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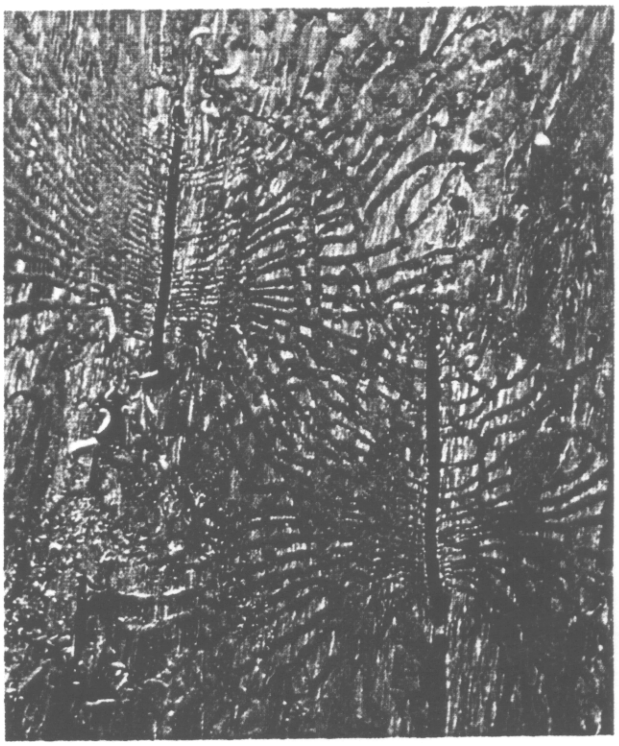

IPS ENGRAVER BEETLES: IDENTIFICATION, BIOLOGY, AND CONTROL

BY

R. C. WILKINSON AND J. L. FOLTZ

RESEARCH DIVISION

GEORGIA FORESTRY COMMISSION

AUTHORS

Robert C. Wilkinson is a Professor of Forest Entomology in the Department of Entomology and Nematology at the University of Florida. He received the B.S. Degree in forestry and M.S. Degree in forest entomology from Michigan State University and the Ph.D. Degree in forest entomology from the University of Wisconsin. His special areas of interest are pine-defoliating sawflies and Ips engraver beetles.

John L. Foltz is an Associate Professor of Forest Entomology in the Department of Entomology and Nematology at the University of Florida. He received the B.S. Degree in forestry at Michigan Technological University and M.F. and Ph.D. Degrees in forest entomology at the University of Michigan. He did research on the southern pine beetle in Texas and taught forestry for 3 years in Chile prior to joining the faculty at Florida in 1977. His special interests include the population dynamics and management of insects in intensively managed forests.

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Fig. 1 (Louisiana State University), Fig. 2 (E. P. Merkel), Fig. 8 (Duke University), and Fig. 11 (R. A. Schmidt). Terry Price of the Georgia Forestry Commission provided information on stand damage and Ips infestations in Georgia.

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IDENTIFICATION, BIOLOGY, AND CONTROL

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It has been estimated that from 1973-1979, three species of Ips engraver beetles killed pine timber in the South with a volume equal to over 1 million cords of pulpwood and 66 million bd. ft. of sawtimber. This Georgia Forest Research Paper tells what Ips beetles look like, the damage they cause, and how to recognize their infestations. It also gives a general account of their biology and discusses some of the factors that play key roles in their abundance. Because published information on Ips is so limited, our guidelines for control are based partly on field experience and consultation with other forest specialists.

BEETLE APPEARANCE AND DAMAGE

Ips engraver beetles are small, brown to black, cylindrical beetles that live within the inner bark of southern pines. The name engraver refers to the fact that their tunnels are partially cut into the surface of the sapwood underneath the bark. Unlike most other kinds of bark beetles, Ips beetles have a rear end that looks as if it had been cut off at an angle and hollowed-out. Closer inspection with a magnifying lens also shows that there are a number of spines bordering the hollowed-out area (Fig. 1). The three principal species of engraver beetles attacking southern pines are the eastern six-spined engraver [Ips calligraphus (Germar)] which is about 5 mm. (1/5 in.) long, the eastern five-spined engraver [Ips grandicollis (Eichhoff)] which is about 4 mm. (1/6 in.) long, and the small southern pine engraver [Ips avulsus (Eichhoff)] which is about 3 mm. (1/8 in.) long.

The 6-spined Ips is usually found in large-diameter material such as portions of the trunk from stump level to the first live branches. The 5-spined Ips usually occurs in medium-sized material such as the upper trunk and branch bases. The small (4-spined) Ips usually infests the smaller portions of branches and tree tops. This last species sometimes infests only part of a tree crown, leaving the tree to survive with a partly dead top.

Note: It is common to find one or more species of Ips plus other important pest species such as the black turpentine beetle [Dendroctonus terebrans (Olivier)] (abbreviated BTB) or sometimes the southern pine beetle [Dendroctonus frontalis Zimmermann] (abbreviated SPB) infesting the same trees, however both the BTB and SPB have rounded rear ends that are not hollowed-out and no spines are present (Fig. 2). Assistance in identifying bark beetles can be obtained through an office of the Georgia Forestry Commission or County Agricultural Extension Agent.

