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TECHNICAL COOPERATION PROGRAMME

Regional Strategy for Forest Health Management in Central America

Belize, Guatemala, El Salvador, Honduras and Nicaragua

International Consultants Report

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FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

A devastating outbreak of bark beetles has severely affected Central America over the past 5 years. Over 100,000 ha of pine forests have been lost to date. The major pest has been the southern pine beetle, *Dendroctonus frontalis* Zimmermann, though other *Dendroctonus* and *Ips* species also have been involved. The resource lost during this outbreak has caused widespread and significant economic impacts. The extensive tree mortality also has increased the risk of catastrophic wildfires and negatively affected water quality, wildlife, and recreation. The outbreak ultimately may result in large areas of deforestation, as the affected forests frequently are converted to other uses.

In response to the outbreak, Honduras, Nicaragua, Belize, Guatemala, and El Salvador requested technical assistance from the Food and Agriculture Organization (FAO) of the United Nations through the Technical Cooperation Programme (TCP). A regional TCP was initiated in May 2002. The primary objectives of the TCP were to assist in the containment of the bark beetle outbreak and to support the implementation of integrated pest management strategies designed to reduce the incidence and impacts of future outbreaks. To meet these objectives, a Regional Coordinator was appointed to coordinate the project, and each country selected a National Coordinator and National Consultant. Train-the trainer workshops were scheduled with the goal of producing qualified instructors in bark beetle management in each country. The attendees would then conduct training sessions in their own country for entomologists, foresters, ecologists, and government officials with responsibilities in forest management. International Consultants on bark beetle and forest management also were recruited to provide bark beetle expertise, evaluate existing programs, and recommend improvements in short- and long-term strategies for pine bark beetle management.

Two technical backstopping missions were conducted as part of the TCP. The FAO Forestry Protection Officer, the Regional Project Coordinator, and the International Consultant on bark beetle management visited Honduras and Belize from June 19 –29, 2003, and then Guatemala, El Salvador, and Nicaragua from November 14-26. The objectives of these missions were to 1) examine the current extent and severity of the infestations and their impacts; 2) meet with the professionals and agencies charged with bark beetle prevention, detection, and suppression and evaluate their programs; and 3) recommend procedures, technologies, coordination, and/or training that would facilitate the effective management of current and future outbreaks. Based on observations of the impacts of the outbreaks and discussions with individuals involved in forest pest management from all sectors, the following analysis and evaluation of the pine bark beetle management programs in Central America was prepared by the International Consultant. Included are general and specific recommendations, with an emphasis on strategies or activities that realistically can be accomplished and integrated into current programs.

BACKGROUND

Honduras

Honduras has an extensive bark beetle management program, initiated in 1982 (Billings and Schmidtke 2002). The Corporación Hondureña de Desarrollo Forestal (AFE-COHDEFOR) employs a national pest coordinator, Vicente Espino, as well as coordinators in each forest region that help plan detection and suppression programs. They also provide training and extension services to all levels of forest managers. A database was established in 1982 that tracks the location, suppression, impacts, and costs of bark beetle infestations. The Escuela Nacional de Ciencias Forestales (ESNACIFOR), the forestry school in Siguatepeque, offers instruction in bark beetle biology and control. Dr. Ronald Billings, principal entomologist with the Texas Forest Service, has provided technical assistance for the past 20 years.

Honduras suffered a severe outbreak of the southern pine beetle (SPB), *Dendroctonus frontalis*, in 1962-1964, and 28% of the pine forests were affected. Another outbreak occurred in the early 1980s. Losses to bark beetles were greatly reduced upon implementation of the SPB management plan recommended by Billings (1982). Over 70% of infestations detected between 1984 and 1993 were controlled, primarily by cut-and-remove or cut-and-leave (Billings and Schmidtke 2002). A substantial outbreak began in 2000. The Honduran government passed an emergency bill in late 2001 to provide the funding and resources required to combat the outbreak, but approximately 10,000 ha had already been impacted.

Belize

The Mountain Pine Ridge Forest Reserve (MPRFR) was established in 1944. According to a report by Global Forest Nursery Development Co. (2002), the Reserve was sparsely stocked and was characterized as an open pine savannah. Intense fires occurred frequently, and regeneration was scarce. A management plan was installed in 1956, at which time logging and fire control were initiated. After installation of the management plan, the pine stands within the reserve became more extensive and densely stocked. Logging was suspended in the early 1970s and very little harvesting has been conducted in the MPRFR since that time.

Pine stands were planted in the savannahs of southern Belize in the early 1950s. These stands now range from open and sparse to dense tracts with little diameter growth. Management of these forests is often by concessionaires, with supervision by the Forestry Department.

Guatemala

Bark beetle outbreaks in Guatemala have been reported over the past 70 years (Cano Alvarado 2003). *Dendroctonus* bark beetles have affected over 5,000 ha of forestland in

Guatemala in the past 5 years, including over 1,000 ha lost in 2003 (Hernandez Davila 2003). Two species are responsible for the majority of the tree mortality: *Dendroctonus frontalis* and *D. adjunctus*. In northern Guatemala in the Petén Region, *D. frontalis* has severely impacted forests of *Pinus caribaea*. *Dendroctonus adjunctus* and *D. frontalis* attack *P. oocarpa* in the western high lands and the eastern mountains, though current losses have not been as severe as in the north. Historically this region has been severely impacted by bark beetles, with *Pinus hartwegii* (*P. rudis*) as the primary host and *D. adjunctus* as the primary attacker (Castañeda 1980, Billings and Schmidtke 2002). The red turpentine beetle, *D. valens*, is often found near the base of trees infested by other *Dendroctonus*.

El Salvador

El Salvador has the smallest forested area of the Central America countries, and had 48,400 ha of coniferous forests in 2000 (Rodriguez 2003). Occasional, small bark beetle outbreaks have occurred, and public response to suppression actions has been mixed (Billings and Schmidtke 2002). *Dendroctous frontalis*, *D. mexicanus*, *D. adjunctus*, and *D. valens* are the primary species involved in attacks on pines (Landaverde Toruño 2001).

Nicaragua

The coniferous region in Nicaragua is concentrated in the province of Nueva Segovia, which contains approximately 60,000 ha of pine forests. Bark beetle outbreaks have been a recurrent problem, and infestations of *Dendroctonus mexicanus* (probably *D. frontalis*) and *D. parallelocollis* were reported in stands of *Pinus oocarpa* in 1986-7 (Maes 1992). An outbreak of *D. frontalis* began in 1998. An organized suppression was not initiated until 2001, when funds and technical assistance became available. As a result, the infestation covered a wide area and was difficult to control. A buffer was initiated, but the cutting was halted after protests by the landowners. After 6 months and meetings with the affected communities, a decree was issued allowing buffer cutting to continue. Overall approximately 5,600 ha were treated (Billings and Schmidtke 2002). The subsided in early 2002, but over 30,000 ha of pines had been killed.

