Magnolia - *Magnolia* spp.

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SECTION 1

Introduction

MAGNOLIA BASICS

This chapter is adapted from a review article submitted for publication in the *Journal of Environmental Horticulture* in 2012, entitled "Management of Pests, Plant Diseases and Abiotic Disorders of Magnolia Species in the Southeastern U.S.: A Review" by Gary W. Knox, William E. Klingeman, Mathews L. Paret and Amy F. Fulcher.

The **genus*** *Magnolia* encompasses a group of about 240 species of trees and large shrubs. They are native to southeastern Asia, eastern North America, Central America, the Caribbean, and parts of South America. Magnolias grow in both temperate and tropical climates and may be both evergreen and deciduous. These plants characteristically have showy, fragrant flowers that are white, pink, red, purple, or yellow. The flowers are followed by showy red or pink fruits displaying red, orange, or pink seeds, each of which hangs from the fruit by a thread-like strand.

Magnolia is one of two genera currently recognized in the Magnoliaceae family. Molecular systematics and re-examination of morphological characteristics resulted in all genera other than *Liriodendron* (i.e., *Michelia* and *Manglietia*) being combined into *Magnolia* (Figlar and Nooteboom, 2004). The Magnoliaceae family has an ancient taxonomic origin with fossil remains dating between 36 and 58 million years ago. Surviving magnolia species represent some of the more primitive flowering plants. Magnolia flowers do not have true petals and sepals but are composed of petal-like **tepals**. Flowers do not produce true nectar but attract pollinating beetles with fragrant, sugary secretions. Beetles of the Nitidulidae family are the primary pollinators of magnolia flowers, in part because magnolias evolved long before bees and other flying pollinators.

Magnolia species are found in a wide range of soils and climates, but they are most often associated with moist soils in mixed deciduous-coniferous or evergreen woodlands. In cultivation, most magnolias grow best in moist, well-drained, slightly acidic soils in locations receiving full sun to light shade. Plants grown in warm or dry climates benefit from planting locations shaded from afternoon sun, although magnolias can tolerate full sun and heavier soils.

Magnolias have been harvested for timber and medicinal uses but are usually cultivated for their beautiful flowers, fruits, foliage, and plant forms. Asian cultures have long cultivated several *Magnolia* species for their flowers. First introduced to Europe and America in 1780, various Asian species were recognized for their free flowering character and

**For definitions of bold terms, see the digital version of this book at the SNIPM website* http://wiki.bugwood.org/SNIPM.

became immensely popular. Intensive breeding programs began hybridizing magnolias to develop more floriferous and **hardy** forms with a wider range of flower colors. The hybrids and selections produced by these breeding programs, still ongoing, have resulted in many superior ornamental trees. Many people consider magnolias to be some of the most popular flowering trees in the United States. Most widely grown, deciduous magnolias were selected from the early spring-blooming *M. denudata*, *M. liliiflora*, *Magnolia stellata*, and their hybrids (Callaway, 1994).

Other magnolias are grown for their value as shade trees. The American tree, southern magnolia, *M. grandiflora*, was introduced to Europe in 1731. This tree quickly became popular because of its glossy evergreen foliage, large beautiful flowers, and elegant form. *Magnolia grandiflora* was also found to be widely adaptable to different climates, soils, and exposures. Thus, it was the first magnolia to be planted widely as a street or shade tree and is now grown nearly worldwide wherever suitable climate and soils exist.

Several *Magnolia* species are widely produced by commercial nurseries in the southern United States (Table 9.1), and total sales of these flowering deciduous species in 2007 were $18,287,000 (USDA, 2009). *Magnolia grandiflora* is the most widely grown magnolia because its cultivars are heavily favored for landscape use. Other species produced by many growers are *M. virginiana* and *M. stellata* cultivars and hybrids. Small numbers of nurseries produce *M. × soulangeana* and cultivars derived from complex hybrids of these and other deciduous species (i.e., *Magnolia* 'Jon Jon') and *Magnolia figo* (= *Michelia figo*). New yellow-flowered hybrids derived from *M. acuminata* are becoming popular but are not commonly grown. Less widely known natives such as *M. ashei*, *M. macrophylla*, and *M. tripetala* are rarely produced. Of the more recently introduced Asian species such as *M. laevifolia (=Magnolia dianica=Michelia yunnanensis)*, *M. insignis* (=*Manglietia insignis*), and *M. maudiae* (=*Michelia maudiae*), only the latter is currently produced. Table 9.2 lists the characteristics of magnolia species and cultivars widely grown by nurseries in the southeastern United States.

Production

Magnolias may be produced in the field, in containers, by modified field production, or by any combination of these methods in the southeastern United States (Knox, 2012). Commercial production of magnolias may start with seeds, particularly for species that root poorly, for production of **native species**, or as **rootstock** for grafting or **budding**. The nursery and landscape industries currently emphasize production and use of cultivars; thus, most magnolias are propagated by cuttings that are rooted to produce a liner (young transplant). In the southern United States, **budding** and grafting are only used with cultivars of certain genera that are difficult to root, such as *M. acuminata* hybrids.

Host Plant Resistance

Most magnolias are considered to be "trouble-free" with few pests and diseases (Dirr, 1998). Phytochemicals in *Magnolia* species show a wide range of biological activity. Phenolics and neolignans are among the magnolia compounds with antimicrobial, **nematicidal**, and insecticidal properties (Kamikado et al., 1975; Li et al., 2009; Nitao et al., 1991). Other magnolia compounds act as attractants of natural enemies (Azuma et al., 1997).

Studies comparing host plant resistance among *Magnolia* species are rare, but Held (2004) found *M. grandiflora*, *M. ×soulangeana,* and *M. virginiana* were resistant to Japanese beetle (*Popillia japonica*), as are *Magnolia* species in general (Klingeman, personal communication). Studies with the major pest, *Neolecanium cornuparvum* (Magnolia scale), found *M. acuminata* and *M. stellata* 'Merrill' and 'Royal Star' were highly susceptible while *M. grandiflora* 'Little Gem' and *M. virginiana* were resistant (Vanek and Potter, 2009).

Many other studies included one or two *Magnolia* species in host plant resistance research but collectively also provide evidence for the relative pest resistance of this **genus**. Santamour and Reidel (1993) inoculated seedlings of 23 tree taxa with four common root knot nematode species (*Meloidogyne arenaria* races 1 and 2, *Meloidogyne hapla*, *Meloidogyne incognita,* and *Meloidogyne javanica*) and found *M. grandiflora* was resistant to all four nematode species. In greenhouse tests with 35 taxa, Bernard and Witte (1987) found *M. ×soulangeana* 'Alexandrina' would not host *Meloidogyne hapla*, the primary root knot nematode of woody ornamentals in Tennessee.

Similarly, *M. ×soulangeana* exhibited host plant resistance to *Lymantria dispar* (gypsy moth) by losing less than 4% of its foliage in a study of gypsy moth feeding and defoliation of 21 shade and flowering trees (Peterson and Smitley, 1991). In choice test feeding preference studies with eight woody taxa, *M. grandiflora* was not consumed by adult *Phyllophaga ephilida* (June bug; Coleoptera: Scarabaeidae; Diagne et al., 2006).

Table 9.3 lists insecticides and **IRAC** codes used within a pesticide rotation plan to achieve selected insect control against **key pests** of ornamental plants, including magnolias.

SECTION 2

Abiotic & Wildlife Stressors

Winter burn

Winter Burn: Winter burn or scorch (see Abiotic & Wildlife Stressors section introductory image) is a common problem of evergreen and semi-evergreen magnolias grown in the upper South. Winter burn is characterized by desiccated leaf margins, often most extreme on the side exposed to wind or greater sun exposure (Relf and Appleton, 2009). Magnolias that are evergreen or semi-evergreen continue losing moisture through their leaves year-round. Magnolias are especially vulnerable to winter burn on warm, sunny days when the ground is frozen and plants cannot take up water to replace that which is lost through transpiration. Container **liners** are more likely to suffer from scorch than bareroot **liners**.

In areas of the upper South where winter burn is a problem, a few simple practices should help reduce the incidence and/or severity of winter burn. Broad-leaved evergreens should be lined out earlier in the fall than their deciduous counterparts (Adkins et al., 2010). This allows roots to become more established prior to the onset of freezing conditions and drying winds. Allowing the root system to establish before harsh weather will help ensure that the plant is optimally hydrated until the soils freeze. As with all container **liners**, evergreen and semi-evergreen magnolias should be well watered prior to lining out in the field. Anti-desiccants have not been found to consistently benefit plants during transplanting or lining out (Relf and Appleton, 2009). Growers should plan for regular irrigation in the fall to increase the availability of water to the newly planted **liners**.

Cold Damage: *Magnolia stellata* and *M. ×soulangeana* are early bloomers, and in the upper South, flower buds are commonly killed by freezing temperatures. These magnolias, *M. stellata* in particular, have a low chill requirement, and therefore flower buds open very early in the late winter/early spring, often just after a brief warm spell between freezing temperatures. Flower petals die and turn brown due to the freeze damage. Flowers of *M. stellata* and its hybrids are more resistant to freeze damage than those of *M. ×soulangeana*. This is purely an aesthetic problem, as the overall health of the plant is not affected.

Excess nitrogen fertilizer or warm temperatures late into the fall season can cause plants to remain actively growing too late in the season, and as a result, the basal portion of the trunk does not sufficiently harden before cold weather (Hartman et al., 2000). Magnolias are thin-barked trees and are thus considered prone to **bark cracking**. **Bark cracking** can be an indication of this type of cold damage. Yellow-flowered magnolias can be particularly susceptible to bark cracks at the base of the trunk (Figure 9.1). Cracked bark usually becomes evident in the spring but may occur due to freezing conditions in the late fall to early spring. Avoid **bark cracking** by halting **fertigation** at the appropriate time, e.g., September 15 in Middle Tennessee. Also summer top-dressing should use a fertilizer that will not continue releasing nitrogen too late in the season. Most controlled-release fertilizers release less nitrogen during colder temperatures. Reducing irrigation frequency and volume towards the end of the growing season can also help plants to stop growing and prepare for cold temperatures.

Bark cracking on magnolia also occurs due to **frost cracking** and **sunscald**, which have many similarities (Franklin and Clatterbuck, 2004). **Frost cracking** and **sunscald** both cause vertical cracks through the bark to the wood. Both often happen on the south or southwest side of a tree since this is where the greatest winter temperature fluctuations occur. The temperature of bark receiving direct sun exposure is often 68 °F greater than ambient temperatures during the winter (Sinclair and Lyon, 2005); snow exacerbates the temperature increase. **Frost cracking** and **sunscald** are linked to root injury, aboveground wounds, and pruning cuts. Inadequate hydration is linked to **sunscald** but not frost cracks (Harris et al., 2004; Hartman et al., 2000).