Although much of the time Ips breed harmlessly in fresh logging debris and weakened trees, both the numbers of beetles and the trees that they infest can increase rapidly during warm, dry weather. This is especially so when such other factors as fire, lightning, wind, ice, logging/thinning, or disease have stressed or damaged large numbers of trees to the extent that they are susceptible to beetle attacks. Besides killing trees, Ips cause additional economic losses when they introduce bluestain fungus plus other degrading microorganisms into pulpwood and sawlogs. A new problem has also arisen because Ips, BTB and other beetles sometimes attack and kill slash pines that have been treated with Paraquat® to induce lightwood formation.

HOW TO RECOGNIZE INFESTED TREES

The presence of reddish-brown boring dust in the crevices of bark on pine trees, logs, or logging debris is the first but often overlooked sign of attack by Ips beetles (Fig. 3). Healthy trees with a good supply of moisture usually produce sufficient resin at pressures high enough to either "pitch-out" attacking beetles from their entry holes or to trap such beetles in resin within the inner bark. Dime-sized, resinous, yellowish- to reddish-brown pro-

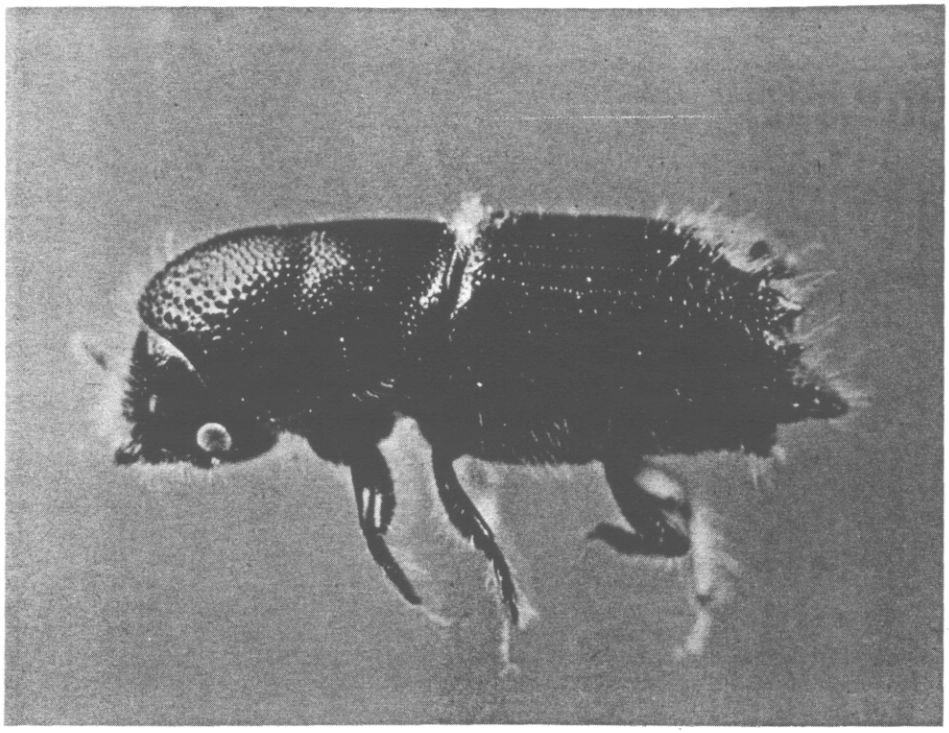

Fig. 1. Eastern six- spined engraver (Ips calligraphus).

