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Wood-boring Insects of Trees and Shrubs

Bastiaan M. Drees, John A. Jackman and Michael E. Merchant*

Many insects feed and make their homes in the bark, trunks and branches of shade trees and shrubs in Texas. Insect borers belong to several different insect groups including a variety of beetles, moths and horntail wasps.

Most insect borers are attracted to weakened, damaged, dying or dead plants. These are referred to as "secondary invaders" because they attack only after a plant has been weakened by another stress. Secondary invaders are a symptom of other problems with the health of the tree or shrub, but may contribute to its decline. Secondary invaders include species from groups already mentioned, but also may include termites, carpenter bees and carpenter ants.

Many other insects live in dying or dead trees, including natural enemies (predators and parasites) of the insect borers, sap or fungi feeders, or species which merely use the spaces provided by the tunnels and galleries as living quarters.

Wood-boring insects that attack healthy trees and shrubs are called "primary invaders." Primary invaders may eventually kill trees.

Damage

Borer infestations often go unnoticed until plants or parts of plants begin to die or show external signs of damage. Wood-boring insects often produce sawdust-like frass (excrement). Their holes are normally round, oval or semicircular and are found in a random pattern on the plant. Woodpecker damage is sometimes confused with that of wood-boring beetles; however, woodpecker damage will not produce frass. One woodpecker, the yellow-bellied sapsucker, produces square holes in rows around a trunk or branch. (See photo on page 6.)

Borers tunnel in the inner bark layer (cambium), which transports nutrients and water to the leaves. When the cambium layer is completely girdled the plant eventually dies above or beyond the damage site. Partial girdling reduces plant growth and vigor above the site of attack. On occasion, tunneling makes the tree weak, causing limbs and branches to fall. Borer damage can severely affect the quality of lumber and can make trees susceptible to disease.

Wood-boring Insects

Long-horned beetles or round-headed borers (Coleoptera: Cerambycidae)

Adults are called long-horned beetles (Fig. 1) because their antennae are occasionally longer than their bodies. Larvae tunnel underneath bark and into the heartwood. The tunnels are oval to almost round in cross section because of the round shape of the larvae (Fig. 2). Larvae of some species are legless, but most have three pairs of small legs on the first three segments behind the head capsule. While tunneling, larvae continually pack their tunnels with excrement (frass), which looks like compressed wood fibers, or push frass out of the holes they produce. This excrement, along with the sap exuded by the plant in response to the damage, is often visible on the outside of infested trunks or branches. Many species of beetles belong to this group, but most are secondary invaders. Some examples of long-horned beetles are described below.

Locust borer (*Megacyllene robiniae*) adults are medium-sized (¾ inch long) long-horned beetles frequently found feeding on goldenrod or other flowers in the fall. They are dark brown to black with distinctive gold-yellow markings. Larvae hatch from eggs laid in bark crevices. Visible symptoms of infestation are wet spots

*Professor and Extension Entomologist; Professor and Extension Entomologist; and Professor and Extension Urban Entomologist, The Texas A&M University System.

and frass on the bark of black locusts. Later, larvae tunnel into the inner bark and construct cells in which they spend the winter months. In a year the larvae are fully grown and about an inch in length.

Cottonwood borer (*Plectrodera scalator*) is frequently found on cottonwood, poplar or willow trees. Adult beetles are large (1¼ inches long) with an attractive black and whitish-yellow pattern. They are active from May through August. The larvae (1.75 to 2 inches long) tunnel at the base of the trunk or below ground level. They require about 2 years to develop.

Red-headed ash borer (*Neoclytus acuminatus*) is one of the most common wood-boring beetles. It has a narrow body with a reddish thorax and light brown wing covers marked with four yellow lines on each. The yellow lines are slanted downward toward the middle, giving the appearance of a "V" across the back. The antennae are rather short and the long legs are thin and fragile. Red-headed ash borers feed in many species of wood including ash, oak, elm and even grapes. Adults can be found on dead log piles and frequently emerge from firewood.

Red oak borer (*Enaphalodes rufulus*) attacks oak and maple trees and can be a serious pest in nurseries. The reddish-brown adults (⅝ to 1⅛ inches long) lay eggs individually in bark crevices during July and August. Larvae tunnel under the bark and into the heartwood. Infested sites can be recognized by the frass around the buckled bark near the gallery entrance. Larvae often tunnel completely around the trunk or branches they infest, producing noticeable scars or girdling. Red oak borers feed for more than a year before pupating in chambers tunnelled into the heartwood. Damage kills limbs or terminals and increases the risk from secondary invaders and diseases.

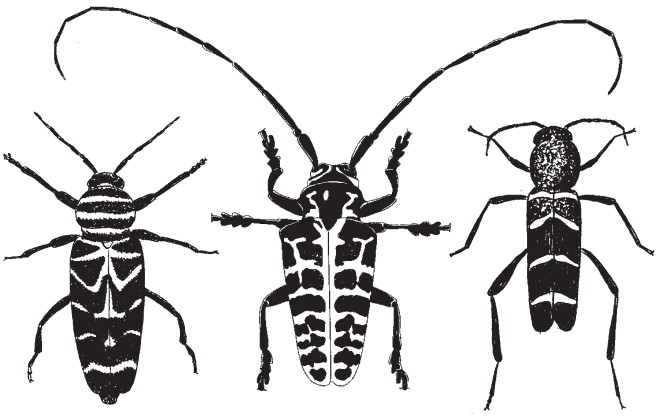

Figure 1. Long-horned beetles or roundheaded borers: locust borer (left); cottonwood borer (center); and red-headed ash borer (right).

