Methods for the Prevention and Treatment of Bark Beetles

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The Tano Road Association

A Real Life Bark Beetle Scenario Along Tano Road…..

"……one property owner ignored his dying piñon trees. After three weeks, the bark beetle eggs hatched, the larvae matured, exited the tree, and spread to his other piñon trees. By summer's end, he had lost 50% of his piñon forest, and the beetles spread to his neighbors' property.

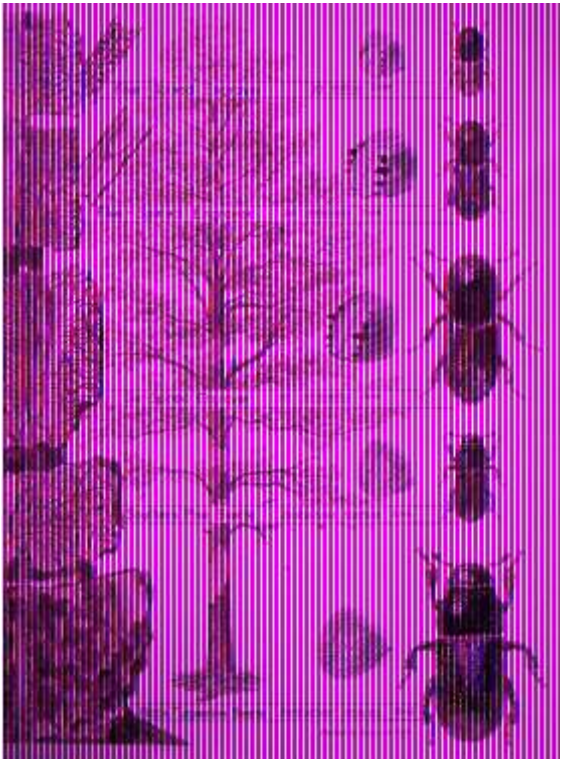
……and another property owner, concerned about his dying piñon trees, hired a tree firm to cut and mulch them. He instructed that the mulch be spread under the living piñon trees. The eggs, larvae, and beetles survived the mulching, and infested the remaining piñon trees.

……yet another property owner hired a tree firm to cut down his dying and dead piñon trees. He instructed them to wrap the cut wood in black plastic in hopes that the accumulated heat from the sun would kill eggs, larvae, and beetles. The beetles quickly found an exit from the plastic and infested other trees. Over the summer, many of the eggs hatched, the larvae survived the heat, and the beetles escaped."

Other nearby owners in this area sought advice about how to protect their property from the Bark Beetle infestation. This booklet of guidelines explains step by step what they learned, how they applied what they learned, and the happy results.

The Battle of the Beetles

A Summary of Guidelines and Methods for the Prevention and Treatment of Bark Beetles[1]



BARK BEETLE 101, A BEGINNER COURSE

This is a "best practices" summary of the prevention, treatment and mediation of Bark Beetle infestation. There are many different approaches and methodologies in dealing with Bark Beetles, and depending to whom you are talking, each will have particular value. However, we have taken the more conservative approach which generally represents the best practice among professionals. We do not

argue that there are no other methods, only that the methods we suggest are generally found by professionals as producing the most consistent, effective results.

Our particular type of beetle is the Ips Bark Beetle borer [Six-spined engraver, *Ips calligraphus calligraphus G*ermar)].

Bark Beetles are nearly always fatal according to the New Mexico State University Extension Office because even if the beetle invasion itself does not kill the tree, the beetle carries the *blue stain* fungus which always kills the tree.

In the view of the Extension Office, there is no cure once a tree is infested and an infested tree should be **cut down and hauled away immediately**. The Extension Office notes that infested trees must not be chipped and used as mulch since some beetles will survive the chipping process and simply breed in the mulch, often at an accelerated rate of reproduction. Further, during the chipping process, the beetles will swarm out of their nests in the infested tree and go immediately to neighboring piñons. This is also the collective wisdom of most entomologists and arborists.

But why Bark Beetles this year and not another? Simply, the reason is stress as a result of the drought. Strong piñons with large well developed root systems seek out what little water is available while weaker piñons can not. The weaker piñons struggle to just survive, producing little new needle growth and few new candles, conserving energy to the root system.. The effect in this "survival mode" is a piñon with severely reduced pitch sap flow in the tree. It is this reduced sap flow which permits successful Bark Beetle infestation In a Darwinian sense, this is nature's way of eliminating weak trees and reducing demand on an already scarce water supply.

The Bark Beetle has, like most insects, a definite life-cycle. They are part of a larger category of insects known as "tree borers". Adult males bore into the bark of the piñon, generally on the main trunk initially. The holes are about 1/8 of an inch and easily seen by the naked eye. Once past the bark of the piñon, the males enter the outer cambium of the tree and begin chewing tunnels up and down the cambium. These tunnels are the mating chambers for the female Bark Beetle.

