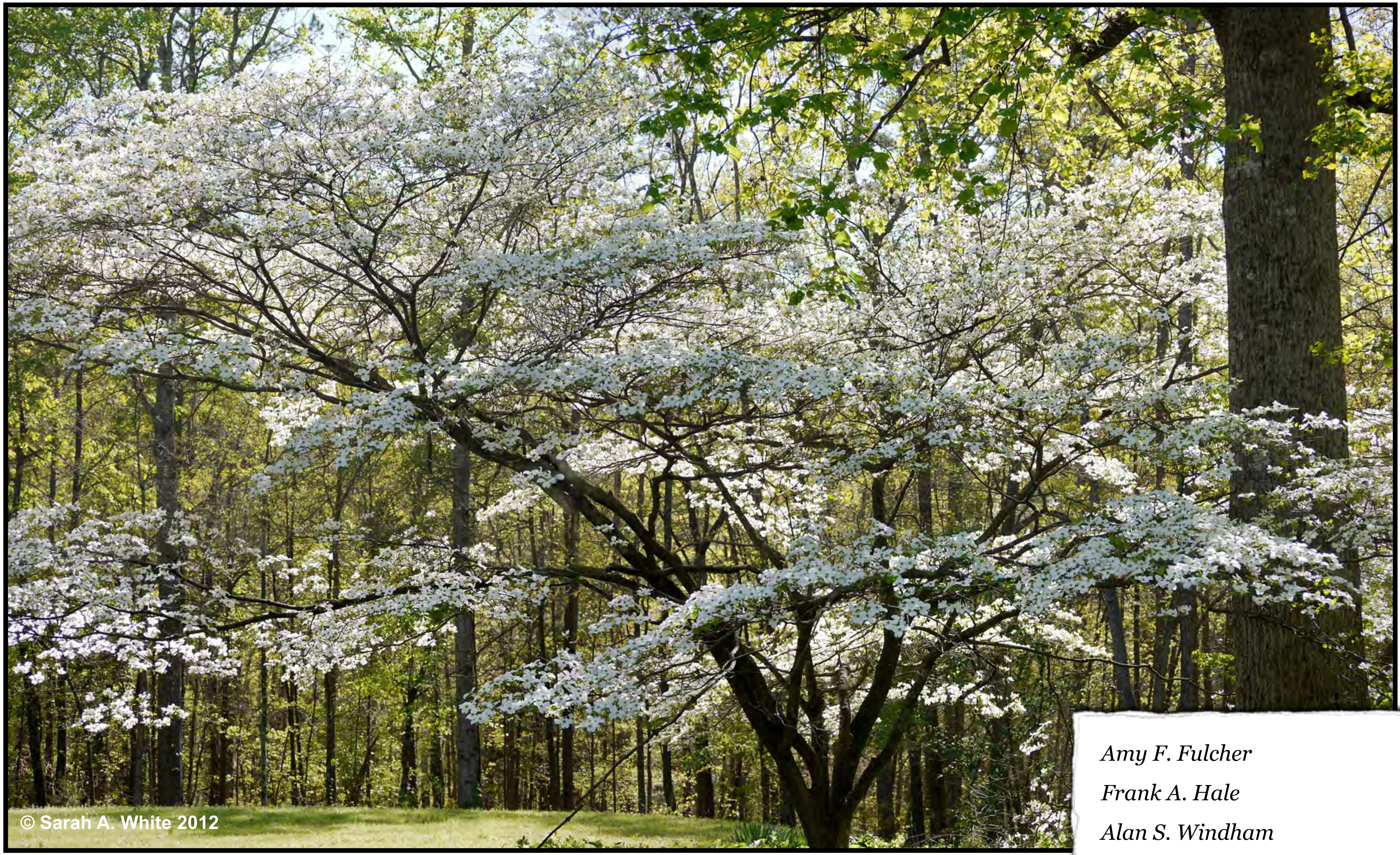
Dogwood - *Cornus* spp.



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SECTION 1

Introduction

DOGWOOD BASICS

1. Overview
2. Economic Value and Significant Dogwood Species and Selections
3. Horticulture Management & Production Practices

Dogwood tree species are widely represented in North America, South America, Europe, and Asia. Xiang et al. (2006) categorized *Cornus* into four major taxonomic groupings that include the big-bracted dogwoods, the dwarf dogwoods, the blue- or white-fruited dogwoods, and the Cornelian cherries. The big-bracted group, or clade, includes: *C. florida, C. florida* subspecies *urbiniana, C. nuttalli, C. disciflora, C. kousa, C. kousa* var. *chinensis, C. capitata,* and several subspecies of *C. hongkongensis.* In the United States, dogwood trees are largely grown for showy bracts that are often incorrectly called flowers. Dogwood trees most commonly grown by the commercial trade for their attractive bracts are members of the big-bracted clade: *C. florida* and *C. kousa* and their numerous selections and hybrids (Cappiello and Shadow, 2005).

Cornus florida is native to a wide range of the eastern United States, from north Florida to Michigan, New York, Massachusetts, and as far west as eastern Texas and Oklahoma. *Cornus kousa* and its varieties are native to Japan, Korea, Taiwan, and China, where these trees grow in mixed woodlands, streamsides, and valleys between 400 and 2,200 meters in elevation (Hillier Nurseries, 2007). *Cornus florida* is an understory tree indigenous to mesic forest areas. Currently, *C. florida* is considered endangered, exploitably vulnerable, and threatened in Maine, New York and Vermont, respectively (USDA NRCS, 2012).

Economic Value and Significant Dogwood Species and Selections

Flowering dogwood, *C. florida,* is one of the most popular landscape trees in the United States with $30,901,000 in total sales (USDA, 2009). Dogwoods are grown in many field nurseries in the Southeast (Tennessee, North Carolina, and Virginia are ranked 1st, 4th, and 9th, respectively in dogwood production) and are widely planted in landscapes throughout the eastern United States (USDA, 2009). Dogwood-producing nurseries have a very high income potential with gross returns of up to $60,000 per acre (Witte, 1995). Many cultivars are available that have originated from *C. kousa*, *C. florida,* and various *Cornus* hybridizations (Dirr, 2009).

