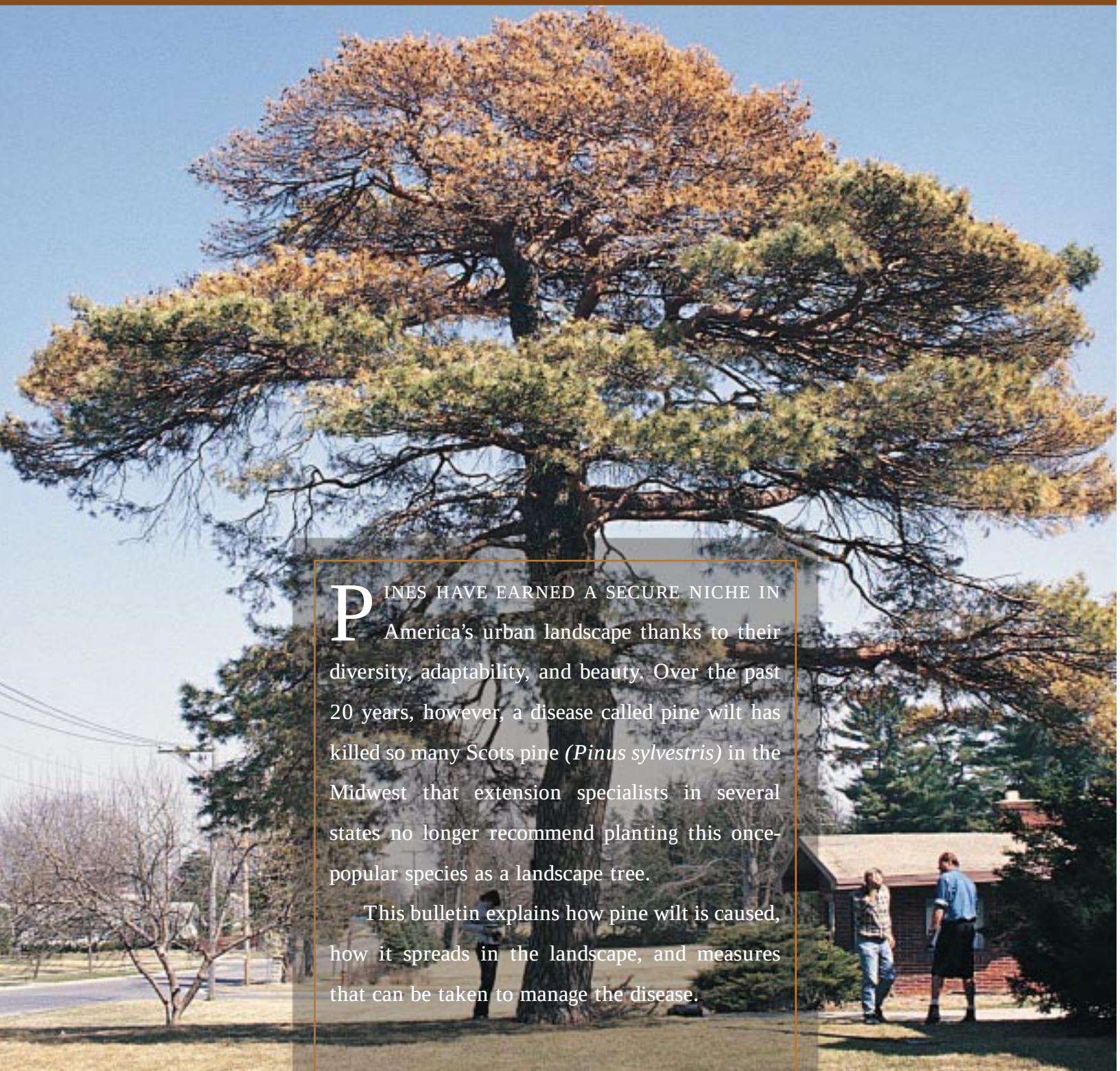
Sustainable Urban Landscapes

PINE WILT

A fatal disease of exotic pines in the Midwest



PINES HAVE EARNED A SECURE NICHE IN America's urban landscape thanks to their diversity, adaptability, and beauty. Over the past 20 years, however, a disease called pine wilt has killed so many Scots pine *(Pinus sylvestris)* in the Midwest that extension specialists in several states no longer recommend planting this once-popular species as a landscape tree.

