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THE BOXWOOD BULLETIN

Understanding the Current & Emerging Threats to Boxwood

Addenda to Registered Cultivar Names, Boxwood Art, ABS Tribute to Mrs. Robert L. Frackelton

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Saving American Gardens from Boxwood Blight

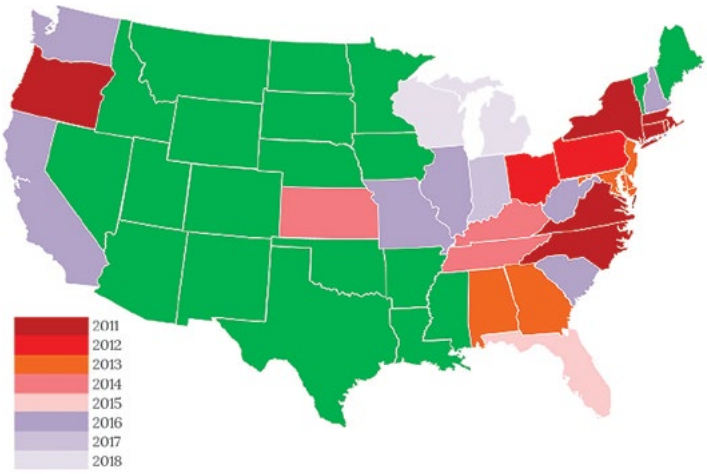

Figure 1 Boxwood blight tracker by year of the first interception or detection from 2011 to 2018

Boxwood was first planted in North America by Nathaniel Sylvester in 1653 on a Shelter Island plantation in New York, and it has since become a landmark species in American landscape. This prominence is attributed to its utility, resiliency, and low maintenance. Boxwood is prized for use as individual specimen plants, hedges, parterres, and landscape groupings. Other important applications include: decorative boxwood greeneries for holidays, and boxwood sculptures for learning, ritual purposes, and whimsy. Boxwood plants also are frequently grown as topiary or bonsai due to their high tolerance to heavy pruning.

Once-regarded as a low maintenance plant, boxwood is now threatened by boxwood blight, an emerging fungal disease caused by *Calonectria pseudonaviculata* in the United States, and also by *Calonectria henricotiae* in Europe. This disease was first reported in the United Kingdom and New Zealand in the 1990s, and now it is widespread in Europe. In the U.S., North Carolina and Connecticut were among the first states severely affected by boxwood blight in 2011. Since then this disease has spread to other states via nursery trade. As of December 31, 2018, twenty-eight states and the District of Columbia have reported interceptions of diseased plant materials or boxwood blight rampages (Figure 1), impacting historic and established boxwood plantings as well as landscaping businesses. Boxwood blight ruined the Woodrow Wilson Presidential Library garden in 2016 (https://www.newsleader.com/story/news/local/2016/09/21/boxwood-blight-leaves-presidential-library-garden-bare/90799326/). More recently, this disease invaded the Tudor Place in Washington D.C., and devastated most of its boxwood plantings (https://www.tudorplace.org/who-we-are/garden/preserve-the-garden/). Even some landscape companies have been sued by homeowners for spreading the disease to established gardens that their families have treasured for generations.

While boxwood blight continued to spread over the past 7 years, its negative impacts on American gardens would have been much greater without timely interventions by the federal and state regulatory agencies, horticulture industry, research and extension communities. Three most notable interventions at the national level were (1) development of boxwood blight Best Management Practices (BMPs), (2) institution of the Boxwood Blight Cleanliness Program, and (3) educational programming. The boxwood blight BMPs were developed by Horticultural Research Institute - the research arm of AmericanHort, and the National Plant Board (NPB) in consultation with the research community. The Cleanliness Program was developed by NPB and implemented by state Department of Agriculture to prevent the spread of boxwood blight via the nursery trade. Both the American Boxwood Society and AmericanHort have hosted a number of educational events. At the state level, a full quarantine protocol against boxwood blight was enacted in both Pennsylvania (2016) and Tennessee (2017); this disease was declared a nuisance in Illinois (2017). At the local level, many nurseries instituted their own sanitation programs. These interventions have had immediate benefits, curbing the spread of boxwood blight and reducing disease impacts. In the meantime, researchers have developed some new tools for controlling this destructive disease through the funding from Farm Bill, Section 10007 via USDA Animal and Plant Inspection Service, the Floriculture and Nursery Research Initiative via USDA Agricultural Research Service, and the horticultural industries.