Cornus florida is **hardy*** from USDA Plant Hardiness Zones 5 through 9, surviving winter low temperatures as cold as -25 to -35 °F. Trees grown from seed collected from

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

southern *C. florida* **provenances** should not be planted in the north as flower bud hardiness is inadequate. *Cornus kousa* is **hardy** from Zones 4 through 8. The flower buds of *C. kousa* are more cold **hardy** than those of *C. florida*. *Cornus kousa* and *C. florida* are both native to wooded areas and prefer moist, well-drained soils. *Cornus florida* and *C. kousa* tolerate heavy soils reasonably well but not flooded soils. *Cornus florida* roots do not tolerate soil compaction (Day et al., 2000). *Cornus kousa* also appears to be more tolerant than *C. florida* of acidic fogs that have been associated with air pollution. In *C. florida,* for example, trichomes can dehydrate, and stomate viability is degraded in direct proportion to increasing acidity (Stipes, 1995).

Anecdotal information suggests that *C. kousa* may be more drought tolerant than *C. florida* in the landscape (Dirr, 2009). However, Augé et al. (2002) found that many *C. kousa* seedlings did experience leaf curl and scorch under water deficit and high temperature conditions in field soils at an east Tennessee arboretum. *Cornus florida* is more adapted to climatic and soil conditions experienced in the lower South than *C. kousa* and *C. kousa* x *C. florida* hybrids (Hardin et al., 2002). *Cornus florida* responds to drying soil conditions with premature leaf drop and cellular osmotic adjustment (Augé et al., 2002). In a study of **mature** trees, Tschaplinski et al. (1998) found that although *C. florida* as a whole was not drought tolerant, leaves were moderately dehydration tolerant and performed better than crabapple (*Malus* spp.) and Carolina silverbell (*Halesia diptera*) in similar studies (Augé et al., 2002). These observations are consistent with the fact that *C. florida* trees do not possess a drought avoidance architectural advantage, such as capacity for deep rooting. Observations under commercial production conditions also support the hypothesis that *C. florida* is not deep-rooted when in its native habitat. For both *C. kousa* and *C. florida,* near maximum photosynthetic rates can be maintained across a range of container moisture contents (Fulcher and Geneve, 2011).

Horticulture Management and Production Practices

Propagation Overview: Dogwood can be propagated by seed, cutting, tissue culture, and grafting (Hartmann et al., 1997). Seed propagation is used for **rootstock** production and for production of landscape-sized *C. florida*. Cuttings are not a common propagation technique for dogwood. When used, *Cornus florida* cuttings are treated with 8,000 ppm IBA in talc or quick-dipped in 10,000 ppm IBA and then rooted under mist. Softwood cuttings of *C. kousa* should be taken from June through July, wounded, and treated with 8,000 ppm IBA talc or 2,500 ppm IBA and NAA (Fordham, 1984). Tissue culture is possible for the big-bracted *Cornus* but is limited by being successful only with seedlings or seeds and thus, is not helpful in rapidly increasing numbers of a new selection (Kaveriappa, 1997; Trigiano et al., 1989).

Budding is used almost exclusively to propagate cultivars and other selections (Figure 7.1). Seeds are densely planted in rows rather than seed beds to facilitate grafting--commonly 18 to 20 seeds per linear foot (Halcomb, 2002). Dogwood seeds are covered in sawdust to prevent soil crusting. Late frosts are a serious threat to dogwood seedlings. A range of techniques is used to protect dogwood seedlings from frost: straw, paper towels, winter wheat intercropped, polypropylene row covers, and burlap (Halcomb, 2002).

When grafting, *C. florida* is typically used as the **rootstock** for both *C. florida* and *C. kousa* **scions**, although flowering dogwood can be reciprocally budded (Fulcher, 2010). In

most commercial systems, plants in the field are **T-budded** onto seedling **rootstock** in August, approximately 9 months after sowing the **rootstock** seed (Halcomb, 2002).

Dogwoods will have seedling variability in vigor, leaf color, and disease susceptibility. Because *C. florida* is native to such a wide geographic range across a broad range of cold hardiness zones, seed **provenance** (geographic origin of seed) is important (Dirr, 2009). In the warmer areas of the southern U.S., bareroot seedlings should be lifted and transplanted in the fall rather than winter for optimal survival (Ruter et al., 1994).

Many dogwoods in commercial trade are sold as named selections, or cultivars, that are propagated by grafting (Cappiello and Shadow, 2005). Some seedling-propagated plants may be sold with simple "white" or "pink" catalog descriptions. Anecdotal information suggests that pink and red flowering dogwoods tend to be more susceptible to pest and plant disease problems than white dogwoods.

Production Methods Overview: Dogwoods have traditionally been produced in the field, harvested, and sold as B&B trees, although container production is increasing rapidly in part due to garden center demand for container-grown plants (Basham, 2004). The market, time to sale, and resources available all affect production methods and inputs. Geographic location, production method, and inputs affect the production time needed to grow marketable trees.

Container Production: Container production usually begins with an approximately 24 to 32-inch tall bareroot liner being transplanted into a #3 or #5 container. Using a **soilless substrate** with excellent drainage is essential because dogwoods in container production seem more prone to root rot than those in the field (Stolz et al., 2007). Pine bark is most commonly used as a **substrate**. Those dogwoods that do not succumb to root rot in a poorly-draining **substrate** will still have reduced root mass (Wilson and Fulcher, unpublished research). For this reason, irrigation must also be closely managed. Dogwoods like neither very dry nor saturated **substrate** conditions. **Substrate** that is kept evenly moist, but with good aeration, for example by using either **cyclic irrigation** or a controlled water table, often helps maintain plant health (Fulcher, 2010). Care should be taken to avoid transplanting into too large of a container size at any one time. Some growers successfully transplant a trade 3-gallon pot (or "#3") into a #7, and #7 into a #15. Pot-in-pot container systems can provide roots with a cooler growing environment. Dogwoods are generally considered intolerant of salts, whether on roots or applied aerially to foliage. Nutrient fertilizers essentially act as salts, and low to medium fertilizer rates are considered sufficient for plant growth (See Field Production section; Townsend, 1980, 1983, 1984).