Due to the large number of dead trees, the local sawmills were soon flooded and timber prices crashed. Without a market for the beetle-killed timber, most of the trees felled in the buffer were not salvaged. In addition, a large percentage of the trees killed are still standing. *Pinus caribaea* was heavily affected, whereas above 800 m *P. oocarpa* was not attacked as severely. Ordinarily *P. oocarpa* is highly susceptible to *Dendroctonus* attack. The treated area was the focal point for severe wildfires in April 2003 which covered some 8,000 ha.

CURRENT CONDITIONS AND OBSERVATIONS

Honduras

The outbreak of pine bark beetles has declined. Few active infestations were observed in June 2003 in the forests of Olancho, Francisco Morazán, and El Paraíso, regions that were heavily infested in 2000-2002. It was evident that bark beetles had killed substantial numbers of pines in recent years, as stands of dead pines covered many of the hillsides. Direct control of infestations was infrequently applied. Small areas had been cut-and-removed or cut-and-left. Selected large infestations were treated by felling the freshly-attacked trees and a buffer strip of uninfested pines. A very limited amount of salvage of beetle-killed timber was underway, and it was apparent that most of the affected pines would not be utilized.

Almost every pine stand had been burned recently. These burns were primarily started by local residents interested in maintaining open pine stands. Livestock grazed on grasses promoted by the frequent fires. In some areas, corn or beans had been planted under the pines or in areas that had been salvaged. As a result of fire, very little pine regeneration was noted. Most pines stands appeared even-aged. Competing vegetation was scarce, and pine density ranged from sparse to densely-stocked. Resin-tapping was prevalent in some stands, particularly in El Paraíso, with every tree utilized for resin production. Markets for resin are low in the area as the main production facility is located far away near other forested areas. Some reports indicate that resin-tapping may predispose trees to beetle attack, but this relationship must be substantiated. Recent Peace Corps postings on websites indicate some conflict between resin-tappers and loggers.

AFE-COHDEFOR continues to provide training on bark beetle management to foresters and land managers, and the wrap-up of a week-long session led by national forest pest coordinator Vicente Espino was observed on June 20. Local communities and cooperatives also are involved in beetle detection and suppression, and discussions about bark beetle management were held with a cooperative in El Paraíso. Infestations detected within the community are treated as quickly as possible, and cut-and-leave is the primary method of suppression. Vacated and felled trees are removed later if market conditions allow. Priority for treatment is assigned based on infestation size, with large infestations receiving high priority. Local timber industries are interested in removing timber as part of standard forest management. However, their main focus is on harvesting of stands rather than thinning.

The Department of Forest Protection of AFE-COHDEFOR recently prepared a report entitled “Estrategia Nacional de Protección Forestal”. This publication provides a blueprint for an integrated approach for preventing and suppressing fire and insect outbreaks in Honduras’ forests for 2003 through 2015. It encourages participation at all levels and establishes timetables and targets in all facets of bark beetle and fire management. If fully implemented, this strategy could effectively reduce forest losses to fire and pests and improve forest management.

Belize

A large bark beetle outbreak began in the Mountain Pine Ridge Forest Reserve in early 2000. Three infestations were observed in the southeast portion of the reserve. These infestations were not treated immediately. Belize was attempting to cope with the effects of Hurricane Keith, so fuel and manpower were in short supply. The infestations continued to expand, and finally coalesced. A large expanding front of the infestation moved to west and northwest. Containment lines 240 feet in width were finally cut to slow the infestation, but by November approximately 80% of the pines in the Reserve had been killed. In late 2000 the Belize government allocated $1 million in emergency funds for suppression. A stakeholders meeting was convened in December in Belmopan to formulate a strategic plan for bark beetle management. However, the outbreak collapsed in December 2000, and bark beetle activity has remained at moderate to low levels since that time. Only two small infestations were currently active during our visit in June 2003. The eastern part of the Reserve was under contract to a private logging company. Infestations were treated rapidly by cut-and-remove or cut-and-leave, and resource loss in this section of the Reserve was minimal.

Pine stands on the coastal savannah of southern Belize were also affected by bark beetles in 2000. Detection flights were made regularly in some areas, but none were conducted in others. Small infestations were initially treated by cut-in-front, in which only the green infested trees and a buffer were felled. This technique had mixed success, and managers switched to cut-and-leave (felling of all currently-infested pines and a buffer of uninfested trees), which proved efficacious. Activity in this region by *Dendroctonus* also subsided in late 2000. *Ips* and *Dendroctonus* bark beetle infestations occur periodically, and these are treated by cut-and-leave.

A complicating factor in the recent bark beetle outbreak is the discovery that the primary agent may be a new species of *Dendroctonus* (Midtgaard and Thunes 2003). Scientists with the Norwegian Forestry Group found the bark beetles in the MPRFR did not respond to the lures used for the southern pine beetle. The size of adults was quite variable, and galleries were often horizontal rather than the winding, S-shaped type associated with SPB. An analysis of the DNA by Larry Kirkendall, a taxonomist with the University of Bergen in Norway, indicated the Belize bark beetles are a new species closely related to SPB. Further testing is needed to verify the validity of the new species. Pheromone trapping in 2001 by Bob Haack yielded all *D. frontalis*.

Guatemala

The Instituto Nacional de Bosques (INAB) oversees forest management on all productive, non-reserve forested lands in Guatemala. Its responsibilities include forest pest management. INAB currently has 32 offices spread through 9 regions of the country. Funding for INAB is very limited and much of that money is targeted to fire. Therefore INAB must utilize the local communities and landowners in pest management programs. Aerial detection flights are too costly, so private landowners and citizens are trained in bark beetle detection. When suspect infestations are reported, a forestry

technician will ground-check the spot and fill out a data form. Their technical report is due within 8 days of receiving notification of the infestation. A decision on suppression of the infestation is made based on projected volumes and potential utilization of the felled trees. The landowner can sell the salvaged timber, but they are required to have a sanitation plan in place. Private landowners may hire a forester to prepare the plan, but many are just now being trained in bark beetle management and there is no certification required. INAB can complete the plan if the landowner can't do it, and the costs can be passed to the landowner unless that person is impoverished. INAB must approve any salvage plans, and the process may take over a month to complete. The decision to suppress the infestation is based on the location of the infestation (slope, access, potential for increased expansion, etc.), community needs and goals, and the ability to utilize the trees. On community lands, INAB will mark the trees and local workers will apply the treatment, while on private lands the landowner takes care of the entire process. INAB has oversight of all treatment activities.