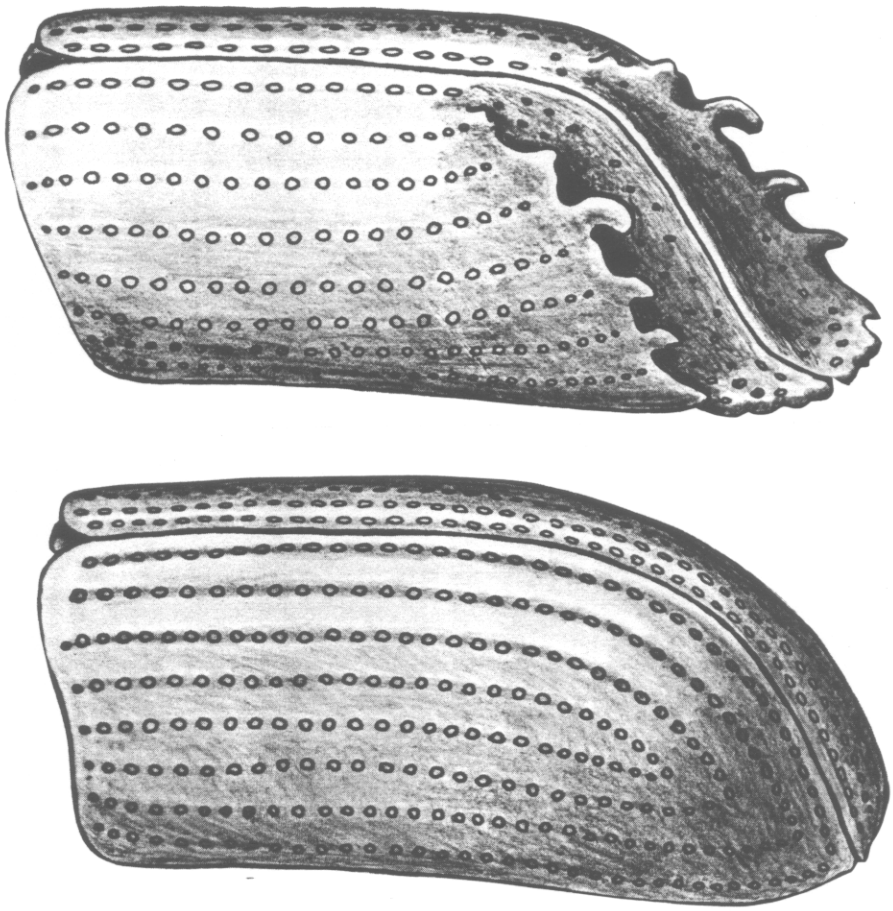

Fig. 2. Rear end of Ips engraver beetle (above) is hollowed-out and bordered with spines. Rear end of a Dendroctonus bark beetle (below) is rounded.

jections called pitch tubes often form over the beetles' entry holes (Fig. 4). These pitch tubes are a mixture of resin produced by the tree together with small chips of inner bark and sapwood plus feces added by the attacking beetles. The presence of an entry hole in the center of a pitch tube usually indicates that the attacking beetles were successful in infesting the inner bark; the absence of such a hole usually indicates that the beetles were unsuccessful. If the bark around a freshly-made and successful attack is carefully cut away with a knife, adult beetles can often be seen in their tunnels within the inner bark (Fig. 5).

The beetles do not act alone in killing the trees that they infest. Bluestain fungus spores are carried by attacking beetles into the inner bark and adjacent sapwood, where infection of the tree by the fungus takes place. Once the colonies of bluestain fungus have grown into the outer sapwood of an attacked pine, the upward flow of water into the tree crown stops and the foliage wilts. Such foliage then changes from dull-green to yellow-green to red-brown (Fig. 6). These color changes may require only 2-4 weeks during the summer but take much longer during the winter. Foliage color changes indicate that an infested tree is dying or dead.

Parent beetles and then young adult beetles leave the bark of a successfully infested tree through small, round emergence holes. These emergence holes look much like shot holes scattered over the surface of the bark (Fig. 7). Most of the beetles have emerged from such holes in the bark by the time that a tree's foliage has turned brown, but sometimes the beetles leave while the foliage is still green or yellow. Therefore the only sure way to determine if Ips are still present in a tree is to remove and examine the inner surface of several sections of bark showing signs of attack on the outside (such as boring dust or pitch tubes).

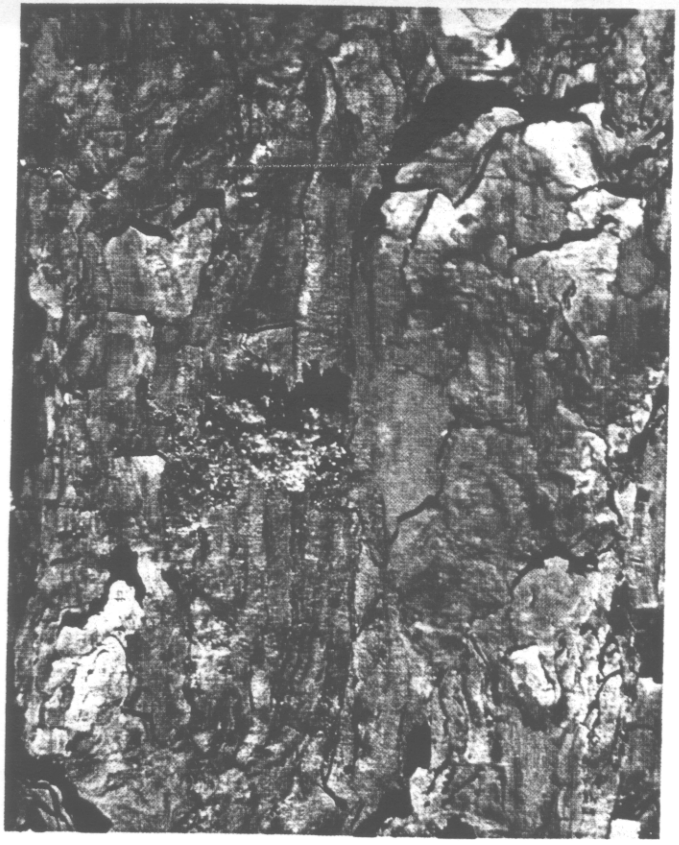

Fig. 3. Ips boring dust in a bark crevice.

