Boxwood Blight- A New Threat to Boxwood in the U.S.

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www.ct.gov/caes

Boxwood Blight in Connecticut

- In October 2011, samples of boxwood with unusual symptoms were submitted to The Connecticut Agricultural Experiment Station (CAES) for diagnosis.
- Symptoms included leaf spots and blights, rapid defoliation, distinctive black cankers on stems, and severe dieback.

Chronology

- 6 October 2011
  - CAES received an email inquiry from an arborist with photos of boxwood with unusual symptoms (Fairfield County).
  - Requested sample of symptomatic plants.
- 11 October 2011
  - CAES received boxwood samples.
  - Tentatively diagnosed a new disease called boxwood blight.
  - Sample had been mailed, so stems and leaves were contaminated with soil.
  - Requested another sample.

Chronology (cont'd)

- 17 October 2011
  - CAES received another sample of boxwood from a 7-year-old boxwood planting (Middlesex County) with symptoms similar to those exhibited in the first sample.
  - Tentatively diagnosed boxwood blight.
  - Sample was mailed, so stems and leaves were also contaminated with soil.
- 24 October 2011
  - CAES staff visited property to obtain an official sample for confirmation.

Boxwood Blight Sample from Residential Property in Middlesex County.

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Boxwood Blight in Connecticut (cont'd)

- CAES tentatively identified this new disease as boxwood blight, caused by the fungus *Cylindrocladium pseudonaviculatum*.
  - Had never been reported in U.S. or CT.
- Sent samples to national mycologists at USDA-APHIS-PPQ (Beltsville, MD) who confirmed the fungus as *C. pseudonaviculatum* (26 October 2011).

Boxwood Blight Timeline in U.S.

Date*	**Location**
10/24/2011	Surry County, **North Carolina**
10/26/2011	Middlesex County, **Connecticut**
10/31/2011	Carroll County, **Virginia**
12/13/2011	Providence County, **Rhode Island**
12/14/2011	Prince Georges County, **Maryland**
12/19/2011	Barnstable County, **Massachusetts**
12/20/2011	Washington County, **Oregon**
12/23/2011	Westchester County, **New York**
01/23/2012	Lancaster County, **Pennsylvania**