This bulletin explains how pine wilt is caused, how it spreads in the landscape, and measures that can be taken to manage the disease.

FIGURE 1
Scots pine, 10 to 12 years old, dying from pine wilt. The diseased tree at right shows more advanced needle browning than the diseased tree at left, whose needles are still primarily green but faded in color.

FIGURE 2
Scots pine with partial dieback due to pine wilt.

In the Midwest, more than 90 percent of the trees killed by pine wilt have been Scots pine.

Symptoms and impact

Pine wilt typically kills Scots pine within a few weeks to a few months (Figures 1–3). The needles initially turn grayish green, then tan-colored to brown (Figure 1). Resin flow from the wood also ceases as the tree declines. Needles remain on the dead tree for a year or more. Scattered branches on a tree may be affected initially (Figure 2), but the problem soon spreads to the remaining branches (Figure 3). In other situations, however, the entire tree turns brown all at once.

Other pine species are occasionally killed by pine wilt, and display a similar pattern of symptoms. The disease appears occasionally in Austrian *(Pinus nigra)*, jack *(P. banksiana)*, mugo *(P. mugo)*, and red *(P. resinosa)* pines, and rarely in white pine *(P. strobus)*. In the Midwest, however, more than 90 percent of the trees killed by pine wilt have been Scots pine. Native pine species are usually not susceptible to pine wilt.

Tree age influences the risk of pine wilt. Almost all cases of the disease have appeared in trees more than 10 years old. Pine wilt has not had a major impact on Christmas tree plantations of Scots pine. However, pine wilt has appeared in Scots pine plantations in which trees older than 10 years have not been harvested, and in abandoned Scots pine plantations. Nevertheless, the primary impact of pine wilt is on Scots pine in landscape plantings and windbreaks.

The center of the pine wilt problem in the United States is in the Midwest. Iowa, Illinois, Missouri, Kentucky, eastern Kansas, and southeastern Nebraska have experienced heavy losses of Scots

FIGURE 3
A Scots pine killed by pine wilt.

