHDEFOR in the 1970's and the early 1980's. Since the early 1980's when COHDEFOR could no longer support the forest management activities in the area, the pine forest has been largely unmanaged and only under the fire protection of the Honduran military.

Since then, these forests have been largely maintained by frequent, unplanned, uncontrolled, human-caused fires. People ignite the fires to improve grass for grazing, to attract game animals to green regrowth, to control ticks and other pests, and to facilitate travel and access by keeping trails open and vegetation low. There is also a general perception on the part of the people who set fires that the fires are needed to "clean up" the pine savanna. "Los pinares se ponen feo sin quemar" is a common

Figure 12. Open, fire-maintained Caribbean pine on the road to Pranza. The structure of this stand may reflect very frequent fire, with a fire-free period in the 1970's that allowed for the regeneration of the majority of the trees. Note scattered mid-story trees *Byrsonima crassifolia* and *Curatella americana*. Photo by R. Myers.

refrain. These indigenous people, having lived for millennia in a fire environment, have a fire culture that has probably been important in maintaining the extent and quality of the native pine savannas. Current fire prevention messages are at odds with the culture of fire use in the area. TNC's Two Faces of Fire campaign will be discussed later in this report and is an alternative to current fire prevention messages.

Even though many of the people see a need for the fires, the community leaders view fire as negative. They point to the huge fires that burn for days during the dry season and the few places where fire has damaged entire pine stands as indications of fire´s damaging effects.

The community is in the process of gaining management and harvesting rights to at least a portion of the pine forests near the village of Mocorón. Fire prevention and control are foremost in the minds of both the community and the government agencies that are negotiating the transition to community control and use. The community has no capacity to fight fires or to implement a fire management program. Opportunities to promote and implement a more integrated approach to a community-based fire management of these pine forests will be discussed later in this report.

Laguna de Brus

Observation 1: Meeting with community leaders. Community leaders of Laguna de Brus expressed concern about how

COHDEFOR's restrictions on burning were inconsistent with community needs. That notwithstanding, COHDEFOR recognizes that it does not have the capacity to enforce burning regulations. The community leaders were concerned that we were there to tell them that they should not burn. They expressed the need to burn primarily to improve forage for grazing. They also burn to prepare their agricultural fields, kill insect larvae that attack corn, and to facilitate the hunting of iguana.

Observation 2: Visit to pine stands near the community and grasslands to the northeast. Just outside of the village of Laguna de Brus, pines are restricted to "islands," i.e. slight rises, in a "sea" of seasonally inundated grasslands with scattered palmetto. These pine islands consist primarily of large mature trees and there is little or no regeneration (Figures 13 & 14). They burn frequently, primarily from annual fires started in the grassland for forage improvement purposes. The frequency of burning accounts for the lack of pine regeneration. The pines are also being selectively logged for local use. Permission to cut trees is obtained from COHDEFOR. Because of the lack of regeneration, the harvestable trees will soon be exhausted. Creating fire-free intervals of several years would allow for regeneration and long-term maintenance of the pine stands. This could be a community effort to sustainably manage the stands as communal forests.

The frequent firing of the grasslands for livestock forage follows the widely used

Figure 13. Communal pine forest just outside of the town of Laguna de Brus. The nearly annual burning and harvesting will soon lead to the disappearance of the pines. These stands could be managed with fire for sustainable use. Photo by R. Myers.

practice of burning patches throughout the year. Burns during the wet to early dry season go out at night. Later dry season fires are likely to burn into previously burned patches and are thus limited in size. The progression from newly burned patches to patches that are "greening up" facilitate the rotation of livestock from one green patch to the next throughout the year.

There is no reason why the wetter, treeless grassland cannot continue to burn annually to meet the objectives of forage improvement (Figure 15). Techniques would have to be implemented to prevent some of the annual fires from entering the pine stands. This might mean creating annual black lines around the pine stands, or conducting prescribed burns in the grasslands at the beginning of the dry season that would protect the pine islands from dry season fires, as long as the community was committed to keeping fires out of the pine stands for several years. From the air there appears to be a number of sandy rises in the coastal savannas that could support pines or are very sparsely stocked with pines. These areas presumably could support pine forest if the frequency of fire were reduced and there if there is an adequate pine seed source.