* Confirmed by national mycologist, USDA-APHIS

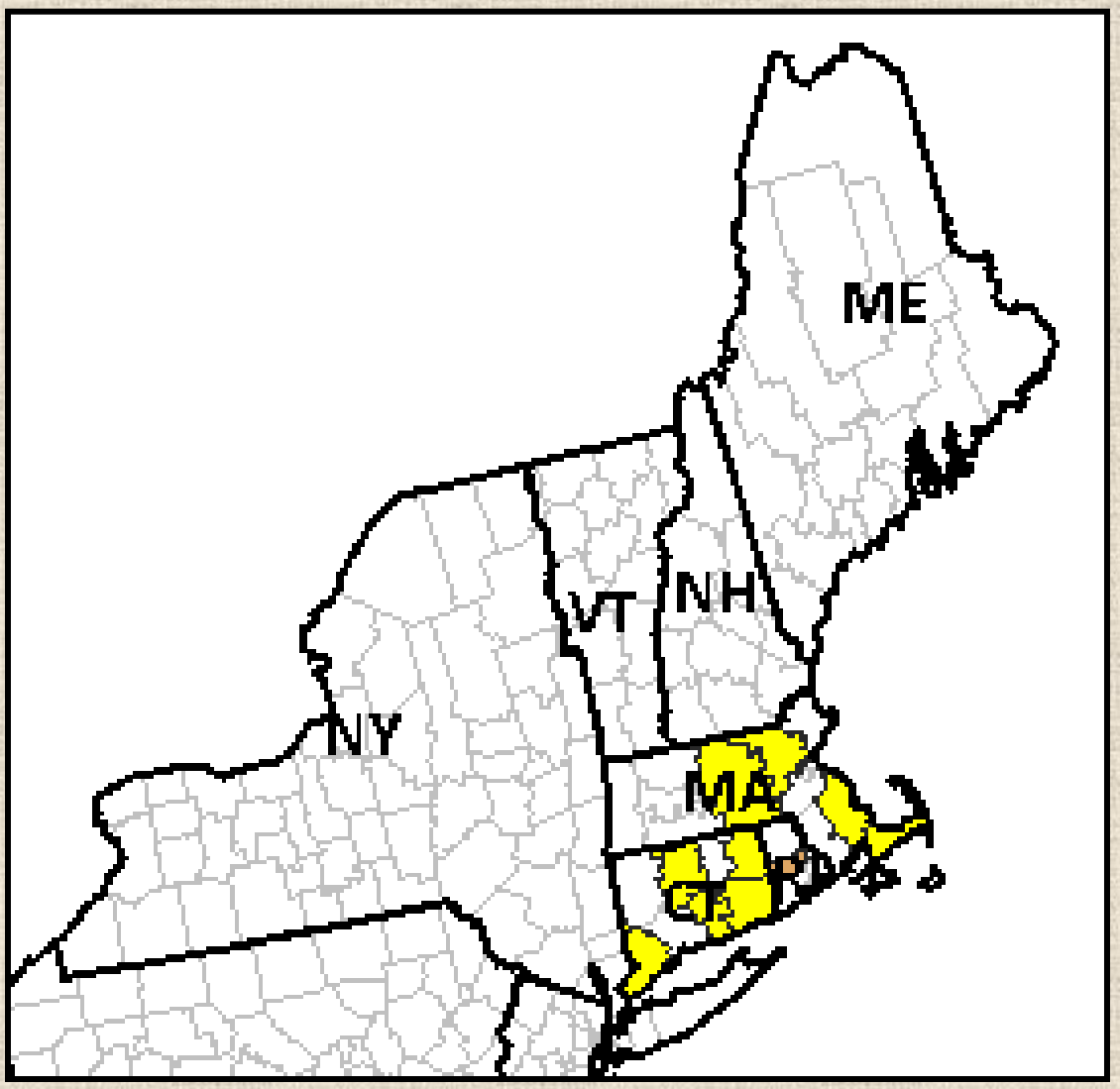
Boxwood Blight in CT

- Confirmed in residential landscapes, garden centers, and nurseries in the following 5 counties:
  - Fairfield
  - Hartford
  - Middlesex
  - New London
  - Windham

Boxwood Blight in New England

National Agricultural Pest Information System (NAPIS)

http://pest.ceris.purdue.edu



Legend

- Established by Consensus
- Established by Survey
- Being Eradicated
- Eradicated
- Found
- Not Found
- Survey in Progress
- No Survey

Boxwood Blight

- First described in the United Kingdom (UK) in the mid-1990s.
- In 2002, boxwood blight was found in New Zealand.
  - The causal agent was described and formally named as a new species, *Cylindrocladium pseudonaviculatum.*
- Later in 2002, the boxwood fungus from the UK was named *Cylindrocladium buxicola*.
  - They are now known to be synonyms for the same fungus.

Boxwood Blight Causal Agent

Cylindrocladium pseudonaviculatum

=

Cylindrocladium buxicola

Boxwood Blight (cont'd)

- Boxwood blight has been reported throughout Europe.
  - Belgium, Croatia, France, Georgia, Germany, Ireland, Italy, the Netherlands, Slovenia, Spain, Switzerland.
  - Not present in Austria.
    - Have an aggressive policy to immediately destroy all infected *Buxus* spp. every time boxwood blight is detected.
  - New outbreaks continue to be reported.

Origin of the Boxwood Blight Fungus

- Geographic origin of the boxwood blight fungus is not known.
- It is NOT known how or when the pathogen was introduced into the U.S.

Hosts

- Boxwood blight has been reported to occur on all *Buxus* species (natural and laboratory infections).
  - Some species and cultivars appear to be more susceptible than others.
  - Possibly as a result of physical traits.
- For example:
  - *Buxus sempervirens* 'Suffruticosa' (English boxwood) and *B. sempervirens* (American or common boxwood) appear to be highly susceptible.

List of Hosts in Connecticut

- ***Buxus sempervirens*** (Common boxwood)
  - ‘Suffruticosa’
  - ‘Elegantissima’
  - ‘Artic Emerald’
  - ‘Jade Pillar’
  - 'Graham Blandy'
- ***Buxus microphylla*** (Littleleaf boxwood)
  - ‘Golden Dream’

List of Hosts in Connecticut (cont'd)

- ***Buxus microphylla* var. *japonica*** (Japanese boxwood)
  - 'North Star'
  - 'Green Beauty'
  - 'Baby Gem'

List of Hosts in Connecticut (cont'd)

- ***Buxus sinica* var. *insularis*** (Korean boxwood)
  - 'Winter Gem'
  - 'Winter Green'
  - 'Tide Hill'
  - 'Uptight'

List of Hosts in Connecticut (cont'd)

- ***Buxus sinica* var. *insularis* X *B. sempervirens* hybrid**
  - 'Green Mountain'
  - 'Green Gem'
  - 'Green Velvet'
  - 'Chicagoland'
  - 'Green Ice'
  - 'Big Leaf Gordo'

Known Hosts- Europe and UK

- *Buxus balearica*
- *B. bodinieri*
- *B. glomerata*
- *B. harlandii*
- *B. microphylla*
- *B. macowanii*
- *B. riparia*
- *B. sinica*
- *B. sempervirens*
- *Sarcococca* spp.