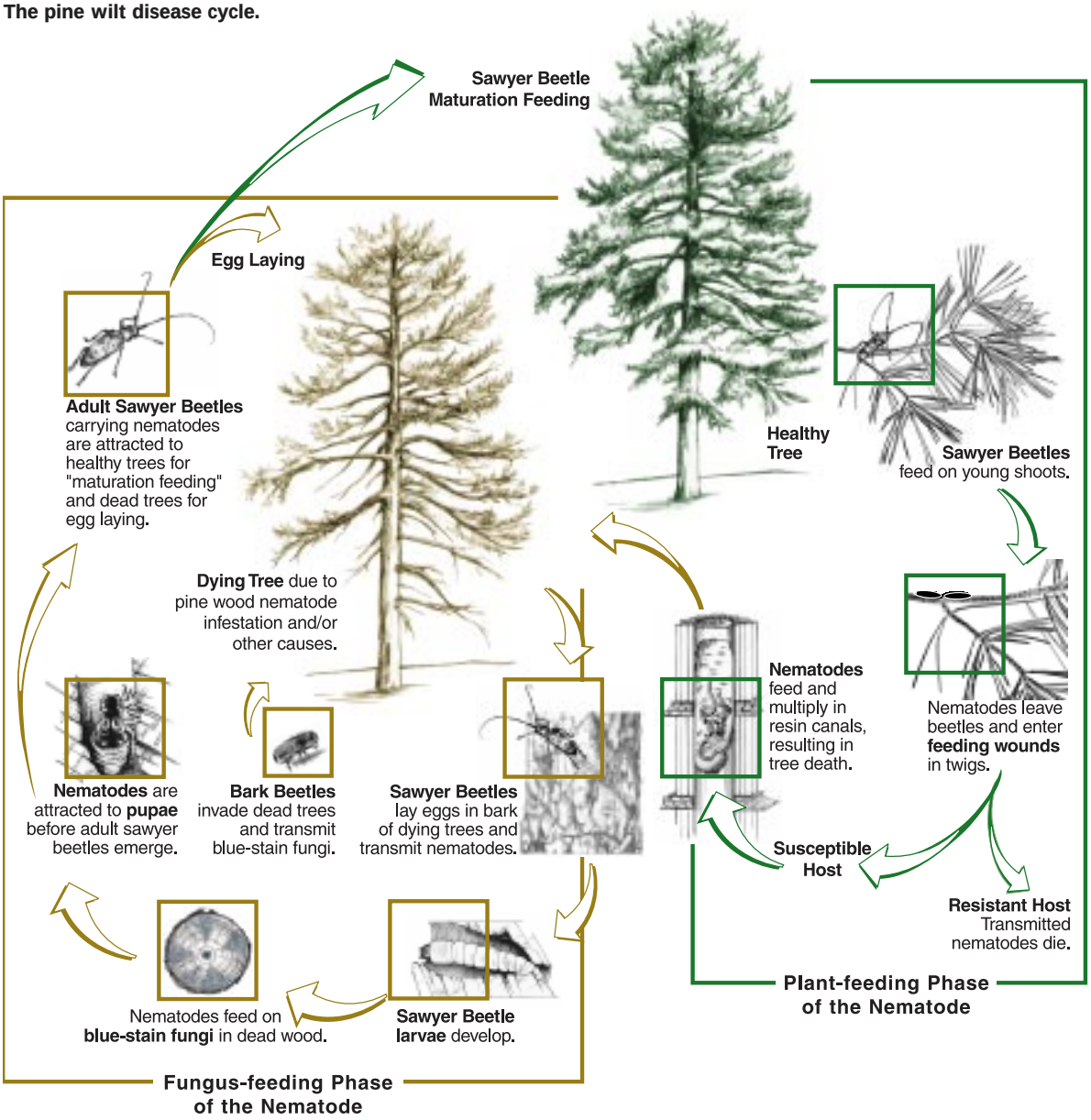
pine. However, neighboring states such as Indiana, Ohio, and Minnesota have reported relatively few cases of pine wilt.

The greatest losses to pine wilt have occurred in Japan. During the 20th century, the disease spread through highly susceptible Japanese black *(P. thunbergiana)* and Japanese red *(P. densiflora)* pine forests with devastating impact. Pine wilt has appeared in China within the past 20 years, and in Korea and Taiwan within the last decade.

How pine wilt attacks pines

Several organisms are involved in pine wilt (Figure 4). The pinewood nematode, *Bursaphelenchus xylophilus*, is probably native to the United States. These microscopic-sized (1 mm in length), worm-like animals (Figures 5 and 6) feed not only on blue-stain fungi (*Ceratocystis* spp.) (Figure 7) that live in the wood of dead and dying pines but also on the living plant cells surrounding the resin canals, or water-conducting passages, of pines.

FIGURE 4
The pine wilt disease cycle.



Interaction of the pine wood nematode with sawyer beetles to cause pine wilt.
Redrawn with permission from Wingfield, ed. (1987) *Pathogenicity of the Pine Wood Nematode*, APS Press, St. Paul, MN.

The pinewood nematode, *Bursaphelenchus xylophilus*, is probably native to the United States.

FIGURE 5
Microscopic view of the pinewood nematode.

FIGURE 6
A distinguishing feature of the pinewood nematode is a stirrup-shaped structure called a spicule (see arrow) at the posterior end of the adult male nematode.

FIGURE 7
Sectors of cobalt-blue discoloration in a Scots pine log, caused by blue-stain fungi.

Nematodes are unable to move very far without help from an insect vector. The life cycle of the pine sawyer beetle (*Monochamus* spp.) (Figure 8), also known as the longhorned beetle because of its very long antennae, is closely intertwined with the life cycle of the pinewood nematode. Female pine sawyer beetles lay their eggs under the bark of dead or dying pines, usually during the summer. The grubs hatch and feed under the bark, then tunnel deep into the wood. The grubs form pupae, and then adult beetles, ¾ to 1 ½ inches in length, which emerge from the tree any time from late spring to early fall.

