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Towards Integrated Protection from the Southern Pine Beetle

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*ABSTRACT—Current southern pine beetle (*Dendroctonus frontalis *Zimm.) control depends heavily upon direct approaches having short-term payoffs. Chemical or physical tactics have failed to check epidemics in the Gulf South. A major challenge lies in developing and using indirect methods for managing this pest. Promotion of stand resistance and biotic agents, and manipulation of stand density and cutting practices, hold prospect for reducing the incidence and severity of beetle-caused losses.*

After almost 100 years of effort on the part of foresters and entomologists, the southern pine beetle (SPB) remains the most serious enemy of pine forestry in the Deep South; no fully satisfactory method for its control has yet been devised. So complex and fundamental are its interrelations with soils, forest sites, host vigor, parasites, predators, diseases, and climatic factors that single tactics are usually ineffective. This paper considers needs for broad-based strategies, integrated with resource management operations and objectives, and outlines how available and anticipated tactics can fit into such strategic concepts.

SPB is native to pine and pine-hardwood forests in the entire southern United States as well as in Central America. Its developing brood and associated fungi kill trees by destroying the phloem and cambium.

In the Deep South, the beetle passes through 5 to 7 generations each year. During mild winters, flight and attack on new trees may occur in any month. Populations usually peak in July. In the Piedmont-Appalachian Mountain areas the beetle has 3 to 5 generations per year, with populations generally peaking in August-September.

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Applied Controls

There is little information on occurrence of SPB or on measures taken to suppress it during the period of virgin timber harvests prior to 1920. Only the major infestations were recognized, and the killed trees were salvaged only if reasonably accessible to logging railroads.

The earliest recommendation was felling followed by burning or exposure to solar heat (St. George and Beal 1929) to raise inner bark temperatures sufficiently to kill the brood. These physical methods of control fell into disuse when synthetic organic insecticides became available but are being reconsidered for environmental reasons. A recent re-application is the "cut and leave" method in Texas (Texas Forest Service 1975) in which infested trees are felled towards the center of an infestation with the crowns left intact. In summer, the combined effect of bole drying and heating may reduce beetle broods. Survivors may, however, disperse to other areas.

Removal of infested trees is useful in economically salvable areas. Where salvage is reasonably prompt, the method removes a large number of beetles that might otherwise spread to surrounding stands. Salvage is presently the most widely used control method in the South.

Early chemical controls involved introducing inorganic poisons systemically into pines. The need to inject the chemicals during the short period between attack and the time when water conduction ceased (Thatcher 1960) made the method impractical. Formulation of the synthetic chlorinated hydrocarbon lindane (BHC) in No. 2 fuel oil was developed in the early

1950's, and found wide use in SPB control for nearly 20 years. BHC sprays were used on unmerchantable material in salvaged stands, and on trees and stands too small or too inaccessible to be salvaged. Many operators sprayed all infested trees, including those to be salvaged later.

Indirect controls include manipulation of food supply, microclimate, or biological agents. Occasional efforts of this sort have been limited to removing trees damaged by wind, hail, or floods and to attempts to increase or maintain tree growth by silvicultural practices. However, preventing or suppressing beetle damage has seldom been a primary consideration in applying silvicultural practices.

Natural Controls

Insect parasites and predators have been most studied of the natural controls, but results are primarily lists of such organisms. The biology and roles of most of these agents in regulating beetle numbers are still poorly understood. Moore (1972) in a North Carolina study found that the combined action of all insect predators and parasites caused 24 percent mortality of SPB brood.

Predation by birds has been observed for years. Overgaard (1970) noted that in Louisiana three species of woodpeckers reduced SPB brood numbers in standing trees by 24 percent, but that some survived in dislodged bark. Woodpeckers destroyed up to 50 percent of the brood in some trees in North Carolina but averaged much less and varied seasonally (Moore 1972).

Several species of pathogenic bacteria and fungi have been isolated from SPB (Moore 1971), and their combined action resulted in 22 percent mortality of broods in North Carolina. Several species of nematodes have been identified from SPB (Massey 1974), though little influence on beetle survival has been observed (Moore 1972). Likewise, many species of mites are SPB associates, but their roles are not known.