Tikales between Laguna de Brus & Laguna de Ibans

Observation 1. Burning of the *tikales*. There are extensive herbaceous wetlands between Laguna de Brus and Laguna de Ibans that contain large stands or patches of the palmetto, *Acoelorraphe wrightii*, known locally as *tikales* (Figure 16). A canal connecting the Rio Platano with Laguna de Ibans crosses one of these extensive *tikales*. Fires set from the canal have been burning the tikales every year. The palm provides an important construction material for the communities along

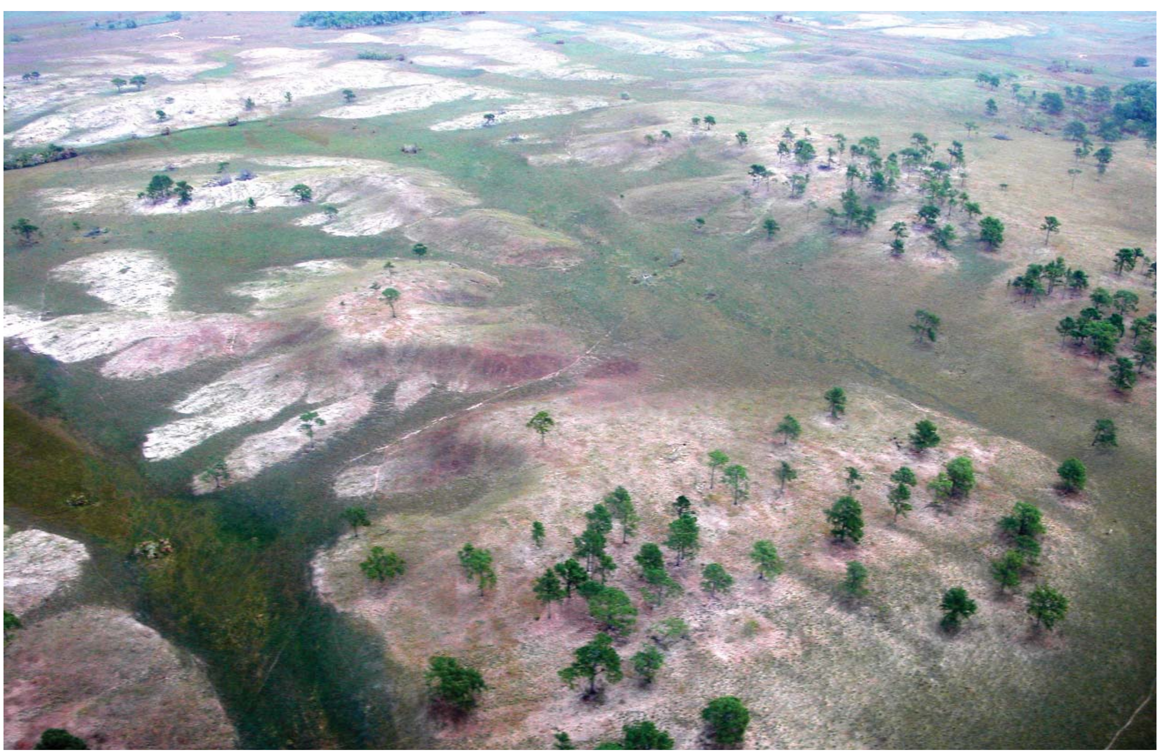

Figure 14. Pine islands on sandy, well-drained rises near the coast between Puerto Lempira and Laguna de Brus. Nearly annual fires are preventing pine regeneration and creating the very sparse stands of pine. Photo by R. Myers.

Figure 15. Treeless wet savanna with scattered palmetto near Laguna de Brus that is burned nearly every year to improve forage for cattle. Photo by J. O'Brien.

the coasts. They use the palm fronds for roofing thatch and the stems for walls. There is some concern that fire affects the quality and utility of the palm fronds. Nonetheless, the palm is highly flammable and clearly depends on fire. The *tikales* could be protected from these annual ignitions by burning both sides of the canal during a period when the fires would not spread far and go out at night.