Field Production: Field production begins by transplanting or "lining out" 18-inch-tall and larger barerooted seedling **liners**. Test soil and incorporate fertilizer as needed prior to lining out. Apply fertilizer (side-dress) in mid- to late February and late June with a total (yearly) of 50 pounds of nitrogen per acre or less (Halcomb, 2002). Some container-grown plants may also be referred to as "**liners**" and when used, are mostly planted in the fall. Plan to space **liners** at a minimum of 4 feet apart within rows. Consider the width of mowers, space needed to harvest trees, and distance across which an air-assisted sprayer can adequately deliver pesticides to trees to determine feet between rows, number of rows in a block, and number of rows between driveways (See Chapter 3). Transplanted **liners** will take approximately 5 to 6 years to reach a harvestable size (Halcomb, 2002). Drip irrigation can increase the quality of the trees and also decrease production time.

With *C. florida*, increasing the rates of nitrogen applied to crops appears to have decreased anthracnose severity when weather patterns were not conducive for development of the disease (Anderson et al., 1992). In general, increasing nitrogen fertilizer rates decreased Cercospora leaf spot but increased powdery mildew and spot anthracnose on bracts. However, nitrogen would have to be applied at 250 pounds per acre before an increase in powdery mildew is noticed (Anonymous, 2008).

Research conducted in Alabama showed that trees receiving 37.5 to 150 pounds of nitrogen per acre had similar flower bud set in two out of three years, but those receiving

600 pounds per acre had more flower buds (Anonymous, 2008). This contradicts earlier works indicating that excessive nitrogen rates would lead to shoot growth, not flower bud development (Witte et. al., 2000). In any case, 600 pounds of nitrogen per acre is considered excessive (Bilderback et al., 2007). Current nitrogen recommendations for field production are 50 pounds of nitrogen per acre.

General Production: Care should be taken whether growing dogwoods in field or container production to plant dogwoods at the proper depth. Grower observation and research show that *C. florida* is very sensitive to deep planting (Fare, 2005; LeBude and Bilderback, 2008). Ideally, transplanted **liners** and container-grown dogwood trees should be planted with the final soil level even with the **root flare**. The **root flare** is usually apparent at the point where larger first order lateral roots, or scaffold roots greater than 0.04 inch in diameter, emerge from the trunk (Anonymous, 2004).

In production, *Cornus* is often allowed to develop permanent branches as low as 1 foot above the ground. Several methods of training limbs are used by commercial growers depending on expectations of the market. Very high quality dogwoods primarily have horizontally oriented lateral branches, which creates an airy, layered appearance. These trees often have a definitive **central leader**. Vertically oriented lateral branches are removed with thinning cuts. For other markets, the plants are sheared with hedge shears to develop a fuller canopy. For some markets, *C. kousa* may be grown as multi-stemmed trees.

Insect and Mite Pest Management

L to R: Twospotted spider mite, granulate ambrosia beetle, dogwood borer

INSECT & MITE PESTS

1. Dogwood Borer
2. Flatheaded Appletree Borer
3. Granulate Ambrosia Beetle
4. Dogwood Club Gall
5. Dogwood Twig Borer
6. Rose Leafhopper
7. Dogwood Sawfly
8. Scale Insects: Cottony Maple and Walnut
9. Twospotted Spider Mite
10. Whitefringed Beetle
11. Broad Mite

Dogwood Borer (*Synanthedon scitula*): The dogwood borer is a destructive insect pest of dogwood. Feeding injury is inflicted by these moth **larvae** on the **cambium** layer beneath the bark on the trunk and at the base of older branches. **Larvae** are cream-colored with a reddish-brown spots apparent directly behind the head on the thorax. A full-grown larva is about 0.6 inch long. The adult dogwood borer is a blue-black moth with clear wings and some yellow markings. The adult moth does not damage the tree.

These moths emerge during about a four-month period from spring through early fall, beginning in March in the extreme South, in late April in eastern Tennessee, in mid-May in Virginia, and late May in Connecticut. The female moth lives only 7 to 9 days. New moths continue to emerge, mate, and lay eggs over an extended period of time from infested trees. **Larvae** that hatch within a growing season often do not mature into adults until the following year. The larva does its damage while tunneling and developing inside

the tree from one year to the next (Figure 7.2). After this feeding period, the larva forms the pupa, and in 8 to 12 days, the adult emerges.

Eggs deposited on the dogwood trunk by the moth hatch into tiny **larvae** in 8 to 10 days. Some of the young **larvae** find an opening in the bark where they can enter. Once beneath the bark, **larvae** are well protected. Larval feeding generally will not kill the dogwood unless the tree is very small. Usually, it takes several **larvae** in one tree to completely kill the tree, which occurs whenever one or more **larvae** eat the **cambium** layer completely around the trunk. Such feeding blocks the flow of food from the canopy to the roots. Often the tree will die back to the point of injury, and new shoots will arise below this point. These new shoots can often be kept to re-grow a new tree providing additional borer injury does not take place.

Fortunately, the dogwood borer does not attack all dogwood trees; injury is seldom encountered on *C. kousa* and its cultivars. Adult moths are also "light-loving" insects. Native trees in their natural understory habitat are seldom attacked. Trees that are never damaged by **sunscald**, lawn mowers, construction equipment, or strong winds are also much less likely to be attacked by borers than trees that are stressed or injured in some way.

Management: Damage from the dogwood borer can be prevented by protecting the tree trunk from **larvae**. Prevention may take place in one or more of the following ways: making pruning cuts in late winter to facilitate healing during rapid spring diameter growth; avoiding physical injury to the tree by unnecessary cutting or bruising; and mulching around trees or removing grass by hand rather than mowing close to a tree.

Insecticides can be used on the lower branches and trunk to kill newly hatched **larvae** before they can enter the tree. Once inside the bark, insecticides may not kill the **larvae**. For maximum protection, an insecticide residue should be on the trunk during the entire egg-laying period. Spray the trunk and the lower limb scaffold. These preventative insecticide sprays will also aid in the control of flatheaded borers. **Entomopathogenic nematodes** can be sprayed in the cracks and crevices of the bark as a rescue treatment for infested, unsprayed trees.

Flatheaded Appletree Borer (*Chrysobothris femorata*): The flatheaded appletree borer is among the most destructive pests of dogwood trees, as well as many other common deciduous shade trees grown for landscape use. This buprestid beetle pest completes one generation per year. Adult female beetles lay their eggs on the sunny side of trees starting in April and continuing into early summer (Hansen et al., 2009).