Twig girdler (*Oncideres* species) damage occurs primarily from egg laying. This insect attacks pecan, mimosa, chinaberry and huisache. The grayish-brown adults (1⅛ inch long) girdle limbs during the fall (late August through mid-November) by chewing a V-shaped groove entirely around twigs, branches or terminals. Eggs are inserted into the bark on the girdled part of the branch away from the tree. Girdled limbs eventually break and fall to the ground, particularly during high winds and storms. Damage can disfigure a young tree and leads to secondary branching, particularly if the terminal is attacked. Larvae reach up to ⅞ inch long and are unable to develop in healthy sapwood. Removing the girdled twigs and branches from the ground during winter and spring and destroying them can reduce the population of these insects.

Twig and branch pruners (*Elaphidionoides* and *Agrilus* species) produce damage superficially similar to that of twig girdlers on elm, hackberry, hickory, maple, oak, pecan, persimmon, redbud, sweetgum and other trees. In these species, however, it is the larvae that girdle twigs and branches underneath the bark. The surface of the severed end of the twig is smooth. The insect usually severs branches where small twigs branch from the main, girdled branch.

Red oak borer larvae girdle main trunks and branches during the second year of larval development.

Female twig girdler beetles chew a V-shaped groove entirely around twigs, branches or terminals. (Photo by M. E. Rice)

Twig and branch pruner larvae girdle from underneath the bark.

Metallic wood-boring beetles (or flat-headed borers) (Coleoptera: Buprestidae)

Adult beetles are flattened, hard-bodied and boat-shaped with short antennae. These are beautiful beetles with distinctive metallic colors (green, blue, bronze, copper). Larvae are cream-colored and legless with widened, flattened body segments just behind the heads. Consequently, when these larvae tunnel beneath bark or into the sapwood they produce oval or flattened tunnels in cross section (Fig. 2). Galleries are often winding and packed with frass. Tunneling can girdle trunks and branches. Many species of flat-headed borers occur in the state. Most are secondary invaders.

Examples of flat-headed borers include the **bronze birch borer** (*Agrilus anxius*), uncommon in Texas because of the lack of host trees; ***Agrilus* species** found on oak and raspberry (*A. bilineatus* and *A. ruficollis*, respectively); **flat-headed appletree borer** (*Chrysobothris femorata*) and a closely related species that attacks recently transplanted or stressed shade, pecan and fruit trees.

Bark beetles (Coleoptera: Curculionidae)

Beetles in this group tunnel below the bark of trees and/or into the wood. Adult beetles are small and reddish-brown to black. Larvae are cream-colored grubs without legs. One member of this group, the European elm bark beetle (*Scolytus multistriatus*), is the carrier of Dutch elm disease. It occurs in the Texas Panhandle, but is infrequently encountered in other parts of Texas. Other members of this group are described below.

Southern pine beetle (*Dendroctonus frontalis*) is a primary pest of southern pine forests. Adult beetles are active during warmer months (when temperatures are above 58 degrees F), and disperse widely to injured, weakened or stressed trees in the spring. Seven or more generations may be completed within a year. When abundant, they can attack healthy trees. Larvae tunnel beneath the bark producing tunnels or galleries in patterns resembling the letter “S” (Fig. 5). This tunnelling quickly disrupts the cambium layer, girdling the tree. Infested trees can have numerous masses of resin called "pitch tubes" on the tree trunk. Needles of newly attacked trees turn reddish-brown 1 to 2 months after infestation during the summer, and up to 3 months afterward in the

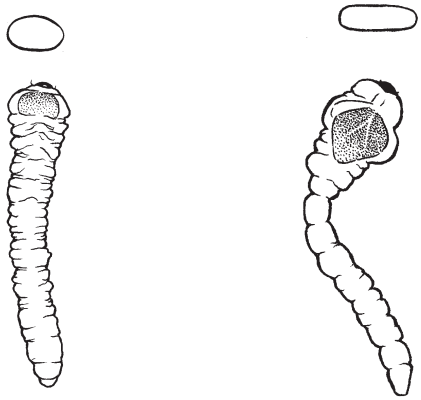

Figure 2. Larvae of round-headed borer (left) and flat-headed borer (right) with cross sections of tunnels (above).

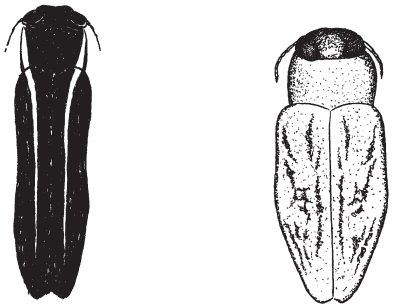

Figure 3. Metallic wood-boring beetles or flat-headed borer adults: *Agrillus bilineatus* (left); flat-headed appletree borer (right).

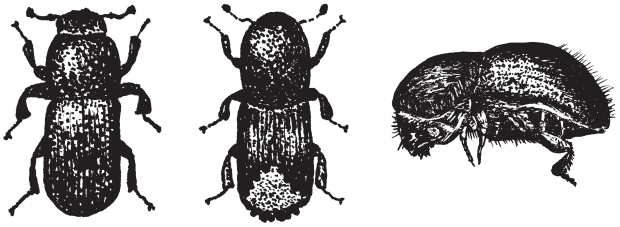

Figure 4. Bark or engraver beetles: Southern pine beetle (left); Ips engraver beetle (center) and granulate ambrosia beetle (right).

"Pitch tubes" are commonly seen on the trunks of pines attacked by pine bark beetles.

winter. Removal and destruction of infested trees may prevent healthy trees in the vicinity from being attacked.