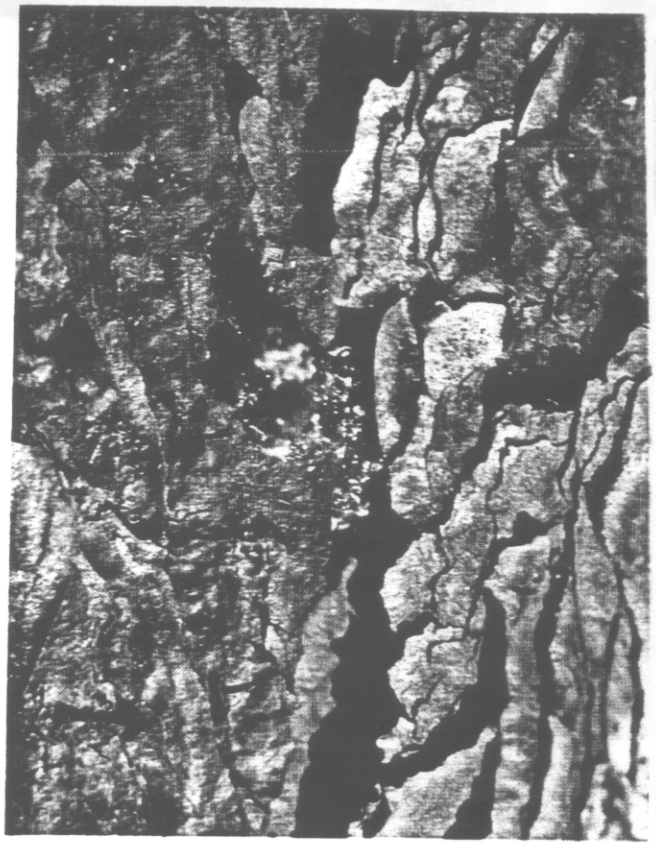

Fig. 4. Resinous pitch tube with an Ips entry hole.

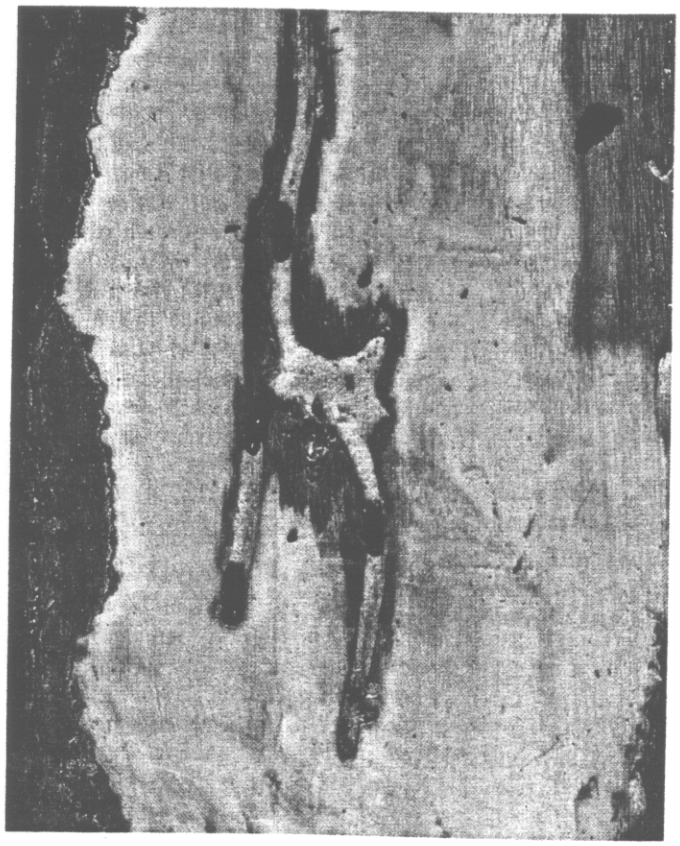

Fig. 5. Male Ips (near central nuptial chamber) and three females making egg galleries within the inner bark.

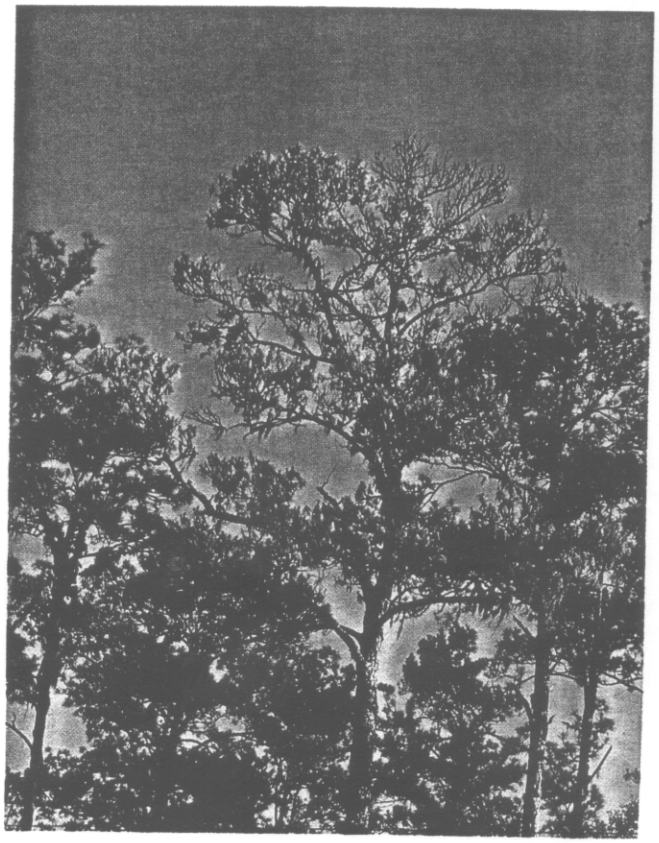

Fig. 6. Red-topped pine killed by Ips and bluestain fungus.