Frost cracking occurs when water in the wood expands and contracts as a result of dramatic temperature fluctuations such as those occurring on warm, sunny winter days with periods of dense clouds or nightfall (Franklin and Clatterbuck, 2004). Frost cracks are a physical separation of the wood. Frost cracks often close and heal, but these trees are not marketable. **Sunscald** occurs when the same dramatic temperature changes damage or kill the **cambium** and bark. Often **sunscald** will not be detectable until spring growth resumes (Harris et al., 2004). At this point, the damage appears as sunken or discolored bark. The bark may then split. If the tree is healthy enough to resume growth, a callus roll will develop around the wound as the season progresses. Wrapping the trunks of young trees with a commercial **tree wrap** made of insulating paper in November can prevent **sunscald** by mitigating temperature fluctuations. Trunk wraps must be removed by early spring. Some basal bark cracks have been observed in conjunction with large pruning cuts near the location of the crack. [Note: refer to the maple chapter for the section on **bark cracking** due to herbicide application.]

Flooding Damage: Flooding damage can occur on evergreen and semi-evergreen magnolias that are grown in **bottomlands**. Flooding fills the macrospores in the soil with water, displacing oxygen-containing air. Root cells need oxygen to respire and to take up water. Hence, drought-like or winter burn symptoms (desiccation symptoms) typically appear in response to flooding and include marginal leaf **necrosis** and partial or complete defoliation. *Magnolia virginiana* is tolerant of saturated soil.

Sapsucker Damage: Sapsuckers are a type of woodpecker. **Sapsuckers** peck at trees and feed on sap, bark, and small insects that are attracted to the sap (Vann and

Robbins, 2008). Sapsucker damage is more common on larger trees in the landscape than in nurseries, but some large-caliper nursery growers may experience problems with **sapsuckers**. Sapsucker damage can be distinguished from trunk-boring insect damage by the many uniform rows of sapsucker holes forming rings around the trunk and large branches (Figure 9.2), whereas borer damage occurs more randomly. Sapsucker damage is often extensive, creates entry points for disease-causing organisms and boring insects, and generally weakens the plants, making plants more susceptible to other types of stresses.

Insect Pest Management

Magnolia serpentine leaf miner damage

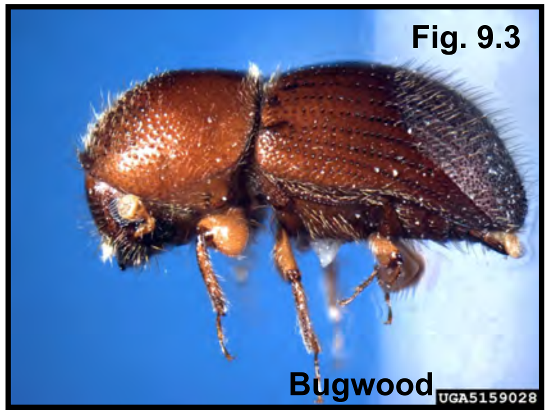
INSECT PESTS

1. Magnolia Serpentine Leaf Miner
2. Ambrosia Beetles
3. Scale Insects: Cottony Cushion, Calico, Magnolia, Tuliptree, False Oleander, and Japanese Maple
4. Yellow Poplar Weevil
5. Leaf-Footed Bugs
6. Magnolia Root Borer
7. Thrips
8. Cranberry Rootworm

Magnolia Serpentine Leaf Miner (*Phyllocnistis magnoliella*): *Phyllocnistis magnoliella* (Lepidoptera: Gracillariidae) is widespread throughout the eastern United States, and **larvae** feed within leaves of both sweetbay (*M. virginiana)* and southern magnolias (*M. grandiflora*) (Drooz, 1985). After hatching, **larvae** make 3 to 4 tight spirals before next feeding across the leaf in a winding, serpentine pattern that ends near the edge of the leaf (see Insect Pest Management section introductory image). Pupation occurs within the mine and primarily, but not limited to, leaf edges. **Pupae** may be the overwintering state of this caterpillar pest (Dozier, 1920). Affected leaf tissues become necrotic, scorched-looking, and curled. **Larvae** are active and mines are apparent on *M. virginiana* by early July in Maryland and North Carolina (Baker and Bambara, 1999; Gill, 2010). Adult moths, which are darkly colored and nondescript, are active in late July in Florida (Dozier, 1920; Moon and Stiling, 2004), where at least two overlapping generations per year have been reported (Moon and Stiling, 2004).

Management: Limited work has been done to assess pesticide efficacy against *P. magnoliella* on magnolias. Foliar applications of acephate or imidacloprid may be effective (Table 9.3; Gill, 2010; Smith, 2010). Broad spectrum pesticides may limit natural enemies in the nursery and landscape. Parasitic wasps *Zagrammosoma multilinieatum* and *Synpiesis* spp. have been reared from parasitized **pupae** collected in Gainesville, FL (Dozier, 1920).

Ambrosia Beetles [including Granulate -formerly Asian- Ambrosia Beetle *(Xylosandrus crassiusculus*), Black Stem Borer *(Xylosandrus germanus*), and Black Twig Beetle (*Xylosandrus compactus*)]: Exotic ambrosia beetles, primarily *Xylosandrus crassiusculus* and *Xylosandrus germanus* (Coleoptera: Curculionidae), attack over 100 tree species and are among the most damaging pests of nursery-grown trees and some shrubs (Hoffman, 1941; Oliver and Mannion, 2001; Cole 2008; Adkins et al., 2010; Atkinson et al., 2011). They are noted as an occasional pest for magnolia (Knox, personal observation). Female beetles are 0.08-0.12 inches in length, with males being much smaller. Both genders range in color from reddish-brown to black depending on species (Wood, 1982; Atkinson et al., 2011). Ambrosia beetles become active in early spring (Oliver and Mannion, 2001). Ambrosia beetles bore into host tree trunks and excavate galleries in the heartwood where adult females deposit eggs, and **larvae** develop (Hoffman, 1941; Weber and McPherson, 1983). Female ambrosia beetles inoculate trees with symbiotic ambrosia fungus on which the **larvae** feed (Baker and Norris, 1968; Atkinson et al., 2011). After approximately 60 days, **mature** female beetles mate with males and emerge from the galleries to find new hosts. Although *X. crassiusculus* and *X. germanus* are capable of producing three generations per year in the southern United States, plant injury is primarily inflicted by the first generation for reasons that are not understood.



Xylosandrus crassiusculus (Figure 9.3) and *X. germanus* (Figure 9.4) typically attack small **caliper** (< 3.5 inch diameter) tree trunks and branches (Dixon et al., 2005). *Xylosandrus germanus* ranges from central Georgia (and possibly north Florida) north to Connecticut (Dixon et al., 2005). Attacks by these borer beetles occur most heavily within 39 inches of the base of the trunk and are rare on smaller diameter branches above the first scaffold branches (Oliver and Mannion, 2001). Damage is characterized by 'frass tooth picks' that are pushed out of holes as beetles excavate their galleries. The diagnostic value of these is short-lived as they are easily dislodged by wind, rain, and irrigation exposing a 0.04 inch round entry hole. Infested plants die or become unmarketable from boring damage or infection by a secondary pathogen (Buchanan, 1941).

Xylosandrus compactus (Figure 9.5) is an occasional pest of magnolias and more than 200 other plant species, including red maples, flowering dogwood, and redbuds that serve as common hosts, as well as many other ornamental plants (Dixon et al., 2005). Injury may be inflicted on otherwise healthy plants, particularly in twigs less than 0.8 inch diameter, and can limit plant growth and affect aesthetic losses (Dixon et al., 2005). Cankers may be observed on larger twigs and branches that extend 0.4-8.3 inches away from the 0.03 inch entry holes that indicate the point of attack (Dixon et al., 2005). Populations of these beetles may be encountered in the southeastern United States along the **Coastal Plain** from Florida to North Carolina and west to Texas (Wood, 1982; Dixon et al., 2005). Adult male and female *X. compactus* are generally smaller than *X. crassiusculus* and *X. germanus* and are dark brown to black (Dixon et al., 2005). Within excavated twig galleries, females establish brood galleries either individually (typically in twigs smaller than 0.3 inch diameter) or in groups of up to 20 females (in twigs and branches ranging between 0.3-0.9 inches). Development from egg stage to adulthood takes about 28 days at 77 ^{o}F (Dixon et al., 2005). Adults overwinter within damaged twigs (Wood, 1982) and like *X. crassiusculus*, emerge during the first warm days in spring with highest population levels found between June and September (Dixon et al., 2005).

Management: Effective ambrosia beetle management begins with monitoring adult flight with ethanol-baited traps, which can be made easily by growers (Ranger et al., 2011). Optimal trap height to capture first adult flight of *X. germanus* and *X. crassiusculus* appears to be 20 inches and < 67 inches, respectively (Reding et al., 2010). To limit *X. compactus* populations, prune and destroy infested twigs and branches from affected host plants (Dixon et al., 2005). When adult beetles are captured, growers can protect their trees by spraying susceptible tree trunks with **pyrethroids**, such as permethrin or bifenthrin, every three weeks to prevent beetles from boring into the tree. It is recommended that growers avoid spraying tree canopies because this wastes insecticide, negatively affects natural enemies, and results in secondary pest outbreaks (Frank and Sadof, 2011). Once beetles are inside trees, there is no effective control for either beetle **larvae** or the associated fungus, and infested trees should be removed and destroyed (Atkinson et al., 2011).

Cottony Cushion Scale (*Icerya purchasi*): In the United States, cottony cushion scales (Homoptera: Margarodidae) are found in the western states, as well as along the Gulf Coast and eastern states as far north as North Carolina (Johnson and Lyon, 1988). Winter temperatures of about 10 °F may limit spread of cottony cushion scales in landscapes and nurseries. Scales can persist season-long if protected in propagation structures and greenhouses (Baker and Frank, 2010). Immature cottony cushion scales reduce vigor of host plants, including boxwood, cypress, hackberry, *Magnolia* spp., *Malus* spp., maples, nandina, oak, pecan, *Pittosporum* spp., *Prunus* spp., *Pyrus* spp., quince, rose, salvia, and willow, by piercing plant tissues and sucking out sap (Johnson and Lyon, 1988; Baker and Frank, 2010). Heavily infested plants become chlorotic and often become darkened by excreted **honeydew** and resultant **sooty mold**. Leaves and fruit on heavily infested plants may drop prematurely following environmental or other stressors.

Cottony cushion scales are often obscured by exuded wax that helps to protect them from predation and direct pesticide contact (Figure 9.6). Beneath the wax, adult females are about 0.2 inches long and rusty red with black legs and antennae. Male cottony cushion scales are about 0.1 inches long and slender. Adult male scales are uncommon and when present, are reddish-purple insects that have metallic blue wings (Baker and Frank, 2010). Cottony cushion scales have about two generations per year in their northern range with three and more generations possible in southern U.S. landscapes.