Feeding injury is primarily caused by the **larvae** that feed beneath the bark, damaging the **cambium** and **sapwood**. Larval feeding produces winding galleries packed with sawdust-like frass (excrement). The fully developed **larvae** tunnel into the heartwood and form pupal chambers that are plugged with frass. They begin to pupate from late April to mid-June with pupation lasting 1 to 2 weeks. The emerging adults exit branches and trunks by chewing D-shaped exit holes in the bark. These borers can do considerable damage to trees grown in a nursery in as little as a year, thus making infested trees unsalable.

Flatheaded appletree borers prefer to attack stressed or dying trees and tend to avoid actively growing ones. Proper irrigation, fertilization, and other practices that promote active growth will help reduce infestations and tree damage. Protective insecticide sprays should be applied to the trunk in late April and mid-June. Recommended **systemic neonicotinoid** insecticides that are applied to the soil around the base of the plant in early spring can provide a good control option for landscape trees.

Granulate Ambrosia Beetle – formerly known as the Asian Ambrosia Beetle – (*Xylosandrus crassiusculus*): The granulate ambrosia beetle is able to attack apparently healthy (although probably stressed) trees, shrubs, and vines across a wide range of host plants. The reddish-brown female beetles are 0.08 to 0.1 inch long, while the males are only 0.05 inch long. The **larvae** are white, legless, "C-shaped" and not easily distinguishable from the **larvae** of other ambrosia beetles, bark beetles, and most weevils (Ellis and

Horton, 1997). **Larvae** feed on the ambrosia fungi that the adult beetles introduce into the brood galleries. Pathogenic wilt fungi can also enter the tree through the holes made in the bark by attacking adult beetles.

Signs of attack include 0.04-inch-diameter tubes of sawdust-like frass sticking out from the many small holes in the trunk and **wilting** and oozing sap. The flight of the adult female beetles, determined by trap catches, primarily occurs in late winter or very early spring, often in concert with the first periods of warm weather (70 °F and above) while the trees are still dormant. If trees are being attacked, recommended insecticide sprays should be initiated at three-week-intervals and discontinued only after the plants have leafed out.

Dogwood Club Gall (*Resseliella clavula*): Injury from the dogwood club gall is most easily recognized as a distinct swelling to stems that occurs near branch tips. **Galls** may be found on transplanted trees as well as those growing in their natural habitat. The woody plant gall is caused by a small (0.08 inch), reddish-brown fly, *Resseliella clavula*.

In the spring, the female fly lays eggs in the small terminal leaves. After hatching from eggs, the tiny **larvae** bore into the twig at the base of a leaf. About one month after eggs are laid, **gall** swelling becomes noticeable. The larva completes its growth inside the **gall** by September, exits and drops to the ground where it overwinters as a pupa. The adult flies will emerge the following spring and repeat the cycle.

A light infestation of club galls will hardly be noticed and does not stunt tree growth. Most buds that develop in stem tissues beyond the **gall** will die. Trees with many **galls** will not be attractive, and the number of flowers the following spring will be reduced.

Management: The club gall can be controlled by pruning and insecticides. Future infestations can be reduced by pruning out and burning twigs containing **galls** before August 1 in central Tennessee.

Dogwood Twig Borer (*Oberea tripunctata*): The dogwood twig borer is a dark black-green, long-horned beetle that measures about 0.5 inch long and has three black spots on the light tan to reddish **prothorax**, or collar region, directly behind the head of the adult beetle. Beetles are usually found only in small numbers.

Adult beetles begin to appear in April and May in northern Georgia, from May through July in Pennsylvania, and from late May to early August in Michigan. Beetles chew on the leaf mid-vein, beneath the leaf, which may cause leaves to curl downward but causes little actual damage to plant health. The more serious damage from this pest has been associated with egg laying and feeding by the resulting larva, called a roundheaded borer. The female adult beetle uses chewing mouthparts to make small punctures around the branch to girdle it. Two girdles are made 0.5 to 1 inch apart and about 3 to 6 inches from the tip of a small branch. The beetle then lays an egg between the two separate girdles. The egg hatches in 7 to 10 days, and the young larva tunnels into the bark. The developing larva tunnels down the center of the limb, expelling frass through a row of small holes in the bark. A portion of the branch may be cut off from within. The **larvae** pass the winter in the center of the stem. The borer pupates between two plugs of sawdust. The development from egg to adult usually takes two years.

Wilted leaves and drooping girdled twigs are the main evidence of damage. Since the beetle occurs in small numbers, trees are not likely to be killed, but appearance may be impaired.

Management: Prune infested limbs in the spring before the adult beetles emerge. Make pruning cuts below the tunneled part of the branch and burn cuttings. This pruning cut will often be 6 inches or so below the girdled area.

Rose Leafhopper (*Edwardsiana rosae*): Dogwood leaves become white and stippled due to the feeding activity of the rose leafhopper. Leafhoppers overwinter as eggs in the stems of roses, blackberry, or raspberry. Eggs usually hatch in the spring after the threat of frost has passed. The young, greenish-white, red-eyed **nymphs** feed on the underside of the leaves until they mature.

The first brood of adults migrates to dogwood, maple, elm, apple, and other woody host plants. Leafhopper females insert eggs into leaf undersides. The eggs soon hatch, and the summer generation continues to develop. Several generations will develop during the season.

Management: Rose leafhopper can be controlled by spraying dogwood foliage with recommended labeled insecticides when leafhoppers appear. Repeat applications at 7- to 10-day intervals as needed. A soil or media drench of a recommended **neonicotinoid** insecticide in the spring will give season-long control.

Dogwood Sawfly (*Macremphytus tarsatus*): The dogwood sawfly is a defoliating wasp pest primarily of gray dogwood in the Great Lakes states and the Northeast. Sawflies are classified in the same insect order (Hymenoptera) as ants, bees, wasps, yellowjackets, hornets, and horntails. While they do not sting, the adult female sawflies use their serrated ovipositor to insert eggs into the leaf tissue. Adult wasps emerge from late May through July and soon deposit more than 100 eggs in the underside of a single leaf. The **larvae** of foliar feeding sawflies have more than five (usually eight) pairs of fleshy prolegs on the abdomen, while butterfly, moth, and skipper caterpillars (Lepidoptera) have a maximum of five (Figure 7.3). After hatching, the yellowish orange **larvae** skeletonize the leaf. They soon molt to the second instar stage and become covered with a white, powdery material that can be rubbed off. They then devour all of the leaf except for the midvein. The last instar **larvae** are 1 inch long with four rows of black spots in addition to the white material. The **larvae** leave the plant in search of a place to overwinter, where they bore into rotting wood and can even damage wooden clapboard, wood-fiber wallboard, or garden furniture (Klingeman and Taylor, 2007). There is just one generation per year.