Fighting boxwood blight has been and will continue to be a tough battle in the foreseeable future. Below I will share some the latest exciting research to help garden enthusiasts and boxwood professionals better understand 'the enemy' – the boxwood blight pathogen, to substantially reduce its accidental introduction, and to more effectively manage the disease at sites of contamination.

Figure 2 Three diagnostic symptoms of boxwood blight

Know the enemy

As indicated by the disease name, boxwood is the prime host of this pathogen. Initial symptoms appear as dark or light brown spots on leaves (Figure 2 left). This may be quickly followed by leaf blighting and leaf drop (Figure 2 middle), as well as black streaks on young branches and stems (Figure 2 right). These symptoms are typical of boxwood blight and they can be used to separate this disease from other common foliage diseases such as *Volutella* blight and *Macrophoma* leaf spot.

Are all boxwood species, varieties, and cultivars susceptible to this disease? The short answer is 'Yes.' However, their susceptibility levels differ greatly with some species and cultivars being much more susceptible than others. According to Dr. Kelly Ivors of North Carolina State University who evaluated over 70 cultivars commonly-used in the U.S., the ten least susceptible cultivars are Green Beauty, Northern Emerald, Wedding Ring, Wintergreen, Golden Dream, Winter Gem, Nana, Franklin's Gem, Wee Willie, and Richard. Nine of these are Asiatic cultivars belonging to *B. microphylla* or *B. sinica*, while Richard is a *B. harlandii*. None of the English and American boxwood made this short list.

The same pathogen can also attack pachysandra and sweet box plants. Specifically, it caused leaf spots on Japanese spurge (*Pachysandra terminalis*) (Figure 3 top) and Himalayan sweet box (*Sarcococca hookeriana* var. *humilis*) (Figure 3 bottom) near infected English boxwood in a Virginia garden. Similarly, it can cause leaf spots on Allegheny spurge (*Pachysandra procumbens*) and Windcliff Fragrant pachysandra (*Pachysandra axillaris*) under controlled conditions per Dr. James LaMondia of Connecticut Agricultural Experiment Station. Likewise, *Sarcococca confusa*, *S. orientalis*, *S. vegans*, *S. ruscifolia*, *S. saligna*, and *S. wallichii* are also susceptible, as demonstrated in a recent study at the University of Georgia. These species all belong to the family of Buxaceae.

Can this pathogen infect a non-Buxaceae plant? The answer is 'Maybe.' In a recent study we applied the boxwood blight pathogen onto 27 common groundcovers or companion plants from 21 families. Under controlled environments, this pathogen caused disease symptoms and reproduced itself in a dozen of plants. These plants included *Alchemilla mollis*, *Arctostaphylos uva-ursi*, *Brunnera macrophylla*, *Epimedium youngianum*, *Galium odoratum*, *Geranium sanguineum*, *Phlox subulata*, *Tiarella cordifolia*, *Callirhoe involucrata*, *Iberis sempervirens*, *Mazus reptans*, and *Vinca minor*. These plants are potential hosts of this pathogen. They could potentially carry and spread the pathogen from infected nurseries or sites to new locales. They, along with pachysandras and sweet boxes, should be added to the watchlist and taken into consideration when developing boxwood blight mitigation programs.

Boxwood blight spread in the U.S. since 2011 is an unfortunate fact, but its development status here is about 20 years behind Europe by two accounts. First, its distribution remains limited in most affected states. Second, most positive diagnoses to date are in gardens and public spaces rather than production

Figure 3 Leaf spots of Japanese spurge and Himalayan sweet box in a garden (Photo courtesy of Ping Kong/Virginia Tech (top), and T. Michael Likins/Chesterfield Cooperative Extension, Virginia (right)

nurseries. We are in a much better position than Europeans in dealing with this disease. We also have more tools today than 20 years ago. We may have a better chance to contain this disease in the U.S. Following I propose two different approaches to mitigating this disease in American gardens and public spaces for states, counties and areas with and without this disease.