Female cottony cushion scales can be diagnosed by the presence of 3/8-inch-long ridged egg sacs formed from waxes extruded from the underside of the female body. The ovisac contains hundreds of reddish oval eggs that may hatch to **crawlers** within three weeks (in summer) to eight weeks (in winter) of being laid. All three nymphal instars are mobile as **crawlers**, seeking leaves and twigs to feed on, and upon hatching, can travel up to 36 inches in 10 minutes (Baker and Frank, 2010). Adult female scales may live 2 to 3 months and may not need to feed after beginning to lay eggs. They are capable of producing **ovisacs** and laying eggs after moving away from the host plant.

Management: Cottony cushion scales have relatively few known predators and parasites. Vedalia beetles (*Rodolia cardinalis*) effectively control cottony cushion scales when temperatures are warm but are susceptible to insecticides and may become non-target casualties following pesticide applications (Baker and Frank, 2010). A parasitic fly from Australia, *Cryptochaetum iceryae*, has been introduced to control cottony cushion scale. Whether the fly has successfully become established or is effective at controlling *I. purchasi* in mid-southern states has not been determined (Baker and Frank, 2010).

Dinotefuran is specifically labeled for cottony cushion scale control, and other insecticides are labeled to provide control of scales and scale **crawlers**. Use of spreader-stickers, including summer horticultural oil that can be used at 2 quarts/100 gallons (4 tsp/gal), is recommended to improve cottony cushion scale control by helping pesticides penetrate the waxy ovisac and scale covering. Horticultural oils themselves are moderately toxic to scales and may also help disperse **sooty mold** (Baker and Frank, 2010).

Calico Scale (*Eulecanium cerasorum*): Calico scale adults and **nymphs** (Homoptera: Coccidae) are readily visible on branches and leaves, giving trees a bumpy appearance under heavy infestation (Johnson and Lyon, 1988). Adults are rounded and globular, about 0.25-0.3 inches long, and at maturity, are checkered in a white and dark brown "calico" pattern (Figure 9.7). **Nymphs** are small, cream colored ovals. In addition to magnolias, including *M. stellata*, calico scales infest buckeye, dogwood, elm, flowering crabapple, hackberry, honeylocust, maples, pears, *Pyracantha* spp., redbud, sweetgum, Virginia creeper, walnut, *Wisteria* spp., yellowwood, and *Zelkova* spp. (Hubbard and Potter, 2005, 2006; Krischik and Davidson, 2007). Scale feeding on phloem sap results in excreted **honeydew** that accumulates beneath infested trees. Calico scale feeding, as well as the **sooty mold** that grows on **honeydew**, results in reduced tree vigor, premature leaf **abscission**, and branch dieback, all of which predispose infested trees to increased environmental stress (Hubbard and Potter, 2006; Krischik and Davidson, 2007).


Fig. 9.7

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Calico scales have one generation per year. **Juveniles** overwinter as second instar **nymphs** on bark. Females can generate up to 4,600 eggs each that remain protected beneath the female body until **crawlers** emerge. Egg laying begins approximately in late April in Kentucky, and eggs hatch almost synchronously about mid May, following ~818 degree day accumulation (at base about 40 °F; Hubbard and Potter, 2005). **Crawlers** disperse during the next 2 to 3 weeks to feed on leaf undersides. After feeding from late September to mid-October (Kentucky), **nymphs** migrate back to bark to overwinter (Hubbard and Potter, 2005).

Management: Twigs and branches can be inspected for **nymphs** and adults in spring, before leaf emergence, and whenever **honeydew** and **sooty mold** are detected. When foliage is present, inspect the main leaf veins using double-sided tape wrapped around a twig to monitor tiny cream-colored **crawler** emergence (Hubbard and Potter, 2006; Krischik and Davidson, 2007). Prune and destroy any lightly infested branches. Heavy infestations may require chemical foliar sprays, soil drenches, and granular **systemic** insecticide treatments. Contact insecticides may kill **beneficial insects** and should be timed for application to coincide with **crawler** emergence. Predators and other **biological control** organisms, including green lacewing adults and **larvae**, may be enhanced by using sticky bands to limit ant access to magnolia scales in landscape plants (Vanek and Potter, 2010). Avoid broad-spectrum insecticides when natural enemies are present and direct sprays toward stems, branches, and leaf undersides. **Biological control** agents, including many different predators and parasitoid species, may suppress calico scales. Curative efficacy by **biological controls** in landscapes and nurseries, however, has not been sufficiently tested (Hubbard and Potter, 2006; Krischik and Davidson, 2007).

Magnolia Scale (*Neolecanium cornuparvum*): Magnolia scale, *Neolecanium cornuparvum* (Homoptera: Coccidae), is a pest native to the United States that, at about 0.3-0.4 inches (up to 0.5 inches) long, is one of the largest scale insects encountered in U.S. landscapes and nurseries (Herrick, 1931; Vanek and Potter, 2010). *Magnolia stellata*, *M. acuminata*, *M. liliiflora*, *M. ×soulangeana*, and *M. grandiflora* are the preferred host plants of this pest (Herrick, 1931; Johnson and Lyon, 1988; Vanek and Potter, 2009). Magnolia scales produce copious amounts of **honeydew**. When coupled with feeding injury to magnolias, which removes photosynthates and induces cell **necrosis** due to phytotoxic saliva, heavy scale infestations can cause branch death, loss of tree vigor, eventual tree decline, and death (USDA Forest Service, 1985; Vanek and Potter, 2009).

Fig. 9.8

Magnolia scales pass through a single generation per year, overwintering as first instar **nymphs**, which are elliptical and slate gray in color and often gather in masses along the undersides of 1- to 2-year-old twigs (Johnson and Lyon, 1988). In New York, first instars molt approximately in late April or early May, and the second instars molt during early June (Johnson and Lyon, 1988). By July in Ohio and Kentucky (Boggs et al., 1998; Townsend, 2005), or August in New York and Pennsylvania (Johnson and Lyon, 1988; Mazzey and Masiuk, 2011), the large, cream-to-yellow-colored females (Figure 9.8) give live birth to the next generation of scale **nymphs**. Newly emerged **nymphs** are mobile for a short time and then settle to feed on the semi-hardwood new growth of host plant twigs.

Management: In small populations, the large female scales can be removed by hand before **crawlers** hatch (e.g., before mid-July). Severely infested branches can be pruned and destroyed. Use horticultural **dormant oil** sprays when magnolia stems are dormant and before buds swell and break in April (Mazzey and Masiuk, 2011). When natural enemies including ladybird beetles, predatory mites, and parasitic wasps are present, azadiractin, horticultural "summer" oil, insecticidal soap, and neem oil extract may be good choices to conserve **biological controls**. Predators and other **biological control** organisms, including green lacewing adults and **larvae**, may be enhanced by using sticky bands to limit ant access to magnolia scales in landscape plants (Vanek and Potter, 2010). Fall foliar and stem sprays may be made after egg hatch, which occurs around September in Kentucky (Vanek and Potter, 2010), starting in early October and on 7- to 10-day intervals, once early instar **crawlers** are actively feeding and while they remain relatively unprotected by cuticular waxes. Effective insecticides include acephate, buprofezin, carbaryl, chlorpyrifos, cyfluthrin, deltamethrin, dimethoate, dinotefuran, esfenvalerate, imidacloprid, lambda-cyhalothrin, malathion, permethrin, and thiamethoxam (Townsend, 2005; Mazzey and Masiuk, 2011). Repeat insecticide applications may be necessary regardless of the pesticide chosen.

Tuliptree Scale (*Toumeyella liriodendra*): Tuliptree scales (Homoptera: Coccidae) are significant pests of tulip poplar (*Liriodendron tulipifera*) in silviculture and landscapes, as well as *Magnolia* species and linden in landscapes and nurseries (Hoover, 2006). Tuliptree scales feed on all stages of seedling, sapling, and poletimber poplar trees, reduce tree vigor and health, and cause distortion and death of infested trees (Burns and Donley, 1969). Tuliptree scales are large: about 0.3 inch in diameter, and are light gray-green to pinkish orange ovals mottled with black (Figure 9.9; Hoover, 2006). *Toumeyella liriodendra* overwinters as second instar **nymphs**. **Nymphs** resume feeding in spring, and females give live birth to up to 3,000 **crawlers** beginning in August (Hoover, 2006). Mating occurs in June. Females produce copious amounts of **honeydew** from June through August (Burns and Donley, 1969). **Nymphs** are dark red and about 0.02 inches long and may be dispersed by crawling, as well as via wind and transfer on plumage of songbirds (Hoover, 2006). There is only one generation per year (Burns and Donley, 1969; Hoover, 2006).

Management: Dormant-season horticultural oils can be applied to trees and shrubs while dormant. Summer oil treatments can be made to control eggs, **crawlers**, and immature instars on actively growing trees and shrubs. Control with oil is achieved by smother-

ing and ostensibly through disruption of cellular respiration. **Crawler** stages can be treated with acephate, azadirachtin, buprofezin, carbaryl, chlorpyrifos, cyfluthrin, cyfluthrin plus imidacloprid, deltamethrin, dinotefuran, horticultural oil, imidacloprid, insecticidal soap, lambda-cyhalothrin, neem oil extract, and thiamethoxam insecticides. Broad spectrum insecticides, including acephate, carbaryl, cyfluthrin, deltamethrin, imidacloprid, and lambda-cyhalothrin, may result in non-target kill of beneficial arthropods. Tuliptree scales have several reported predators including a predaceous moth larva (*Laetilia coccidivora*), a ladybird beetle (*Hyperaspis proba proba*), and syrphid fly (*Baccha costata*; Burns and Donley, 1969).

False Oleander Scale - aka Magnolia White Scale - (*Pseudaulacaspis cockerelli*): False oleander scale (Homoptera: Diaspididae) is an armored scale pest of Chinese origin that is commonly encountered on foliage of many ornamental *Magnolia* spp., as well as aucuba, *Eleagnus* spp., English ivy, flowering dogwood, oleander, and yew plants in landscapes and nurseries in Georgia, Florida, and Alabama (Johnson and Lyon, 1988; Deckle, 1976; Hamon and Fasulo, 2007). Foliage of affected plants can be scouted by looking on both leaf surfaces for the pear-shaped, slightly convex, yellow-brown scale exuviae. The shiny white female armor (Figure 9.10) may extend 0.08-0.12 inches and is composed of secreted waxes and cast skins. Males are smaller, at about 0.04 inch long (Deckle, 1976; Hamon and Fasulo, 2007). Feeding injury may be apparent as chlorotic spots on the upper leaf surface with scales attached to the leaf under side. Heavy infestations of false oleander scale may lead to premature leaf drop and loss of host plant vigor (Hamon and Fasulo, 2007). False oleander scales are present year-round where encountered, and controlled greenhouse studies indicate that a single generation can complete development within about five weeks (Tippins, 1968).