Feeding preferences of dogwood sawfly **larvae** indicated host plant resistance in *Cornus* spp. (Klingeman et al., 2007). In this study, *C. florida*, *C. kousa*, and *C. mas* appear to be resistant to dogwood sawfly larval feeding, while the eastern Asian species, *C. alba* 'Sibirica', was the most susceptible, followed in preference by the U.S. natives *C. racemosa* and *C. sericea* 'Flaviramea'.

Management: Dogwood sawfly can be controlled by spraying the foliage with recommended labeled insecticides when dogwood sawflies are first detected.

Cottony Maple Scale (*Pulvinaria innumerabilis*): The cottony maple scale is a very large and conspicuous scale insect found on a wide variety of ornamental plants. Adult females are generally reddish-brown and have a median ridge. Adult females overwinter and enlarge rapidly in the early spring. The white **ovisacs** containing up to 1,000 eggs are developed under the raised abdomen in mid- to late spring. The newly hatched **crawlers** move to leaves in late spring, where they develop into adults in late summer. This scale produces large quantities of **honeydew**, which frequently supports the growth of **sooty mold**.

Management: If given time, lady beetles and other predators and **parasitoids** often control this pest without the need for insecticides. **Dormant oil** can be applied in late winter while the trees are still dormant. Target the **crawlers** (first active immature stage) with a recommended labeled insecticide in the late spring to early summer. A couple of applications at weekly intervals may be needed.

Walnut Scale (*Quadraspidiotus juglansregiae*): The walnut scale can also cause extensive damage to dogwood by inhibiting the terminal growth of limbs and by encrusting the limb and trunk leading to death of the tree. Initial infestations occur on the underside of limbs and can completely encrust the limbs within 2 to 3 years. The walnut scale has two generations per year. The adult female walnut scale lays eggs in June and again in August in Ohio, and in mid-May and in mid-August in California. The **crawlers** emerge from the eggs several weeks after they are laid.

Management: Adults are difficult to control because of the wax-like protective covering over their bodies. **Juvenile crawlers** are the easiest stage of the walnut scale to control. Consult with your local county Extension agent for when to expect **crawlers** and apply the recommended chemical controls.

Twospotted Spider Mite (*Tetranychus urticae*): Twospotted spider mites are warm-season mites that can quickly build to tremendous numbers in hot, dry weather. These non-insect pests can develop from egg to adult in only eight days when air temperatures are between 77 °F and 95 °F. Twospotted spider mites attack more than 180 host plants, including 100 cultivated species. Twospotted spider mite populations often increase on common plants such as violet, chickweed, pokeweed, wild mustard, and blackberry. They can then disperse to other plants, including dogwood.

Twospotted spider mites damage leaves by piercing the outer leaf surface with their sharp, slender mouthparts. When they extract the sap, a tiny bit of leaf tissue collapses in the area of the puncture. Soon, a small chlorotic spot forms at each feeding site. After a heavy attack, an entire plant may become yellowed, bronzed, partially defoliated, or completely killed. Twospotted spider mites are generally found on the underside of the leaves where they feed, lay eggs, and spin webbing. High populations of twospotted spider mites, especially during extended dry periods, can entirely cover leaves with silk strands of webbing.

Inspect dogwoods periodically during the spring and summer. Use at least a 10x magnifying glass to look for the mites, cast skins, eggs, and their webbing on leaf undersides. When **scouting**, hold a white paper or card beneath plant foliage and dislodge mites onto the card. Pale yellow mites can be observed as they crawl across the card. Observe the top of leaves for the tiny, chlorotic feeding spots on either side of the mid-vein.

Management: Begin chemical pesticide treatments at the first signs of mite damage because population levels can build rapidly. At least two sprays will be needed about five days apart. Summer horticultural oil sprays should not be made more than once per week. Some miticides have a long residual activity so that one application is sometimes sufficient for control of small populations. To slow the buildup of resistance to some of the new miticides, the label may limit its use to once per year or not allow it to be used in successive applications. Some miticides only control immature mite stages, so a different miticide to control adult mites may be required.

Whitefringed Beetle (*Naupactus* [=*Graphognathus*] *leucoloma*): Whitefringed beetle is a plant-feeding weevil that is native to South America. It was initially introduced into Florida in 1936. They can be found in clustered populations that extend across nearly the entire southeastern United States and have also been found in Michigan and several western states (Klingeman et al., 2002). Adult beetles are gray in color with a light band of pale **setae** (hairs) extending along the outer margins of their wing covers (Ketchersid, 2002). Two pale longitudinal lines run along each side of the thorax and the head, one just above and one just below the eye (Figure 7.4a).

Fig. 7.4a
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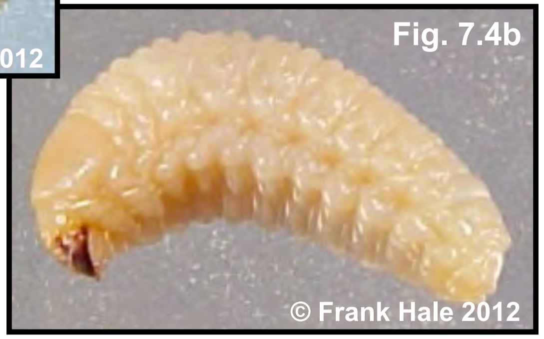

Fig. 7.4b
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Females reproduce by **parthenogenesis**, which means that they do not need to mate with a male to produce viable eggs. All whitefringed beetles found in the United States are female, although males can be found in South America. Adults emerge from the soil in mid-June at about the same time Japanese beetles first emerge. They begin to lay eggs 5 to 25 days afterward. The egg laying period extends through the summer and into the fall. Thus, various ages and sizes of **larvae** can be found in the soil at any one time.