Figure 16. Fire in an extensive marsh with patches of tikal between the Rio Platano and Laguna de Ibans. Photo by R. Myers.

Figure 17. Community pine forest near Plaplaya. Pine regeneration is lacking due to dense canopy and understory, and due to the grazing of cattle. Periodic burning would facilitate regeneration in open areas and reduce the fuel hazard. Photo by R. Myers.

Plaplaya & the Pine Savannas of Rio Platano Biosphere Reserve

We visited 1) a community pine forest on the landward side of the waterway near the community of Plaplaya (Figure 17), and 2) the pine savannas on the southeast side of Laguna de Ibans which represent the only pine savanna inside the boundaries of the Rio Platano Biosphere Reserve (Figure 18).

Observation 1: Community pine forest. The Plaplaya site is not a natural pine forest. Due to its proximity to the communities along the coast, the forest has been used for years for livestock and selective wood harvest. It is likely that the large pines established on old pasture land or agricultural plots after they were abandoned. Today the community protects the forest from fire and controls other uses. To them, fire is a negative. The site could be managed for sustainable harvesting of pines using fire to keep fuel loads low and to facilitate regeneration. The site currently lacks pine regeneration. This is likely due to the shade produced by the dense pine stand and the dense shrub layer. Periodic burning would stimulate pine regeneration in open patches. In the continued absence of fire, the pines will eventually die out whether community harvests the trees or not.

Observation 2: Rio Platano Biosphere Reserve pine savanna. Southeast of Laguna de Ibans lies an extensive pine savanna inside the Rio Platano Biosphere Reserve that is in a nearly natural state. Selective logging for local use and frequent burning occur in the accessible areas near the lagoon. Local people using the pine forest strongly feel that the pinelands need to burn, although people living in the com-

Figure 18. Frequently burned pine savanna in the Rio Platano Biosphere Reserve. Note burned and unburned patches created by an early dry season fire. Patches remaining fire-free for three to four years may allow for pine regeneration. These early dry season burns were very low intensity and low severity. Photo by R. Myers.

munities along the coastal strip expressed concern about the frequent burning. The landscape was a good example of Caribbean pine forest and savanna with herbaceous marshes and wet grasslands occupying poorly drained areas (Figure 18). As with other areas, there is very little pine regeneration due to the frequent burning. This area could be managed with fire through a community fire management project.

4 conclusions & recommendations

Integrated Fire Management

The Nature Conservancy's Global Fire Initiative is promoting the concept of Integrated Fire Management (Myers 2006) as a means of maintaining sustainable ecosystems and communities. The term "integrated fire management" is not new and has been used in many different ways and contexts. TNC's use of the term implies integrating three interacting components (strategies, actions and processes) of fire with the goal of maintaining sustainable communities and ecosystems. The components are 1) the technical aspects fire management, e.g. prevention, suppression, fire use; 2) the ecological role that fire plays in the ecosystems under consideration; and 3) the culture of fire in the communities living in and using those ecosystems. Integrated Fire Management can be visualized as a triangle with the three sides: 1) fire management, 2) fire ecology, and 3) the socio-cultural aspects of fire (Figure 19).

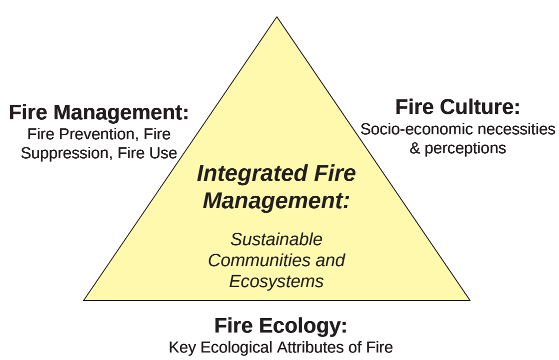

Figure 19. The Integrated Fire Management triangle illustrates a conceptual framework that integrates basic perceptions of fire and the need to use fire by local communities with the beneficial and detrimental role that fire may play in ecosystems, coupled with all the technical aspects of fire management.