Suppression of bark beetle infestation varies by community. Some communities actively practice forest management, and local governments may hire a forester. Forest products are utilized for timber and firewood. In some cases agriculture and forestry coexist, with corn underplanted beneath the pines. Other communities do not manage their forests, as they may have cultural or religious objections to felling trees. Bark beetle infestations are not suppressed. Neighboring communities may initiate illegal harvesting in these areas.

INAB has prepared a pamphlet designed to educate communities on bark beetle prevention and suppression. The objective is to get this important information to all communities and foresters to insure that decisions on forest pest management actions are consistent and informed. These pamphlets should improve community and landowner involvement in bark beetle detection and control and demonstrate the benefits of prompt suppression.

Forests on protected lands in Guatemala are administered by the Consejo Nacional de Areas Protegidas (CONAP). CONAP currently has no personnel trained in forest pest management. Communication and coordination in bark beetle management between CONAP and INAB often has been difficult. Information on infestations on protected areas rarely is entered into the database maintained by INAB. A new National Committee on Forest Health (Sanifor) was recently established, and this committee should facilitate cooperation among all agencies with forest health responsibilities.

Forest management training opportunities are increasing in Guatemala. In response to severe bark beetle outbreaks and continued deforestation, many organizations have established projects to increase the capacity of the government and communities to practice sustainable forest management (including this FAO TCP). Programa Regional Forestal de Centroamérica (PROCAFOR), CATIE (Centro Agronómico Tropical de Investigación y Enseñanza), CCAD (Comisíon Centroamericana de Ambiente y Desarrollo), and OIRSA (Organismo Internacional Regional de Sanidad Agropecuaria)

all are providing funding and expertise to improve forest health capabilities in Guatemala.

Very few currently-infested trees were observed during our trip in November 2003 (the northern region of Petén was not visited). In the coniferous forests of the Chiquimula Region, the aftermath of *Dendroctonus* infestations was observed. Forest fires in 2001 had helped trigger an outbreak of *D. adjunctus*. Response to the outbreak varied widely. Some areas had been left untreated due to community practices, while other areas had been harvested. We were told of a private company that had cut and peeled, sprayed, and then burned infested trees to suppress an infestation. We also visited Iximche National Park, site of Mayan ruins. Many large trees had been attacked and killed by bark beetles, and the infestation was still spreading through the park. As this is a religious site, no control of the affected trees is permitted. It is also likely that the new species of *Dendroctonus* is prevalent in Guatemala during outbreaks, but the species composition of the bark beetles in the different regions has not been determined.

El Salvador

El Salvador no longer has vast acreages of coniferous forestland due to extensive deforestation, and therefore has not sustained the severe bark beetle outbreaks common in neighboring countries. Fire is a much larger concern, and many of the bark beetle infestations develop as a consequence of the impacts of forest fires. Two active infestations near San Salvador were examined in November 2003. The first was in a hillside stand of *P. caribaea* near the subdivision of Villa del Mar. Control measures were slowly being implemented. Though the loggers had been advised on proper suppression techniques by an expert from the Plant and Animal Health Department, it appeared that the buffer and fresh attacks were not the first trees felled, and the infestation continued to expand. The other infestation was in a stand of 20-year old *P. caribaea* in El Carmen in the foothills of the San Salvador volcano. Twenty ha had been affected to date, and infested trees were still present. Beetles collected from the site were subsequently identified as the new *Dendroctonus* species. The infestation is on private land, but the landowner has yet to take action.

The coniferous forests in the mountainous areas near Chalatenango were also visited. This area had been impacted by bark beetles, and most of the infestations observed were small. No current activity was evident, though some infested individual trees may still contain beetles. Some of the infestations had been felled. Extraction and utilization of the downed material was proceeding slowly, and *Ips* beetles were attacking the felled trees.

Entomologists in the Plant and Animal Health Department are responsible for oversight of bark beetle infestations on private lands and non-protected public lands. They rely on local communities to detect infestations. Private landowners must obtain a license to cut trees. In pine plantations, trees can be cut but not removed until the license is granted, while in natural stands no felling is allowed without the license. Cut and remove usually is the only suppression method applied. A representative of the Department of Forestry

must visit the site and make a report. Currently there is no computerized database for tracking bark beetle infestations, and at the end of the year the infestation reports are summarized and a final report issued. The Department has the authority to force landowners to suppress infestations, but usually it tries to reach an agreement on control with the landowner.

Protected areas are under the purview of the Ministry of the Environment and Natural Resources. About 1500 ha of pine forests are protected. Bark beetles are not considered pests in protected areas, and 1000 trees have been attacked and killed in recent years. Adjacent landowners have threatened lawsuits to force suppression of infestations in protected areas. There is very little information exchange between the agencies responsible for bark beetles on private and protected areas.

A National Strategy for bark beetles has been developed, but funds are lacking for its full implementation. In addition, very few government personnel have a detailed knowledge of bark beetle integrated pest management. In an effort to improve communication, three workshops on forest land management problems are held annually with private landowners and government officials. The landowners not participating in the workshops could be reached through the National Strategy. There is a need for the Minister of Agriculture to sign off on the strategy and supply the necessary monies.

One aspect of the National Strategy is an increased emphasis on bark beetle prevention, but there is not a clear understanding of what constitutes a high hazard stand. Densely stocked stands and areas affected by fire appear most susceptible, but studies correlating stand conditions with the incidence of bark beetle attack are needed. For the protection of individual trees, applications of methyl parathion have used on lightning-struck pines or other trees considered at risk.

Nicaragua

The Instituto Nacional Forestal (INAFOR), a division of the Ministry of Agriculture and Forestry, has responsibility for forest management and protection in Nicaragua. A National Strategy for management of bark beetles has been prepared. In addition, a new forest law has been enacted and INAFOR is currently attempting to enact it. About 30-40% of forest lands are protected in Nicaragua (mostly hardwoods), and these areas fall under the jurisdiction of the Ministerio del Ambiente y los Recursos Naturales (MARENA). The government designates which areas are protected, including private lands. The goal is to maintain forests on these lands to protect watersheds and improve water quality. INAFOR tries to coordinate bark beetle prevention and suppression with MARENA within protected areas.

Local communities and INAFOR personnel are responsible for the detection of infestations. When a suspect spot is reported, INAFOR does a ground check, usually within 3 days. For general forest areas, a report is prepared and submitted to the landowner. With assistance from INAFOR, the landowner develops a treatment plan. The local INAFOR office has the authority to approve the plan and supply a treatment

permit. This process usually requires fewer than 15 days. The landowner is responsible for implementing and funding the treatment plan. However, at the peak of the recent outbreak the government paid for suppression. If the landowner does not want to take action, the local community and government may become involved. The landowner can be forced to suppress infestations on his land. To date, through the coordination of INAFOR, landowners have been convinced of the necessity of infestation suppression. The landowner is able to sell or utilize the treated trees. On protected areas, INAFOR notifies MARENA of the infestation. MARENA must conduct an on-site evaluation and make a treatment recommendation. This process often takes up to 4 months. As on non-protected areas, the owner implements the treatment and can utilize the products.