While adult whitefringed beetles have been observed feeding on over 385 plant species distributed among 41 families, **larvae** are considered the primary damaging stage. The **larvae** feed on root cortical tissue of more than 240 different species, which can cause severe damage and death of plants. **Larvae** are pale-yellow, C-shaped, and legless (Figure 7.4b). The feeding injury is inflicted on plant roots and underground structures with the **larvae's** prominent brown mandibles.

Scouting highly preferred host plants like young dogwoods or common ragweed can confirm the presence of adults. The adults leave C-shaped feeding scars and fecal material on leaf margins (Figure 7.5a). Once this adult feeding injury is found, adult females can often be located by shaking foliage and observing the base of the plant for their presence. The symptoms of larval feeding such as yellowed, curled, or wilted leaves are often mistakenly attributed to disease, drought, or alternative pests. Plants that do not die are often stunted. A plant suspected of hosting whitefringed beetles can be dug from the soil, and the soil surrounding the roots can be sifted to look for feeding **larvae** or the pale **pupae** (Figure 7.5b).

Management: To achieve effective population reductions, adults need to be controlled before they can lay eggs on twigs and other debris on the soil surface. Scheduled insecticide applications need to be applied on the plants and the total soil surface while adults are encountered during **scouting** (June through September). Keep infested fields free of weeds. Do not use leguminous cover crops such as red clover. Instead, use oats, sudex, or small grains. Do not plant dogwoods near other preferred hosts such as kobus magnolia or yellowwood.

Fig. 7.5a
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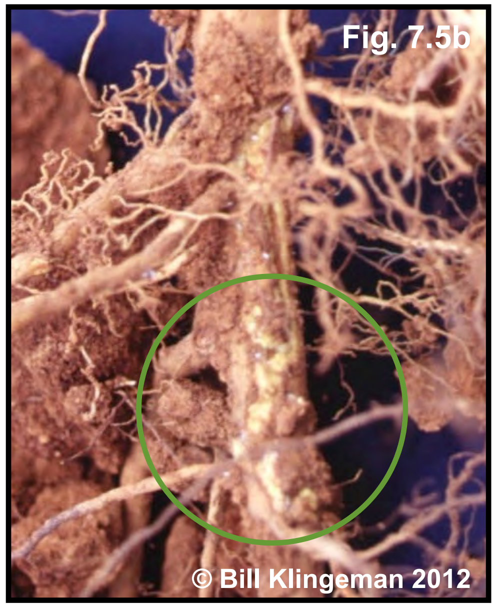

Fig. 7.5b
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Broad Mite (*Polyphagotarsonemus latus*): Broad mites are distributed worldwide and feed on a diverse range of plants (57 botanical families). An adult female broad mite is less than 0.2 mm long, about half the size of a **mature** twospotted spider mite (Figure 7.6a). Their tiny size and translucent-to-slight-yellowish coloration make them very difficult to see. A dissecting microscope is preferable to using a 10X or 20X hand lens. The broad mite eggs, oval-shaped with 30 or more bumpy knobs across their surface, are often easier to detect than the mites themselves. Cyclamen mite eggs are similar in size and appearance except that they lack the knobs found on broad mite eggs.

Broad mites prefer to feed with piercing-sucking mouthparts on flower and leaf buds and on the underside of expanding new leaves (Klingeman and Hale, 2003). Developing leaf tissues become brittle and contorted. Leaf edges curl, and the leaf becomes cupped or strap-shaped (Figure 7.6b). Foliage and flowers can become silvery, purple, or copper-colored. Affected leaves and fruit may drop prematurely. Shortened internodes and a greater-than-average number of lateral buds will break. Plants can stop growing and even be killed when under heavy attack. While it is not fully understood how feeding injury occurs, observations suggest that salivary toxins injected into plant tissues during feeding cause the damage.

Management: Several strategies can be used to manage broad mites in production systems. Broad mites are heat sensitive. Eggs, **larvae**, and adults can be killed by immersing infested plant cuttings in water heated to about 112 °F for 15 minutes. Test a few cuttings from each plant species first, since some plants are damaged by hot water immersion. A predatory mite, *Neoseiulus* [=*Amblysieus*] *barkeri*, is reported to feed on broad mites and is commercially available. Not all registered miticides will control broad mites on ornamentals. Because broad mites are seldom found on fully expanded leaves, successful management using miticides relies on thorough treatment of buds and axils where new plant growth is found.


Fig. 7.6a


Fig. 7.6b

Section 3

Disease Management

Dogwood anthracnose

Common Disease Pests

1. Dogwood Anthracnose
2. Septoria Leaf Spot
3. Powdery Mildew

Dogwood Anthracnose (*Discula destructiva*): Dogwood anthracnose attacks both *Cornus florida* and Pacific dogwood (*C. nuttallii*), while *C. kousa* is considered a very minor host (Daughtrey and Hibben, 1994). The disease was first detected on *C. nuttallii* in 1976 near Vancouver, WA, with symptoms first detected on *C. florida* a few years later (Daughtrey et al., 1996). The origin of the *Discula destructiva* pathogen is unknown; however, genetic evidence indicates that *D. destructiva* has been a relatively recent introduction into the United States (Daughtrey et al., 1996). Dogwood anthracnose infection occurs on both cultivated plants and natural stands of *C. florida*. The disease has spread throughout the West Coast, East Coast, and the southern Appalachians causing tree mortality near 80% in some areas (Holzmueller, 2006). Dogwood anthracnose has not been a major problem for nurseries growing flowering dogwood. It is possible that early publicity about the disease prompted changes in cultural practices that minimized the disease. Alternatively, fungicide cover sprays that are applied for powdery mildew management may have lessened the impact of *D. destructiva*.

Foliar symptoms of the disease include necrotic **lesions** surrounded by a reddish area (sometimes a halo), dead tissues along the leaf margins or at the tip of the leaf, shot holes, followed by death of the whole leaf (see Disease Management section introductory image; Hibben and Daughtrey, 1998). Leaves may cling to the branches until the following year. In the southern United States, defoliation is a major symptom. Symptom severity also varies depending on light intensity (Chellemi, 1992). Dogwoods growing in full sun are likely to have smaller **lesions** with purple margins, while trees growing in full shade are more likely to have whole leaves disfigured by the fungus. Branches and twigs often die due to dogwood anthracnose infection. For this reason, the disease was once known by the common name “lower branch dieback”. Brown, oblong cankers may also form on branches and the trunk, often at the base of dead branches. The area may be swollen, and the bark may split open.