Low temperatures appear not to be important to SPB mortality in southern Coastal Plain forests. St. George and Beal (as cited in Thatcher 1960) found that eggs and pupae survive −5° F, abnormal so far South. In the Appalachians, however, cold weather occasionally kills up to 95 percent of brood over large areas (Flavell et al. 1970).

Site and Stand Relationships

The tree is both food and shelter for SPB. Quality and quantity of this food and shelter can influence how the beetle population fares. In turn, tree and stand conditions are altered by various site factors. Infestations in southeastern Texas and southwestern Louisiana often occur on poorly or imperfectly drained soils and in stands that tend towards overstocking (Lorio 1968). Soil water variations affect tree rooting, and by increasing moisture stress probably increase susceptibility to SPB attack. Soil water status may also influence susceptibility through alteration of tree oleoresin exudation pressure, water content of the inner bark, bark carbohydrates and nitrogen fractions, and monoterpene and resin acid composition of xylem oleoresin (Lorio and Hodges 1968, Hodges and Lorio 1969, 1973).

Climatological effects include both the direct influences of rainfall and temperature on insect activity and indirect effects through modification of tree condition. Observations often relate bark beetle increases to drought, which may be the primary cause of heavy pine mortality, the beetles merely assisting in killing the trees. Excess precipitation may also weaken trees, making them attractive to bark beetles. King (1972) found years of epidemics associated with low summer rainfall in Georgia, with preceding high winter rainfall in Texas, and with high spring rainfall and low early summer rainfall in North Carolina and South Carolina. Kalkstein (1974) concluded that in Texas and Louisiana SPB activity increased with moisture surplus and late winter potential evapotranspiration.

Lightning-struck trees provide niches for sustaining limited populations during endemic periods (Hodges and Pickard 1971). Direct correlations of SPB activity with tree physiological condition are lacking except for the work with trees under stress from flooding, drought, or root diseases.

Ongoing Research

Past research generally has been fragmented. Key information for managing the beetle is not available. Coordinated research and development programs, such as the USDA Southern Pine Beetle Research and Applications Program (Leuschner et al. 1977) are needed to produce the necessary information and integrate it into practice.

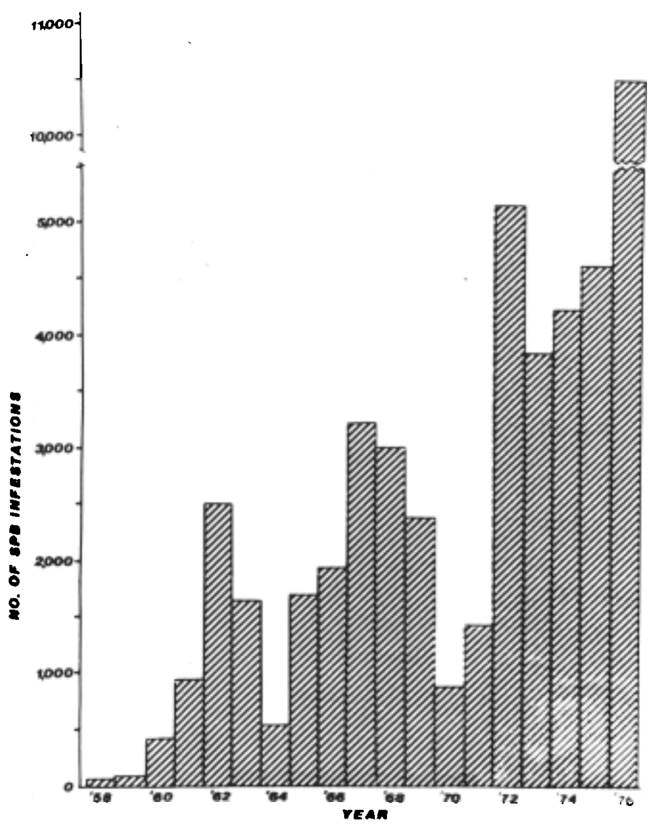


Figure 1. Number of southern pine beetle infestations in east Texas since 1958. (Texas Forest Service)

There are good biological reasons to anticipate useful results from integrated programs. Unlike introduced insects, which may proliferate because their natural controls are absent, SPB is a native pest. Historically, epidemics have subsided without destroying all available host trees. Thus controls must exist, and presumably can be discovered. In 1975, about 60 percent of spot infestations discovered by aerial observation in Texas were found to be inactive when checked on the ground. Some combinations of natural phenomena thus continue to limit spread, although the general epidemic infestation continues at a serious level.