Management: Armored scale insects such as **mature** false oleander scale are difficult to control. Pesticide applications are best timed for **crawler** emergence. Double-sided sticky tape can be used to monitor egg hatch and **crawler** activity. Dead scales do not fall from plants; thus, to assess pesticide efficacy, crush the waxy covering. When crushed, gut contents will be extruded from live armored scale insects. Acephate, bifenthrin, diazinon, fenoxycarb (against immature scales only), horticultural oils, and malathion have been effective at managing scale insects on ornamental plants, including false oleander scale populations (Leibee and Savage, 1994). Use of horticultural oils will conserve **natural enemy** populations.

Japanese Maple Scale (*Lopholeucaspis japonica*): Japanese maple scale is a small, oyster shell-shaped, armored scale believed to have been introduced to the United States from Asia. Japanese maple scale is currently found throughout much of the eastern half of the United States (Gill et al., 2011). Its wide host plant range includes *Magnolia* spp. (Fulcher et al., 2011). Japanese maple scale infestation can cause branch dieback progressing to plant death, although this is uncommon. Because Japanese maple scale is small and easily overlooked, plants are often heavily infested when first noticed. It can spread over a significant portion of a nursery before the pest is detected, and *L. japonica* infestation has caused nursery crop shipments to be rejected.

Japanese maple scale is expected to have two generations a year in the mid-southern United States. This scale overwinters as an immature nymph on trunks and branches and matures to an adult in spring (Miller and Davidson, 2005). First generation **crawlers** emerge in mid-May and the second generation in early August (Fulcher et al., 2011; Gill et al., 2011). Japanese maple scale **crawlers** hatch over an extended period, and first and second generations overlap (Fulcher et al., 2011; Gill et al., 2011). **Crawlers** develop wax rapidly, starting about three days after hatch (Fulcher et al., 2011). In Kentucky, **crawler** hatch coincides with flowering of *Syringa reticulata* 'Ivory Silk' (tree lilac) and *Hydrangea quercifolia* (oakleaf hydrangea; Fulcher et al., 2011). In Maryland, the first generation began at 795 degree days (50 °F base temperature, starting January 1) and peaked at 1,144 degree days, while the second generation started at 2,200 degree days and peaked at 3,037 degree days (Gill et al., 2011).

Japanese maple scale can be difficult to detect because the lavender **crawlers** are very small (as are adults) and generally require 16X or greater magnification to detect. Japanese maple scale is most readily observed on bark of dormant deciduous host plants and on developing magnolia fruit and leaves. Managers may need to pull aside branches of densely branched trees and shrubs when **scouting**. Bodies of adult *L. japonica* scales have a white waxy coating, while female body, eggs, and **crawlers** are lavender.

Management: Japanese maple scale and other armored scales are difficult to control. Plants with thick canopies can be difficult to successfully treat for scale insects because the dense foliage interferes with spray penetration. Pruning practices may need to be adjusted to open canopies and enable greater spray penetration. Placement of water sensitive paper inside the canopy before spray application can ensure that pesticides are penetrating the canopy to reach infested portions of the plant. Best pesticide efficacy occurs if applications are timed for **crawler** emergence. Double-sided sticky tape can be used to monitor egg hatch and **crawler** activity. Dead scales do not fall from plants, and pesticide efficacy must be assessed. When crushed, live armored scale insects will exude gut contents. This scale's small size makes this difficult to do in the field. To better assess mortality after pesticide application, clip an infested twig or branch and flip the scale upside down to expose the body. A hand lens or microscope will show dead scales as shriveled and papery, while live scales are firm and plump. Acephate, bifenthrin, diazinon, fenoxycarb (against immature scales only), horticultural oils, and malathion have been effective at managing scale insects on ornamental plants (Leibee and Savage, 1994). Use of horticultural oils will conserve **natural enemy** populations.

Yellow Poplar Weevil (*Odontopus calceatus*): Yellow poplar weevils, also called magnolia leafminer, tuliptree leafminer, and sassafras weevil (*Odontopus calceatus*, Coleoptera: Curculionidae), are widespread throughout the eastern United States where the **larvae** feed on leaves and buds of tulip poplar (*L. tulipifera*), sassafras, and both sweetbay and southern magnolia (Burns, 1971; Johnson and Lyon, 1988). Heavy infestations can lead to multiple stem leaders that emerge from beneath a killed apical terminal and defoliation of the tree canopy. Weakened and malformed trees may become liabilities in the landscape. Populations have occasionally reached damaging levels in tulip poplar orchards and **mature** trees within the Appalachian Mountain region (Burns, 1971; Heinrichs et al., 1973).

Adult beetles (Figure 9.11) are about 0.1 inches long, rounded, and dark brown or black. Beetles overwinter in leaf litter beneath host plants and emerge with warm daytime temperatures to begin feeding in late March and early April, chewing notches and holes in expanding leaves and buds. In late April and early May, eggs are laid on leaf undersides along the mid-vein (Burns, 1971). Weevil **larvae** feed as leafminers, inflicting initial feeding injury in late April through May. Early larval feeding causes blotch mines that may contain up to 19 white, legless **larvae** (Burns, 1971). Most larval feeding occurs in May, after which **larvae** pupate within the mine. Leaves with mines may look scorched. Adults continue to feed, causing significant injury into summer (Burns, 1971) and until August in Mississippi (Heinrichs et al., 1973). *Odontopus calceatus* bears only one brood per year in the Ohio River Valley (Burns, 1971).

Management: Late spring frosts may kill **larvae** and adults that have emerged from overwintering sites. Known natural enemies include two pteromalid wasps, *Heterolaccus hunter* and *Habrocytus peircei*, two eulophid wasps, *Horismenus fraternus* and *Zagrammosoma multilineatum*, and an ichneumonid wasp, *Scambus hispae* (Burns, 1971). Insecticides labeled for beetles and caterpillars that feed on leaves may provide some control.

Fig. 9.11

Leaf-Footed Bugs (*Leptoglossus fulvicornis* and *Leptoglossus phyllopus*): Ranging from Massachusetts to Texas, leaf-footed bugs (Heteroptera: Coreidae) feed on and can damage developing and mature magnolia fruits (Mitchell and Mitchell, 1983). *Magnolia* species are the only known breeding hosts. Eggs are laid in linear masses along the midrib on leaf undersides. **Nymphs** and adults are active in late summer and fall as fruits develop.

Management: Gryon pennsylvanicum and *Anastatus* spp. can parasitize eggs but will not control infestations (Mitchell and Mitchell, 1983). Control of leaf-footed bugs may be necessary or desirable if growing *Magnolia* spp. to collect seed for propagation, particularly if the *Magnolia* spp. in question are rare or endangered. Magnolia breeders should also be aware of the potential damage inflicted by this pest.

Magnolia Root Borer (*Euzophera magnolialis*): Magnolia root borer, *Euzophera magnolialis* (Lepidoptera: Pyralidae), is a wood boring pest with **larvae** that feed on magnolia roots 0.2 inch and larger and tunnel about 6 inches up into the trunk above the crown (Leibee, 1992). The resulting girdling injury can injure and even kill nursery seedlings (Leibee, 1992; Outcalt, 1990; Popenoe, 2008). Root feeding may be in a spiral, causing affected roots to have a candy cane-patterned injury (Leibee, 1992). Larval feeding limits root function, including nutrient and water uptake, thereby inducing initial plant decline. Adult moths live about 10 days (Leibee, 1992), and adults and **larvae** are often difficult to detect. They are more of an economic threat to magnolias under nursery production, rather than in an urban landscape (Leibee, 1992). Eggs may be deposited on the tree bark (a single female can lay about 400 eggs under lab conditions) from the crown up to about 4.5 feet (Leibee, 1992), and **larvae** tunnel down to feed on tree roots. As **larvae** mature, they migrate up toward the crown and begin tunneling beneath bark to pupate. In Florida and the deep southern United States, *E. magnolialis* has at least two generations per year, where adult moth flight activity occurs from February through April and again from June through August (Leibee, 1992; Popenoe, 2008).

Management: High fertilization and irrigation rates in nurseries may mask plant injury by allowing adventitious roots to overcome damage symptoms and plant stress (Popenoe, 2008). If first order lateral, or structural, roots are compromised, root systems may only persist shallowly once trees are planted in the landscape, yielding poor structural support to the **mature** tree. Information about pesticide efficacy against this insect is limited. The extent to which **biological control** may be effective is unknown. Root and crown drenches with a **systemic** insecticide labeled for borers may provide some control.

Thrips (*Caliothrips striatus*): *Caliothrips striatus* (Thysanoptera: Thripidae) is a thrips insect native throughout the eastern United States (Wilson, 1975). Though not considered a significant pest, Tyler-Julian et al. (2012) identified several Magnoliaceae species as host plants to *C. striatus*, including the native *L. tulipifera, M. grandiflora* and *M. virginiana* and the non-native *Magnolia delavayi, Magnolia foveolata*, *M. insignis* × *M. grandiflora* (hybrid), *M. laevifolia*, *Magnolia lotungensis*, *M. maudiae,* and *Magnolia tamaulipana*. Magnolias in the affected botanic garden where thrips occurred exhibited damage caused by *C. striatus,* that appeared as yellow-brown flecks on the leaf surface. The irrigated magnolias in the botanic garden are believed to have attracted this thrips from drought-affected native vegetation surrounding the garden (Figlar, personal communication). Adults were sometimes visible on leaves and appeared black with two white bars. *Caliothrips striatus* is believed to be capable of using *M. grandiflora* both for feeding and for reproduction.

Management: As a minor pest, this thrips will rarely need to be controlled. When pest populations threaten plant health or aesthetics, pesticides may be used (Table 9.3).

Cranberry Rootworm (*Rhadopterus picipes*): Cranberry rootworm, *Rhadopterus picipes* (Coleoptera: Chrysomelidae), occurs east of the Mississippi River and has an extremely broad host plant range. In addition to *M. virginiana* and other magnolia species, host plants include camellia, cherry laurel, goldenraintree, *Ilex crenata*, *Ilex cornuta*, oaks, photinia, rhododendron, rose, silver maple, sycamore, sumac, sassafras, and Virginia creeper. Adult beetles are about 0.2 inch long, dark brown, and shiny (Figure 9.12). Adults bear one brood per year and emerge from late April to mid-May in Mississippi (Harman, 1931; Oliver and Chapin, 1980; Johnson and Lyon, 1988). Adults are nocturnal feeders, hiding in leaf litter and debris during the day. Adults feed for about 2 weeks after emergence and then seek refuge in leaf litter where they deposit eggs (Oliver and Chapin, 1980).