Generally, the stronger trees do not attract heavy infestations of Bark Beetle since if a male Bark Beetle does bore an entry hole into a healthy piñon, it is almost immediately closed over by a rich flow of piñon sap, expelling the Bark Beetle and sealing off the entry hole. In subsequent years, these sealed off entry holes will appear as dark amber colored sap nodule, hard to the touch. Because the male Bark Beetle has not successfully prepared the mating tunnels in a healthy piñon, no further infestation occurs. It is for this reason that adequate water supply, essential for pitch sap flow in piñons, is a key factor in preventing Bark Beetle infestation.

It is said by arborists and scientists alike that the male Bark Beetle then emits a pheromone which signals to female Bark Beetles the readiness of the prepared mating tunnels in the infested piñon tree. The females enter the tunnel network, lay eggs in the tunnels which then hatch and begin feeding on the pitch sap of the piñon. The male exits the tree at this time and will travel no more than about 60 feet [although they can fly up to 3 miles but rarely do] to another piñon under stress and the process begins over again. The female dies after laying her eggs. The typical lifecycle of the Ips Beetle is 6 to 8 weeks in the warm weather periods.

In the crevices of the tree and bark, you will often see the “saw dust” tailings of the beetles which are generally from the tunneling activity of the newly hatched larvae. When this is evident the piñon is already heavily infested. Prior to this, however, you may only see the entry holes which would indicate eggs may have been laid by the female but have not matured to larva yet and the evidence of the saw dust from the tunneling has not occurred.

Once the eggs are hatched, the larvae will begin feeding on the pitch sap of the piñon and extend massive networks of horizontal tunnels around the entire circumference of the piñon [termed girdling] to tap-off all vertical sap flow as a food source for the larvae colony. It is because of this activity that evidence of heavy infestation of Bark Beetle is easily noted by yellow or brown needles on the piñon from the top down resulting from the starved sap supply of the tree.

To make matters worse, the Bark Beetle is host to the blue stain fungus [*Ceratocystis ips* (Rumbold) C. Moreau] which attaches itself to the undercarriage of the beetle shell and is deposited into the phloem of the

piñon. Santa Fe's integrated pest manager, Fabian Chavez, notes that the fungus can clog a tree's waterways, rendering watering ineffective in trees that have already been infested with the fungus even though the beetles may have left the tree or been killed by pesticide.

However, as Dan Herms, an entomologist at Ohio State University notes not all Bark Beetles carry the fungus and so it is not a given that once a beetle infestation occurs, the fungus has been introduced. It is for this reason that systemic treatments can be effective. In a laboratory environment, the fungus can be rather easily killed. However, at present, there is no science which has identified a systemic fungicide treatment to kill the blue stain fungus in the piñon.

Further, Winter weather does not always provide relief from infestation. Chavez said that even low temperatures don't always kill the beetles because they have a substance in their bodies that is also found in antifreeze that protects the beetle from freezing in the cold.

Other factors can also put a tree under stress. Needle tip fungus is common among piñons and while rarely will kill the tree by itself; it will place the piñon under stress and therefore make it susceptible to Bark Beetle. Pitch Moth, another common pest to the piñon, will generally only kill the piñon over a period of years but will also put the piñon under stress as well.

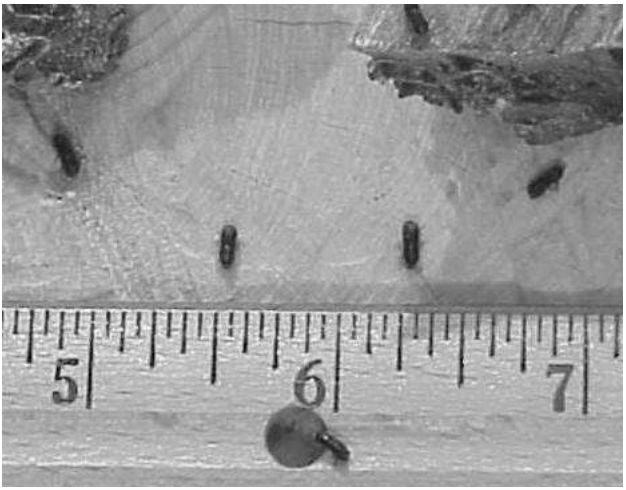
Twig beetles, over time, kill the new twigs at the tips of the limbs. Remove limbs and twigs that are infested, and dispose of them before the larvae hatch.

Of greater nuisance is mistletoe, the yellow-green growth sometimes called “witch’s broom” that invades both piñon and juniper trees. Piñon dwarf mistletoe (Arceuthobium divaricatum) is a small, parasitic plant. The external shoots are yellow-green to brown, have small scale-like leaves at the nodes of shoots, and are perennial. Mistletoe extracts nutrients and water from the branches of the host tree eventually killing the branch. If left unattended it will not only kill the tree but spread to other nearby trees.