Ips engravers (*Ips*. spp.) are often mistaken for the southern pine bark beetle because their appearance and damage are similar. Their gallery patterns tend to be more parallel to each other, however (Fig. 5). Ips usually attack weakened trees only. Recently felled wood should be covered with plastic to prevent Ips beetle infestation. The black turpentine beetle, *Dendroctonus tenebrans*, is another species attacking pines.

Shothole borers (*Scolytus rugulosus*) are secondary pests of common fruit trees (peach and plum), wild plums and occasionally ash, elms and hawthorne. These bark beetles tunnel through the bark and make small holes in the bark crevices.

Granulate ambrosia beetle (*Xylosandrus crassiusculus*) is a newly introduced species that attacks healthy, stressed or freshly cut elm, pecan, peach, *Prunus* species, oak, sweetgum and other trees in east Texas. Tiny (2 to 3 millimeters long), dark reddish-brown adult female beetles tunnel into twigs, branches or small tree trunks, excavating a system of tunnels in the wood or pith in which they lay eggs. They also introduce a fungus on which the larvae feed. Visible damage includes wilted leaves on infested branches and protrusions of compressed wood dust from numerous small holes, resembling toothpicks pointing outward. Dead and dying areas of bark (cankers) can form at the damage site, eventually girdling the tree and killing it. There are several generations per year. Chemical control of this species has been generally unsuccessful. Native ambrosia beetles are also called shot-hole or pine-hole borers. These species have similar biologies but rarely attack healthy, vigorous trees.

Protrusions of compressed wood dust signal attack by the granulate ambrosia beetle.

Weevils (Coleoptera: Curculionidae)

Adult weevils have a characteristic snout that bears the chewing mouthparts (Fig. 6). Larvae are legless and cream-colored, and generally feed in cells or hollowed out cavities underneath the bark rather than in galleries or tunnels as do bark beetles. Virginia pine plantings in Texas have suffered extensive damage from the **deodar weevil**, *Pissodes nemorensis*. These weevils attack the trunks during the winter, where young trees are in poor planting sites. Several weevil species attack the bases and roots of woody ornamental plants.

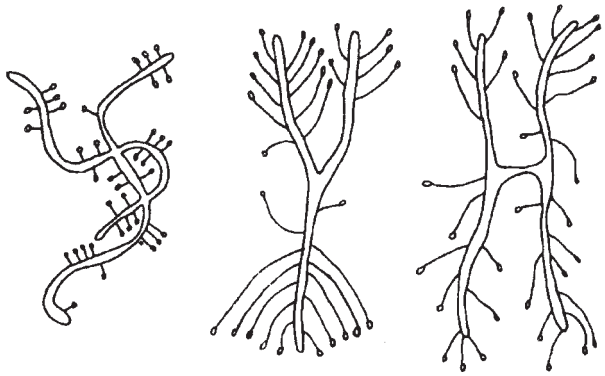

Figure 5. Left to right: "S"-shaped egg galleries of the Southern pine beetle; "Y"- or "H"-shaped egg galleries of the Ips engraver beetles.

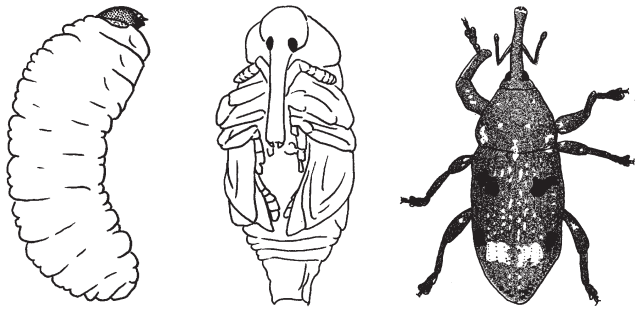

Figure 6. Deodar weevil larva, pupa and adult.

Wood-boring caterpillars (Lepidoptera)

These insects are the immature stages of several kinds of moths. Caterpillars can be easily identified by their “false legs” (prolegs) with tiny rows of

hooks on the undersides of some of the abdominal segments (Fig. 7). Adult moths are rarely seen except when reared from the host plants or collected in blacklight traps. Several kinds of moth larvae tunnel into woody ornamental plants:

Carpenterworms (*Prionoxystus robinae*) are large larvae that tunnel through the trunks of oak, elm, black locust, willow, ash, boxelder, poplar, cottonwood, Chinese tallow and fruit trees such as pear and cherry. These larvae develop over 2 or 3 years, initially feeding underneath the bark but later tunnelling into the heartwood. Outward signs of attack include piles of sawdust and excrement, particularly in cracks and crevices. Carpenterworms may enter and exit the trunk of the tree several times during their development. Several closely related species with similar life cycles also occur in Texas, but may develop in other host trees. Adult moths, which emerge in the spring, are rather large with spotted wings.

Peach tree borer (*Synanthedon exitiosa*) is one of the most important insect pests of peach and plum. Adult peach tree borer moths mate and lay their eggs on the trunks of peach and plum (*Prunus* species) trees during August and September. These daytime fliers are one of several species often called clear-wing moths, and they look superficially like wasps (Fig. 7). Larvae hatch from eggs in about 10 days and tunnel beneath the bark for 10 to 11 months before emerging from the base of the trunk. Infected trees exhibit dieback, yellowing of leaves, stunted growth and possible death if larvae girdle the trunk near the soil line (from 10 inches above the ground to 3 inches below the ground). After emerging, they drop to the soil to pupate at the base of the tree. Affected trees can be identified by masses of sap around damage sites at the base of the trunk. Infestations can kill scaffolding limbs or entire trees.