There have been problems with this current system. The long delay between detection and treatment in protected areas allows infestations to continue expansion. Consequently, suppression of these large infestations is difficult. Compounding this problem is the desire of MARENA to limit the size of the buffers to 5 m. This size buffer is not sufficient for small to medium sized infestations, and certainly is inadequate for large spots. Some communities are opposed to cutting and did not take action until large areas had been affected. Most communities and landowners do not want to control infestations unless they can receive an economic return. During outbreaks the mills are overloaded and there is no incentive for landowners to treat their infestations. Even when mills are not at capacity they often only want large sawlogs, so infestations in stands of small diameter trees are not suppressed. In some cases, landowners have already sold standing trees to sawmills, so they have no reason to expedite control.

These problems also affect the capacity to implement prevention activities. Though forest management plans call for thinning and other activities, most landowners and communities do not do anything until the final harvest. The benefits of thinning were evident during the last outbreak. The forests in the area around San Fernanado had been thinned by timber companies with local sawmills. Bark beetle infestations in these forests were less numerous and less likely to expand than infestations in other areas.

Communication is sometimes lacking. The communities were not well informed when the initial buffer strips were felled in an attempt to stop the bark beetle infestation, and resistance to the cutting soon became evident. Meetings were held in the local communities before the second round of buffers were cut, and public acceptance of the strategy was greatly increased. However, little communication between the communities and the forestry agencies has occurred since the buffers were completed. Also, no database is kept to document the location, treatment, and affected areas of individual infestations.

The outbreak in Nueva Segovia has ended, and no active, expanding *Dendroctonus* infestations could be located in November 2003 during our visit. Some individual infested trees were observed, but these were probably *Ips* beetle infestations from populations building in the dead material.

RECOMMENDATIONS

REGION-WIDE RECOMMENDATIONS

In 2002 Ron Billings, Texas Forest Service, and Paul Schmidtke, USDA Forest Service, conducted an assessment of bark beetle and fire management in Central America (Billings and Schmidtke 2002). They provide an excellent analysis of the forest protection programs currently in place. They stress the need for increased government and public awareness for forest problems and advocate coordinated efforts between countries and organizations for forest protection. There is a definite need for extension materials for training, and they suggest the creation of a forest protection web page that would facilitate technology and information transfer. Stable funding for regular and emergency detection, prevention, and suppression programs is essential.

These recommendations are echoed, and based on observations during this visit, the following recommendations are suggested to supplement and expand on those of Billings and Schmidtke.

Compile basic biological data on *Dendroctonus* in Central America. There is a need for biological information on SPB and other *Dendroctonus* spp. specific to each country. A clear concise record of SPB behavior should be compiled from best source material within Central America. Reliable documentation of generations/year, seasonal behavior, dispersal, population cycles, natural enemies, impacts, etc. is necessary. This data can be assembled from the SPB database, studies at ESNACIFOR and universities, previous reports from each country, and forester observations. The management guide by Núñez Hernandez (2001) could provide the framework for an updated guide on SPB in Honduras and the other countries. Bark beetle management experts in each country would be responsible for evaluating the information and selecting the material acceptable for inclusion. This information would be beneficial in training and for planning management activities. The data would document the importance of SPB integrated pest management (IPM) and provide impetus for increased funding for forest management. The preparation of these materials would also indicate knowledge gaps and help guide the direction of future SPB research in Central America.

Use pamphlets to reach communities. The pamphlet on bark beetles in pine prepared by INAB in Guatemala should serve as a model for Central America. Each country should develop their own brochure, with information on identification, detection, suppression, and prevention of bark beetles specific for their country. These pamphlets should be distributed to communities within coniferous-forested areas through local forest management offices. The pamphlets should contain the names, addresses, phone numbers, and e-mail addresses (if available) of local contacts for reporting suspect infestations and obtaining further information on bark beetle management.

Utilize communities and other agencies in detection of infestations. Using information provided in the pamphlets described above, members of local communities should be encouraged to report any suspect bark beetle infestations. Personnel in other

government agencies who frequently spend time in areas with pine forests should be trained to recognize bark beetle infestations and instructed where to report any potential spots. Agencies conducting aerial surveys should also be enlisted to assist in detection.

Develop a hazard-rating system for forests. The identification of highly-susceptible stands is paramount in planning hazard reduction activities and in prioritizing detection surveys and suppression activities. A simple hazard-rating system specific for conditions in each country is needed. Given the limited amount of funding and manpower available for bark beetle hazard reduction, the best hazard system to use initially would be one that only differentiates between high hazard stands and all others. The goal is to provide a simple, accurate system that allows the quick, easy recognition of high hazard stands. Only a few variables should be utilized in the system, and these should be easy to collect. Common factors used in hazard rating systems are tree species, host and total basal area, stand, age, average tree height, percent host type, and site (i.e. ridge, sideslope, lowland). The variables used and their values that correspond to high hazard could be determined based on forester observations and experience and an examination of current and past data on spot locations. The system could be refined as better information on the relationship between stand conditions and beetle infestation is gathered.

Through research, a more detailed hazard rating system that utilizes more variables and produces more output categories of hazard could be developed over time. These complex rating systems are beneficial for providing government officials and forest managers an overview of current forest conditions and as a basis for funding of prevention programs. Enlist the research community in the development of these hazard rating systems and the creation of risk maps.

Develop long-term bark beetle management plans, with an emphasis on prevention. Communities, landowners, industries, and managers of public lands should be encouraged to develop long-range bark beetle management plans in advance of the next outbreak. Prevention is the key for reducing long-term losses to bark beetles, and the focus of these plans should be prevention. Healthy, well-managed pine stands are more resistant to the initiation and spread of bark beetle infestations. The hazard-rating systems described above should be used to identify high hazard stands and to allocate funds and manpower for risk reduction. Management plans should also include guidelines for infestation suppression, setting the conditions under which immediate suppression of active infestations could commence for the various areas covered under the plan. With approved management plans already in place, the interval between spot detection and suppression should be greatly reduced.

Improve monitoring of population levels. Annual monitoring of bark beetle populations is necessary to anticipate outbreaks and for the appropriate allocation of funds, equipment, and manpower for bark beetle management. An effective monitoring system is vital for determining when population levels begin either increasing from endemic to epidemic levels or declining to low levels. Pheromone traps are generally used for this purpose. Several trap designs are available. Lindgren funnel traps are reliable and sturdy. The initial cost for these traps is steep, but their durability may make

them more cost-effective in the long run. However, these traps are often stolen. Cheaper traps can be made from heavy plastic, similar to the prototypes provided by Brian Sullivan, USDA Forest Service. Regardless of the trap selected, it is important that only one trap type is used for monitoring so the results can be compared between areas and over time.