The only sure way to rid the tree of mistletoe is to remove the infested branch. Removing only the visible mistletoe does prevent further spore

dispersion in the Autumn months but the actual infection remains.

Add any of the stress factors together and you multiply the susceptibility to Bark Beetle and the piñon's ability to fight off an infestation.



Six-spined engraver, *Ips calligraphus calligraphus* (Germar)

PREVENTION AGAINST BARK BEETLE

◆ Water

As we have discussed, watering your piñons well, especially during the winter months, is an effective defense against Bark Beetle. Understanding the life cycle of the Bark Beetle, rich sap flows in the piñon resulting from adequate watering seal off initial entry holes made by the male and prevent infestation.

Be sure to build holding wells around the trunk of the piñon [ideally out to the drip-line of the tree] to allow for maximum soaking of the tree. Generally, two fills of the well should be considered an adequate watering at a time.

◆ Topical Pesticide [Spraying]

In addition, local nurserymen will suggest spraying with the insecticide Sevin or the environmentally friendly permethrin. Spraying can be another effective tool against Bark Beetle depending on when the spraying is done. Spraying must be done prior to infestation. Since spraying is topical, that is, dried into the bark of the piñon**, spraying after infestation will not kill any beetles** already into the cambium of the piñon.

Spraying coats the bark of the tree. When the male Bark Beetle begins making an entry hole in the outer bark of the piñon, the insecticide is ingested by the beetle which dies from paralysis. But if the spraying is too old [anywhere from 2-6 months efficacy] then the tree must be re-sprayed to extend the protection. Spraying once in the Spring and again in mid-Summer can serve as an effective preventative.

Throughout Colorado, permethrin has been used for years instead of Sevin since it has been shown to be well tolerated by wildlife. Permethrin is made from a concentration of the chrysanthemum flower, and when highly distilled, it is extremely effective as an insecticide. Synthetic forms have now been formulated with equal effectiveness. Once it dries it is safe for pets and wildlife to be around. Permethrin, like all insecticides, is a topical spray to the bark. It is only a preventative, prior to an infestation of the Bark Beetle. To repeat, spraying a tree after

infestation will not save the tree.

Systemic Pesticide

Once the Bark Beetle is inside the tree the only logical way to attempt to save the tree would be with some type of chemical which enters the sap system of the tree and kills the pest feeding on the sap inside the tree. This type of treatment is termed systemic.

Here is the problem with systemic treatments. Bark Beetles feed on the sap and make extensive tunnels where newly hatched larvae feed; sap flow can no longer reach the extreme upper portions of the piñon. That is why an active infestation of Bark Beetle is visible from afar by the fading, dying needles from the top of the piñon downward. In effect, they are strangling the nutrient flow to the tree.

In order for a systemic treatment to be effective, there must still be sap flow in the tree to carry the insecticide to the infested areas. If the infestation is too far advanced, feeding the insecticide to the roots will soak into the root system but not go up the trunk where the Bark Beetle is nesting, so prompt application is everything. As soon as any infestation is noticed, immediate application is required followed by heavy watering to maximize sap flow uptake. It is a race against time, but it can be successful.

Even though our Extension Office does not recognize any such systemic treatment, several products are currently available which have had favorable results. In any event, it can be an effective preventive measure, particularly in concert with other methods.

Using a systemic pesticide has added benefits in that it also attacks infestations of pitch moth and tip beetle [a cousin of the Bark Beetle], and with an extended residual efficacy [up to 12 months] systemic pesticides can provide longer term protection.

◆ Root-Saturation Systemic Pesticide

Perhaps the most effective systemic treatment against a variety of piñon maladies is produced by Bayer AG. It is the systemic pesticide imidacloprid [Merit, Bayer Advanced Tree and Shrub Insect Control]

which is fed into the piñon via the root system. The application rate is 1 oz. of the Bayer liquid pesticide per 1 inch of piñon trunk circumference. Using a common cloth tape measure, a piñon with a trunk circumference of 32 inches [10 inch caliper] would require 32 ounces of pesticide, diluted in 1-2 gallons of water and applied at the root base of the tree.

When to apply the Bayer AG is mostly a matter of weather. The tree must be in sap flow, or in its growing cycle, in order to insure that the pesticide is brought up into trunk and branch system of the piñon. Generally this is in the warm weather period of Spring. It must be noted, however, that it may require 4-6 weeks to be fully distributed throughout the piñon and therefore that length of time will be required to achieve maximum protection. Warmer weather accelerates the sap flow so the pesticide is fully distributed in the piñon more quickly. However, wait too late and the risk of Bark Beetle infestation increases. Apply in April or May for ideal results.

In view of the time required to fully distribute the Bayer AG throughout the piñon, using it when an infestation is discovered may not allow enough time, or sap flow uptake, to kill the beetle before the tree dies. It is a gamble, but may be judged worth the expense.