Integrated Fire Management is an approach to addressing the problems of, and issues posed by, both unwanted and desirable fires within the context of the natural environments and socio-economic systems in which they occur, by evaluating and balancing the relative risks posed by fire with the beneficial or necessary ecological, economic and social roles that it may play in a given conservation area, landscape or region. It looks for cost-effective approaches to preventing unwanted fires. When fires do occur, it provides a process for 1) evaluating whether the effects will be detrimental, beneficial or benign; 2) weighing relative benefits and risks; and 3) responding appropriately and effectively based on stated objectives for the area in question (Myers 2006).

Below is a discussion of the three legs of the Integrated Fire Management Triangle as they relate to the situation and issues we found in the Mosquitia:

Key Ecological Attributes Related to Fire

(1) The Mosquitia of eastern Honduras has some of the best examples of tropical Caribbean pine savannas and related ecosystems in Central America. Throughout Mesoamerica and the Caribbean very few examples of tropical pine and pine/oak ecosystems are actually protected for their biodiversity and natural processes. Where protection does occur it is usually under the umbrella of intensive silviculture and

fire protection that favors pine production at the expense of the biotic diversity and landscape mosaic found in dynamic natural systems.

(2) These ecosystems are fire-dependent, i.e. without fire, or with inappropriate fire—too much or too little—they will change in structure and species composition with the loss of habitats and the species that depend on the savannas and pine forests. Failure to incorporate fire into the conservation and management of these ecosystems will eventually result in their loss. Although fire prevention and suppression are important actions to avoid the negative impacts of unwanted fires, especially during the height of the dry season, many of the fires that occur annually are doing more good than harm.

(3) The importance of fire in maintaining the Caribbean pine forest and savanna ecosystems can be inferred from a) the life history and morphological characteristics of the pines and many other species which allow them to persist and respond positively in an environment characterized by very frequent fires, and b) the tremendous amount of ecological information available from related pine savanna ecosystems in Belize, the southeastern coastal plain of the United States, and the Bahamas (Myers 2000).

(4) The primary evidence that fires in the Mosquitia may currently be too frequent is the paucity of pine regeneration and pines of younger ages. At a landscape scale, the natural structure of the pines under an appropriate fire regime should be a mosaic of even-aged stands of varying sizes, i.e. the trees within a stand are all the same age, but the stands should represent different age classes, i.e. there should be a matrix of open stands of old trees with successively denser stands of younger trees interspersed in the matrix. Regeneration should occur in patches that lack a dense pine overstory and have recently burned. Survival of seedlings depends on a fire-free interval of three to five years

Forest management techniques have been developed that take advantage of this natural forest structure with selective logging taking place in older stands followed by burning, which stimulates pine regeneration in the harvested patch. Burning also thins younger stands of dense regeneration and protects other areas from wildfires. From a conservation perspective, dense pine plantations are not good surrogates for natural pine forests and savannas.

(5) The biodiversity of the pine savanna ecosystem is in the ground cover. Forest management and silvicultural practices that disturb the ground cover are thus undesirable. This is a frequently overlooked fact in the management and maintenance of pine forest ecosystems. Management and conservation efforts tend to focus on managing the pines for commercial purposes and local uses rather than in maintaining the entire ecosystem. Equally damaging to the ground cover is the planting and maintenance of dense pine plantations that shade out the ground cover. Past efforts at managing these pine ecosystems in both Honduras and Nicaragua have focused on converting the savannas to dense pine forests. The natural structure of the pine ecosystem is open, park-like stands of mature pines, with denser stands of young pines and regeneration that are naturally thinned by the repeated fires. This forest structure permits a continuous ground cover with scattered shrubs and includes islands of hardwood trees in areas with

appropriate soils and an accommodating fire regime.

We know of no place in Mesoamerican pine ecosystems where the biodiversity value of the ground cover is recognized and the ecosystem protected accordingly. In fact, floristic studies of ground cover vegetation are lacking throughout the region. In most cases, the grasses have not even been identified. Fire is essential in maintaining the diversity of species in the ground cover and the regeneration of the pines. There are ecologically appropriate forest management techniques for natural pine forests and savannas that maintain the natural structure of the pine population and leave the ground cover intact.