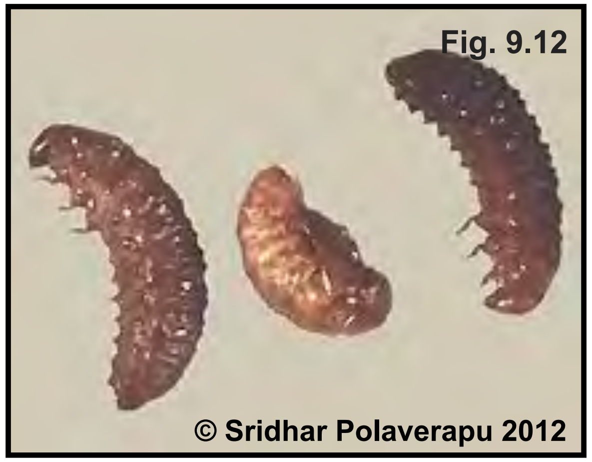

Fig. 9.12

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Management: Pesticides including carbaryl, imidacloprid, permethrin, and spinosad may provide control when beetles are actively feeding. Applications should also be directed toward leaf litter and debris beneath the affected plant where nocturnal beetles will hide. **Entomopathogenic nematodes** including *Heterorhabditis bacteriophora* and *Steinernema scarabaei* have shown some potential for cranberry rootworm control (Polavarapu, 1999; van Tol and Raupp, 2005).

SECTION 4

Disease Pests

Bacterial leaf spot on magnolia

DISEASE & NEMATODE PESTS

1. Bacterial Leaf Spot
2. Verticillium Wilt
3. Phytophthora Root Rot
4. Bacterial Blight
5. Anthracnose
6. Algal Leaf Spot
7. Powdery Mildew
8. Phyllosticta Leaf Spot
9. Pestalotiopsis Leaf Spot
10. Nematodes

Bacterial Leaf Spot (*Xanthomonas* sp.): *Xanthomonas* sp. causes bacterial leaf spot on magnolia. The disease is a serious issue in production under conditions of high rain and wind or heavy overhead irrigation, all of which lead to easy movement of the bacteria from plant to plant. The pathogen can enter through wounds, **stomata**, and **hydathodes**. Symptoms of bacterial infections vary but usually start as small necrotic **lesions** with a yellow halo region. Under ideal environmental conditions, the pathogen can cause severe **blighting** of the foliage (see Disease Pests section introductory image).

Management: Manage overhead irrigation carefully to prevent high leaf wetness during nights and overcast conditions. If ideal environmental conditions for the pathogen persist, the disease can be managed by use of copper-based bactericides (Table 9.4). The disease is an issue in nursery production due to poor management of overhead irrigation systems and is not usually seen in the landscape.

Verticillium Wilt (*Verticillium albo-atrum* and *Verticillium dahlia*): *Verticillium* sp. is a vascular pathogen of magnolia as well as many other ornamental shrubs and trees. It can cause dieback of leaves and branches, often at one side of the tree. Infected plants often show vascular discoloration, a characteristic symptom of verticillium wilt. The fungus may kill large areas of cambial tissue and allow opportunistic fungi such as *Nectria* sp. to infect the area and form elongated cankers (Chartfield et al., 1996). Symptom progression can be slow, but the plants will completely die in 1 to 2 years. *Verticillium* sp. survives in soil as microsclerotia that can be disseminated by wind, soil movement, and on equipment. The fungus penetrates through root wounds or direct penetration, and root stressors such as drought favor its development. The disease symptoms are caused by the fungus plugging the vascular system.

Management: Avoid stressful conditions for the plants including overwatering, drought, and root wounding that will aid *Verticillium* sp. to infect magnolia.

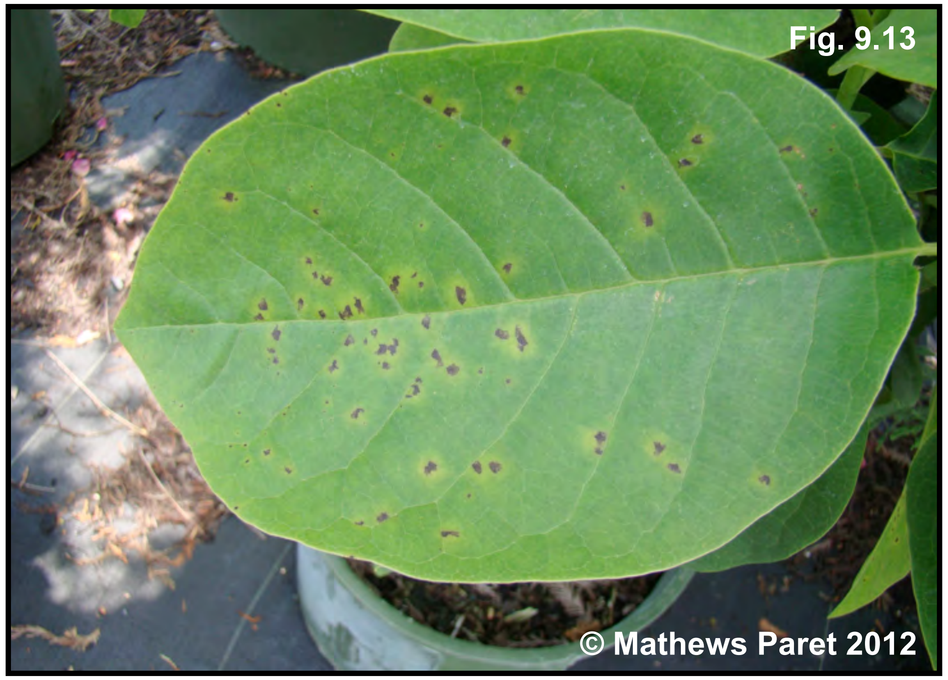
Sanitize pruners frequently when pruning roots of susceptible species. Fungicides are not effective in management of verticillium wilt. *Verticillium* sp. can survive in soil for many years, so avoid planting susceptible species in areas previously infected by this fungus.

Phytophthora Root Rot (*Phytophthora cinnamomi*): Phytophthora root rot symptoms include yellowing of leaves, sudden **wilting**, premature leaf drop, slowed shoot growth, limb dieback, and plant death. This disease is a major concern in container production of southern and saucer magnolias (Hagan, 2001).

Phytophthora cinnamomi survives as **hyphae** in infected roots and as resting structures known as chlamydospores in crop debris and soil. The oomycete causal agent is easily and quickly spread by contaminated water in nurseries where irrigation water is recycled without treatment. Root infection can be common and severe if container **substrates** are saturated.

Management: Proper irrigation management and preventive and timely fungicide applications (Table 9.4) are important in managing phytophthora root rot in container grown magnolias. Avoid conditions that allow water to pool around containers. Thoroughly wash and disinfect recycled containers before use.

Bacterial Blight (*Pseudomonas syringae* pv. *syringae* and *Pseudomonas cichorii*): These *Pseudomonas* sp. cause leaf spots similar to bacterial leaf spot on magnolia (Miller, 1976; Mullen and Cobb, 1984; Hagan, 2001). Symptoms are small necrotic spots with a yellow halo (Figure 9.13). The leaf spot symptoms caused by *Pseudomonas* sp. are difficult to distinguish from bacterial leaf spot, caused by *Xanthomonas* sp. However, *Pseudomonas* sp. is much more an issue during cooler, wetter conditions. Both *Pseudomonas* species are aggressive pathogens on southern magnolia.



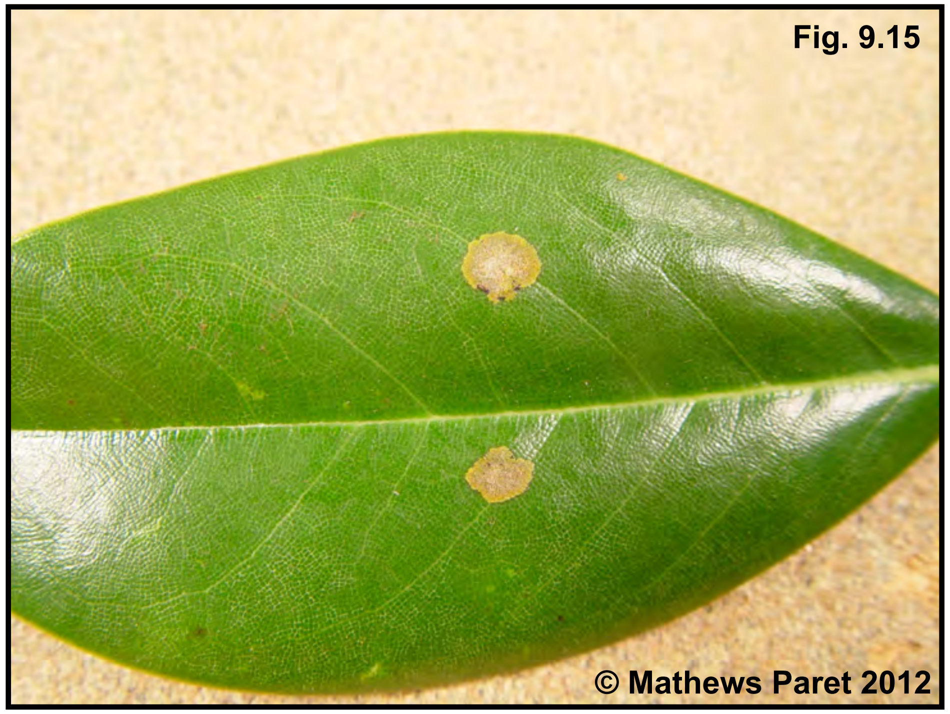
Management: Manage overhead irrigation carefully to prevent high leaf wetness during nights and overcast conditions. If ideal environmental conditions persist, the disease can be managed by use of copper-based bactericides (Table 9.4). The disease is an issue in nursery production due to poor management of overhead irrigation systems and not usually seen in the landscape.

Anthracnose (*Colletotrichum* spp.): Anthracnose causes large circular spots near margins of magnolia leaves (Figure 9.14). The leaves develop a burned appearance or angular spots with a yellow halo, and this can lead to premature leaf drop (Hagan, 2001). Black, blister-like fruiting bodies develop on the upper side of the spot. A pink spore mass oozes from these fruiting bodies at later stages. Spores can be spread by splashing water. The fungal organism can overwinter in dead leaves and branches during winter. The disease is often reported on southern magnolia.

Management: Remove infected leaves at the early stages to prevent any disease spread. A fungicide management plan is required if the infection becomes severe (Table 9.4).

Algal Leaf Spot (*Cephaleuros virescens*): The key symptom of algal leaf spot is the formation of raised blotches on the leaves (Figure 9.15). These spots develop a velvety appearance, and plant tissues beneath the spots die. Severe infection can cause premature leaf drop. The disease mostly affects weaker plants in the nursery or landscape and is commonly seen on southern magnolia. Algal spores can swim in water on the leaf surface. Thus, continuous rain during warm, windy conditions serves as a major factor in spread of the algal spores. In addition, the algae may survive on infected leaves and twigs and result in repeated infection year after year.

Management: For early crop stage management, removing infected leaves and plant debris will serve as useful strategies. Overhead irrigation should be managed to avoid long periods of leaf wetness. Crop canopy management is also important as dense canopy favors disease conditions.