Other species of clearwing moths are: 1) the **lilac** or **ash borer** (*Podosesia syringae*), which has its adult flight period during the spring and early summer; 2) the **dogwood borer** (*Synanthedon scitula*); and 3) the **lesser peach tree borer** (*Synanthedon pictipes*).

Other caterpillar pests that occur in Texas include: the **southern pine coneworm** (*Dioryctria amatella*), which tunnels around the bases of Virginia pine trunks (Fig. 8); *Euzophera ostricolorella*, a **root collar borer** that infests potted magnolia; and the **American plum borer** (*Euzophera semifuneralis*), which invades damaged or improperly pruned branches on a wide variety of woody ornamentals.

Managing Wood-boring Insects

Prevention

Since most wood-boring insects are considered secondary invaders, the first line of defense against infestation is to keep plants healthy. Proper care of trees and shrubs discourages many borer pests and helps infested plants survive. Good sap flow from healthy, vigorously growing trees, for example, defends the plant from damage by many borer pests. Good horticultural practices include:

- Selecting well adapted species of trees and shrubs that are not commonly attacked by wood borers in your area. Arizona ash, birch, cottonwood, locust, soft maple, flowering stone fruits (such as peaches and plums), slash pines (in west Texas), willow and poplar are especially prone to borer attack.

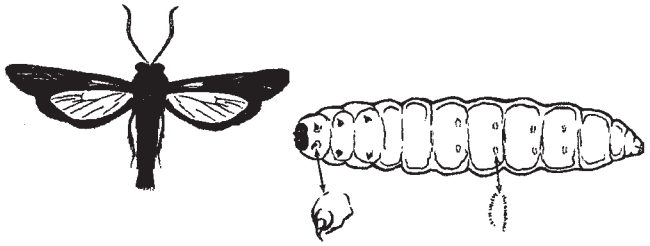

Figure 7. Clear-wing moth and underside of larva showing true legs (right) and false legs (prolegs) bearing tiny rows of hooks (crochets).

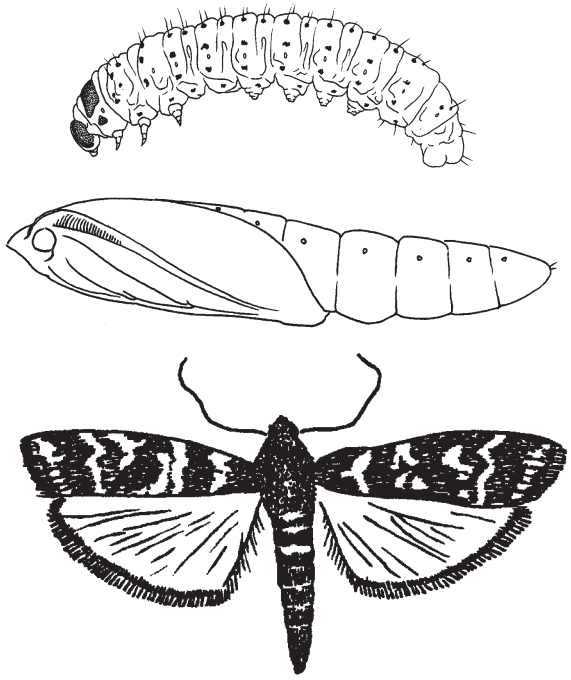

Figure 8. Southern pine coneworm larva (top), pupa (middle) and adult (bottom).

- Choosing and preparing a good planting site to avoid plant stress, freeze damage, sun scald and wind burn.
- Minimizing plant stress and stimulating growth by using proper watering and fertilization practices.
- Avoiding injury to tree trunks from lawn mowers, weed trimmers or construction.
- Promptly caring for wounded or broken plant parts using pruning or wound paint during all but the coldest months of the year.
- Properly thinning and pruning during colder months.
- Removing and destroying infested, dying or dead plants or plant parts, including fallen limbs.
- Wrapping tree trunks and limbs with quarter-inch hardware cloth spaced about 1½ inches from the tree's surface where woodpecker damage is likely.

Wrapping trunks to prevent borer attack is ineffective and may, under certain conditions, increase the rate of infestation. Using plastic trunk protectors to help prevent injury from lawn mowers and weed trimmers is a good idea.

Non-chemical control for infested plants

Once trees and shrubs are infested, non-chemical options for borer control are limited. One option is to remove and destroy heavily infested or injured plants. Also, inspect damage sites closely to determine if the larvae can be extracted from the plant with a pocket knife, wire or other suitable tool.

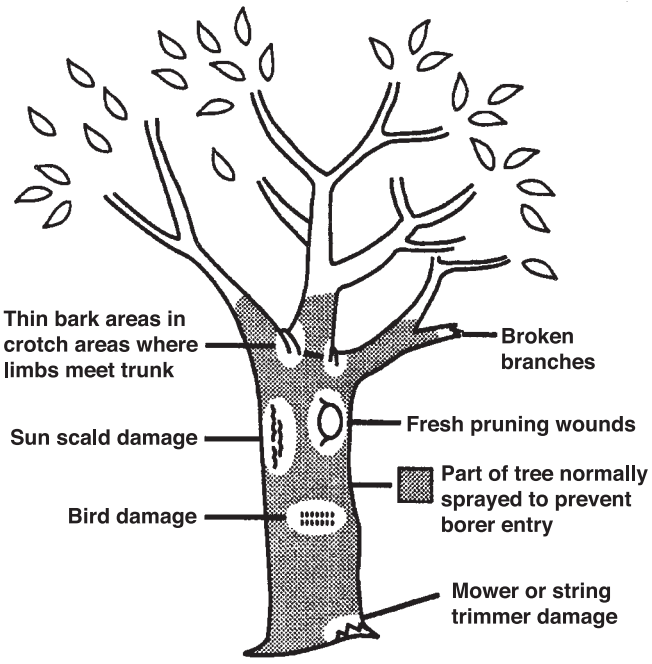

Figure 9. Sites where borers are most likely to enter a tree. The shaded areas are the most critical sites for treatment to prevent borer entry.