(6) As long ago as 1955, the role of fire and the need for fire-free intervals to stimulate pine regeneration were recognized in the Mosquitia. Parsons (1955) stated that "the most serious effect of fires is the killing of the young pine seedlings… Replanting is unnecessary, for the pines are prolific seed producers. What is needed is complete fire protection of cut-over areas for from five to ten years or until the natural regeneration has reached eight to ten feet in height. A simple system of firebreaks would accomplish much towards this end for often a narrow foot trail is sufficient to stop the flames."

Our data from Belize indicate that many trees over 1 to 1.5 meters in height can survive low intensity fires, suggesting that a fire-free interval of five years or less may suffice. We oppose the use of extensive mineral soil fire breaks to limit fire spread because of the damage done to the ground cover. Blacklines, timing of burns, and judiciously placed burned areas should be considered instead of mineral soil fire breaks.

(7) Damage to soils and soil erosion were frequently cited as detrimental effects of fire on the pine savanna ecosystem in the Mosquitia. There is considerable misunderstanding regarding the role and impact of fires on soils and water quality. Pine ecosystems are notably nutrient-poor. The paucity of nutrients is a function of soil parent material and is not the result of nutrient loss due to fires. Nutrient-poor, fire-maintained ecosystems have a tremendous capacity to capture and recycle nutrients released from low-intensity fires. In fact, one of the beneficial roles that fire plays in these ecosystems is the release and recycling of nutrients locked in dead plant material. Nitrogen in plant material is volatilized by fire, but this nutrient is recaptured by nitrogen-fixing legumes common in these ecosystems and by nitrogen fixation by blue-green algae that are stimulated by soil pH changes following fire.

Studies on nutrient retention and loss in Caribbean pine savannas in Belize demonstrated the resistance of savanna vegetation to nutrient losses following fire (Kellman et al. 1985; 1987). It was concluded that repeated burning has not reduced the fertility of the surface soil and that burning make Ca and Mg available for plant uptake that would otherwise be in insoluble forms.

Fire does expose the soil surface to erosion, but because virtually none of the ground cover plants are killed by fire, their roots are intact and the protective vegetation cover returns within a few weeks of fire. Erosion is most likely to occur during intense downpours during wet season thunderstorms and tropical storms. Areas burned late in the dry season may be subject to erosion at the onset of the wet season storms, but areas burned earlier in the dry season may have one to three months of vegetation regrowth of ground cover species before heavy rains occur. By the time the rains begin, the soil is protected by the ground cover vegetation. This fact points to another reason why it is important to allow most early dry season fires to run their course, and/or conduct early- to mid-dry season prescribed burns. (See Hudson et al. [1983] for a discussion of season of burn and wildfire effects on surface runoff and erosion in *Pinus oocarpa* stands in Honduras. They propose that early dry season prescribed burns are more protective of soils than late dry season wildfires.) Suppression actions only shift the majority of fires to the late dry season when they are more damaging to trees and soils.

Damage to soils is probably greatest in artificially dense pine stands that are killed by intense fires. In these situations, the ground cover has been eliminated or greatly reduced by the dense canopy shade and the system cannot respond with the rapid regrowth that normally occurs after a fire.

(8) Though we have reported that late dry season fires may be more damaging to the pines and soils, such fires are important ecologically. Research results in the pine savannas of the southeast United States, coupled with observations after prescribed burns and wildfires in the Caribbean pine savannas of Belize, demonstrate that late dry season fires are important in stimulating the flowering and seed production of many herbaceous species, particularly the grasses (Robbins & Myers 1992; Platt 1999). The key is variability in the fire regime, in this case season of burn, within the limits that are ecologically appropriate for the ecosystem.

Socio-economic Necessities & Perceptions Related to Fire

(1) As long as humans have been living in the Mosquitia it can be assumed that they have been burning it. Everywhere in the world where people live in fire-prone environments they burn the vegetation; they burn it for a variety of reasons and they burn it frequently. This long history of burning, perhaps as long as 12,000 years, is likely to have been important in creating and extending the pine savanna conditions that we are now trying to conserve.