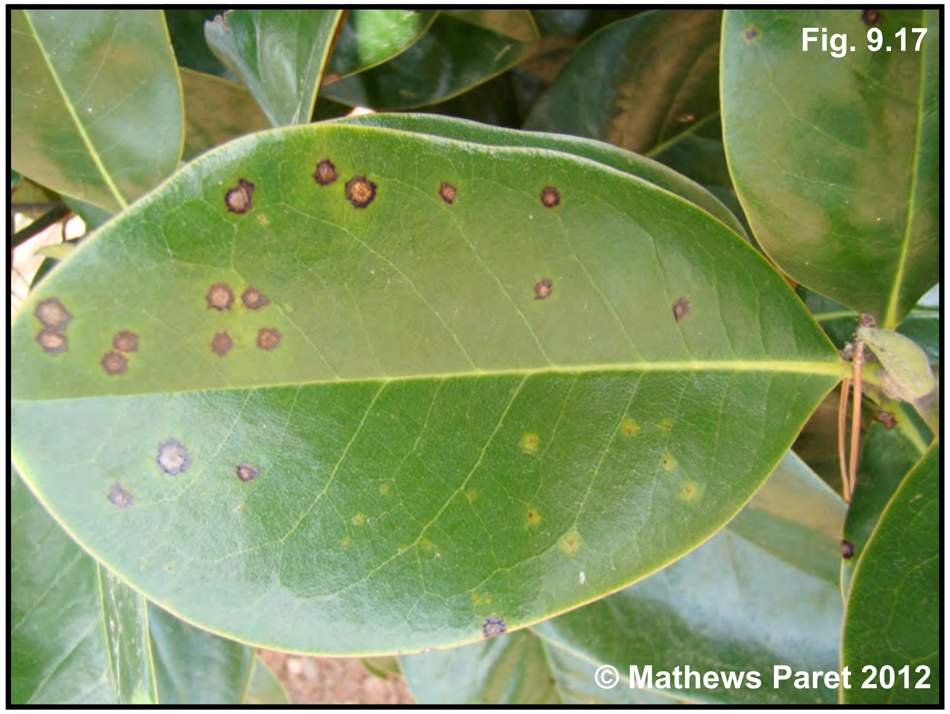
Powdery Mildew (*Microsphaera alni* [*M. penicillata*] and *Phyllactinia corylea* [*P. guttata*]): Two species of fungi cause powdery mildew on magnolia. The symptoms include white powdery patches on top sections of the leaves (Figure 9.16; Hagan, 2001). The patches can cover the entire leaf during severe infection. Plant stunting and leaf curling can occur. Powdery mildew fungi overwinter as **hyphae** in dormant buds or as spores on fallen diseased leaves. Spores are spread by wind in spring to early summer. Powdery mildew can be an issue in production when days are warm-to-hot and nights are cooler with dew formation on leaves. Overcrowding plants and lack of aeration are environmental conditions that support powdery mildew infection. Powdery mildew is commonly found on saucer and star magnolias.

Management: Plant disease management tools include use of good cultural practices. Plant canopies should be maintained to allow air movement. Similarly, plants in production should be spaced to allow air movement around plants. Scout for the disease during times when days are warm and nights are cool. If the infection is spotted and these environmental conditions are likely to persist, it will be necessary to implement a fungicide spray program (Table 9.4).

Phyllosticta Leaf Spot (*Phyllosticta magnolia*): Phyllosticta leaf spot is an occasional disease on southern magnolia in the landscape. Symptoms are small black spots on the upper leaf surface (Hagan, 2001; Pataky, 1997). Borders of these spots become purple to black, and centers turn off-white and develop black fruiting bodies. Warm, moist conditions favor this disease. The disease organism is spread to new leaves by splashing water.

Management: Overhead irrigation should be managed to avoid long periods of leaf wetness during warm, humid conditions. Removing infected leaves early in disease progression can prevent spread of phyllosticta leaf spot.

Pestalotiopsis Leaf Spot (*Pestalotiopsis* sp.): Pestalotiopsis leaf spot of magnolia causes unique circular spots with a necrotic center and a black border and usually occurs during cooler weather conditions (Figure 9.17). Fungal spores of the pathogen are spread by wind and water movement.



Management: Overhead irrigation should be managed to avoid leaf wetness overnight and during overcast conditions. Maintaining an open canopy is also helpful in minimizing conditions favorable for disease development.

Nematodes (*Belonolaimus* sp. and *Meloidogyne* sp.): Magnolia species are hosts of sting nematodes (*Belonolaimus* species) that cause roots to darken and rot (Hagan, 2005). Unknown nematodes have been found on some *Magnolia* species (Santamour and Batzli, 1990). Other studies found various *Magnolia* species were tolerant or resistant to many root knot nematodes (*Meloidogyne* species; Santamour and Reidel, 1993; Bernard and Witte, 1987).

Management: Nematodes are minor pests of magnolia. Control is not practical in most situations.

Virus and canker diseases are not documented on *Magnolia* species. Table 9.4 lists fungicides labeled for *Magnolia* species.

References

Adkins, C., G. Armel, M. Chappell, J.-H.Chong, S.D. Frank, A. Fulcher, F. Hale, K. Ivors, W. Klingeman, A. LeBude, J. Neal, A. Senesac, S. White, J. Williams-Woodward, and A. Windham. 2010. Pest Management Strategic Plan for Container and Field-Produced Nursery Crops in Georgia, Kentucky, North Carolina, South Carolina and Tennessee. A. Fulcher (ed.). Southern Region IPM Center. http://www.ipmcenters.org/pmsp/pdf/GA-KY-NC-SC-TNnurserycropsPMSP.pdf. Accessed April 19, 2012.

Atkinson, T.H., J.L. Foltz, R.C. Wilkinson, and R.F. Mizell. 2011. Granulate ambrosia beetle, *Xylosandrus crassiusculus* (Motchulsky) (Insecta: Coleoptera: Curculionidae: Scolytinae). Florida Cooperative Extension Service, IFAS, University of Florida, EENY-131.

Azuma, H., L.B. Thien, M. Toyota, Y. Asakawa and S. Kawano. 1997. Distribution and differential expression of (E)-4,8-dimethyl-1,3,7-nonatriene in leaf and floral volatiles of *Magnolia* and *Liriodendron* taxa. Journal of Chemical Ecology 23(11):2467-2478.

Baker, J.M. and S. Bambara. 1999. North Carolina pest news: Ornamentals and turf 14(12).http://ipm.ncsu.edu/current_ipm/99PestNews/99News12/ornament.html. Accessed April 19, 2012.

Baker, J.M. and D.M. Norris. 1968. A complex of fungi mutualistically involved in the nutrition of the ambrosia beetle *Xyleborus ferrugineus*. Journal of Invertebrate Pathology 11:246-250.

Baker, J.B. and S. Frank. 2010. Cottony cushion scale. North Carolina Cooperative Extension ENT/ort-51. http://www.ces.ncsu.edu/depts/ent/notes/O&T/shrubs/note51/note51.html. Accessed April 19, 2012.

Bernard, E.C. and W.T. Witte. 1987. Parsitism of woody ornamentals by *Meliodogyne hapla*. Annals of Applied Nematology 1:41-45.

Boggs, J.F., D.J. Shetlar, J.C. Martin, P.J. Bennett, J.A. Chatfield, G.Y. Gao, and C. Carlson. 1998. Insect and mite activity noted in Ohio nurseries and landscapes: 1997. OSU-ARDC, Ornamental Plants Annual Report Research Review special circular 157. http://ohioline.osu.edu/sc157/sc157_6.html. Accessed April 19, 2012.

Buchanan, W.D. 1941. Experiments with an ambrosia beetle *Xylosandrus germanus* (Blfd.). Journal of Economic Entomology 34:367-369.

Burns, D.P. 1971. Yellow poplar weevil. USDA Forestry Service Forest Pest Leaflet 125.

Burns, D.P. and D.E. Donley. 1969. Biology of the Tuliptree scale, *Toumeyella liriodendri* (Homoptera: Coccidae). Annals of the Entomological Society of America 63:228-235.

Callaway, D.J. 1994. The world of magnolias. Timber Press, Inc., Portland, Oregon.

CDMS. 2011. CDMS Label Search. Crop Data Management Systems, Inc. Accessed October 21, 2011. http://premier.cdms.net/webapls/formsloginRef.asp?/webapls.

Chatfield, J., S. Nameth, and N. Taylor. 1996. *Verticillium* wilt of landscape trees and shrubs. Ohio State University Extension factsheet. HYG-3053-96.

CDMS. 2011. CDMS Label Search. Crop Data Management Systems, Inc. http://premier.cdms.net/webapls/formsloginRef.asp?/webapls. Accessed April 19, 2012.

Cole, K.W. 2008. Granulate ambrosia beetle. Indiana Department of Natural Resources. http://www.in.gov/dnr/entomolo/files/ep-GranulateAmbrosiaBeetleFactsheet.pdf. Accessed April 19, 2012.

Deckle, G.W. 1976. Florida armored scale insects. Florida Department of Agriculture Consumer Services, Division of Plant Industry. Arthropods of Florida and Neighboring Land Areas 3:1-345.

Diagne, A.B., R.N. Story, and A.M. Hammond. 2006. Adult *Phyllophaga ephilida* host plant feeding preference. Florida Entomologist 89:391-395.

Dirr, M.A. 1975, rev. 1998. Manual of woody landscape plants. Stipes Publishing L.L.C., Champaign, Illinois.

Dixon, W.N., R.E. Woodruff, and J.L. Foltz. 2005. Black twig borer, *Xylosandrus compactus* (Eichhoff) (Insecta: Coleoptera: Curculionidae: Scolytinae). Florida Cooperative Extension Service, IFAS, University of Florida, EENY-311.

Dozier, H.L. 1920. An ecological study of hammock and piney woods insects in Florida. Annals of the Entomological Society of America 13:326-380.

Drooz, A.T. 1985. Insects of eastern forests. U.S. Department of Agriculture Forest Service, miscellaneous publication 1426.

Engelbrecht, C. 2005. Host/pest list for diseases on ornamentals in Iowa. School IPM Landscape Pilot Project. http://www.ipm.iastate.edu/ipm/schoolipm/sites/default/files/Host_Disease_Pest_Guide_List.pdf. Accessed April 19, 2012.

Figlar, R.B. and H.P. Nooteboom. 2004. Notes on Magnoliaceae IV. Blumea 49:88-100.

Frank, S.D. and C.S. Sadof. 2011. Reducing insecticide volume and non-target effects of ambrosia beetle management in nurseries. Journal of Economic Entomology 104:1960-1968.

Franklin, J. and W. Clatterbuck. 2004. Bark splitting on trees. University of Tennessee Extension publication SP630. https://utextension.tennessee.edu/publications/Documents/SP630.pdf. Accessed April 19, 2012.