There are several resources to buy the Bayer AG: Newman's Nursery, Paynes Nursery, Santa Fe Greenhouse, Home Depot and Walmart. A quart [32 oz.] costs $32 at normal retail but can be found at discount at times as low as $18. Newman's also carries the one gallon size for $75 and has been known to offer quantity discounts at the case level [12 quarts or 4 gallons].

Bayer AG, even as a concentrate, can become expensive depending on the size of tree to be treated. Generally, trees are selected because of previous illness, they are recent transplants, or they are particular specimens of landscape importance. To treat every piñon on a property would be very costly.

u **Systemic Pesticide Injection**

There is a systemic treatment which uses an injection system placed in the trunk of the piñon at about chest height. This patented system was developed by Dr. Roger Webb who founded Tree Tech in Morriston, Florida. The company is located at:

Tree Tech
950 S.E. 215th Avenue
Morriston, Florida 32668
1-800-622-2831
1-352-528-5335
info@treetech.net
http://www.treetech.net

Dr. Webb advises that he can sell his restricted use product only to licensed professionals. The insecticide is highly toxic and under the registration of the EPA.

The only licensed company west of the Mississippi is located in Albuquerque:

NARROW LEAF, INC.
100 A Pueblo Road N.W.
Albuquerque, New Mexico 87114
505-897-1172

There are 3 patented products from Tree Tech which can all effectively kill Bark Beetle:

- **Dendrex**
- **Vivid II**
- **Harpoon**

Because piñon sap is pitch-like, water based injections will not work……the water will not penetrate the sap. As a result, Dendrex, which is water based, is not effective for our piñons.

Vivid II and Harpoon are both petroleum based injections and will travel in the pitch sap of the piñon. Some recommend using a combination of both Vivid II and Harpoon on each infested piñon with Bark Beetle. For

example, in one large piñon 16 injectors were used and, at $20 per injection, the treatment becomes expensive. Smaller piñons require less. As a result, a careful evaluation is required so that the investment is prudent. Some piñons may have become too infested to be saved because the sap flow may have been too restricted for the insecticide to travel up to the extremities of the piñon. Use of injection in this instance would provide little if any benefit.

Successful injections generally will travel systemically throughout the circulatory system of the tree over a period of days. Trees with weak sap flow may take longer to make the entire circuit and Bark Beetle activity may continue in selected areas until the insecticide can reach those areas. A successfully dispensed injector will collect clear tree sap of the piñon back inside the injector [a kind of back-flow] which is evidence the insecticide has been fully integrated into the circulatory system of the tree. The holes drilled for each injector are not a threat to the piñon as the tree will sap-over the hole immediately following the removal of the injector.

The advantage of systemic pesticide injection is that the response time, when effective, is a few days rather than the weeks required by the root-saturation method.

Again, systemic injection can be expensive [about $20 per injection]. Spaced 4 inches apart around the circumference of the trunk of the tree at chest height, 4 injections would treat a 5 inch trunk at chest height. However, to cut down and haul off a large tree could easily cost $100 and to treat this large specimen tree would cost about the same and maybe save it. Some specimen trees can not even be replaced, [even at $8,000-$10,000 which is what Coates estimates some are worth,] because they simply are not available, and even if they were available, the risk of transplant at such a size is significant.

With systemic injection the piñons with the severe infestations will probably result in a total needle-loss but as long as the twigs are flexible there is evidence of sap flow and the tree could survive. New needle growth could come as early as October or as late as next spring and watering trees treated with Vivid II/Harpoon increases the effectiveness of the injection.

The injectors stay in the tree for 36-48 hours. Narrow Leaf must also remove each injector as a part of their EPA license and comes back up to Santa Fe in a day or two, which is included in their fee.

One crude test to verify the Bark Beetles have been killed is to just listen for them. Active infestations, particularly at the tunneling stage, produce a faint clicking noise where the beetles are currently "working".

Narrow Leaf stated the U.S. Forest Service recently purchased over $8 million of the Tree Tech system to treat select specimen trees in national forests.

SUMMARY

While there have been varying levels of success with systemic pesticides, both injection and root based applications, topical pesticide application has been quite effective. You should consider that each of the methods suggested should be part of an overall program to protect and treat piñon trees.

The best protocol is to **prevent infestation** in the first place. This is best accomplished by:

① Periodic water soaking the root base,

② application of systemic pesticide imidacloprid [Merit, Bayer Advanced Tree and Shrub Insect Control] in April or May,

③ application of topical pesticide [spraying] of permethrin in early Spring and mid-Summer.

DISPOSAL OF INFESTED TREES

① Once piñons are infested, the "best practices" protocol is to cut them out right away to prevent further infestation to nearby trees, including your neighbor's.

② Immediately remove to the landfill all debris and cuttings from your property.

③ Do not chip the dead trees up, no matter who advises you otherwise as this will cause swarming by the remaining beetles which are not killed by the chipper, most of those fleeing as the wood is being fed into the chipper.