Fend off the boxwood blight pathogen

Keeping the pathogen out remains the most effective method and should be the primary approach for states, counties, and areas where boxwood blight is not yet present. The boxwood blight pathogen produces sticky spores as its dispersal and disease-causing agent. Its chance for spreading via air movement is marginal. Long-distance spread of this pathogen is primarily via infected plant materials. That is great news for gardeners and boxwood professionals! However, also due to their sticky nature, pathogen spores can easily attach to landscaping tools that have come in contact with contaminated materials. They may also attach to shoes, clothes and other personal belongings during visits to sites of contamination. Following are some strategies to block these avenues of pathogen entry.

The **first strategy** is to purchase, retail, and/or utilize blight-free plant materials and prevent the spread of boxwood blight to new sites. Here plant materials include boxwood, pachysandra, sweet box, and other potential host crops. Specifically, they also include both stock plants and greeneries for boxwood.

This strategy begins with looking for reputable suppliers. The best place to start is your state Department of Agriculture - Boxwood Blight Cleanliness Program as exemplified by Virginia (http://www.vdacs.virginia.gov/plant-industry-services-boxwood-blight.shtml). On its official website you can check for a list of participating Virginia nurseries and learn about the BMPs protocol that they have agreed to implement to produce blight-free crops. Once you locate participating nurseries near you, it is time to visit each and see first hand the actual steps taken to protect its crops (Figure 4). Surely you want to see the health of boxwood and related crops, and ask whether they have been recently treated with any fungicide, and if so, when and what? A recent fungicide treatment could mask potential crop health issues including boxwood blight.

All parties in the horticultural chain from growers to consumers have a role to play in implementing this

Figure 4 Boxwood Blight Cleanliness Program at work in Virginia nurseries – restricted access, footbath, and hand spray

strategy for its full benefits. Retailers, commercial landscapers, and ground maintenance personnel are on the front line with an area-wide impact. Nurseries that purchase boxwood and other host plant materials from other production facilities share the same responsibility. It is always advisable for growers to place incoming plant materials, including boxwood and other host plants in this case, in isolated areas for a few weeks without any fungicide program to determine whether they are truly as healthy as they appeared during receipt. Likewise, retailers are advised not to co-mingle incoming plant materials from different suppliers. These simple steps will save you potential plant losses on-site and hassles with your suppliers while protecting your client base. Consumers must do their share of diligence and this is particularly important for those with a well-established boxwood garden. Infected plant materials have been shipped and sold through big box stores nationally. Before you buy new boxwood or any other host plants, ask the garden centers of your interest: where are their plants sourced and are their producers participating in the Cleanliness Program? Buying new plant materials from a wrong retail center could ruin a garden within a few weeks.

The **second strategy** is to prevent cross contamination between job sites. The following steps, practices, and considerations are crucial to achieving this goal.

Sanitizing all the landscaping tools is fundamental. The landscaping tools here include pruners, saws, rakes, hoses, equipment, tarps, shoes, gloves, vehicles, and everything else that is used in establishing new gardens, maintaining existing plantings, and cleaning up infected plant materials. Pruners, saws, rakes, and other landscaping tools must be

Figure 5 Wearing shoe covers at a research site when downloading weather data and having vehicle washed before heading back to office

cleaned and sanitized between job sites. This is best done at the site of first job which reduces the chance of contaminating the working vehicles, spreading the pathogen along the way, and carrying it to next job site or back to the company ground. Likewise, vehicles should be cleaned and sanitized as completely as possible. At a minimum, they should be free of soil and plant debris before leaving a job site. Recommended sanitizers and instructions for their use are available on the Virginia Boxwood Blight Task Force web site (https://ext.vt.edu/agriculture/commercial-horticulture/boxwood-blight.html).

Scheduling and timing boxwood-related jobs could also mitigate cross contamination. Generally, boxwood pruning should be done when foliage is dry, normally late in the morning or afternoon of a sunny day. Maintenance of known infected sites should be placed as the last job of the day, allowing for more effective sanitation. After arriving at a new job site, it is always a good practice to walk through the entire property and scout for signs of boxwood blight infection before doing anything else. If blighted boxwood are seen, prune the healthy-looking ones first and the most severely affected ones at the last.

One consideration of importance is never to assume any job site is free of the blight disease. Whether latent infection (infected but not showing any symptoms) occurs in boxwood blight is yet to be determined. But we do know that infected plants may not show any symptoms for some time depending upon the boxwood cultivar and weather conditions. There is no guarantee that a healthy-looking boxwood garden today will remain healthy a few weeks later unless the owner and maintenance contractor work together to effectively to fend off the pathogen.