Chemical control

Because stressed, unhealthy trees are more susceptible to insect attack, maintaining overall tree health is vital in reducing the risk of wood-boring insect infestations and limiting the need for costly and environmentally damaging insecticides. Older trees and those damaged by drought or other environmental stress also will not benefit from control efforts.

Table 1 lists some insecticides registered by the Environmental Protection Agency (EPA) for wood-boring insect control on trees and shrubs. Some of these products are for professional or commercial use only and not available at retail outlets. In addition, the product labels specify where the product is to be used, such as nurseries or landscapes, and which pest or pest category it targets. Choose products according to the labeled restrictions. Do not use insecticides on fruit or nut trees unless specifically labeled for them. Some products sold mainly through specialty stores may require the purchaser to have a Texas Department of Agriculture pesticide applicator's license.

Application timing and method also may be specified on the label. Some products are preventive only; others are to be used during the target pest's adult flight periods. Bark sprays target egg-laying females or the adult stages emerging from the host plant. They also may kill small larvae. Bark sprays

Sapsucker damage appears as square holes in a tree trunk.

Table 1. Examples of current insecticides and products registered for "insect borers of trees and shrubs." See product labels or Appendix 1 for more specific listings of use sites, user descriptions and insect species or groups.

Insecticide class	Active ingredient	Trade name
Trunk sprays		
carbamate	carbaryl	Sevin® Brand 4F Carbaryl Insecticide GardenTech® Sevin® Ready To Use Bug Killer
organophosphate	chlorpyrifos	Dursban® 50W
pyrethroid	bifenthrin	OnyxPro™ Insecticide Talstar® P Professional Insecticide Ortho® Bug-B-Gone® MAX® Lawn & Garden Insect Killer Concentrate
pyrethroid	permethrin	Astro® Insecticide Bonide® Borer-Miner Killer Concentrate Bonide® Total Pest Control Concentrate Outdoor Formula
spinosyns	spinosad	Ferti·lome® Borer, Bagworm, Tent Caterpillar & Leafminer Spray
Soil drenches		
neonicotinoid	imidacloprid	Marathon® 60 WP Bayer Advanced™ 12 Month Tree & Shrub Insect Control Discus™ Nursery Insecticide
neonicotinoid	dinotefuran	Spectracide Tree & Shrub + Fertilizer Concentrate
Tree injection products		
organophosphate	acephate	Acecap® 97 Systemic Insecticide Tree Implants Acejet Systemic insecticide for Micro-Infusion™
organophosphate	dicrotophos	Inject-A-Cide B®
organophosphate	oxydemeton methyl	Mauget Inject-A-Cide®
neonicotinoid	imidacloprid	IMAjet Systemic Insecticide Mauget® Imicide Systemic Injecticide for tree injection use in ready to use capsules

generally use residual insecticides such as carbaryl or pyrethroid insecticides such as bifenthrin or permethrin. Only a few products are effective on larvae tunneling beneath the bark, such as that of the flatheaded borer beetles. These systemic products usually are applied as soil drenches so the insecticide can be absorbed by the roots or injected into the trunk; the insecticide imidacloprid is applied as either a soil drench or a trunk injection. Dinotefuran also may provide some control of wood-boring beetles.

Retail sale of diazinon, chlorpyrifos (Dursban®) and endosulfan (Thiodan®) products have been discontinued. Diazinon and lindane are no longer available for insect control and chlorpyrifos is available only for use in commercial nurseries. Products containing these ingredients may still be used according to label directions if you first contact the manufacturer to ascertain that usage is allowed. Otherwise they should be disposed of using directions provided by city, county or state pesticide authorities.

Only a few products for controlling wood-boring insects are available at retail stores. Occasionally these products' containers have labels that are taped to the container and cannot be read before purchase. The products' names may indicate target pests, such as Fertilome® Borer, Bagworm, Tent Caterpillar & Leafminer Spray, but the actual label has use directions for only the peach twig borer (a caterpillar of a clearwing moth species) on fruit trees. In other cases, lists of pests on products that are available only to commercial applicators are more extensive than those on products available to homeowners, such as those containing the pyrethroid insecticides, bifenthrin and permethrin.

Know pesticide regulations. Insecticide use is regulated by the Environmental Protection Agency's Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA:http://www.epa.gov/pesticides/regulating/fifra.pdf) and Texas Department of Agriculture.

- The law mandates that pesticides be used according to label directions with a few exemptions: An **user** can use an insecticide for pests **not listed** on the product label as long as the **use site** is listed. Section 2(ee) of FIFRA (page 13) allows for the use of any registered pesticide "against any target pest not specified on the labeling if the application is to the crop, animal, or site specified on the labeling..." Thus, if a particular insect borer is not listed on a product labeled for use on trees and shrubs but others are listed, or other products include mention of those pests, that product may be used to try to control the unlisted pest.
- Some products claiming insect control now being sold may not be registered by the EPA because of an exemption described in Section 25 (b) (on page 89 and on the Web site http://www.epa.gov/PR_Notices/pr2000-6.pdf). Only those pesticides registered by the EPA are listed in this publication.

Both of these sections are also discussed further at the Web site: http://www.epa.gov/pesticides/regulating/labels/label_review_faq.htm#pesticide.