Fulcher, A., F. Hale, and M. Halcomb. 2011. Japanese maple scale: An important new insect pest in the nursery and landscape. University of Tennessee Extension publication W277.

Gill, S. 2010. TPM/IPM weekly report for arborists, landscape managers, and nursery managers. http://ipmnet.umd.edu/landscape/lndscpalerts/2010/10jul02l.pdf. Accessed April 19, 2012.

Gill, S., P. Shrewsbury, and J. Davidson. 2011. Japanese maple scale (*Lopholeucaspis japonica*): A pest of nursery and landscape trees and shrubs. University of Maryland Extension fact sheet.

Hagan, A.K. 2001. Magnolia diseases. 59:231-235. In: R.K. Jones and D.M. Benson (Eds.). Diseases of woody ornamentals and trees in nurseries. APS Press, St. Paul, MN.

Hagan, A. 2005. Nematode pests of annual and perennial flowers, herbs, woody shrubs, and trees. ANR 689. Alabama Cooperative Extension System, Auburn, AL.

Hamon, A.B. and T.R. Fasulo. 2007. False oleander scale, *Pseudalacaspis cockerelli* (Cooley) (Homoptera: Diaspididae). Florida Cooperative Extension Service, IFAS, University of Florida, EENY-149.

Harman, S.W. 1931. The cranberry rootworm as an apple pest. Journal of Economic Entomology 24:180-182.

Harris, R., J. Clark, and N. Matheny. 2004. Arboriculture: integrated management of landscape trees, shrubs and vines, 4th ed. Prentice Hall, Upper Saddle River, NJ.

Hartman, J., T. Pirone, and M.A. Sall. Pirone's tree maintenance, 7th ed. 2000. Oxford University Press, New York, NY.

Heinrichs, E.A., E.E. Burgess, and E.L. Matheny, Jr. 1973. Control of leaf-feeding insects on yellow poplar. Journal of Economic Entomology 66:1240-1241.

Held, D.W. 2004. Relative susceptibility of woody landscape plants to Japanese beetle (Coleoptera: Scarabaeidae). Journal of Arboriculture 30:328-335.

Herrick, G.W. 1931. The magnolia scale (*Neolecanium cornuparvum* Thro). Annals of the Entomological Society of America 24:302-305.

Hoffmann, C.H. 1941. Biological observations on *Xylosandrus germanus* (Bldfd). Journal of Economic Entomology 34:38-42.

Hoover, G.A. 2006. Tuliptree scale. Entomological Notes. Penn State Cooperative Extension. http://ento.psu.edu/extension/factsheets/pdf/tuliptreeScale.pdf. Accessed April 19, 2012.

Hubbard, J.L. and D.A. Potter. 2005. Life history and natural enemy associations of calico scale, *Eulecanium cerasorum* (Homoptera: Coccidae), in Kentucky. Journal of Economic Entomology 98:1202-1212.

Hubbard, J.L. and D.A. Potter. 2006. Managing calico scale (Hemiptera: Coccidae) infestations on landscape trees. Arboriculture and Urban Forestry 32:138-147.
Johnson, W.T. and H.H. Lyon. 1988. Insects that feed on trees and shrubs, 2nd ed. Comstock University Press, Ithaca, NY.

Kamikado, T., C. Chang, S. Murakoshi, A. Sakurai, and S. Tamura. 1975. Isolation and structure elucidation of growth inhibitors on silkworm larvae from *Magnolia kobus* DC. Agricultural and Biological Chemistry 39:833-836.

Knox, G.W. 2012. Commercial nursery production of Magnoliaceae in the southern United States. Proceedings of the 2nd International Symposium on the Family Magnoliaceae (ISFM): 262-269. May 5-8, 2009. Guangzhou, China.

Krischik, V. and J. Davidson. 2007. IPM (integrated pest management) of Midwest landscapes. University of Minnesota Extension Service, Center for Urban Ecology and Sustainability. http://www.entomology.umn.edu/cues/ipmbook.htm. Accessed April 19, 2012.

Leibee, G.L. 1992. Unearthing a magnolia menace. American Nurseryman 173:70-77.

Leibee, G.L. and K.E. Savage. 1994. Insecticidal control of magnolia white scale (false oleander scale) (Homoptera: Diaspididae) on *Magnolia*. Proceedings of the Florida State Horticural Society 107:226-228.

Li, G.-H., L.-Z. Dang, L.-J. Hong, L.-J. Zheng, F.-F. Liu, L. Li, Y.-J. Liu, and K.-Q. Zhang. 2009. Nematicidal activity of honokiol and magnolol isolated from *Magnolia tripetala*. Journal of Phytopathology 157:390-392.

Mazzey, K. and M. Masiuk. 2011. Magnolia scale. Woody ornamental IPM factsheet. Penn State University Cooperative Extension http://woodypests.cas.psu.edu/factsheets/InsectFactSheets/pdf/MagnoliaScale.pdf. Accessed April 19, 2012.

Miller, J.W. 1976. Bacterial leaf spot on saucer magnolia. Florida Department of Agriculture and Consumer Services Plant Pathology circular 163.

Miller, D.R. and J.A. Davidson. 2005. Armored scale insect pests of trees and shrubs. Cornell University Press, Ithaca, NY.

Mitchell, P.L. and F.L. Mitchell. 1983. Range extension of *Leptoglossus fluvicornis* with observations on egg parasitism. The Southwestern Entomologist 8:150-153.

Moon. D.C. and P. Stiling. 2004. The influence of a salinity and nutrient gradient on coastal vs. upland tritrophic complexes. Ecology 85:2709-2716.

Mullen, J.M. and G.S. Cobb. 1984. Leaf spot of southern magnolia caused by *Pseudomonas cichorii*. Plant Disease 68:1013-1015.

Nitao, J.K., M.G. Nair, D.L. Thorogood, K.S. Johnson, and J.M. Scriber. 1991. Bioactive neolignans from the leaves of *Magnolia virginiana*. Phytochemistry 30:2193-2195.

Oliver, A.D. and J.B. Chapin. 1980. The cranberry rootworm: Adult seasonal history and factors affecting its status as a pest of woody ornamentals in Louisiana. Journal of Economic Entomology 73:96-100.

Oliver, J.B. and C.M. Mannion. 2001. Ambrosia beetle (Coleoptera: Scolytidae) species attacking chestnut and captured in ethanol-baited traps in Middle Tennessee. Environmental Entomology 30:909-918.

Outcalt, K.W. 1990. *Magnolia grandiflora* L: Southern magnolia. In: Silvics of North America, USDA Forestry Service Agricultural handbook 654, Vol. 2 Hardwoods, Washington, D.C. http://www.na.fs.fed.us/pubs/silvics_manual/volume_2/magnolia/grandiflora.htm. Accessed April 19, 2012.

Pataky, N.R. 1997. Verticillium wilt disease. University of Illinois Extension Plant Disease RPD No. 1010.

Peterson, N.C. and D.R. Smitley. 1991. Susceptibility of selected shade and flowering trees to gypsy moth (Lepidoptera: Lymantriidae). Journal of Economic Entomology 84:587-592.

Plant & Supply Locator. 2011. Plant & Supply Locator, Hutchinson Publishing Corporation, Taylors, SC. www.plantlocator.net. Accessed April 19, 2012.

Polavarapu, S. 1999. Insecticidal nematodes for cranberry pest management, pp. 79-90. Proceedings at the National Workshop on Optimal Use of Insecticidal Nematodes in Pest Management. Polavarapu, S. (ed). Rutgers University, Chatsworth, NJ.

Popenoe, J. 2008. Magnolia, Southern magnolia *Magnolia grandiflora*. University of Florida F-IFAS Extension. http://cfextension.ifas.ufl.edu/documents/Magnolia.pdf. Accessed April 19, 2012.

Ranger, C.M., M.E. Reding, K.J.K. Gandhi, J.B. Oliver, P.B. Schultz, L. Caňas, and D.A. Herms. 2011. Species dependent influence of (--)-α-Pinene on attraction of ambrosia beetles (Coleoptera: Curculionidae: Scolytinae) to ethanol-baited traps in nursery agroecosystems. Journal of Economic Entomology 104:574-579.

Reding, M., J. Oliver, P. Schultz, and C. Ranger. 2010. Monitoring flight activity of ambrosia beetles in ornamental nurseries with ethanol baited traps: influence of trap height on captures. Journal of Environmental Horticulture 28:85-90.

Relf, D. and B. Appleton. 2009. Managing winter injury to trees and shrubs. Virginia Tech Extension publication 426-500. http://pubs.ext.vt.edu/426/426-500/426-500.html. Accessed April 19, 2012.

Santamour, F.S., Jr. and J.M. Batzli. 1990. Host checklist of root-knot nematodes on broad-leaved landscape trees. Journal of Arboriculture 16:162-168.

Santamour, F.S., Jr. and L.G.H. Riedel. 1993. Susceptibility of various landscape trees to root-knot nematodes. Journal of Arboriculture 18:257-259.

Sinclair, W.A. and H. Lyon. 2005. Diseases of trees and shrubs, 2nd ed. Cornell University Press, Ithaca, NY.

Smith, H. 2010. Leafminer pests of Connecticut nurseries. Connecticut Agricultural Experiment Station. http://www.ct.gov/caes/lib/caes/documents/publications/fact_sheets/entomology/leafminer_pests_of_connecticut_nurseries.pdf. Accessed April 19, 2012.

Tippins, H.H. 1968. Observations on *Phenacaspis* [= *Pseudacaulaspis*] *cockerelli* (Cooley) (Homoptera: Diaspididae), a pest of ornamtnal plants in Georgia. Journal of the Georgia Entomological Society 3:13-15.

Tyler-Julian, K., O. Demirozer, R. Figlar, T. Skarlinsky, J. Funderburk, and G. Knox. 2012. New host records for *Caliothrips striatus* Hood (Thysanoptera: Thripidae). Florida Entomologist. In press.

Townsend, L. 2005. Magnolia scale. University of Kentucky Cooperative Extension Service Entfact-431.

U.S. Department of Agriculture. 2009. 2007 Census of Agriculture, Washington, DC.

U.S. Department of Agriculture, Forest Service. 1985. Insects of eastern forests. A. T. Drooz (ed.). U.S. Department of Agriculture, miscellaneous publication 1426. Washington, DC. 608 p.

van Tol, R.W.H.M. and M.J. Raupp. 2005. Nursery and tree application. In: Grewal, P.S., R.-U. Ehlers, and D.I. Shapiro-Ilan (eds.), Nematodes as biocontrol agents. CAB Intl. London, UK.

Vann, S. and J. Robbins. 2008. Sapsucker damage on woody plants. University of Arkansas Extension publication FSA7561. http://www.uaex.edu/Other_Areas/publications/PDF/FSA-7561.pdf. Accessed April 19, 2012.