Another expense is the pheromone lures used with the traps. For now, lures designed for the southern pine beetle (frontalin with alpha-pinene or host terpenes) should be used. These can be purchased from several sources, but again, consistency is important. The lures must be deployed immediately or stored in a freezer.

The cost of the traps and lures may dictate how many traps can be utilized annually. All areas forested with pines should be monitored, with at least 2 sets of 3 traps in each department. The traps should be left in place for at least 1 month, with the contents collected weekly. The optimal time for monitoring must be determined. These monitoring surveys are designed to capture dispersing beetles, so the traps should be deployed during periods of dispersal. If this information is not known, then research is needed to select the best time for trapping. Baited traps first should be run year-round for several years to ascertain the period of peak catch of bark beetles and their associated predators. Trap catches should be related to the numbers of infestations in order to develop a predictive monitoring system.

Practice prompt and effective suppression. Each community, forestry office, private forest-based company, or other entity charged with forest management should have well-trained personnel in charge of treatment decisions. These individuals would be charged with assigning treatment priorities and managing the activities of the work crews. They should have access to a SPB database so they can track infestations under their purview and ensure that active infestations are treated in a timely manner.

Until more effective suppression measures are developed and tested in Central America, the main methods of treatment should remain cut-and-remove and cut-and-leave. All active, expanding infestations should be felled promptly following ground evaluation. All currently-infested trees should be included in the treatment when possible. Partial treatment should be used only for very large infestations that are expanding too rapidly for fellers to keep up. In these cases, the fresh attacks and a substantial buffer of uninfested trees should be felled. Frequent post-treatment monitoring is essential, and any breakouts should be felled immediately.

To increase the efficacy of SPB suppression, the downed material should be removed and utilized if possible. Cut-and-remove treatments are dependent on markets for the timber. Local communities could be encouraged to utilize the felled trees for firewood or construction, particularly those trees containing brood. Removal has associated problems such as a lack of timber markets, corruption in the logging industry, and agricultural or residential encroachment into the cleared areas, and these issues must be addressed by the government.

Cut-and-leave is very effective in suppressing small, expanding infestations. Any additional measures that could increase the efficacy of this treatment should be used if feasible. Prescribed burning immediately following felling can kill brood, but may kill the regeneration as well and lead to wildfires if not properly contained. Debarking the infested trees will increase brood mortality, but this technique is time-consuming and not usually necessary, and should not be a function of the felling crews. The practice of hiring and training local crews with chain saws to apply cut-and-leave treatments has been successfully implemented previously in Honduras and Nicaragua, and should be encouraged and expanded.

Trap trees have been suggested as method of suppressing or reducing SPB populations (Midtgaard and Thunes 2003). There are three different techniques utilizing trap trees. 1). When SPB populations are at a low level; trees are baited at intervals throughout the forest during periods of beetle dispersal. The goal is to delay the onset and decrease the severity of outbreaks. This tactic is being tested in Texas and Louisiana, and is not recommended until the results of that study are known. 2) The second technique is a trap crop. Many trees within a stand are baited. After the trees are attacked and the infestation begins to expand, the stand is cut down and removed. The goal of this tactic is to direct dispersing bark beetles to stands targeted for removal, protecting other stands from attack. This technique is applicable for univoltine bark beetle species, and would have little impact on area SPB populations. 3). The third technique, similar to #2, is to bait trees already scheduled for removal as part of normal forest activities. During periods of moderate to high beetle activity, 1 or more uninfested trees slated for removal within the next 2 days are baited. The idea is to attract flying beetles these trees and quickly remove them before expanding spots develop. This procedure is repeated throughout the harvest. This technique has not been tested for SPB, and its effects on area-wide populations are unknown. If baited trees are not removed quickly, the infestation could spread and bark beetle problems could be exacerbated. In lieu of lures, bolts from freshly-attacked trees could be leaned against the target trees to attract beetles. These infested bolts should not be used in areas that do not have current SPB activity.

Increase training opportunities and effectiveness. Intensive training of foresters and land managers on SPB IPM should continue through the train-the-trainer program. Efforts should be increased to provide information and training to local communities, as they are very influential in forest management. There exists a real need for training materials in Spanish developed exclusively for Central America and each country. Trainers are still using slides and translated handbooks from the United States. Forest conditions and bark beetle communities differ between the United States and Honduras. The Spanish field guides for aerial detection, ground-checking, and direct control (Billings et al. 1990, 1996 a, b) are based on USDA Agricultural handbooks, but were expanded to include information on bark beetles in Central America. More copies of these handbooks are needed in Central America. The current training materials provide valuable information, but they should be revised to discuss SPB behavior and management specific to Central America. The two pamphlets on bark beetles produced by AFE-COHDEFOR: “Método de Control Directo” and “Guía Práctica de Reconocimiento” provide a good starting point in the development of these training aids.

All training should be coordinated among the various agencies and international organizations interested in forest management. Coordination will be cost-effective, avoid duplication and/or mixed messages, and help ensure that the widest audience is reached.

Produce a guide to the *Dendroctonus* and other bark beetles of Central America. While the training materials described above would be beneficial to all personnel and communities involved in forest management, there is a need for an illustrated guide to the pine bark beetles in Central America. This information is available as a part of much larger publications, but a concise field guide describing the various species and their galleries would be of great benefit to forest entomologists and other forest health specialists. It could also include brief life histories, a list of hosts, and treatment options. This guide would be used in conducting field evaluations, developing treatment treatment recommendations, and planning forest management activities.

Determine the range, impact, and existence of the new *Dendroctonus* species in Central America. A new species has tentatively been identified in Central America, though there is debate within the forest entomology community as to whether this is indeed a new species. This species has been implicated in the large outbreaks in Belize, and is also thought to have caused significant mortality in Guatemala and El Salvador. Specimens from Nicaragua and Honduras also have been identified as the new species. There is speculation that the new species acts as a secondary pest, attacking in concert with or subsequent to *D. frontalis*. As the new species apparently does not respond to frontalin, the attractant pheromone of *D. frontalis*, another collection method is required until a suitable attractant can be determined. The suggested method is to collect infested bark or bolts from various infestations. The bark and bolts should be taken from 3 different areas of the infested tree, the top, middle, and base. The infested material from these sections should be placed separately in rearing cans or cages and the emerging beetles collected. The beetles should be sent to qualified taxonomists for identification. This method will help ascertain if the new species is present, delineate the species complex, and provide clues of each species role in the causation of tree mortality.