Firewood

Adult wood borers sometimes emerge from firewood stored indoors. While most of these insects are not considered harmful, old house borer and powderpost beetles will attack seasoned, dry wood inside the home (see the Texas AgriLife Extension Service publication E-394, "Structure-Infesting Wood-Boring Beetles"). Treating firewood with insecticide is both ineffective and potentially dangerous to the homeowner. Wood should be stored outdoors away from the house until just before use. If firewood is infested with borers it can be treated by wrapping it in a tarp and allowing sunlight to heat it. Stacking wood layers in alternate directions will help it dry and reduce areas that can harbor insects. Firewood can spread exotic wood-borer species. Do not transport firewood to new areas, such as out-of-state camp grounds. Obtain campfire wood locally for use on such occasions.

Policy Statement for Making Chemical Control Suggestions

All pesticides are potentially hazardous to people and the environment. Pesticide users are legally required to read and carefully follow all directions and safety precautions on the container label. The user is always responsible for the effects of pesticide residues, as well as problems that could arise from drift or movement of the pesticide to neighboring areas. Label instructions are subject to change, so read the label carefully before buying or using any pesticide. Proper disposal of leftover pesticides and "empty" or used containers is an essential step in safe pesticide use. Never pour leftover pesticides down a drain.

Regardless of the information provided in an Extension publication, always follow the product's label. When in doubt about any instructions, contact the pesticide seller or the manufacturer listed on the label. Store all pesticides in their original, labeled containers and keep them out of the reach of children.

Suggested pesticides must be registered and labeled for use by the Environmental Protection Agency and the Texas Department of Agriculture. The status of pesticide label clearances is subject to change and may have changed since this publication was printed. County Extension agents and appropriate specialists are advised of changes as they occur.

References

(Available from the Texas AgriLife Extension Service)

L-1826, *Carpenter Bees*

E-412, *Carpenter Ants*

E-394, *Structure-Infesting Wood-Boring Beetles*

Table 1 lists generic or approved common names for insecticides. These ingredients may be found in a large number of products, whereas trade names are used by specific manufacturers or distributors of these insecticides. For convenience, examples of some of the most commonly available trade names for these generic ingredients are given on page 7.

Appendix

Summary of information obtained from product labels for treatment of wood-boring insects of trees and shrubs currently registered by the Environmental Protection Agency. Read and carefully follow directions provided on the actual product label.

Trunk sprays

Carbaryl, a carbamate insecticide

Sevin® Brand 4F Carbaryl Insecticide (43.0 percent carbaryl): **Caution**. For agricultural or commercial use only. In forested areas such as non-urban forests, tree plantations, Christmas tree farms, parks and rural shelter belts, and for rangeland trees, for treating cypress tip moth, locust borer, Nantucket pine tip moth, olive ash borer and pitch pine tip moth, apply 1 quart of product per acre; as a preventive treatment only, for elm bark and Ips engraver beetles apply as a trunk spray a 2 percent solution (5 fluid ounces per gallon) per acre no more than two times per year. On pecans for twig girdler, apply 2 to 5 quarts of product per acre. On peaches, plums, prunes and nectarines, apply 2 to 3 quarts of product per acre for lesser peachtree borer or peach twig borer. Observe bee caution. Repeat applications as necessary up to a total of three times per year per crop but not more often than once every 7 days. For lesser peachtree borer, thoroughly spray the limbs and tree trunks at weekly intervals during moth flight. Also see the product labels for rates of other formulations: **Sevin® Brand 80S, 80WSP and XLR Plus Carbaryl Insecticides**.

GardenTech® Sevin® Ready To Use Bug Killer (0.126 percent carbaryl): **Caution**. For trees including shade trees and those in shelter belts, plantations, parks and recreational areas, and for ornamentals including roses and wooded shrubs; for treating European pine shoot moth, locust borer, Nantucket pine tip moth, ash borer, pitch pine tip moth and subtropical pine tip moth. Where pests appear, direct the spray toward the upper and lower leaf surfaces and small trunks, stems and twigs to the point of runoff. Repeat as necessary up to a total of four times for trees and six times for ornamentals and shrubs but not more often than once every 7 days. On fruit trees including peaches and plum, for treating lesser peachtree borer and peach twig borer. Do not apply within 3 days of harvest.

Chlorpyrifos, an organophosphate insecticide

Dursban® 50W (50.0 percent chlorpyrifos): **Danger**. For use by certified applicators or people under their direct supervision; this product may be used only on ornamentals grown in nurseries and to treat evergreens, shade and flowering trees, and nonbearing fruit trees infested with:

- Weevils such as blackvine, cranberry, yellow poplar and pine reproduction weevils, use 1 pound per 100 gallons;
- Borers, including clearwing moths such as ash, dogwood, lesser peachtree, lilac, oak, peachtree, rhododendron borers; metallic wood borers such as bronze birch, flatheaded appletree and twolined chestnut borers; longhorned borer beetles such as cottonwood, locust, red oak borers, pales weevil adults and Zimmerman pine moth: Use 2 pounds per 100 gallons, spraying trunks and lower limbs of trees and shrubs when adults begin to emerge for borers, and for peachtree borers spraying flowering trees and shrubs on the genus *Prunus* as a trunk spray before newly hatched larvae enter trees and thoroughly wet all bark areas from ground level to scaffold limbs;
- Pales and northern pine weevils, use 6 pounds per 100 gallons applied as a cut stump spray or drench;
- Other beetles such as ambrosia, Anobiidae, black turpentine, European elm bark, mountain pine, native elm bark and southern pine beetles: Use 16 pounds per 100 gallons, to achieve a preventive treatment by spraying the main trunk of trees in the early spring or when the threat of attack exists from nearby infested trees or to achieve remedial treatments spraying the main trunk of infested trees or logs when damage occurs but before beetles begin to emerge;
- Weevils such as northern pine, pitch eating weevils: Use 32 pounds per 100 gallons for pine seedlings, treating immediately after transplanting to thoroughly wet the foliage and stems to the point of runoff, not using more than 6 gallons of spray dilution per acre.