IPS TUNNELING AND LIFE CYCLE

The pattern of Ips tunneling within the inner bark of pines is related to their life cycles, which are somewhat similar for all three species. It is the male beetles that usually start attacks by boring through the outer bark into the inner bark. Here each male hollows-out a small nuptial chamber, into which 2-4 females are attracted (Fig. 5). After mating, each female bores a tunnel called an egg gallery which passes mostly through the inner bark but also scores the sapwood. Egg galleries usually start at a nuptial chamber and generally follow the wood grain. Colonization of a tree by numerous male and female Ips commonly results in somewhat "Y"- or "H"- shaped gallery patterns within the inner bark (Fig. 8). The eggs are laid singly within small pockets chewed out of the sides of the egg galleries, are capped with plugs of chewed-up inner bark, and hatch after incubating for several days. Larvae emerging from the eggs feed singly within the inner bark in larval galleries. These larval galleries extend from the sides of the egg galleries and enlarge as the larvae grow. The "C"-shaped larvae are less than 6 mm. (¼ in.) long, whitish, and legless, with an orange-brown head (Fig. 9). When fully grown, the larvae pupate at the ends of their galleries or in rounded pupal chambers. The pupae then change into young adult beetles which are orange-brown in color. These young adults feed in short, winding tunnels on bluestain fungus fruiting bodies and inner bark until they mature. The mature (red-brown) adult beetles then bore out of the bark through emergence holes and join other beetles in repeating the life cycle.

FACTORS INFLUENCING IPS ABUNDANCE

Temperature plays an important role in determining the rate of buildup of Ips populations. Because very little brood development takes place below a base temperature of about 15°C (59°F), the beetles are not considered to be a problem during cool weather. Ips can become a problem when the weather warms up because they develop faster as the temperature rises, at least within the limits shown in Table 1.

Table 1. Development of the eastern six-spined engraver at different temperatures.

Average daily air temperature		Average length of one beetle generation
(°C)	(°F)	(days)
18	65	100
21	70	50
24	75	33
27	80	25
29	85	20

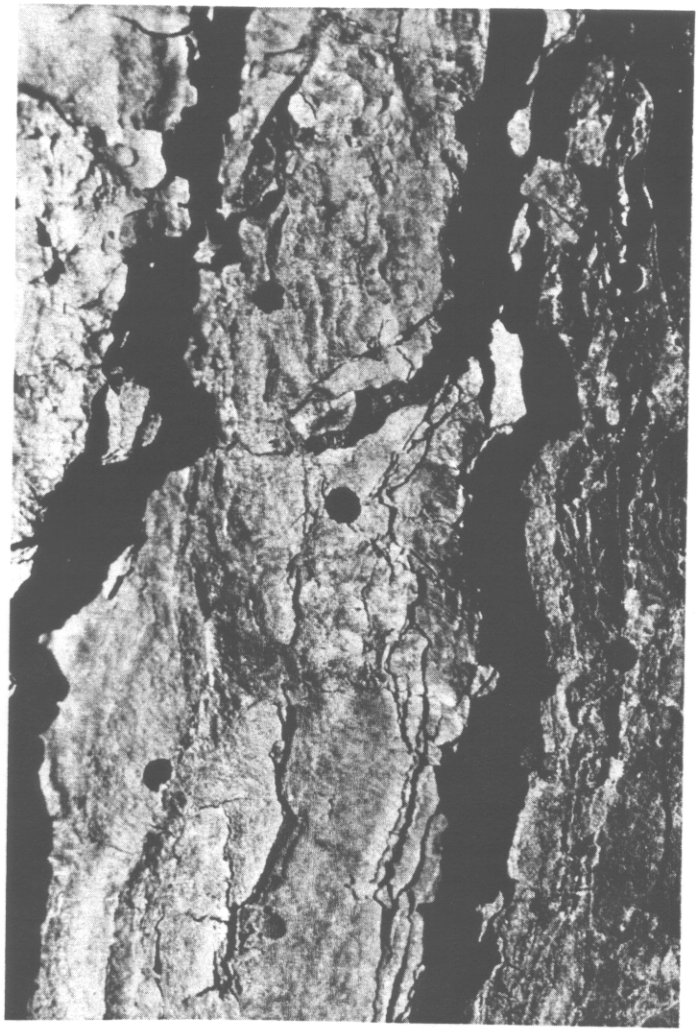

Fig. 7. Ips emergence holes in pine bark.