It is not recommended to "solarize" your infested cuttings and debris by covering them with a 6 mil black [or clear] plastic blanket and letting the heat build-up by the sun kill the beetle.

> Note: Our Northern New Mexico daytime temperatures are not consistently high enough for long enough to kill beetles deep inside the wood cuttings. The rapid cool off of our nighttime temperatures throughout the year makes it unlikely the required high sustained temperatures can be reached for the recommended 30 days of a "solar oven effect". Some beetles may be killed in the smaller branches, however, those nesting in the larger main trunks are more likely to survive and pose a threat of further infestation. Furthermore, it is very difficult to keep the wrapping air-tight and escape-proof.

<u>It is essential to remove the dead tree from the property altogether</u>.

Burning infested wood in your stove or fireplace can result in other risks. Of course the beetle will not survive the fire. However, even if the temperature outside has been consistently below freezing for several weeks, Bark Beetles can still be alive and feeding on the recently felled piñon in your wood pile and, as a result, they may infest healthy trees nearby. Using this firewood of infested piñons may be a false economy.

BARK BEETLE CHECK-LIST[2]

The last major Bark Beetle infestation was 2 years ago when entire forests of piñons were lost to the beetle. It was also a time of severe and sustained drought. This recent infestation rivaled that of 50 years ago. In an effort to gather the most effective methods for managing the beetle infestation, there are many different suggested approaches from a wide variety of sources and at times conflicting points of view. This may simply be the result of the fact that the last major infestation of 50 years ago was so long past that the methods which were used then are out of date.

This Check-List purposely takes a conservative, "best practices" approach, and is a combination of the wide range of sources noted here. Further, geography is also a factor. For example, "solarizing" [see item 5 below] may be very effective in Albuquerque but not recommended in Santa Fe's higher altitude. While there are alternate methods available for handling a beetle infestation, those methods may pose a risk for continued infestation of nearby piñons and are not recommended here.

Here are some reminders when dealing with Bark Beetle infestation:

2. Remember, Bark Beetle infestation is a community problem.

Bark Beetle is in the tree only 21 days, and further infestation can be widespread before it is clearly obvious, so inspect often and act quickly.

3. Inspect your piñons frequently, especially after temperatures begin rising in the Spring.

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[2] Sources: New Mexico State University Cooperative Extension Service, "Conifer Pests in New Mexico", 1977; USDA, United States Forest Service, Southwestern Region; Tom Sharpe, The Santa Fe New Mexican, August 13, pg. A-1 & August 14, pg. A-2 and Dr. Erica Elliot, September 8, 2002, pg. F-7; Wes Smalling, The Santa Fe New Mexican, September 24, 2002, pg. A-5; Wren Propp, The Albuquerque Journal, September 27, 2002, pg. A-1; Fritz Thompson, The Albuquerque Journal, September 29, 2002, pg. A-1, A-10; Dr. Roger Webb, Tree-Tech Injection Systems, Morriston, Florida; Narrow-Leaf Inc., Albuquerque, New Mexico; Santa Fe Greenhouses, "Dealing With The Bark Beetle"; Coates Tree Service, Santa Fe, New Mexico; Roy's Tree Service & Pest Control, Santa Fe, New Mexico; Newman's Nursery & Greenhouse, "Treating Pinons with Bark Beetle", August, 2002, Santa Fe, New Mexico.

⇨ Look for yellowing or hay-colored needles which signal that the tree is or has been infested.

⇨ Even if the needles are green, inspect the bark for reddish-brown sap formations (pitch tubes), tiny one sixteenth pinholes in the bark, or rusty brown sawdust in the crevices or on the ground.

⇨ Listen for clicking noises from the tree, and sniff for strong resin scent.

⇨ Any of these symptoms signal that the tree has been infested.

4. When you detect an infestation, act quickly and decisively.

5. If you catch the infestation early enough, you may be able to use a systemic insecticide to kill the beetle. Early detection is the key here. Early stage is defined as the condition where entry holes are evident but the "saw dust" residue is not yet present.

6. If you are trying to save the tree by using a systemic insecticide, regular, deep-soaking watering will much improve survival.

Note: Apply slow drip irrigation to important trees during all seasons. If you haven't installed an automatic irrigation system, then a water-efficient, effective, and inexpensive method is to purchase soaker hoses ($8 each) from Wal-Mart, Home Depot, or your garden supply. Lay a soaker hose under the tree's drip line, attach to garden hose, and turn faucet only one-fourth turn. Let run three or four hours. If water accumulates on the ground, reduce the flow.

7. Successful systemic treatment can be evidenced by flexible twigs and the emergence of new needle growth on the outer limbs.
8. If the tree is too far gone, usually evidenced by no green needles, no sap flow to upper limbs and brittle twigs, then the **tree should be cut down** in large sections and

physically removed from the property, immediately. Do not leave the infested tree standing because the beetle larvae will hatch, exit and kill other trees.