Rainy periods and use of overhead irrigation are conducive to secondary infection. Trees grown in shade and areas of the plant that are more shaded are prone to severe infection. This is attributed to the increased humidity and reduced evaporative demand rather than the direct effect of light levels. Leaf surfaces stay wet longer under these conditions and may be subject to increased spore germination. Trees experiencing **drought stress** also have greater disease susceptibility (Erbaugh et al., 1994).

Management: Careful management of environmental conditions during production can aid in preventing or reducing this disease. Use **micro-irrigation** rather than overhead irrigation. Irrigation management may help limit the incidence of other fungal pathogens as well. Consider the use of shade cloth carefully as greater shade can make the environment more conducive to infection. Prune for good light penetration. Use hand pruners rather than shears and make selective cuts back to the point of origin. If improperly pruned with heading back cuts, branches may experience a proliferation of growth from a single point. The resulting architecture leaves foliage susceptible to plant pathogen spread. Space plants to allow adequate light and air penetration. Fungicides are necessary for protecting susceptible plants when disease pressure is severe. Chlorothalonil, as well as propiconazole, tebuconazole, and triforine, which have **systemic** control efficacy, are effective at managing dogwood anthracnose (Britton, 1993; Smith and Britton, 1992; Windham and Windham, 1992). Fungicide applications and related expenses can be substantially reduced by growing dogwoods like *C. florida* 'Appalachian Spring' that are resistant to dogwood anthracnose (Gardner et al., 2003; Klingeman et al., 2004).

Septoria Leaf Spot (*Septoria cornicola, Septoria cornicola* var. *ampla,* and *Septoria floridae*): Septoria leaf spot is more common in landscapes than nurseries, as many nurseries apply multiple fungicide cover sprays to combat powdery mildew. Septoria leaf spot causes little harm other than marring the aesthetics of dogwood leaves. However, in a conducive environment, the symptoms may become severe during late summer through early fall. Symptoms include purplish spots, about 0.25 inch in diameter (Figure 7.7). Spots develop grey centers over the season, but the dark purple border remains. Spots are angular and are often delineated by veins (Sinclair et al., 1987).


Fig. 7.7

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Susceptible dogwood species include pale, grey, pagoda, redosier, and flowering dogwood. Flowering dogwood (*C. florida*), Siberian dogwood (*C. alba* 'Siberica'), and yellow twig dogwood (*C. sericea* 'Faviramea') appear to be more susceptible in landscapes than in field or container nurseries (Daughtrey and Hagan, 2001). White cultivars seem to be more susceptible than pink-bracted cultivars.

Management: Chemical control measures are not usually needed but may be warranted for container-produced trees going to high-end markets. Good plant spacing and pruning can aid air circulation, limiting infection. Irrigation in the early morning or micro-irrigating container-grown trees, which applies water to the **substrate** surface, can limit leaf wetness and reduce infection.

Powdery Mildew (*Erisyphe pulchra* [=*Microsphaera pulchra*] and *Phyllactinia guttata*): Dogwood powdery mildew is caused by *Erisyphe pulchra* (synonymous with *Microsphaera pulchra*) and *Phyllactinia guttata*. *Erysiphe pulchra* is the more common of the two powdery mildew fungi; *Phyllactinia guttata* is rarely observed on *C. florida*.

Dogwood powdery mildew occurred rarely in the United States until 1994 when it was diagnosed extensively on dogwoods in landscapes, nurseries, and woodlands. Powdery mildew led to the destruction of tens of millions of dollars of dogwoods in production. In the years following the arrival of powdery mildew, disease management costs increased more than tenfold from $120/ha/year to $1,975/ha/year, and those who couldn't afford the increased production costs reportedly abandoned fields (Li et al., 2009).

In the past, fungi that caused powdery mildew were often identified by distinctive appendages on their ascocarps. Recent DNA analysis of the powdery mildews show that morphology of the asexual stage (**conidia** and condiophores) can be more accurately used to identify these fungi than appendages on their ascocarps. The asexual stage of *E. pulchra* is *Oidium* sp. It forms **conidia** that serve as **inoculum** that develop and cause re-infections throughout the season. The initial symptoms are circular or irregular white colonies of the fungus on the upper leaf surface that are comprised on **mycelia** and **conidia** (Figure 7.8). These colonies coalesce, and leaf tissue becomes darker with yellowish or brownish patches. As the season progresses, the leaves develop reddish pigmentation, and in some cases, the reddening may be the only obvious indication of infection. Symptoms may be mistaken for **drought stress** or root or trunk damage that inhibits adequate water uptake. Toward the end of the growing season, light brown to black chasmothecia are visible primarily on the lower leaf surface. Chasmothecia are the most important overwintering structure for *E. pulchra* in Tennessee (Klein et al., 1998; Mmbaga, 2000). Powdery mildew negatively affects bloom. Flowering dogwood stressed by powdery mildew will often set fewer flower buds as compared to healthy trees.

Management: Host plant resistance is a cornerstone of IPM and is a key strategy for powdery mildew. There is a range of susceptibility to powdery mildew among the *Cornus* **genus**. *Cornus florida* is generally very susceptible. *Cornus kousa* and *C. kousa* x *C. florida* hybrids tend to be resistant to highly resistant. 'Jean's Appalachian Snow', 'Kay's Appalachian Mist', 'Karen's Appalachian Blush', and 'Appalachian Joy' are highly resistant flowering dogwoods from the University of Tennessee dogwood development program (Windham et al., 2003). Powdery mildew resistance is caused by reducing pathogen infection efficiency and reduced **hyphae** development and asexual reproduction (Li et al., 2006; Li et al., 2007). Resistance may also be related to antifungal compounds found in the waxy cuticle of the leaves of resistant plants.

Preventing powdery mildew infection with fungicide applications has increased biomass (tree height and trunk **caliper**; Hagan et al., 2002; Windham et al., 1998; Windham et al., 1999). Biweekly fungicide applications of chlorothalonil, thiophanate methyl, and demethylation inhibitors (fenarimol, myclobutanil, triadimefon, and propiconazole) can prevent infection. Strobilurins can also be effective against powdery mildew and have a different **mode of action**, therefore they can be part of a pesticide rotation for powdery mildew applications. Also, some stobilurins have short re-entry intervals, which can make scheduling critical production practices and pesticide applications easier.