The primary traditional reasons for burning the savanna are probably 1) maintaining low vegetation stature to facilitate travel between communities, to hunting areas, to agricultural plots, and to areas used for gathering materials and foodstuff; 2) stimulating the production of desired materials and foodstuff and/or to facilitate the ease in gathering those items; 3) facilitating hunting by attracting game animals to the tender vegetation regrowth in recently burned areas; 4) controlling pests such as ticks and chiggers; and 5) burning to clear vegetation for planting of crops.

These motives are as valid today as they have been for millennia. Added to these traditional reasons is the burning to improve forage for domestic livestock.

(2) There is a conflict between the traditional burning practices of the peoples living in the Mosquitia pine savannas, and national policies that focus on commercial pine management and forest protection. Current fire prevention campaigns present all fires as being bad and needing to be prevented—campaigns that, if successful, will lead to undesirable changes to the very ecosystems we are striving to protect. The indigenous populations—especially those actually living

in, and gaining their livelihood from, the pine savanna—have an understanding of the role of fire and the situations where it is both beneficial to them and to the environment. Until the present, their culture has not been focused on the pines as a product of commercial value.

(3) The need to maintain the pine forest in a healthy, productive state was illustrated both in the Mocorón area, where the community would like to gain control of the management of the forest and reap economic gains from it, and in the Laguna de Brus area, where frequent burning, primarily for forage improvement coupled with selective logging, will eventually lead to the loss of pine stands accessible to the community for their use. Clearly there needs to be a new approach to fire that recognizes its ecological, traditional and economic roles and uses.

(4) TNC has been promoting the concept of Two Faces of Fire as a message that integrates fire's role, uses and impacts. There are good fires and bad fires. Good fires are those, managed or unmanaged, that maintain the biodiversity and overall ecological health of the pine savanna and related ecosystems. Good fires are also those that meet the traditional needs of indigenous communities, i.e. facilitating access, controlling pests, etc., while still playing their appropriate ecological role. Good fires are agricultural fires that remain under control, or any fire intentionally set for economic or traditional purposes that continue to maintain the health of both ecosystems and communities. Bad fires are escaped agricultural fires and fires entering commercial pine forests and other pine savannas too frequently. The results are eventual forest loss by preventing pine regeneration. Bad fires include any agricultural fire that escapes into fire-sensitive vegetation like tropical broadleaved forests. Bad fires are also those that threaten human life and property.

The Two Faces of Fire message recognizes that fire is a vital ecological process in specific ecosystems and a necessary traditional tool for human livelihoods. It seeks to manage fires that are beneficial and to prevent fires that are detrimental.

(5) Although we visited only a handful of communities, we saw opportunities for innovative community-level projects to deal with fire in ways that are beneficial to both people and the ecosystem.

Mocorón could use a community managed fire project in the nearby pine plantations that they hope to control. This would primarily focus on identifying where fuels need to be reduced to protect standing timber, fire needs to be prevented for several years where to allow for pine regeneration, and where most fires can be allowed to run their course until ecological or management needs change.

The town of Laguna de Brus could use a community forest project to protect and maintain the islands of pine that are near the village. This would involve decisions about where and when places should burn.

The villages along Laguna de Ibans could manage the pine savanna within the Rio Platano Biosphere Reserve to meet their local needs.

Fire Management

Fire management encompasses all technical strategies, actions and decisions involving fire prevention, fire suppression and fire use.

(1) **Prevention:** The prevention of unwanted or undesirable fires is the

hallmark of fire management in both fire-dependent and fire-sensitive ecosystems, as it is considerably cheaper and more effective to prevent unwanted fires than to try to put them out after they are ignited. Prevention is an essential component of all fire management programs because there is always the risk of fires that threaten health, life and property or which are ecologically and economically damaging. In many places, prevention campaigns and programs have been so successful that undesirable environmental changes result.