9. **Take Note:** It is not recommended to keep the cut up dead trees on your property under a plastic blanket.
10. Remove the dead tree from the property altogether.

11. **Do not chip** or shred the **dead tree** in order to use it as mulch. The beetles will swarm while chipping and infest other trees on your property. Further, using the chips as mulch only provides a breeding ground for further beetle infestation.

12. **Rake up** all the dead **needles** under the tree, place them in plastic bags and remove them from the property.

13. Firewood ordered for winter should only be seasoned wood [1 year old] where sap has hardened and the wood dried out. Fresh cut piñon is an ideal breeding ground for Bark Beetle. If you already have unseasoned firewood, cover the stack tightly with plastic tarps or sheeting.

14. **Do not collect** piles of tree **cuttings** and tree debris, even healthy ones, on your property as they can also serve as nesting grounds for the beetle.

15. In early spring, just after the last freeze, **trees can be sprayed** with Sevin or permethrin to provide protection against new Bark Beetle infestation. Depending on the concentration of the spray and thoroughness of the spraying, protection will last from 2 to 6 months. The proper concentrations can be applied only by a licensed nurseryman or arborist.

    - Recent studies indicate that proper spraying is 90% effective in protecting the tree.

16. Spraying after an infestation will not kill the beetle already inside the tree.

> **Note:** Do not attempt to save the infested tree by spraying or watering, it will not survive. Because the Bark Beetle is a carrier of the Blue Stain fungus, fungal spores quickly germinate and infest the sapwood, blocking the flow of water throughout the tree. Generally speaking, you cannot save an infested tree, unless very early detection allows the successful use of systemic pesticide injections.

14. Maintain the health of your trees, living and dead:

> - Remove all dead trees within sixty feet of your house.
> - Remove all dead branches on trees within thirty feet of your house.
> - Remove live tree branches close to the ground (four to six feet) from all trees within thirty feet of your house for fire prevention
> - Remove all debris from the ground within thirty feet of your house. This does not include the matted needles "duff" under healthy trees, but does mean all needles from under infested trees.

15. If you hire someone to spray or remove your trees, check their credentials and their references. There are wide variances in the fees and services offered. Sometimes you get what you pay for.
16. Spraying after an infestation will not kill the beetle already inside the tree.

APPENDIX I

Ips Bark Beetles in the South

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[1]Entomologist, USDA Forest Service, Southern Region, State and Private Forestry, Forest Pest Management, Pineville, La.

[2]Professor of Forest Entomology, Department of Entomology and Nematology, University of Florida, Gainesville, Fla.

There are three principal species of *Ips* bark beetles (Coleoptera: Scolytidae) attacking pines in the Southern United States: the eastern six-spined engraver, *Ips calligraphus calligraphus* (Germar); the eastern five-spined engraver, *Ips grandicollis* (Eichhoff); and the small southern pine engraver, *Ips avulsus* (Eichhoff). From 1973 to 1979, these three *Ips* species caused the loss of an estimated 6.6 million board feet and 1.1 million cords of pine timber in the South.[3] The only insect to kill more pine timber in the South is the southern pine beetle, *Dendroctonus frontalis* Zimmermann, which often attacks trees in combination with one or more of the three *Ips* species, and the black turpentine beetle, *Dendroctonus terebrans* (Olivier).

Ips beetles usually attack weakened, dying, or recently felled trees and fresh logging debris. Large numbers of *Ips* may build up when natural events such as lightning storms, ice storms, tornadoes, wildfires, and droughts create large amounts of pine suitable for the breeding of these beetles. *Ips* populations may also build up following forestry activities, such as prescribed burns that get too hot and kill or weaken pines and clear-cutting or thinning operations that compact soils, wound trees, and leave large amounts of branches, cull logs, and stumps for breeding sites.

Distribution

Two subspecies of *Ips Calligraphus* are recognized: *Ips calligraphus ponderosae* (Swaine) and *Ips c. calligraphus.* The distribution of *Ips c. ponderosae, I. c. calligraphus, I. grandicollis,* and *I. avulsus* within the United States is as follows: *Ips c. ponderosae* is a western subspecies and will not be discussed further in this leaflet; *Ips c. calligraphus* is primarily an eastern subspecies that occurs naturally from southern Canada to the Gulf of Mexico and a small population has apparently been introduced into California; *Ips grandicollis* is also an eastern species found from Canada south to the Gulf and on some of the Caribbean Islands and accidental introductions have also established populations in South and Western Australia; and finally, *Ips avulsus* is the only species confined almost entirely to the Southern United States.

Signs of Infestations

[3]Data taken from yearly unpublished reports of the Southern Forest Insect Work Conference, calendar years 1973-79, Survey of Damage Caused by Forest Insects in the Southeast.