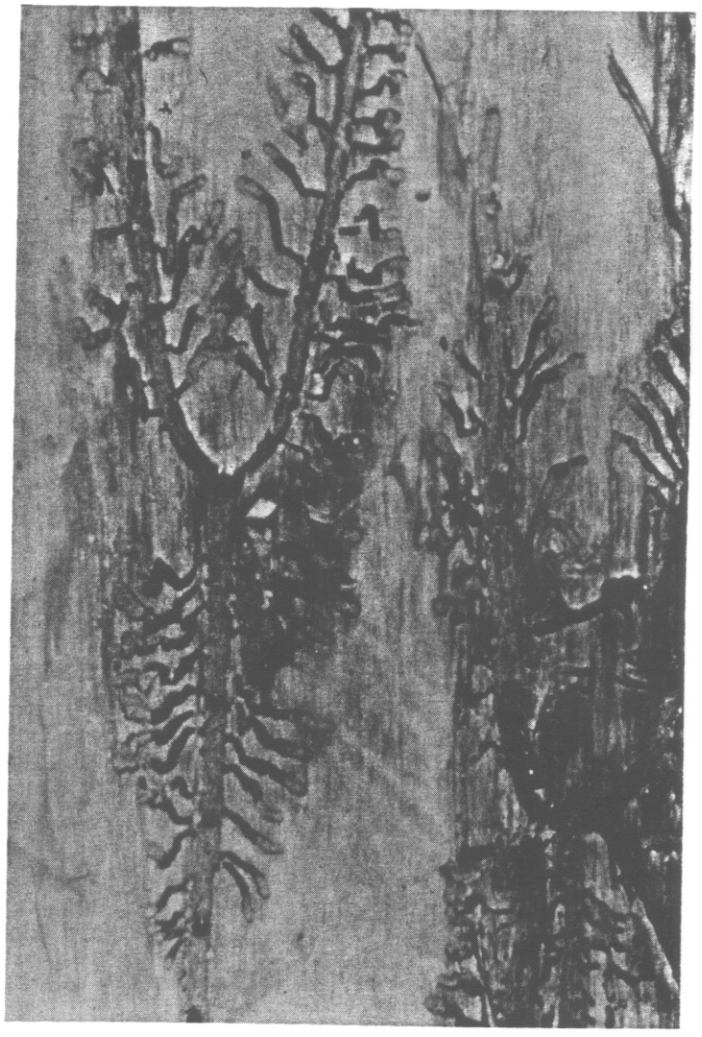

Fig. 8. "Y"- and "H"-shaped brood gallery patterns within the inner bark.

Prolonged droughts during the growing season have historically been associated with outbreaks of Ips beetles in North America. One of the most damaging outbreaks ever recorded in the South took place in association with the severe drought of 1954 in south Georgia. Total volume loss of pine sustained during the period July 1954 through January 1955 was estimated at more than 100,000 cords. Based on past weather records, timber growers in Georgia can expect that a severe drought will probably occur at least once during the lifetime of a pulpwood stand or at least twice during the lifetime of a sawtimber stand. Pine trees growing in shallow soils (for example around pond edges, in drainages, or on rock ridges) or in heavy clay soils are especially subject to high moisture stress during droughts. This decreases the ability of such trees to resist the attacks of Ips and other bark beetles.

Fire and Ips infestations go together. The higher the burning index, the greater is the intensity of a fire and the greater is damage to a stand of timber. The probability of Ips infestations and/or death of fire-damaged slash and longleaf pines in natural stands is high when 80% or more of the trunk is charred and 50% or more of the foliage is consumed by fire, as shown in Fig. 10. A recently completed study in north Florida indicates that this "rule of thumb" also applies in a general way to 8- and 15-year-old slash pine plantations. The probability of an Ips infestation is also increased in pines when their roots are damaged by fire, a condition often overlooked but commonly associated with heavy pine litter build-up on the ground around shallow-rooted trees. Prescribed burning of excessive ground litter and understory vegetation under relatively safe conditions helps to reduce chances that a wildfire will some day cause severe damage to trees and induce beetle attacks. On the other hand, too-frequent or careless burning can weaken pines to the extent that Ips beetles will attack them. Ips also infest some otherwise-healthy trees whose roots have been damaged by fire plows or other fire control equipment.

Lightning is another important factor in Ips abundance. During one 1963 survey involving 586 spots of dead trees in south Georgia, it was found that lightning strikes were associated with Ips and BTB infestations from 40 to 60% of the time at different locations. Lightning damage results in reduced resin flow alongside the path of a strike on the trunk of a pine, so allowing attracted beetles to more readily infest a struck tree. The number of

Fig. 9. Ips larvae feeding on inner bark.

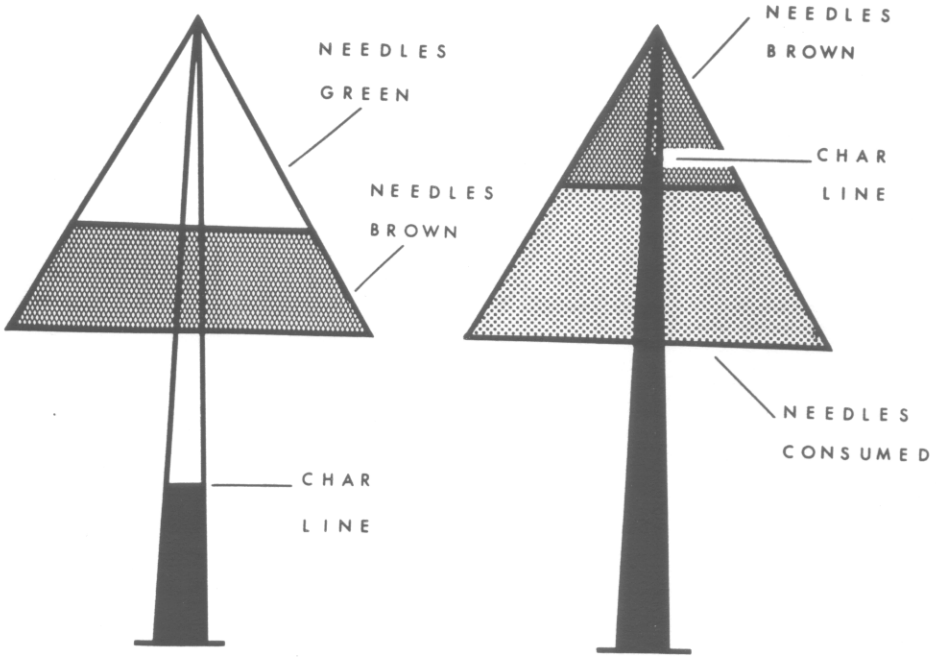

Fig. 10. Fire damage to pine. Tree on left will probably live. Tree on right will probably die and be infested by Ips.

trees infested by Ips following a lightning strike can vary from only one tree to a group of over 100 trees. Groups of infested trees are most often found in dense stands growing in shallow soils.