It is equally important for homeowners and professionals alike to practice good techniques where the landscape has boxwood blight or not. Specifically, it is recommended that field crew wear freshly laundered clothing each day when working in gardens and public spaces that are not known to have the disease. On the other hand, when pruning, scouting, or removing infected plants, field crews should wear disposable gloves, clothing (e.g. Tyvek®), and shoe covers. If disposable clothing and shoe covers are not available, clothing and shoes should be changed before leaving a site.

As positive diagnoses continue to emerge, landscape companies, if not yet practicing them, are urged to develop and adhere to clearly outlined sanitary protocols aimed at reducing the risk of spreading boxwood blight. They are also advised to share with their clients these protocols and documentation on how all the tools have been sanitized including products and recommended concentrations as well as exposure times, etc. right before leaving the last job site, and to get the clients consent prior to starting a job. By taking these steps, landscape companies will better retain and grow their client base. They may also help avoid potential lawsuits that may be filed against them for spreading the boxwood blight pathogen. In addition, they make a significant contribution to the disease mitigation effort at the regional level.

The **third strategy** is to avoid bringing the pathogen home after visiting contaminated sites including public and private gardens and friends' properties. The health of your garden will be as good as the care you take. In addition to buying blight-free stock plants and hiring reputable landscape companies, do your own share of diligence to fend off the boxwood blight pathogen. The following are some steps my team takes every time we visit a contaminated site (Figure 5). First, upon arrival at the site, we wear gloves, disposable shoe covers or clothing (Tyvek®) depending upon how close we will be to the infected plants. Second, we bag disposable gloves, covers and clothing, then spray shoes and hands with 70% ethanol before getting into the vehicle and heading back. Third, we have our vehicles washed in a car wash before returning to office. Fourth, we take a shower then change our clothes immediately after arriving home. In addition, I have a pair of shoes for doing yard work to protect my nearly 60 year old boxwood plantings. These steps have served us well. Homeowners and boxwood enthusiasts are encouraged to develop protocols that work for them in protecting their gardens.

Better manage and contain the disease

Containing accidental disease introduction is as important as fending off the pathogen. This effort consists of scouting, eradication, and remediation. Our goal is to prevent the disease from outwardly radiating to adjacent gardens and production nurseries.

Scouting is the critical first step. The earlier the disease is detected, the easier and more likely it may be contained or even eradicated. Where and when to look will have tremendous impacts on the scouting outcomes.

Where new infection of boxwood blight will most likely show up is directly tied to the pathogen movement. The vast majority of positive diagnoses to date are due to the purchase of infected plant materials and use of contaminated landscaping tools. A limited number of cases are due to the movement of contaminated animals and infected plant debris blown or transported from a neighboring property. Therefore, scouting should focus on gardens where (1) new boxwood and other host plant materials have been added or utilized, (2) landscape maintenance was recently performed, and (3) disease has been seen in the neighborhood.

The best times to scout for new infections are the spring and fall seasons for most parts of the United States. This pathogen does not like hot and dry conditions. The optimum temperature for its spore germination and infection is about 75°F with the maximum at 82°F. Thus, summer might be too hot for boxwood blight infection, especially in the southern states. This disease generally is most active in the spring and fall seasons. Like other fungi, the boxwood blight pathogen spores require free water for germination and infection; and it takes a few days for infected leaves and stems to develop symptoms under ideal conditions. Thus, scouting after rain events will further increase the chance of finding the disease.

Eradication is to remove infected materials to prevent the disease from spreading to healthy-looking plants in the same garden and to adjacent plantings and production nurseries. Plant disease is a result of interactions between host and pathogen under the influences of environment; this is commonly termed "Disease Triangle". A disease becomes rampant when a virulent pathogen meets with a susceptible host under favorable conditions. In the case of boxwood blight, most existing plantings are English boxwood which is highly susceptible. Also, we have little control over temperature and rain events, the two most important environmental factors for this disease. Pathogen is the most manageable angle of the three; and that is where we can make a difference. The success of this effort relies largely on how much of affected boxwood shrubs are removed and how this removal process is handled.