Increase communication concerning bark beetle activity and management between and within countries. Bark beetles don't recognize country boundaries, and outbreaks in one country may soon affect another. Frequent communication between bark beetle specialists in Central America should increase their ability to respond quickly and effectively to emerging outbreaks. Reports on bark beetle management activities should be shared with professionals in other countries. This TCP should help spark increased communication, and the creation of a web page as recommended by Billings and Schmidtke would be an ideal way to share and disseminate information. SPB and other bark beetle experts in Mexico and the United States should be included in this information exchange. Forest entomologists within the Government and in Universities should develop methods of distributing new and vital information on bark beetles to all foresters and to communities and landowners in affected areas.

Ensure compatibility in database management and reporting. Each country should track individual infestations, resource losses, and suppression activities in a permanent database. Though each country may utilize a different system, they should work together to integrate compatibility with the other databases as part of their design. Using the same nomenclature for column headings in the data tables would facilitate merging the databases of the countries. Such compatibility would allow the quick preparation of reports detailing bark beetle impacts and activities throughout the Region.

Search for additional opportunities for funding and cooperation from international agencies and researchers. In the past, countries outside of Central America have been instrumental in providing funding and expertise for bark beetle research. One example is the recent work of the Norwegian Forestry Group in Belize. Universities and forest management agencies should seek to develop relationships with international scientists or groups with an interest in bark beetle dynamics and initiate cooperative projects. If possible, interested graduate students in the host country should be involved in project planning and execution. By utilizing outside funding and expertise for bark beetle projects, Central America would increase opportunities to accumulate further knowledge of bark beetles in the Region while producing well-trained bark beetle management professionals for the future.

SPECIFIC RECOMMENDATIONS

Billings and Schmidtke (2002) also listed the following specific recommendations for each country (used by permission of Ron Billings).

Belize

1. Detect, evaluate on ground, prioritize and apply direct control to active SPB infestations remaining in Mountain Pine Ridge.
2. Establish a forest pest coordinator at the national level to provide leadership in forest pest programs.
3. Increase monitoring and surveys of forest regeneration and SPB outbreaks.
4. Provide basic silvicultural and SPB training to technicians.
5. Establish a permanent system for reporting and recording SPB detection, evaluation, control, and loss records.

El Salvador

1. Consider placing responsibilities for detection and control of bark beetle infestations under a single agency (e.g. Servicio Forestal).
2. Identify and/or create a national forest pest coordinator to provide leadership in forest pest programs.
3. Improve media and local political awareness of importance and treatment strategies for SPB.

4. Encourage the thinning of dense pine stands to reduce susceptibitlity to bark beetle outbreaks.

Guatemala

1. Improve coordination among agencies, NGOs, and political leaders, especially at the regional and local level.
2. Identify the various species of bark beetles affecting pine stands in Guatemala and develop identification guides for the more common *Dendroctonus* and *Ips* species.
3. Establish a permanent record-keeping system within INAB and CONAP for recording bark beetle detection, control, and loss records at the local (department) and national level.
4. Identify a national pest coordinator(s) to provide leadership in forest pest programs within INAB and CONAP.
5. Increase the availability of bark beetle field guides for detection, ground evaluation, prevention and control at the department and local level.

Honduras

1. COHDEFOR needs to place increased emphasis on prompt control of bark beetle infestations in certain forest regions (El Paraíso, Francisco Morazán, Copán) to better address the current (2002) outbreak. Redirect forest inventory crews and provide logistical support (vehicles, operating expenses) to treat more infestations in these high priority areas.
2. Re-establish the goal of treating all SPB spots before they enlarge beyond 1 hectare in size.
3. Provide incentives to those COHDEFOR field personnel who have demonstrated outstanding performance in control of SPB infestations in their forest regions.

Nicaragua

1. INAFOR should re-establish a Department of Forest Protection, with at least two national coordinators, one for fires and one for forest pests.
2. INAFOR should establish a permanent record-keeping system for recording SPB detection, control, and loss records at the Department and national levels.
3. INAFOR foresters should be given more training in the proper use of pheromone traps for monitoring SPB populations.

As with the general recommendations above, the following specific recommendations are based on recent observations within each country, and are written to complement and supplement the recommendations of Billings and Schmidtke (2002).

Honduras

Compile data on *Dendroctonus* impacts and suppression. Public interest groups are currently protesting logging in the forests of Olancho. A comprehensive record of the impacts of SPB and documentation of the benefits of timely forest and SPB management would assist the government and forestry agencies in crafting their response to calls for moratoriums on logging. If possible, aerial photographs of regions with no bark beetle control and regions with control should be distributed to these groups to provide a visual picture of the impacts of bark beetles and of suppression actions.

Training. COHDEFOR, USAID, Oficina de Cooperción Canadiense, the Peace Corps, and others should be involved in coordinating, planning and scheduling of training. Annual courses to certify more foresters as forest pest trainers and managers could increase the range and efficiency of training programs. Examples from Honduras should be utilized in the training. More informal training should be scheduled with local communities to increase their awareness of bark beetle problems and enlist their aid in detection and suppression.

Emphasize Prevention. Given the limited utilization of infested material from the large outbreaks, communities should be taught the benefits of prevention. A hazard-rating system is necessary, and once developed, communities, private companies, and local COHDEFOR personnel should attempt to identify high hazard stands. Efforts should be made to reduce the hazard through thinnings or occasionally stand replacement. Forest management focused on thinning rather than stand removal should promote forest health, alleviate friction between loggers and resin-tappers, and reduce erosion. Prevention should substantially reduce stand replacement events by bark beetles, decreasing opportunities for encroachment and land-use conversion.

Population Monitoring. Annual monitoring of bark beetle populations is necessary. The optimal time for monitoring must be determined. Monitoring traps baited with pheromone and turpentine should be deployed in all regions with pine forests. Trained personnel are needed to run the traps and to quickly identify the bark beetles and natural enemies collected. Communities, NGOs, students at ESNACIFOR, and landowners could be enlisted to assist in trap placement and collection. An inexpensive, effective trap constructed from locally available materials should be developed.

Detection. The National Strategy calls for three aerial detection flights per year, one each in February, June, and October. During outbreaks, this frequency may not be sufficient to detect a majority of small infestations before they expand to sizes difficult to suppress. The Department of Forest Protection should look for opportunities to combine aerial bark beetle detection flights with other aerial missions and share costs. A forester could participate in flights primarily undertaken for other purposes, or the agencies conducting the flights could be trained to spot and report potential infestations. If funding limits the number of detection flights, then timing is critical. Flights should be scheduled for 3-4 weeks following the periods when a majority of new infestations are initiated to allow for foliage fade. The appropriate times for flights should be based on

past spot detection records. It may be better to concentrate flights during this period rather than spread them throughout the year.