Trees attacked by *Ips* bark beetles, whether in the forest or around the home, are usually noticed when needles turn yellow or red. Upon closer examination, infested trees will have dry, reddish-brown boring dust in the bark crevices. Some trees may have dime-size or smaller, white to reddish-brown projections, called pitch tubes in the bark crevices.

Pitch tubes are a mixture of pitch and bark particles pushed out by the attacking beetles. The center of the tube contains a hole through which the adult beetle enters the inner bark. If no hole is present in the pitch tube, the beetle attack was unsuccessful. Vigorous trees attacked by a few adults often produce enough pitch to either drown the beetles in the inner bark or push them back out of their entrance tunnels. If the bark around a hole containing dry boring dust is carefully cut away, the beetles can often be seen in their tunnels within the inner bark.

Adult *Ips* beetles carry numerous spores of a bluestain fungus, *Ceratocystis ips* (Rumbold) C. Moreau, in their gut. When the adults attack trees or logging slash, the bluestain spores are excreted with beetle feces into egg galleries, where the spores germinate. Bluestain fungus colonies grow into the outer sapwood of infested pines, stopping the upward flow of water to the tree crown. Lack of water causes needles to wilt and die, gradually changing their color, from dull green to yellow green to red brown. These color changes may occur in 2 to 4 weeks during the summer, but take several months in the winter.

When *Ips* beetles leave a tree, their emergence holes look like scattered shot-holes on the surface of the outer bark. During hot weather, beetles usually leave a tree by the time the foliage turns red brown. During either cool or moist weather, the beetles may leave while the foliage is still green. Therefore, the best way to confirm the presence of *Ips* beetles in a tree is to remove several apparently attacked sections of bark to determine if any beetle life stages are present.

Life Stages

Newly emerged adults of the three *Ips* species are light orange brown in color; mature adults vary from dark red brown to almost black. The posterior of *Ips* adults looks as if it has been cut off at an angle and hollowed out. Close inspection with a magnifying lens shows that *Ips* adults have a number of spines on the outer side of each wing cover near the posterior. In the South, most pine bark beetles that could be confused with *Ips* lack spines and have rounded rear ends that are not hollowed out.

In the adult stage, the three *Ips* species can be distinguished by their size and the number of spines. *Ips calligraphus* adults are about 5 mm (1/5 in) long and have 6 spines on each side near the posterior. Their eggs are oblong, pearly white, and about 1 mm (1/25 in) long by 0.5 mm (1/50 in) wide. The grub-like larvae are small, whitish, and legless, with orange-brown heads up to 1 mm (1/25 in) wide. The pupae are waxy white and similar to adults in size. The eastern six-spined engraver commonly infests thick-barked pines and usually attacks portions of trunks that are 10 cm (4 in) or more in diameter. This is often one of the first bark beetles to attack drought-stricken trees.

Ips grandicollis adults are about 4 mm (1/6 in) long and have 5 spines on each side. The eggs are about 0.9 mm (1/30 in) long by 0.5 mm (1/50 in) wide, and larvae have heads up to 0.8 mm (1/32 in) wide. Pupae are waxy white and similar to adults in size. Recently felled trees and fresh logging debris are favored breeding material. In standing trees, this species is usually found in the upper trunk and basal portions of large branches.

Ips avulsus adults are about 3 mm (1/8 in) long and have 4 spines on each side. The wing covers of *Ips avulsus* are lighter brown than the thorax. The eggs are about 0.8 mm (1/32 in) long by 0.46 mm (1/55 in) wide, and larvae have heads up to 0.7 mm (1/36 in) wide. Pupae are waxy white and similar in size to adults. Fresh, thin-barked logging debris, such as the upper portions of branches and tops of pines, is often infested. The crowns of large, living trees may be attacked and partially or completely killed. It is common to find one or more species of *Ips*, as well as other pine-infesting beetles, inhabiting various parts of the same tree.

Life Cycle

It is usually the male *Ips* that initiates the attacks on living pines or logging debris by boring an entrance tunnel through the outer bark and excavating a small, irregular nuptial chamber within the inner bark. Generally one to four females are attracted to the male beetle in this chamber, where mating occurs. From this chamber, each female then begins constructing an egg gallery. These egg galleries usually follow the underlying wood grain, often resulting in Y- or H-shaped gallery patterns in the inner bark.

Females lay their eggs in niches that are chewed out at intervals on either side of the egg galleries, and cover them with plugs of inner bark. During

warm weather, larvae emerge from the eggs after a few days and make individual tunnels or feeding galleries in the inner bark.

The feeding galleries extend from the niches in the egg galleries, enlarging as the larvae grow. Mature larvae stop feeding, turn chalky white, and pupate at the end of their galleries, or sometimes in rounded pupal chambers. Here the pupae change to young adults. The new or brood adults make short, winding tunnels in the inner bark, consuming bluestain fungus fruiting bodies before maturing and boring out through the bark to repeat the life cycle.