As for how much of an affected shrub is removed, there are three major options: (1) uproot entire shrub, (2) cut to leave a stump, and (3) trim only symptomatic branches and stems while leaving the shrub intact. Each option has its advantages and drawbacks. The trimming option focuses on saving the established boxwood shrubs while attempting to remove affected materials. This potential saving does not come without a cost. An immediate monetary cost is to have an intensive fungicide program in place to protect the saved shrubs with infected but asymptomatic branches. Boxwood blight likely will continue to progress and spread at a level depending upon the conduciveness of weather conditions and the effectiveness of fungicide programs. This disease rampaged through quite a number of gardens in 2018 due to excessive wet weather conditions. The hidden cost is that the disease spreads to other shrubs in the same gardens and, even worse, to adjacent gardens or production nurseries. Both monetary and hidden costs have led managers/owners of many affected gardens (including Tudor Place) to switch to the option of uprooting or cutting affected boxwood shrubs and those in their immediate proximity leaving only stumps (Figure 6). These two options have the potential to eliminate the pathogen in all sources except soil. The soil inoculum may be contained by covering the base of the shrub with mulch including pine needles as done in the Woodrow Wilson Presidential Library gardens. Both options better prevent the pathogen from outwardly radiating to adjacent

Figure 6 Cutting affected boxwood shrubs to stump (Photo courtesy of Joshua Meyer/Tudor Place)

plants and gardens when compared to the trimming option. They may also require considerable investment to remove a large number of affected shrubs. The major difference between these two options is how to rebuild the garden. The uprooting option allows the owner to select and plant with a less susceptible cultivar while the other option rebuilds the garden through regrowth from the stumps. All removed plant materials should be incinerated on-site where practical or taken in double bags or tightly wrapped with plastic to a designated landfill.

When removing affected shrubs, exercising great care is equally important to containing the disease. Shrubs should be individually bagged or wrapped with plastic then dug from soil using an excavator as appropriate, and taken to incineration (Figure 7) or a landfill. Additional steps must be taken to prevent the spread of the pathogen to new locales as discussed above under the **second strategy** section.

Remediation is to rebuild boxwood gardens after infected plant materials are removed. This may be accomplished through two strategies. One is to heavily trim boxwood shrubs to remove all affected foliage and leave a stump for regrowth. The other is to completely remove boxwood shrubs including roots then replant with a new cultivar. Both strategies have pros and cons. The regrowth strategy may have the speed advantage, which is important for slow growing plants like boxwood. However, the new growth will continue to be highly susceptible to the blight disease. The replanting strategy may take a long time to rebuild a boxwood garden if starting with small stock plants; otherwise it will be costly if replanting with large stock plants. But it has the option to utilize a less susceptible cultivar which will be more sustainable in long run. Both strategies face

Figure 7 Eradicating diseased shrubs with great care – wrapping each shrub with plastic, then digging the stumps and roots with an excavator, and moving uprooted boxwood to a site for incineration (Photos courtesy of the Woodrow Wilson Presidential Library, Staunton, Virginia)

Figure 8 Detector boxwood placed on mulched and nonmulched stump areas (Photo courtesy of T. Michael Likins/Chesterfield Cooperative Extension, Virginia)

the same challenge of managing soil inoculum and preventing it from becoming a source of inoculum for regrowth or foliage of newly replanted boxwood; and that is where the mulching technique comes to play.

Mulching reduces boxwood blight up to 100%. In our 2016-2017 study under a landscape setting, stump areas with numerous infected fallen leaves and associated pathogen spores were covered with pine bark or not mulched (Figure 8). Disease control was measured by comparing the boxwood blight development on detector plant - containerized Justin Brouwers boxwood that were placed near the stump and rotated through the mulched and non-mulched areas at 2-week intervals. Mulching provided complete protection of the detector boxwood in all three positive rotations in 2017 and five of the eleven positive rotations in 2016. It also provided excellent protection in four rotations and fair protection in one rotation in 2016.