In addition to the monitoring of dispersing beetles with pheromone traps, local monitoring of populations and detection of new infestations should be encouraged. Communities should be apprised of the importance of identifying population increases early. They should be encouraged to report any suspected infestations. Local residents could be contracted to perform routine monitoring of forested areas and report suspected infestations.

Evaluation. Once infestations are detected, accurate ground evaluations are crucial for assigning treatment priority. The priority for suppression should not rely solely on current infestation size, but should be based on size, location, and potential for future expansion. As the number of available treatment crews is usually limited, it may be difficult to meet the goal of keeping most infestations under 1 hectare in size. Small, rapidly expanding infestations, particularly in areas with little additional beetle activity, should receive high priority. Large infestations are difficult and time-consuming to suppress, and smaller infestations should be controlled before they reach 1 hectare in size. Some crews could be assigned to large infestations, with other crews concentrating on small, active infestations.

To aid in prioritization, several new entries should be added to the evaluation data sheets. Pine and total basal area should be recorded. The presence of fresh attacks should be noted, and an estimate of their number would be helpful. If the field personnel are well-trained, they could select a treatment priority based on the results of their ground evaluation: high, medium, or low.

Belize

Collect basic biological data. Extensive information on the biology of the new *Dendroctonus* sp. in Belize is required to plan an integrated pest management program, if it is indeed a new species. Effective monitoring, detection surveys, prevention, and suppression are dependent on an understanding of the behavior and life cycle of the pest. Belizean graduate students in forestry, biology, or entomology should be encouraged and funded to conduct research on the new species. Cooperative studies could be planned with entomologists from other countries. As beetle populations are currently low in Belize, foresters and students could examine active infestations in Guatemala if possible.

The development of infestations of the new species appears similar to that of SPB. Small infestations have a distinct expanding “spot head”. Large spots may expand in many directions and develop a wide expanding front that moves swiftly across the landscape. This similarity may account for the failure to recognize the possible existence of a new species in Central America. The factors involved in the sudden collapse of the outbreak should be investigated.

All information gathered on the new species should be integrated and condensed, and informative handbooks should be prepared for use by foresters. Training materials must also be developed.

Prevention. Historically, the MPRFR was open pine savannah. In recent years, the pine stocking in many stands increased greatly over traditional levels, and these areas were decimated by the 2000 outbreak. Much of the remaining forest in the eastern Reserve is highly susceptible to bark beetle attack. Pine stands in the southern coastal area are also extremely dense, with little annual diameter growth. Thinning to a pine basal area of 80 ft^2/acre (18 m^2/ha) or less will reduce the likelihood that expanding bark beetle infestations can be established. A forest management plan should be developed for the MPRFR that incorporates thinning as a tool. Thinning would provide a continual economic return while maintaining a sustainable forest. Economic consultants could supply input on finding markets for the timber removed during thinning or salvage operations.

Suppression. Until more information is gathered on the new species, cut-and-remove and cut-and-leave remain the best methods of suppressing infestations. Both have been effective when applied to small infestations, so all infestations should be evaluated and treated quickly if expanding. The cut-in-front technique should not be used, as foliage color is not an accurate indicator of brood stage. All currently-infested trees (plus a buffer of uninfested trees) should be included in the treatment of infestations less than 1 hectare.

Ips bark beetle infestations normally are not treated by cut-and-leave, as the beetles continue to develop in the downed material and can spread to the adjacent standing trees. However, there were reports of heavy predation of the beetle brood by ants in the southern coastal areas. More data is needed to determine if cut-and-leave is a viable treatment option for *Ips* infestations in Belize and elsewhere in Central America.

As the Forestry Department in Belize is small, contracting for bark beetle suppression should be expanded. Responsibilities for detection and suppression of infestations could be shifted to private companies, who could then utilize any timber removed. Oversight from the Forestry Department is critical, and perhaps penalties could be imposed if infestations are not promptly detected and controlled.

Public Awareness. Public and government awareness of the detrimental impacts of bark beetles outbreaks should remain high. Emergency plans for handling outbreaks should be kept up-to-date and supported by the government. Annual meetings of stakeholders in forest management would be useful, and should include discussions of bark beetle preparedness. Visitors to the MPRFR should be surveyed to gather their impressions of impacts of the bark beetle outbreak, and the results should be distributed to appropriate agencies.

Guatemala

Increase government authority to respond to bark beetle outbreaks. Currently the government can advise communities and landowners on suppression of bark beetle infestations, but it has no real jurisdiction to guarantee control. INAB should request the authority to invoke emergency powers to control bark beetle outbreaks, similar to the situation for wildfire. Data and pictures from the previous outbreak should be used to justify the need for prompt suppression.

Expedite suppression of infestations. Infestations continue to expand while foresters develop management plans. To limit resource loss, infestations should immediately be evaluated and expanding ones suppressed. A management plan for suppressing future infestations and regenerating the affected area could then be developed. The use of cut-and-leave should be expanded.

Judicious use of suppression measures. Bark beetle suppression methods on individual spots should be limited to those required for the expeditious and effective control of the infestation. There is generally no need to spray and then burn trees that have been felled during spot suppression. The time, money, and manpower required for these extra treatments could better be utilized in other pest management activities.

Create data sheets for reporting suspected infestations. A standardized data sheet is needed to provide consistent information used in tracking bark beetle suppression and impacts. These data sheets should be distributed to those in the government and within communities who assist in bark beetle infestation detection.

Consolidate databases. INAB and CONAP should consolidate the databases maintained to track bark beetle activity. A consolidation would provide a clearer picture of current and previous impacts and assist in planning future IPM needs and activities.

Increase entomological and forest health expertise within the government. Trained forest protection personnel are needed within INAB and CONAP. The pest management trainers produced by this TCP should continue to provide annual training sessions for foresters.

Protect pines in National Parks and other sensitive areas. Beetle-killed trees in National Parks and other high-traffic areas are a hazard to visitors and decrease the scenic attributes of the site. The focus should be on prevention in these areas. Insecticides can be used to protect trees at risk to attack, such as lightning-struck trees on pines adjacent to currently-infested trees. Dead trees near parking lots, trails, ruins, visitor centers, and other areas of interest to the public should be felled to protect the safety of visitors.

El Salvador

Increase government and public awareness of full impact of bark beetle infestations. The tree mortality resulting from bark beetle outbreaks has far-reaching impacts on

watersheds, water quality, wildlife, visuals, recreation, fire hazard, and public safety. The Minister of Agriculture and Environment, other government officials, and the general public should be made aware of these impacts to expand acceptance of pest management programs.

Implement the National Strategy. Funding is required to fully implement the National Strategy. Increased government awareness of the potential impacts of bark beetle outbreaks should improve the possibility that the funding will be made available.