Many forest entomologists conclude that simple single-tactic cures for this pest are extremely unlikely. They expect a series of minor advances, none of them approaching a cure-all but each opening possibilities which can be exploited along with other tactics.

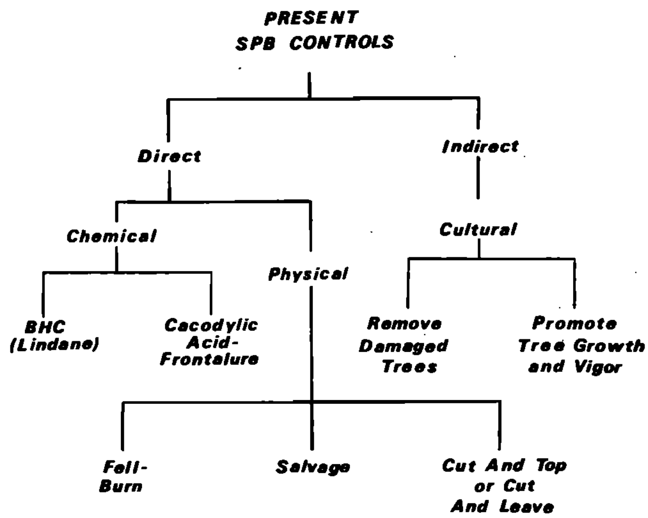
Towards an Integrated Pest Management Scheme for SPB

Forest management plans segregate long-term policies and goals (strategies) from short-term objectives (tactics). Neglect of strategies and overemphasis on tactics can lead to undesirable consequences such as reduced timber volume flow, conflicts between land uses, and unacceptable ecological outcomes—degradation of stand composition, deterioration of site quality, and increased fire hazard. Graham (1964) similarly identified insect control tactics with immediate objectives, and strategies with longer-term, broader purposes and the choices of tactics.

In forest pest management, short-term tactical controls, though attaining immediate goals, contribute little to ultimate resource management. Recent experience in Texas is illustrative. Here, from 1957 to the present, continuing infestations have spread over about 8 million acres of pine timber. Intensive spraying with BHC began in 1958, but the infestation continued to intensify through 1962. It declined in 1963 and 1964 but increased again in spite of continued spraying. In 1969 forest managers stopped spraying and began to concentrate control efforts on salvage and, later, on cut-and-leave. The epidemic declined in 1970, but has since increased to high levels *(fig. 1)*. In Louisiana, infestation followed a similar pattern (Lorio and Bennett 1974).

Use of BHC was originally proposed on the basis of laboratory and field tests against brood within individual trees. The insecticide killed high proportions of beetles. But whether because BHC also killed important predators and parasites, or because too many trees escaped detection and spraying, or for other reasons, spraying as the primary tactic did not control the epidemic. Neither did salvage or cut-and-leave control it.

Figure 2. Currently available tactics for control of the southern pine beetle.



In Texas the approaches were tactical—kill beetles in as many infested trees as possible. Factors other than beetle numbers were overlooked. A strategic viewpoint—to employ a combination of direct and indirect tactics so as to reduce the SPB population throughout east Texas—would have oriented research and control to examination of alternatives.

Figure 2 summarizes tactics currently available. In practice there is little indirect control, for consistent removal of damaged trees or specific action to promote tree vigor is far from common. Direct control is essentially limited to insecticides or physical-mechanical methods. Behavioral chemicals (frontalure) show promise but are not yet operational.

The strategy, or long-term objective, should be to reduce tree losses to tolerable levels by limiting conditions favoring attack. This will require direct action to limit beetle populations, and indirect tactics aimed at producing environmental conditions unfavorable to population growth. *Figure 3* outlines this strategy and the tactics proposed for its support.

Additional research is needed to improve existing direct controls. Chemicals more effective against SPB and more environmentally acceptable than BHC should be developed. Improved understanding of behavioral chemicals such as SPB pheromones may permit their operational use for survey or control.