As mulches are used as physical barrier to block pathogen spores from soil splashing onto foliage, its performance directly relies on the coverage. Complete coverage is required for 100% blockage but additional mulch depth adds little to the control efficacy. Also, mulch type does not matter for this purpose. Mulching is a common practice in American landscaping for aesthetic appearance, water retention, soil temperature stabilization, and other purposes. These benefits should be taken into consideration when selecting mulches for boxwood blight control. Generally, it is advisable not to use synthetic or rock mulch. Synthetic mulch has no soil benefits and does not retain water or nutrients. Similarly, rock mulch does not hold water or nutrients. More importantly, its temperature may fluctuate greatly which is harmful for boxwood's temperamental roots.

The mulching technique performs best with 100% plant protection on two assumptions. First, all

sources of the boxwood blight pathogen other than soil have been eliminated in the garden and its proximity. Second, no other mean of pathogen dispersal than water splash is available. Neither was met at the site where our mulching study was conducted. There were over 400 established boxwood on this property and not all affected ones were removed during this study. There were two dogs and many wild animals - either resident (squirrels, rabbits) or daily visitor (deer, birds) on the property. Those animals could have moved the pathogen spores from the leftover or newly diseased plants to the detector plants. Both are realities in most, if not all, gardens. Thus, the mulching technique should not be used alone for boxwood blight mitigation. Instead, it should be used along with other tools for its maximal performance.

One of these tools is fungicide. A general list of fungicides that may be used for boxwood blight is available on the Virginia Boxwood Blight Task Force web site (https://ext.vt.edu/agriculture/commercial-horticulture/boxwood-blight.html). Actual availability varies with user (grower, retailer, landscaper and home owner) and state. As always, the label must be read carefully and followed strictly every time fungicide is used. This is especially important for gardens and other private and public spaces as fungicide may drift and pose hazards to human and environmental health. They should be used as the very last resort.

To help garden enthusiasts and boxwood professionals time fungicide applications, Dr. Leonard Coop of Oregon State University has developed an infection risk forecasting model for boxwood blight. This model is based upon the disease epidemiology research conducted in Belgium and at Virginia Tech. Specifically, it predicts boxwood blight infection risk using air temperature when the leaf surface is wet. It is web-based at (http://uspest.org/risk/models) and also available for mobile devices. You can download it into Android by searching "boxwood blight" in Play Store" or iPhone likewise. The mobile versions are easy to use. Its interface has an Input tab where you enter your "location name" to search the national weather networks and select a station near you then enter "start date" and set "time span" for prediction. The forecasting results will be instantly displayed in Graph and Table formats. These forecasts should be used as a reference until this model is fully calibrated and validated. We hope the final product will reduce your fungicide applications to the minimum while providing the best boxwood protection.

Look into the future

Boxwood blight will continue to be a huge challenge for years to come. The proposed differential approaches above have the potential to most cost effectively slow boxwood blight spread and minimize its negative impacts in states, counties and areas with and without this disease. This potential may be realized and enhanced by better educating garden enthusiasts and boxwood professionals on diagnostic disease symptoms, pathogen-spread biology, mitigation strategies and tools, by ensuring that everyone in the horticultural chain and every property owner in the neighborhood does his/her share of diligence in fending off the pathogen or effectively containing the disease should an accidental introduction occur, and by developing a network of horticulturists and consumers for early detection, fast reporting and communication of new infections.

This disease has already had significant impact on the American garden and it will likely get worse before getting better. Both developing a better understanding of the pathogen biology and continually innovating control technology are crucial to winning the battle against this disease in the American garden. Among the most urgently needed tools are (1) highly resistant, if not immune, cultivars, (2) effective biological control and other reduced risk products, (3) easy-to-use diagnostic tools like immunostrips, (4) reliable disease-forecasting model, and (5) integration of existing tools such as cultivar, mulching and fungicide protection to increase their synergy. There are also a number of questions of practical importance. For instance, does latent infection occur in boxwood blight? Answering this question could help cut the spread of the disease via nursery trade. What is the stump height required to ensure 100% regrowth and how may this height be related to the age and size of boxwood shrub and also to soil conditions? A related question is how low on stems the boxwood blight pathogen may go from infected foliage. Answers to these questions will help realize the full benefits of the mulching technique. How long can the boxwood blight pathogen survive in the U.S. soil? Whether and how may its survival be related to local climatic environment and soil microbiome? Our preliminary study at multiple locations points to this pathogen not surviving as long as it has been perceived. This initial result is exciting – the pathogen may disappear after a period of boxwood absence, and then this landmark plant may be safely replanted at once-contaminated sites.

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