Correlate impacts of fire on infestations. Research is needed to study the assertion that much of the bark beetle activity in El Salvador is related to fire. If a positive correlation is found, improved recommendations could be developed on the need and timing of prescribed fire for the prevention of bark beetle attack.

Examine the effects of not suppressing infestations in protected areas. Infestations in protected areas usually are not controlled, and they may affect the resources of adjacent landowners. Large infestations may increase the risk of wildfire in these areas, plus they create a falling tree hazard for visitors. These areas should be evaluated for the attributes of value. If healthy pine stands are desired for wildlife, scenic beauty, ecosystem maintenance, etc., then bark beetle control is a necessity. Regulations and guidelines detailing when and where suppression of infestations within protected areas may occur are needed to protect the character of the sites as well as the resources on adjacent lands.

Maintain a centralized database of bark beetle activity. The Plant and Animal Health Department needs a computer to maintain a database to track bark beetle infestations and document effects of outbreaks. Data on infestation attributes and suppression actions on all lands in the country, including protected areas, should be entered.

Expedite suppression of infestations. While it is a good idea to require a license and/or a management plan before allowing spot suppression, the primary concern should be the protection of the resource and a swift halt of the spot expansion. The ideal goal would be to have management plans in place before the onset of a bark beetle outbreak. The plan would outline the conditions under which suppression could occur in every area under the plan. Programs should be initiated to ensure trained foresters, consultants, or contractors are licensed and available in each community for infestation evaluation and suppression. These licensees should provide oversight to all suppression actions, ensuring that control measures are properly applied. Buffers and fresh attacks should be felled first to stop spot expansion.

Nicaragua

Increase cooperation among all agencies concerned with forest management. Past and current reports, data, and other information on bark beetle management strategies and actions should be shared among all agencies with responsibilities in forest management. Annual meetings focusing on bark beetle management should be held and include all interested parties, with participation by the research community. Such meetings and the

exchange of information should facilitate cooperation between agencies and improve management planning.

Develop a database to track bark beetle activity. There is a need to track the resource lost and the suppression actions for each individual infestation. Maintaining a database will assist in land management planning, hazard rating, and efficient allocation of funds and manpower for suppression. The database allows managers to document the impacts of outbreaks and justify requests for increased funding for bark beetle management.

Develop opportunities for utilization of smaller logs. Currently, few management activities are conducted in forests until the final harvest. There is little focus on prevention of bark beetle outbreaks, as there is little incentive for landowners to thin dense stands. Markets are needed for the small diameter logs removed in thinnings and some bark beetle suppression actions. A steady supply of pulpwood and sawtimber produced by prevention activities would stabilize the logging industry and help prevent a glut of timber during outbreaks.

Improve communication between the government and communities. Increasing community awareness of the devastating impacts of bark beetle outbreaks should lower resistance to treatment measures required to stop expanding infestations. The public should be informed that the impacts of outbreaks extend well beyond tree loss, as water quality, wildfire frequency and intensity, and cattle ranching may be affected. Communication should be maintained through every facet of forest management, including prevention and regeneration.

Apply suppression measures promptly and effectively. For bark beetle suppression to be successful, it should be applied when infestations are still small. The primary focus should be to prevent resource loss by protecting the residual stand, rather than receiving an economic return. Cut and leave should be applied promptly if cut and remove cannot be used. The detrimental, long-term economic and environmental impacts of not treating infestations when they are small will greatly outweigh the short-term monetary losses of utilizing cut and leave. Treatments also must be correctly applied. A 5 m buffer is not sufficient, even for small infestations. The use of an inadequate buffer allows the infestation to continue expansion, undermining the purpose of the control action. Proper spot suppression with an adequate buffer will result in reduced resource loss and greatly decrease the need of retreat. The widespread impacts of the recent outbreak illustrate the necessity for swift and effective suppression.

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Literature Cited

Billings, R.F. 1982. Evaluation and recommendations for control of the 1982 outbreak of *Dendroctonus* in the pine forests of Honduras. Unpublished report submitted to USDA Office of International Cooperation and Development and U.S. Agency for International Development. 26 p.

Billings, R.F., J.E. Flores L. y R.S. Cameron. 1996a. Los escarabajos descortezadores del pino, con énfasis en *Dendroctonus frontalis*: Guía para la detección aérea. Texas Forest Service Publ. 149. 27 p.

Billings, R.F., J.E. Flores L. y R.S. Cameron. 1996b. Los escarabajos descortezadores del pino, con énfasis en *Dendroctonus frontalis*: Métodos de control directo. Texas Forest Service Publ. 150. 19 p.

Billings, R.F., H.A. Pase III y J.E. Flores L. 1990. Los escarabajos descortezadores del pino, con énfasis en *Dendroctonus frontalis*: Guía de campo para la inspección terrestre. Texas Forest Service Publ. 146. 19 p.

Billings, R. F. and P. J. Schmidtke. 2002. Central America southern pine beetle/fire assessment. U.S. Agency for International Development Final Report. Washington, D.D. 45 p.

Cano Alvarado, M. F. 2003. El gorgojo del pino: efecto del cambio climático en los años recientes. http://www.iicasaninet.net/pub/sanveg/pdf/gorgojo_pino.pdf

Castañeda, C. 1980. El gorgojo del pino en Guatemala. Universidad de San carlos de Guatemala. Editorial Universitaria. Dirección General de Extensión. Serie Separatas Anuario Vol. 38. 30 p.

Global Forest Nursery Development Inc. 2002. Mountain Pine Ridge carbon sequestration project, Belize C.A. Progress Report #1. 15 p.

Landaverde Toruño, R. A. L. 2001. Los escarabajos descortezadores del género *Dendroctonus* Erickson plaga de las pináceas en Centro América. Organismo Internacional Regional de Sanidad Agropecuaria, Dirección Técnica de Sanidad Vegetal. San Salvador, El Salvador. 31 p.

Maes, J-M. 1992. Plagas insectiles de Nicaragua 1. Coleopteros asociados con *Pinus oocarpa* Schiede. Manejo Integrado de Plagas 23: 13-16.

Midtgaard, F. and K. H. Thunes. 2003. Pine bark beetles in the Mountain Pine Ridge Forest Reserve, Belize: Description of the species and advice on monitoring and combating the beetle infestations. Norwegian Forestry Group, Oslo, Norway. 15 p.

Núñez Hernandez, D. 2001. Manejo integrado del gorgojo del pino *Dendroctonus frontalis*. Programa Regional Forestal para Centro América (PROCAFOR-FINNIDA) and Manejo y Utilización Sostenida de los Bosques de Coníferas en Honduras (MAFOR). 30 p.

Rodriguez, Jorge. 2003. Estrategia regional de sanidad forestal: con énfasis en el descortezador de los pinos. Primer borrador. Proyecto TCP/RLA/2803 de FAO. 48 p.