Windstorms such as tornadoes and hurricanes periodically cause significant amounts of damage that can lead to Ips infestations in pine stands. Tornadoes damaged trees with an estimated volume of 150,000 cords of pulpwood and 6.7 million bd. ft. of sawtimber in Georgia from 1973 to 1980. Pines completely downed or severed by tornadoes are almost always infested by Ips and other pest species. On the other hand, live trees simply tipped from vertical during a hurricane usually escape infestation when rainfall is plentiful for several months following such a storm.

Ice storms also occur periodically in Georgia, sometimes resulting in numerous broken or uprooted pines that are subject to Ips and BTB infestations. Trees growing along stand edges and trees in recently thinned stands are most apt to be damaged by ice. Slash pine planted in the Georgia Piedmont (north of the natural range of slash pine) is reported to be especially susceptible to such damage.

Plantation trees often have a higher incidence of Ips and BTB infestations than do wild trees growing in natural stands. This condition in plantations can sometimes be traced back to planting errors such as selecting the wrong species, variety, or geographic strain of pine for a particular area or site; planting seedlings incorrectly in the field; or planting seedlings too close together both between and within rows. As overcrowded trees grow to merchantable size, many are not thinned when needed and come under stress. In such stands, Ips infestations often begin around lightning struck trees and may spread over one or two acres of stressed trees before subsiding. In other cases, underplanted pine seedlings (those seedlings planted next to older pines or hardwoods already growing on or bordering a planting site) come under stress after growing in competition with the overtopping trees for a number of years. Ips sometimes attack these underplanted trees and then spread to other crop trees. Trees planted too close together in shallow or heavy clay soils may be especially subject to bark beetle infestations during periods of drought.

Logging/thinning activities have a tendency to increase bark beetle attacks wherever careless cutting, skidding, and hauling results in injury to the above-and below-ground portions of residual (future crop) trees. Such injured residual trees attract Ips, BTB and/or SPB, and may be unable to resist their attacks. Fresh logging debris such as large diameter limbs and cull logs, or freshly-cut timber left in contact with the trunks of residual pines can result in Ips attacks upon these trees. Ips beetles are also known to attack standing trees growing immediately adjacent to recently cutover tracts of pine timber; this is most apt to happen whenever small, localized logging operations are interrupted or abruptly ended during warm, dry weather.

At least two fungus-caused diseases, fusiform rust and annosus root rot, can damage pines to the extent that they are infested by Ips bark beetles and other pests. Fusiform rust galls that grow more than half-way around the trunks of pines can weaken the main stems to the extent that the trees break over at the galls during windstorms (Fig. 11) and then are infested. When stands are thinned, the annosus root rot fungus gains entry into the roots of residual trees by way of the freshly-cut surfaces of stumps, especially when thinning takes place during cool, wet weather. Roots colonized by the fungus die, which may lead to eventual death of residual trees because of the disease or because of infestation by bark beetles.

When slash or longleaf pines are continuously worked for gum naval stores by the bark chipping/acid stimulation method during a drought year, they are sometimes infested by BTB, Ips and other insects. A new problem is related to the development of a method for inducing lightwood formation (resin-soaking) in living slash pines. This involves application of the herbicide Paraquat^{R} to artificial wounds made on the tree trunks. Under some conditions, these paraquat treatments strongly induce attacks by the BTB, Ips and various wood-boring beetles. Both insect attacks and tree mortality increase with an increase in concentration of paraquat applied and with the size and