Bifenthrin, a pyrethroid insecticide

OnyxPro™ Insecticide (23.4 percent bifenthrin): **Warning**. For commercial nonfood use in interiorscapes and on outdoor ornamentals, Christmas trees, nurseries, golf courses and other listed sites. Use as trunk sprays to ornamental trees including Christmas trees to control bark beetles and boring beetles, not applying more than 12.8 fluid ounces (0.2 pounds of active ingredient) of this product to trees per acre using spray volumes as directed on the product label and spraying until the bark is thoroughly wetted. Use specifically for:

- *Dendroctonus* bark beetles such as mountain pine beetle, southern pine beetle, and black turpentine beetle and engraver (Ips Species) beetles at 16.32 fluid ounces per 100 gallons, applying to the trunk of the tree with a

hydraulic sprayer in the early spring or before adult flight and tree infestation, applying the spray directly to the main trunk from the base of the tree to at least halfway into the live crown;

- Other bark beetles such as ambrosia beetles, elm bark beetles and metallic wood borers at 16.32 fluid ounces per 100 gallons, spraying mixture to the trunk, scaffolding and limbs of the tree with a hydraulic sprayer in the early spring or before beetle flight and tree infestation;
- Clearwing moth borers such as ash borer, banded ash clearwing, dogwood borer, lesser peachtree borer, lilac borer, oak borer, peachtree borer, rhododendron borer and coleopteran borers such as bronze birch borer and flatheaded appletree borer use 6.4 to 12.8 fluid ounces per 100 gallons, spraying the branches and trunks prior to adult emergence.

Talstar® P Professional Insecticide (7.9 percent bifenthrin): **Caution**. For use outdoors on residential, institutional, public, commercial and industrial buildings, greenhouses, lawns, ornamentals, parks, recreational areas and other listed sites. For ornamentals and trees including but not limited to trees and shrubs, greenhouses and interiorscapes, to control:

- Beetles including twig borers and weevils, use 10.8 to 21.7 fluid ounces per 100 gallons, treating trunks, stems and twigs in addition to plant foliage;
- Pine shoot beetle adults use 21.7 to 43.5 fluid ounces per 100 gallons.

Ortho® Bug-B-Gone® MAX® Lawn & Garden Insect Killer Concentrate (0.3 percent bifenthrin): **Caution**. For use on shrubs and small, nonbearing trees for northern pine weevil, pine shoot weevil and Zimmerman pine moth, and on fruit trees for peachtree borer and lesser peachtree borer.

Permethrin, a pyrethroid insecticide

Astro® Insecticide (36.8 percent permethrin): **Caution**. For use on ornamental trees and shrubs around buildings, parks, recreational areas and other listed sites, such as ornamental greenhouse, interiorscapes and plantscapes, lawns, trees and shrubs. On ornamental trees, for:

- Clearwing moth borers such as banded ash clearwing, dogwood borer, lesser peachtree borer, lilac borer, oak borer, peachtree borer and rhododendron borer: Use 1 to 2 quarts per gallon;
- Bark beetles such as *Dendroctonus* sp., Ips species, elm bark beetles, mountain pine beetle, pine engravers, turpentine beetles and white pine beetle: Use 2 to 5 quarts per gallon;
- Coleopteran borers such as bronze birch borer and flatheaded appletree borer: Use 2 to 5 quarts per 100 gallons;
- Maximum residual control of all the insects listed above, use 5.35 quarts per 100 gallons. Apply to the lower branches and trunks prior to adult emergence, which varies according to pest species, host tree, environmental conditions and geographical location. Thorough coverage of bark is required for control;
- Nantucket pine tip moth, coneworms and seedbugs, use 4 to 8 fluid ounces per 100 gallons. Use 5 to 10 gallons of finished spray per tree for coneworms and seedbugs. Begin application when the adults appear. Repeat applications may be made on 5- to 7-day intervals as needed;
- On noncommercially grown peach trees, for lesser peachtree borer and peach twig borer use ¼ to ¾ teaspoon per gallon for 436 square feet. Do not harvest fruit within 14 days after application. Do not apply more than 3¾ teaspoon per 436 square feet per year.

Bonide® Borer-Miner Killer Concentrate (2.50 percent permethrin): **Caution**. Protects fruits, nuts, trees, shrubs, roses, flowers and vegetables from borers, leafminers and other listed insects.

- For pine beetles use 1 fluid ounce in 1 gallon water applied as a thorough spray, wetting the leaves and branches to dripping point. Spray in late afternoon or evening, when temperature ranges from 50 to 75 degrees F and when there is little or no wind. Spray at the first sign of insects. Repeat as necessary; use at intervals or 4 to 8 days. Do not exceed 16 applications per season.
- For peach tree borers (lesser peachtree, peach twig) apply 2 fluid ounces in 1 gallon water when insects appear. Wet the plants to dripping point. Do not apply within 7 days of harvest. Do not make more than eight applications per year.

Bonide® Total Pest Control Concentrate Outdoor Formula (13.30 percent permethrin): **Warning**. For ornamental trees around the home, use sufficient spray to obtain full coverage of all foliage. Avoid heavy wetting. Use to control pine moths and pine beetles. On peaches to control lesser peachtree borer and peach twig borer: Use 2¾ teaspoons per 5 quarts water. Apply when insects appear. Do not apply within 7 days of harvest. Do not make more than eight applications per season.