One generation of *Ips* may be completed in approximately 21 to 40 days during the summer or may require several months during the winter. Under warm conditions, the short life cycle allows populations to increase rapidly. Because very little development takes place below about 15° C (59° F), *Ips* is not a serious problem during cold weather.

Integrated Pest Management

Beetle-caused damage can be reduced through one or more prevention or suppression techniques.

Prevention: An important factor in determining the incidence and severity of *Ips* activity is the amount of suitable host material available for breeding. Forestry practices that reduce the amount of such material help serve as preventive control measures.

The following practices are recommended during logging or thinning operations:

- Use as much of each crop tree as possible. Avoid leaving logging debris in contact with or close to residual pines.
- Remove harvested timber from a stand as soon as possible, especially during warm weather. Whenever feasible, stack harvested timber or pine firewood away from living pines.
- Minimize the damage to future crop trees that is caused by logging equipment and vehicles. When thinning, use the lightest suitable equipment to minimize soil compaction and root-breakage. Scarred portions of trees and root injuries, especially during hot, dry weather, attract *Ips* and black turpentine beetles. Wounds invite infestation.
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- Use the pine species and spacing intervals best suited to the area to be planted.
- If necessary, thin stands to maintain vigorous and healthy growing conditions.
- Promptly salvage or destroy potential *Ips* breeding material, such as pines that are severely damaged by wind, lightning, fire, disease, insects, or other destructive agents.
- In residential areas, maintain shade tree vigor by watering during periods of drought.
- **Natural Control:** Several insect parasites and predators, as well as fungus diseases, provide some natural control of *Ips* populations. Woodpeckers sometimes remove *Ips* from the bark, especially during the winter when beetle development is very slow.
- **Suppression:** Natural disasters such as prolonged droughts, hot wildfires, or severe windstorms sometimes result in large *Ips* infestations despite good preventive forest management. Logging of beetle-infested and recently killed trees through timber sales is often an effective way to reduce bark beetle populations and minimize further timber losses.
- Chemical control of *Ips* infestations under forest conditions is seldom warranted. If chemical control is necessary to protect high-value trees in residential or recreational areas, the nearest County Agricultural Extension Agent, State Agricultural Experiment Station, or USDA Forest Service office should be contacted in order to obtain current chemical control recommendations.
- Other control methods are burning, chipping, debarking, or burying infested portions of trees. Burning should be restricted to periods of low fire danger, and Federal and State laws should be observed.
- **Timber Management Practices:** Timber owners may consult their nearest county, State, or Federal forestry personnel for recommendations on tree species selection, spacing, thinning, salvage logging, or other management practices to be followed in a particular stand or area.
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APPENDIX II

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Managing Bark Beetle Infestation with Blue Stain Fungus

First, the bark beetle species in our region are only capable of colonizing extremely stressed trees, so, foremost, bark beetles are a plant health problem. Many believe that infested pines are so stressed that they would die even if bark beetles did not finish them off. However, I believe that this is not the case, that if stressed trees can be protected from bark beetles, they could survive, if the ultimate source of stress can be relieved. We are currently testing this hypothesis experimentally in the case of red pine, drought stress, and bark beetles.

Second, in my experience, when bark beetles attack, in most cases it is in overwhelming numbers due to mass attack behavior mediated by the aggregation pheromone they produce. Such a great proportion of phloem is destroyed that the tree is badly girdled and would succumb even if blue stain fungi did not clog the phloem. This means it is necessary to protect the tree from bark beetles, as well as associated fungi [*Ceratocystis ips* (Rumbold) C. Moreau]. Treating with a fungicide alone would not be effective (even assuming the fungicide was effective against blue stain), if the tree were not also protected from the beetles. In our tests, we have found imidacloprid (Merit, Bayer Advanced Tree and Shrub Insect Control) to be effective, but my recommendation is protective bark sprays with Astro [permethrin], which we have found to be very effective against Ips pini, the main bark beetle in the Great Lakes states.

Finally, blue stain fungus [*Ceratocystis ips* (Rumbold) C. Moreau] is not universally present in bark beetle infested trees, and interesting new research is showing that blue stain fungus is not mutualistic, as it has been assumed, but is actually antagonistic, competing with bark beetles for phloem resources. Studies are showing that bark beetle performance and survival are decreased in the presence of bluestain fungus (which hitchhikes in external cavities of the bark beetle, rather than in the gut

and feces).

My bottom line recommendation is to protect stressed pines with Astro bark sprays, and work to alleviate the source of stress if possible. Drought stress is big factor, and there was an increase in bark beetle problems towards the end of last summer, which means there will be high populations this April when over wintering adults become active. However, many pines (which do not occur naturally in most of Ohio) are inherently stressed because they are planted in soils to which they are poorly adapted. This is a more difficult challenge to manage.

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NOTES & FOLLOW- UP ACTIONS