While the sawyer beetle develops within the tree, the nematode also matures. Just after the adult sawyer beetle breaks out of its pupal shell, large numbers of pinewood nematode larvae move into the tracheae (breathing tubes) of the new adult beetle (Figure 9). When the sawyer beetle tunnels to the surface of the bark and flies away (Figure 10), it carries up to tens of thousands of hitch-hiking nematodes.

Pine sawyer beetles are strong fliers and can travel several miles. To mature and breed, the beetles need to feed on twigs of healthy pine trees. This so-called maturation feeding (Figure 11) does little damage to the twigs, but the feeding wounds create points of entry for the pinewood nematode into the healthy tree. The nematodes leave the beetle, probably in response to chemical cues from the injured twig, then enter the twig through the feeding wounds.

If the nematodes enter a resistant pine species, the nematodes soon die. In susceptible pines, though, the nematodes move to the resin canals, then molt to adults, which begin feeding on the living cells lining the resin canals. During warm periods in the summer, pinewood nematodes spread throughout the tree and multiply very rapidly. As they destroy the resin canal cells, the tree's water-moving system becomes clogged and resin flow slows, then stops. At about this time, wilt symptoms develop and the tree dies.

Dying pines attract not only egg-laying pine sawyer beetles but also bark beetles. Bark beetles are not directly involved in the pine wilt disease cycle, but their activities are indirectly related to nutrition of the nematodes. When the bark beetles bore into dying pines, blue-stain fungi living in the beetles also enter. The blue-stain fungi rapidly colonize the wood of the dying tree, leaving behind a characteristic cobalt-blue discoloration (Figure 7). Pinewood nematodes thrive on a diet of blue-stain fungi, so their numbers multiply even faster.

FIGURE 8
Female (left) and male (right) pine sawyer beetle, *Monochamus carolinensis.*

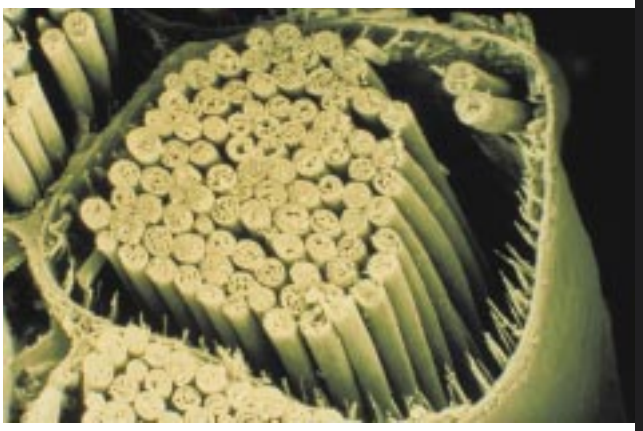


FIGURE 9
Cross-section of trachea (breathing tube) in the thorax of a pine sawyer beetle. The spaghetti-like strands are pinewood nematodes.

FIGURE 10
An adult pine sawyer beetle emerging from a dead pine.

The life cycle of the pine sawyer beetle (*Monochamus* spp.), also known as the longhorned beetle because of its very long antennae, is closely intertwined with the life cycle of the pinewood nematode.

FIGURE 11
Maturation feeding of a pine sawyer beetle on the twig of a healthy pine.

How to sample for pinewood nematode

Careful microscopic examination is needed to avoid confusing the pinewood nematode with the many harmless species of nematodes that also live in trees.