Spinosad, a spinosyns insecticide

Ferti·lome® Borer, Bagworm, Tent Caterpillar & Leafminer Spray (0.5 percent spinosad): C**aution**. For use on fruiting, tuberous and leafy vegetables, stone fruits, apple and citrus trees, ornamentals and

lawns: Use 2.0 fluid ounces per gallon for peach twig borer (a caterpillar of a clearwing moth species) on fruit trees only.

Soil drenches

Dinotefuran, a neonicotinoid insecticide

Spectracide® Tree and Shrub Insect Control + Fertilizer Concentrate (0.43 percent dinotefuran): **Caution**. Available to homeowners through retail outlets for roundheaded borers apply 3 fluid ounces per inch of tree circumference or 9 fluid ounces per foot of shrub height. Note: For professional use, see label for **Safari®**.

Imidacloprid, a neonicotinoid insecticide

Marathon® 60 WP (60 percent imidacloprid): **Caution**. For systemic control on ornamentals in greenhouses, nurseries and interior plantscapes as a soil injection for flatheaded borers including bronze birch and alder borers to trees at a rate of 20 grams per 8 to 16 inches of cumulative trunk diameter or to shrubs at a rate of 20 grams per 8 to 16 feet of cumulative shrub height applied as a soil injection or soil drench as directed on the product label. Also **Marathon® II** (21.4 percent imidacloprid), using different rate.

Bayer Advanced™ 12 Month Tree & Shrub Insect Control (1.47 percent imidacloprid): **Caution**. For flatheaded borers including bronze birch and alder borers apply to the soil as a drench to trees at 1 ounce per inch of distance around the trunk and to shrubs at 3 ounces per foot of height.

Discus™ Nursery Insecticide (0.70 percent cyfluthrin plus 2.94 percent imidacloprid): **Caution**. For ornamentals, nonbearing fruit and nut trees, and in field and container nurseries. Use as a drench and soil injection application for shrubs, evergreens and trees including nonbearing fruit and nut trees.

For flathead borers including bronze birch and alder borers, use 3.4 to 5.6 fluid ounces per 1,000 square feet. Use at the high rate for borer control and with high populations. Application to heavily infested trees may not prevent the eventual loss of the trees because of existing pest damage and tree stress. Note: Cypermethrin is a pyrethroid contact insecticide and will not move into the tree systemically.

Tree injection products

Acephate

Acecap® 97 Systemic Insecticide Tree Implants (97 percent acephate): **Caution**. For ornamental trees with a trunk diameter of 3 inches or larger for treatment of borers. For small trees and shrubs with trunk diameters of 1.5 to 3 inches see the label for **Mini Acecap 97**.

Acejet Systemic insecticide for Micro-Infusion™ (97.4 percent acephate): **Caution**. Micro-Injectable and Micro-Infusable Insecticide for use with the Arborjet Injection Systems to manage of specific insect pests of trees and landscape ornamentals, including conifers, Christmas tree and deciduous tree farms, seed orchards and plantations, and forest trees, shrubs, evergreens and conifers, and trees in Christmas tree plantations and palms in forest areas including nonurban forests, tree plantations, seed orchards, parks, rural shelter belts, rangeland and woodlands including conifers. For treatment of carpenterworm, clearwing borers, cottonwood twig borer, Nantucket pine tip moth, pine coneworm, pine tip moth, buprestid borers including bronze birch borer, flatheaded borers, longhorned borers including red oak borer, and root weevil adults including black vine weevil. Do not treat trees that are moisture stressed or suffering from herbicide damage. Do not inject trees within 2 weeks of any other spray or soil chemical treatment.

Dicrotophos

Inject-A-Cide B® (82 percent dicrotophos): **Danger**. Contains **Bidrin®**, for internal treatment by microinjection for systemic suppression of certain insects on ornamental trees. Not for use on trees for sale or other commercial use, for commercial seed production, for the production of timber or wood products, or for research purposes. For dogwood twig borer and sycamore borer (American plum borer) on oaks and sycamore, and for lesser peachtree borer on flowering stone fruit (noncrop).

Oxydemeton methyl

Mauget Inject-A-Cide® (50 percent oxydemeton methyl): **Danger**. Internal treatment by microinjection for systemic suppression of certain insects on ornamental trees. Treatment limited by tree species to treatment of bark beetles on cedar, cypress, juniper and pine; engraver beetles; red and black turpentine beetles; and Nantucket pine tip moth on Douglas fir and pine.

Imidacloprid

IMAjet Systemic Insecticide (5.0 percent imidacloprid): **Warning**. Microinjectable systemic insecticide for use with Arbojet Injection System in the management of specific insect pests of forests, trees, landscape ornamentals, palms and interior plantscapes (trees, shrubs and evergreens), palms in forest areas including nonurban forests, tree plantations, Christmas tree farms, parks, rural shelter belts, rangelands and woodlands including those with conifers. For treatment of buprestid borers including bronze birch borer, flatheaded borers, longhorned borers and pine tip moth larvae.

Mauget® Imicide Systemic Injecticide for tree injection use in ready to use capsules (10.0 percent imidacloprid): **Caution**. Injection into trees more than 2 inches in diameter that will not produce food within a year after treatment: Use as directed for black vine weevil larvae, bronze birch borer, cottonwood longhorned borer, flatheaded borers including alder and birch borer, pine tip moth larvae and other listed pests. **Also see Mauget Imicide Hp** for use in loadable injectors.

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