Vanek, S.J. and D.A. Potter. 2009. Host plant resistance among *Magnolia* spp. and *Quercus* spp. to soft scale pests. UK Nursery and Landscape Research Report - 2009. UK PR 602. http://www.ca.uky.edu/agc/pubs/pr/pr602/pr602.pdf. Accessed April 19, 2012.

Vanek, S.J. and D.A. Potter. 2010. Ant-exclusion to promote biological control of soft scales (Hemiptera: Coccidae) on woody landscape plants. Environmental Entomology 39:1829-1837.

Weber, B.C. and J.E. McPherson. 1983. Life-history of the ambrosia beetle *Xylosandrus germanus* (Coleoptera, Scolytidae). Annals of the Entomological Society of America 76:455-462.

Wilson, T.H. 1975. A monograph of the subfamily Panchaetothripinae (Thysanoptera: Thripidae). Memoirs of the American Entomological Institute 23:1-354.

Wood, S.L. 1982. The bark and ambrosia beetles of North and Central America (Coleoptera: Scolytidae), a taxonomic monograph. Great Basin Naturalist Memoirs no. 6.

Tables

Table 9.1. Number of production nurseries growing various magnolia species reported[1] for twelve southern states.

Species	Number of nurseries
Magnolia ×soulangeana and other hybrids not derived from *Magnolia acuminata* or *Magnolia stellata*	16
Magnolia acuminata and hybrids	5
Magnolia ashei	2
Magnolia figo	6
Magnolia grandiflora	138
Magnolia macrophylla	1
Magnolia maudiae	1
Magnolia stellata and hybrids	47
Magnolia tripetala	1
Magnolia virginiana (includes var. *australis* and var. *virginiana*)	65

[1] Plant & Supply Locator (2011)

Table 9.2. Characteristics of magnolia species and varieties widely grown by nurseries in the southern United States.

Scientific Name	Common Name	Hardiness Zone [3,4,5]	Leaf Size [1,4,5]	Plant Size [2,4,5]	Flower Characteristics [1,4,5]	Flowering Season [4,5]	Growth Rate [5]
M. acuminata[6] and hybrids	Cucumber-tree	4 - 8	2 - 8"L 1 - 4"W	50-80'H 50-80'W	2 – 4"W, cup-shaped Yellow-green to yellow	Late spring - early summer	Moderate - fast
M. figo	Banana-shrub	7 - 9	1 ½ - 4"L ½ - 2"W	6-10 (20)'H 6-10'W	1"W and 1½"L, cup- or egg-shaped Creamy white to yellow, sometimes with reddish purple edges	Late spring and early summer	Unknown
M. figo var. *skinneriana*	Skinner's banana-shrub	7 - 9	3 - 4"L 1 - 2"W	10-20'H 6-15'W	1" W and 1½"L, cup- or egg-shaped Creamy white to yellow	Late winter, spring, and sporadically in summer and fall	Unknown
M. grandiflora[6]	Southern magnolia	6 - 9	4 - 12"L 1 - 5"W	up to 80'H 30-50'W	6 – 12"W or more White	Late spring, summer	Slow - moderate
M. ×soulangeana and other hybrids	Saucer magnolia	4 - 9	3 – 7"L 1 ½ - 3 ½"W	20-30'H 20-30'W	5 – 10"W, cup-shaped White to deep red-purple	Spring	Medium
M. stellata and hybrids	Star magnolia	4 - 9	2 - 4"L 1 - 2"W	5-15'H 15'W	White, hybrid flower colors range from white to pink to red-purple	Early spring	Slow
M. virginiana var. *australis*[6]	Sweet-bay magnolia	6 - 9	5 - 6"L 1 - 2"W	40-60'H 15-25'W	2 – 3"W White or creamy white	Late spring, summer	Moderate - fast
M. virginiana var. *virginiana*[6]	Sweet-bay magnolia	5 - 9	3 - 5"L 1 - 2"W	10-20'H 10-20'W	2 – 3"W White or creamy white	Late spring, summer	Moderate - fast

[1] Leaf or flower size measurements in inches ("); L = long; W = wide

[2] Approximate plant size in the landscape in feet ('); H = height; W = width

[3] USDA Plant Hardiness Zones listed show maximum range; actual hardiness often is determined by the exact provenance from which a plant is derived.

[4] Callaway, 1994

[5] Dirr, 1998

[6] Native

Table 9.3. Pest-directed insecticidal activity and Insecticide Resistance Action Committee (IRAC) codes for use in developing a pesticide rotation plan to manage key pests of magnolia[1]. Check current products for labeled pesticides, sites for control, and plant[2] and pest species.

Active Ingredient	IRAC Code	Foliar Feeders & Leaf Miners	Soft Scales	Armored Scales[1]	Wood Borers	Thrips
abamectin	6	-	-	-	-	Y
acephate	1B	Y	Y	Y	-	Y
acetamiprid	4A	Y	Y	Y	-	Y
azadirachtin	unk	Y	Y	Y	-	Y
Bacillus thuringiensis	11	Y	-	-	-	-
Beauveria bassiana: BotaniGard	nr	Y	Y	Y	-	Y
bifenthrin	3A	Y	Y	Y	Y	Y
buprofezin	16	-	Y	Y	-	-
carbaryl	1A	Y	Y	Y	-	Y
chlorpyrifos	1B	Y	Y	Y	Y	Y
clothianidin: Arena	4A	Y	-	-	-	-
cyfluthrin: Decathlon	3A	Y	Y	Y	-	Y
cyfluthrin + imidacloprid	3+4A	-	Y	Y	-	Y
Diazinon[3]	1B	Y	Y	Y	-	Y
dimethoate	1B	Y	Y	Y	-	Y
dinotefuran	4A	-	Y	Y	-	Y
esfenvalerate	3A	Y	Y	Y	-	Y
flonicamid	PC	-	Y	Y	-	Y
horticultural oil	nr	Y	Y	Y	-	Y

Table 9.3. (*continued*) Pest-directed insecticidal activity and Insecticide Resistance Action Committee (IRAC) codes for use in developing a pesticide rotation plan to manage key pests of magnolia[1]. Check current products for labeled pesticides, sites for control, and plant[2] and pest species.

Active Ingredient	IRAC Code	Foliar Feeders & Leaf Miners	Soft Scales	Armored Scales[1]	Wood Borers	Thrips
imidacloprid	4A	-	Y	Y	-	Y
insecticidal soap	nr	Y	Y	Y	-	Y
kinoprene	7A	-	Y	Y	-	Y
lambda-cyhalothrin	3A	Y	Y	Y	-	Y
malathion	1B	-	Y	Y	-	Y
methiocarb	1A	-	Y	Y	-	Y
neem oil extract	18B	-	Y	Y	-	Y
novaluron	15	Y	-	-	-	Y
permethrin	3A	Y	-	-	Y	Y
pyriproxifen	7C	-	Y	Y	-	-
spinosad	5	Y	Y	Y	-	Y
tau-fluvalinate	3A	Y	Y	Y	-	Y
thiamethoxam	4A	-	Y	Y	-	Y

nr = not required to have an IRAC code

Y = a product with this active ingredient is labeled for use on the pest indicated; - = Not available for use

[1] Adapted from Knox, Gary W., William E. Klingeman, Mathews L. Paret and Amy F. Fulcher. Management of Pests, Plant Diseases and Abiotic Disorders of Magnolia Species in the Southeastern U.S.: A Review. Journal of Environmental Horticulture: In review.

[2] Check labels carefully to ascertain if any ornamental phytotoxity has been reported and test on a small portion of ornamental plants before spraying the entire nursery crop or range.

[3] Diazinon is no longer available in the market.

Table 9.4. Labeled fungicidal active ingredients and Fungicide Resistance Action Committee (FRAC) Codes to help pest managers integrate plant disease control within a pesticide rotation plan for magnolias[1]. Efficacy and phytotoxicity data available are largely unavailable for magnolia species and cultivars magnolia[2]. Check current products for labeled pesticides, sites for control, and plant and pest species.

Active Ingredient	FRAC Code	Plant Pathogen(s) Managed[3]
azoxystrobin	11	Anthracnose; powdery mildew
Bacillus subtilis strain QST 713	44	Anthracnose; powdery mildew
calcium polysulfides	n.l.	Powdery mildew
chloropicrin	8B	Phytophthora
chlorothalonil + thiophanate methyl: Spectro 90 WDG	M5 + 1	Anthracnose; powdery mildew
clove oil + rosemary oil + thyme oil: Sporatec	n.l.	Anthracnose; powdery mildew
copper	M1	Bacterial spot; syringae leaf spot; anthracnose; powdery mildew
corn oil + cotton seed oil + garlic oil: Mildew Cure	n.l.	Powdery mildew
hydrogen dioxide	n.l.	Phytophthora
mancozeb	M3	Anthracnose
metconazole	3	Anthracnose; powdery mildew
myclobutanil	3	Anthracnose; powdery mildew
neem oil: Trilogy	n.l.	Anthracnose; powdery mildew
polyoxin D zinc salt	19	Anthracnose; powdery mildew
potassium bicarbonate	n.l.	Anthracnose; powdery mildew
potassium phosphite	n.l.	Anthracnose; powdery mildew

Table 9.4. (*continued*) Labeled fungicidal active ingredients and Fungicide Resistance Action Committee (FRAC) Codes to help pest managers integrate plant disease control within a pesticide rotation plan for magnolias[1]. Efficacy and phytotoxicity data available are largely unavailable for magnolia species and cultivars magnolia[2]. Check current products for labeled pesticides, sites for control, and plant and pest species.

Active Ingredient	FRAC Code	Plant Pathogen(s) Managed[3]
potassium phosphate	n.l.	Powdery mildew
potassium phosphate + sulfur: Sanction	n.l. + M2 [4]	Powdery mildew
potassium silicate	n.l.	Powdery mildew
propiconazole	3	Anthracnose; powdery mildew
Reynoutria sachalinensis extract: Regalia	P [5]	Anthracnose; powdery mildew
sulfur	M2	Powdery mildew
tebuconazole	3	Anthracnose; powdery mildew
thiophanate methyl	1	Anthracnose; powdery mildew
triadimefon	3	Powdery mildew
trifloxystrobin	11	Anthracnose; powdery mildew

n.l. = FRAC code not listed; not required to have a FRAC code, or mode of action unknown

[1] Adapted from Knox, Gary W., William E. Klingeman, III, Mathews L. Paret and Amy F. Fulcher. Management of Pests, Plant Diseases and Abiotic Disorders of Magnolia Species in the Southeastern U.S.: A Review. Journal of Environmental Horticulture: In review.

[2] Check labels carefully to ascertain if any ornamental phytotoxity has been reported and test on a small portion of ornamental plants before spraying the entire nursery crop or range.

[3] Plant disease management information for magnolia derived from the ornamentals category within the CDMS Database (Engelbrecht, 2005; CDMS, 2011).

[4] "M" category modes of action have multi-site contact activity

[5] "P"= acts to induce host plant's defense mechanisms