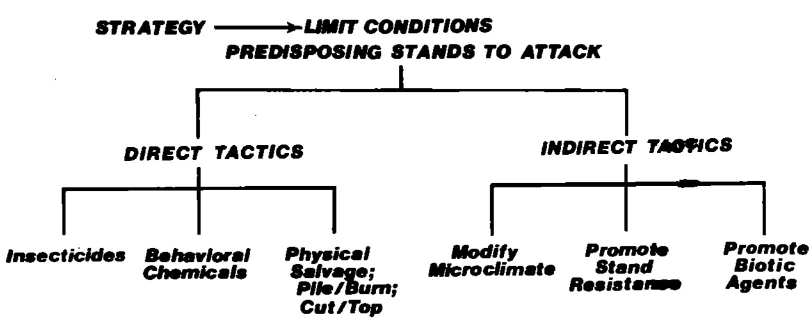
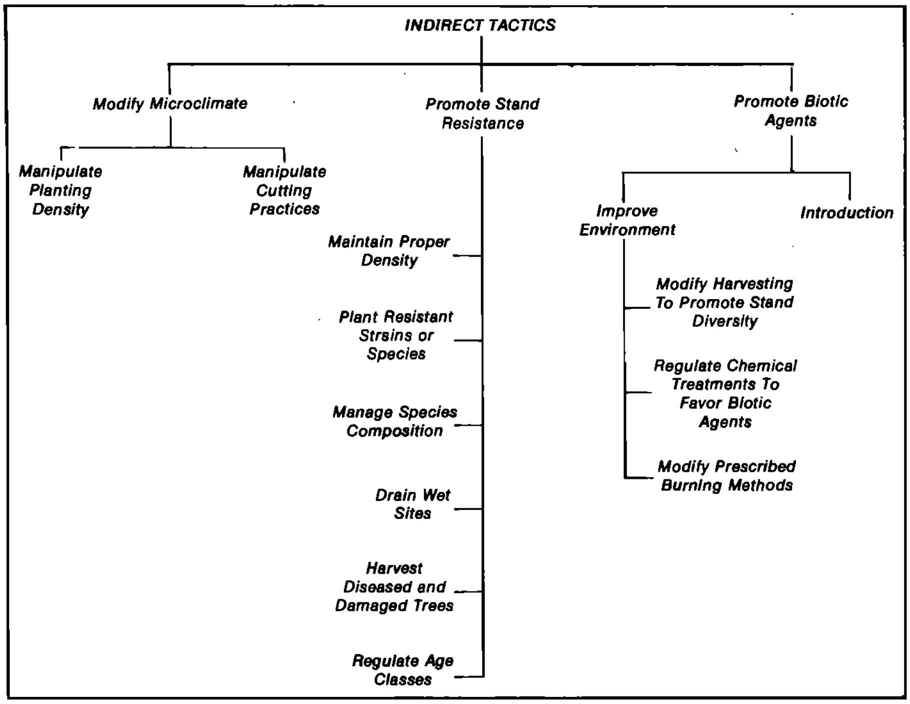


Figure 3. Direct and indirect tactics for a southern pine beetle control strategy.

Figure 4. Indirect tactics for a southern pine beetle management strategy.



Three indirect tactics—(1) promotion of stand resistance, (2) promotion of biotic agents (parasites, predators, diseases), and (3) modification of stand microclimate—are essentially unused for lack of adequate knowledge. *Figure 4* indicates some possible techniques for each of these three tactics.

Modifying stand microclimate and promoting stand resistance both require intensified studies of site-tree-insect interrelationships. Biotic agents can be promoted by introducing new species, or reinforcing established species, and by improving environmental conditions to favor existing species. In the present state of knowledge, the latter approach seems best for SPB conditions.

Decision-Making for Southern Pine Beetle Management

With the development of alternative strategies of direct and indirect tactics, land managers will need a decision-making system for determining when and what controls should be applied. Procedures for sampling populations (Coulson et al. 1975) and cost-benefit determinations for the SPB-pine forest system (Leuschner and Newton 1974, Newton and Leuschner 1975) must be developed. Such techniques will provide means for determining when beetle populations and forest losses have reached levels that justify controls. They will also provide a system by which the forest manager can decide when populations have returned to acceptable levels.

Forest managers and pest control specialists have learned that no single approach so far developed can be relied upon to control SPB. A dynamic pest and the complex southern pine forests have interacted to produce a severe problem. However, the concerted efforts of entomologists, economists, silviculturists, mensurationists, and pathologists have recently been focused on the problem as never before. The prospects for truly managing the beetle, rather than the beetle "managing" southern forestry, are bright. ■

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