When a pine dies suddenly, pine wilt is a leading suspect. To confirm the presence of pinewood nematode in a dying or dead pine, it's necessary to extract the nematode from the wood. A wood sample should be taken from the lower trunk or the base of lower limbs. A disk of wood, 1 inch in thickness and 3 to 4 inches across, makes an adequate sample. Alternatively, wood chips (be careful to exclude bark chips) can be collected using a brace and bit. After wood from the suspect tree is submerged in water, the nematodes leave the wood chips and can be examined under a compound microscope. A trained nematologist or diagnostician can identify the pinewood nematode by the distinctively shaped spicules in the posterior end of the male nematode (Figure 6), as well as by other morphological characteristics. Careful microscopic examination is needed to avoid confusing the pinewood nematode with the many harmless species of nematodes that also live in trees. Nematode extraction is usually done in a diagnostic laboratory at a university or private clinic. In Iowa, contact the Plant Disease Clinic, 351 Bessey Hall, Iowa State University, Ames, IA 50011; in Missouri, contact the Plant Diagnostic Laboratory, 42 Agriculture Building, University of Missouri, Columbia, MO 65211; in Kansas, contact the Plant Disease Clinic, Throckmorton Plant Science Complex, Kansas State University, Manhattan, KS 66506; and in Nebraska, contact the Plant & Pest Diagnostic Clinic, 448 Plant Sciences, University of Nebraska, Lincoln, NE 68583-0722.

Pine wilt in context

Why is pine wilt so severe in parts of the Midwest, yet rare elsewhere in the United States? The Midwest is prone to periods of drought that place pines under stress. High summer temperatures allow explosive reproduction by the pinewood nematode and add to tree stress. Because native pines were scarce in prairie-dominated areas of the Midwest, landscaping has relied heavily on nematode-susceptible, exotic species such as Scots pine. Although no one knew it at the time, planting a susceptible species such as Scots pine into a hot, stress-prone environment turned out to be a recipe for trouble.

Pines sometimes die rapidly even when tests fail to reveal pinewood nematode. Environmental stress—drought and extreme heat are often blamed—coupled with injury by bark beetles also can kill a pine, especially Scots pine. Pines that die for reasons unrelated to nematodes often are colonized by nematodes that enter the tree through oviposition wounds made by sawyer beetles. The nematode is probably only one part of a complex of factors that can attack exotic pines in stressful environments.

It is important to autopsy sick pines for pinewood nematode because its presence poses a clear threat: sawyer beetles can carry it to nearby pines, and susceptible species can succumb. Beetle-induced spread from a single pine can develop into an epidemic that destroys entire windbreaks or groves of Scots pine within a few years.

Cover **PHOTO**

Mature Scots pine suffering from pine wilt.

Management

Despite intensive research, no highly effective management tactics have emerged against pine wilt. Insecticides and nematicides have so far proved to be impractical or ineffective. The "best management practices" today are largely unchanged from 20 years ago, but they can prevent or slow the spread of the disease if followed proactively.

The starting point is containment of the disease through sanitation. Dead pines can become beetle reservoirs, so they should be cut promptly and burned, buried, or chipped. If you spot dead trees in the late fall, you can wait until early spring to remove them because the beetles will not emerge until the weather warms in the spring. Avoid saving wilt-killed pines as firewood because beetles can continue to emerge from the logs.

Is there a risk of spreading pine wilt in infested wood chips? Yes, but it is minimal. Research in Vermont showed that it is possible to transmit the nematode from fresh chips to a young Scots or white pine seedling, but only if the chips are placed in direct contact with wounds on the sapling. Using a few simple precautions, you can safely mulch susceptible pines with chips from pine wilt-killed trees. First, pile the chips for at least 6 weeks; the heating and drying will kill both nematodes and beetles. Second, avoid piling chips against tree trunks when you mulch, and don't mix the chips with soil when planting new trees.

If you are recommending landscape trees, or considering what to plant on your own property, Scots pine should be avoided in Iowa, Missouri, Illinois, eastern Kansas, southeastern Nebraska, and other parts of the Midwest where pine wilt is a major threat. The same goes for Austrian pine, but primarily because it is extremely susceptible to two fungal diseases, Sphaeropsis tip blight (formerly known as Diplodia tip blight) and Dothistroma needle blight. Spruces, firs, hemlocks, white pine, northern white cedar (arborvitae), eastern red cedar, and other junipers face little threat from pine wilt.

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