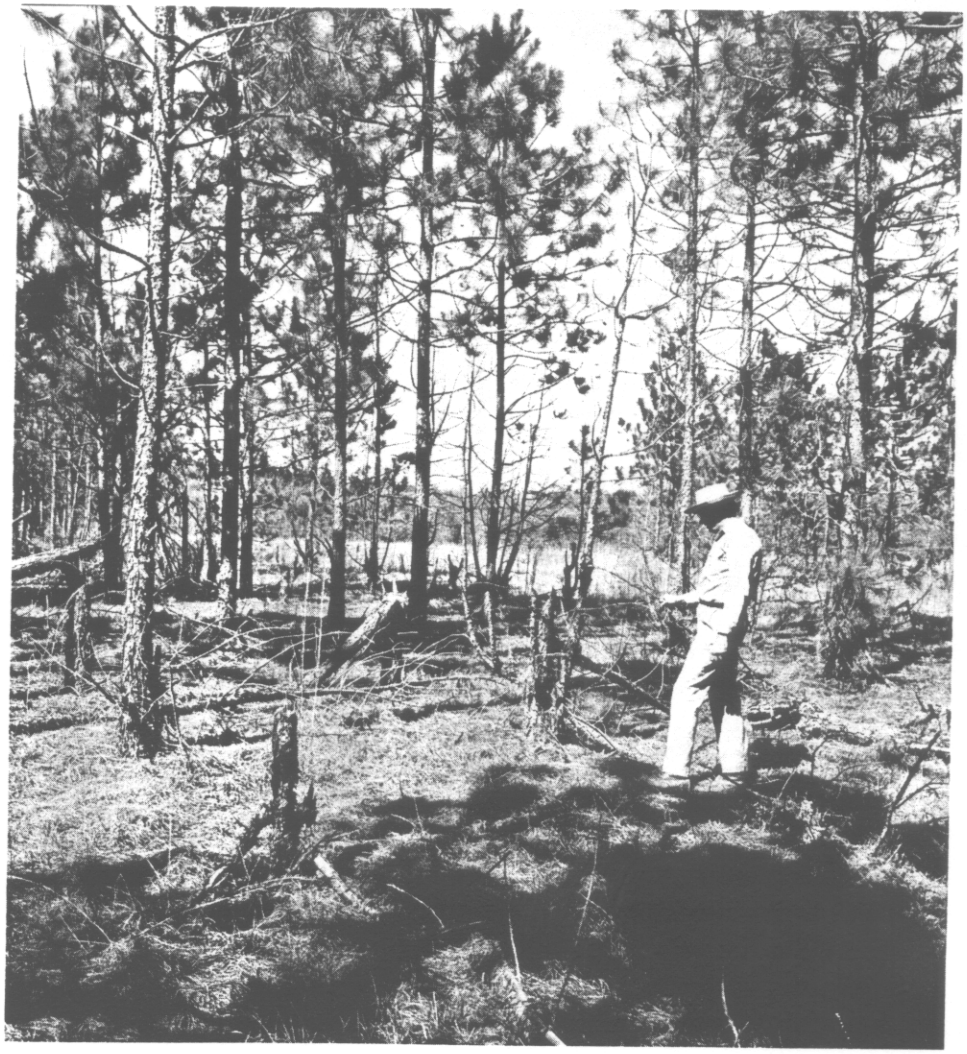

Fig. 11. Trees with fusiform rust stem galls are subject to breakage during windstorms and infestation by Ips.

severity of wounds made on the tree trunks. Tree mortality is highest when paraquat treatments are made during the growing season, rather than when the trees are dormant.

GUIDELINES FOR CONTROL

Preventive actions that help maintain stands in a healthy, beetle-resistant condition are often overlooked. Among these are careful establishment of plantations, thinning of overcrowded stands, prescribed burning, and avoidance of logging injury. Although events such as drought, wildfire, lightning, wind, and ice-storms are usually unpredictable, prompt inspection of stands after such events followed by rapid salvage of heavily damaged, merchantable timber can often minimize losses and reduce the threat of bark beetle infestations. Control of Ips infestations with insecticides is seldom recommended under woodland conditions, however preventive sprays may be needed at times to help reduce mortality of paraquat-treated slash pines caused by beetle infestations.

The following guidelines are offered as a means of helping reduce Ips infestations under woodland conditions:

(1) When establishing a new stand, plant that pine species, variety, and strain that is recommended as being best-adapted to the geographic area and particular site to be planted. Space seedlings at distances recommended for the site and type of crop (pulpwood, sawtimber) to be produced. Underplanting should be avoided.

(2) Thin overcrowded, slow-growing plantations when they are about 15 years old to reduce competition and to increase the growth and vigor of residual (future crop) trees. Trees whose trunks are severely damaged by fusiform rust galls should be removed at this time. When thinning, use the lightest suitable equipment available to minimize root injuries to residual trees. Thin during cool weather to reduce problems with Ips, however see (3) below concerning annosus root rot control.

(3) Immediately treat the cut and damaged surfaces of all stumps with granular borax when thinning stands in areas where annosus root rot is known to be a problem, especially when thinning is carried out during cool, wet weather.

(4) When logging or thinning, use as much of each harvested tree as practical and do not leave large-diameter (4 in. or more) logging debris or logs in touch with or close to living pines. Use continuous logging/thinning in an area rather than small, scattered operations, especially during warm dry weather.

(5) Use prescribed burning in pine stands, if needed to destroy excessive ground litter and understory vegetation that could lead to a damaging wildfire. Postpone burning during periods of drought because of the fire hazard involved and the possibility that trees will be severely injured.

(6) Following events such as wildfire, lightning-, wind-, or ice-storms promptly locate heavily damaged, merchantable timber. When economically practical, salvage such timber to minimize losses and to reduce the number of trees susceptible to beetle attacks.

(7) Suspend gum naval stores operations during periods of severe drought. In commercial lightwood operations involving slash pine; reduce the paraquat concentration as low as possible consistent with the labelled method of application and use only the method and number of paraquat applications recommended on the label. Do not spray insecticides on trees following application of paraquat during the wintertime. Apply 1% water emulsion of lindane insecticide to the basal 1 meter (3 ft.) of tree trunks immediately following an application of paraquat during the spring, summer, or fall. This treatment gives some protection against both the BTB and 6-spined Ips, two major pests of slash pine.

Caution: Timber owners are urged to consult with a forester before undertaking forestry operations such as planting, thinning, prescribed burning, or salvage logging because a number of technical problems and hazards are involved. Information can be obtained through an office of the Georgia Forestry Commission or County Agricultural Extension Agent.

A. Ray Shirley, Director
John W. Mixon, Chief of Forest Research

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