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Tables

Table 7.1. Growth characteristics[1] of selected cultivars of big-bracted flowering dogwood.

Cultivar	Form	Color	Flower	Habit	Growth Rate	Water Use
'Cherokee Brave'	Shrub or small, low branched trees, flat top	Dark green to red in fall.	Reddish-pink with white center	Small tree or shrub	Fast	Medium
'Cherokee Chief'	Spreading, dense	Dark green to red in fall; Reddish new growth	Deep red bracts	Spreading, dense	Slow - medium	Medium
'Cherokee Princess'	Shrub or small, low branched trees, flat top, wider than high	Fall: rust red	White with large bracts- 5" across	Small tree or shrub	Slow - medium	Medium
'Cloud 9'	Spreading, flowering tree	Fall: scarlet	Showy white overlapping bracts, blooms profusely when young	Spreading	Slow	Medium
'Appalachian Joy'	Small, low branched tree, flat top, wider than high	Fall: purple-red	White with extra bracts	Small tree	Slow - medium	Medium
'Kay's Appalachian Mist'	Small, low branched tree, flat top, wider than high	Fall: red	Stiff creamy bracts with purple clefts	Small tree	Slow	Medium
'Jean's Appalachian Snow'	Small, low branched tree, flat top, wider than high	Fall: red	Large, bright white-overlapping bracts	Small tree	Slow - medium	Medium
'Karen's Appalachian Blush'	Small, low branched tree, flat top, wider than high	Fall: red	Large, floppy bracts with pink clefts	Small tree	Slow - medium	Medium
'Appalachian Spring'	Small, low branched tree, flat top, wider than high	Dark green; Fall: red	Large white bracts do not overlap	Upright, small tree	Slow - medium	Medium

[1] Cappiello and Shadow, 2005; Dirr, 2009; and Missouri Botanical Garden, 2011

Table 7.2. Typical macro- (A) and micro-nutrient (B) concentrations reported[1] in recently mature leaves collected in summer from current season's new growth of selected dogwood species and cultivars.

(A) Macronutrient	Nitrogen	Phosphorus	Potassium	Calcium	Magnesium	Sulfur
	% dry weight					
Cornus alternifolia	1.81	0.33	1.40	2.59	0.81	0.60
Cornus controversa	2.06	0.60	0.99	2.60	0.25	0.35
Cornus florida	1.37-1.79	0.14-0.18	0.37-1.18	1.60	4.21	0.70
cultivars [2]	1.57-2.11	0.20-0.35	0.68-1.06	2.39-3.17	0.26-0.62	0.41-0.58
'Cherokee Sunset'	1.91	0.31	0.92	2.80	0.34	0.35
var. *rubra* [3]	1.71-2.13	0.14-0.37	0.72-0.99	2.06-3.16	0.30-0.56	0.34-0.50
Cornus kousa	1.63-1.94	0.14-0.46	0.77-1.13	1.96-2.71	0.23-0.34	0.21-0.32
var. *chinensis* [4]	1.32-1.95	0.13-0.15	0.62-1.49	2.05-2.78	0.24-0.43	0.18-0.42
Cornus mas	1.63-2.07	0.11-0.45	1.00-1.45	2.08-2.45	0.30-0.37	0.25-0.30
Cornus officinalis	1.47	0.19	1.62	1.59	0.39	0.27

Table 7.2. (*continued*) Typical macro- (A) and micro-nutrient (B) concentrations reported in recently mature leaves collected in summer from current season's new growth of selected dogwood species and cultivars.

(B) Micronutrient	Iron[5]	Manganese[6]	Boron	Copper[6]	Zinc[6]	Molybdenum	Sodium	Aluminum
	ppm (µg/g)							
Cornus alternifolia	56	49	47	5	19	0.12	75	35
Cornus controversa	63	48	24	4	11	0.16	63	31
Cornus florida	210	50	22	7	28	nd	nd	1200
cultivars [2]	43-74	27-63	34-44	4-5	10-25	0.12-0.30	310-1390	24-64
'Cherokee Sunset'	62	33	44	5	15	0.12	1117	38
var. *rubra* [3]	45-126	38-60	40-52	5-6	16-19	0.12-0.30	1091-1424	24-32
Cornus kousa	22-49	13-117	11-29	3-5	10-17	0.02-0.12	59-872	23-132
var. *chinensis* [4]	47-60	25-96	11-102	2-19	13-19	0.12-0.35	35-67	86-1275
Cornus mas	28-106	9-32	38-100	3-6	26-30	0.13-0.16	79-141	71-141
Cornus officinalis	59	66	82	5	15	0.12	105	32

[1] Mills and Jones, 1996
[2] White flowering *Cornus florida* cultivars sampled: 'Barton', 'Cherokee Princes', 'Pendula', 'Plena', and 'Welch's Bay Beauty'
[3] Pink or red flowering *Cornus florida* var. *rubra* cultivars sampled: var. *rubra* seedlings, 'Cherokee Chief', 'Junior Miss', and 'Prosser Red'
[4] Chinese flowering dogwood (*Cornus kousa*) cultivars sampled: var. *chinensis*, 'Milky Way', and 'Morning Star'
[5] Surface contamination of foliage from soil and presence of unavailable (physiologically inactive) and immobile iron in plant tissues limits the informative value of iron measured by foliar analyses.
[6] Leaf tissue analyses of Cu, Mn, and Zn may not be reliable indicators of plant nutritional status because *Cornus* spp. foliage in commercial nurseries may be exposed to fungicides and nutrient solutions containing trace elements, and surface level contamination may persist even after leaves are washed.

Table 7.3. Relative tolerance to environmental conditions among common dogwood species and cultivars grown in mid-south United States nurseries.[1]

Dogwood Species	Salinity	Soil pH Range	
		5.0 - 6.5	7.5 - 8.2
Flowering dogwood, *Cornus florida*	Low	Yes	No
Kousa dogwood, *Cornus kousa*	unk[2]	Yes	No
Cornelian cherry, *Cornus mas*	Low	Yes	Yes

[1] Costello et al., 2003
[2] unk = unknown