Existing fire prevention campaigns in the Mosquitia focus exclusively on the negative aspects of fire. The assumption is that all fires are bad and must be prevented. They ignore both the ecological necessity of the pine ecosystems to burn and the traditional needs and perceptions of the indigenous communities. We recommend a more balanced approach that recognizes fire as an essential element of the environment that needs to be managed.

(2) **Suppression:** Control of unwanted fires is the expensive and logistically difficult part of the fire management equation. Suppression of fires is particularly important when the fires threaten life and property or are ecologically damaging.

Except for the limited suppression activities of the Honduran military near Mocorón, suppression capacity in the region is non-existent. Suppression should be community-based and implemented through a fire management plan agreed upon by each community. Decisions can be made about what areas need to be protected from fire for specific intervals, which areas can be allowed to burn, and which areas need to burn either to stimulate regeneration or to protect them from intense wildfires. Such a plan would likely allow many fires to run their course.

(3) **Fire Use:** Fire use is the purposeful application of fire to meet specific economic or ecological objectives. Fires may be controlled or uncontrolled, and planned or unplanned. Prescribed burning is the controlled use of fire using a written plan designed to meet specific objectives. Controlled burning is essentially the same thing but without a written plan. Unplanned, uncontrolled fires can also be used or managed to meet specific objectives and resource management goals. Decisions are made regarding the course of actions to be taken on fires that occur, or are expected to occur, in a given area. Those decisions may involve aggressive suppression; monitoring; or indirect management of where a fire will be allowed to burn based on fuels, natural fire breaks, weather patterns and other factors.

Fires could be purposefully ignited in portions of the pine savanna to reduce fuels, stimulate regeneration, meet traditional needs, and to protect certain areas that need regeneration. Most of this burning could be done using local knowledge of fuels, weather, topography and fire effects that already exists within communities, and using resources available within the community. Most burns would not have to be highly technical prescribed burns, though it would be useful to provide basic prescribed fire training to individuals responsible for the programs.

We see a minor shift in the frequency of human-caused burning (towards less fire) as key to maintaining the ecological integrity of the pine savanna ecosystem and providing sustainable products and services for local communities.

5 next steps

(1) Disseminate report to TNC Honduras/Nicaragua, MOPAWI and COHDEFOR for comment.

(2) Meet with TNC Honduras/ Nicaragua, MOPAWI and COHDEFOR to discuss implementation of selected strategies and actions.

(3) Organize a workshop in Honduras at either the regional level (i.e. dealing specifically with the pine savannas of the Mosquitia) or at a national or international level focusing on integrated fire management issues in all of Honduras' pine forest types or in tropical pine ecosystems in general. Funding is available from the U.S. Forest Service International Programs for a workshop in 2006 or early 2007.

(4) Identify and discuss training needs. Hondurans have participated in three international workshops on fire management organized by TNC's Global Fire Initiative through its Latin American & Caribbean Fire Learning Network. Three people from the Mosquitia participated in a workshop in the Dominican Republic that focused on Integrated Fire Management concepts. One person from COHDEFOR participated in a basic technical training course on prescribed burning held in the Caribbean pine savannas in Belize, and two representatives from COHDEFOR participated in a United Nations Food and Agriculture Organization-sponsored training course for instructors in community-based fire management that was also held in the pine savannas of Belize. Similar training workshops and courses could be held in Honduras. Future workshops and training courses held elsewhere should include key representatives from Honduran agencies and NGO's.

(5) Promote the concepts of Integrated Fire Management within COHDEFOR to better address and manage the large number of fires that occur in all pinelands in the country each dry season.

(6) Promote the Two Faces of Fire as an alternative to existing prevention campaigns.

(7) Identify possible demonstration projects within the Mosquitia or elsewhere in Honduras where Integrated Fire Management concepts can be applied through community-based programs. Seek funding for one or more programs.

(8) Discuss the value of a similar assessment and report for the pine savannas of Nicaragua.

(9) Discuss who in The Nature Conservancy's Honduras/Nicaragua Program or Mesoamerica Conservation Region should take the lead on fire management issues and serve as liaison with the Global Fire Initiative.

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