Symptoms

- Initial symptoms appear as light or dark brown spots or lesions on the leaves.
- Spots enlarge and then coalesce, often with a concentric pattern or a zonate appearance.
- Infected leaves turn brown or straw colored, so infected plants look “blighted.”
- Defoliation occurs very quickly after foliar symptoms first develop.

Leaf Spots

Leaf Spots

Leaf Spots

Leaf lesions with zonate patterns.

Leaf lesions with zonate patterns.

Symptoms (cont'd)

- The fungus also infects the stems, which results in distinctive and diagnostic dark brown to black streaks or lesions, sometimes with an angular, diamond-like pattern.
- Many black lesions can be found along a stem, from the soil line to the shoot tips.
- Infects all aboveground portions of boxwood, but does not appear to infect the roots.

Distinctive black stem cankers.

Black stem lesions.

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Black stem cankers and lesions.

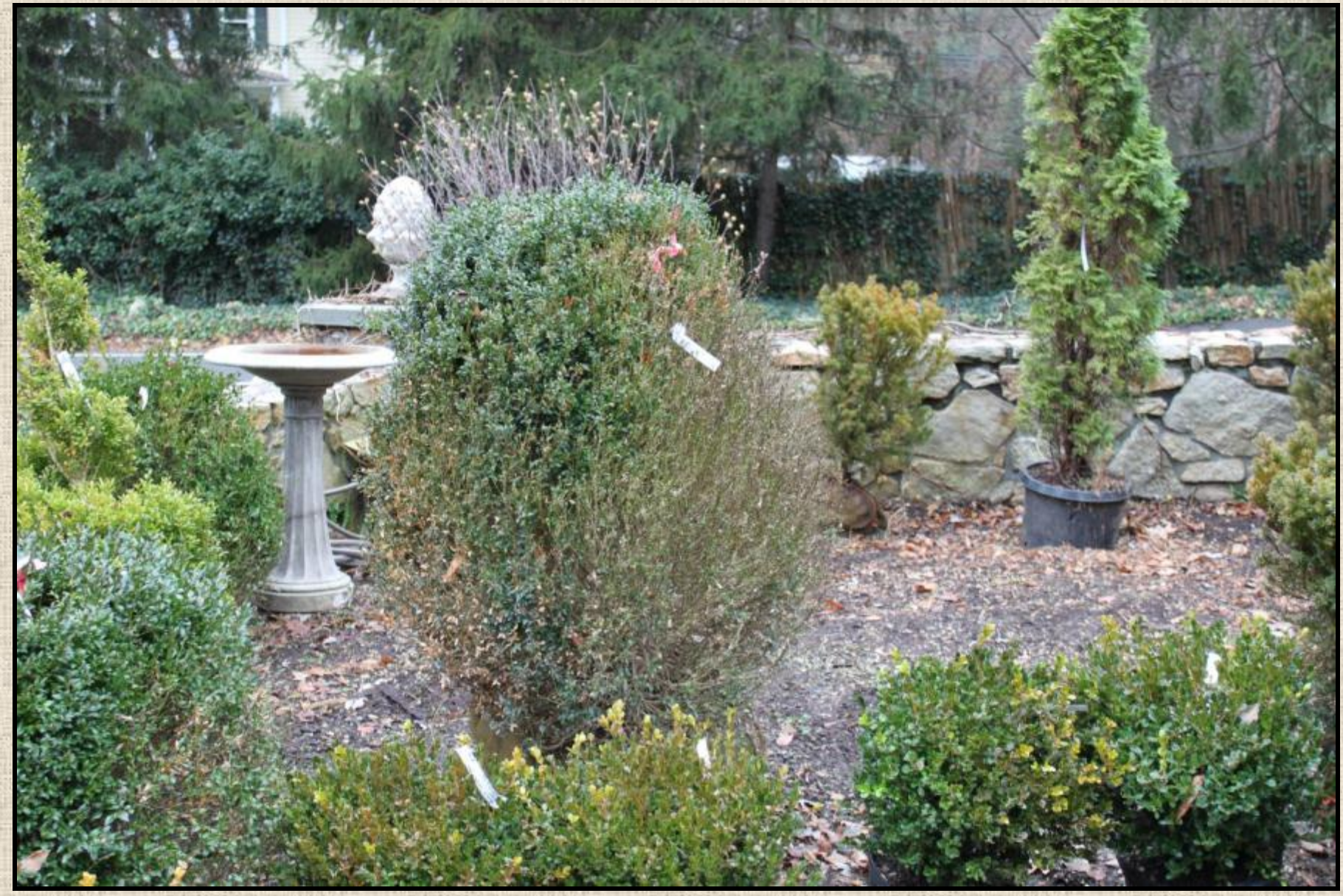
Blighted appearance from leaf and stem symptoms.

Blighted leaves, defoliation, and stem lesions.

Cankers and defoliation.

Symptomatic plants in holding yard.

Symptomatic plants in sales yard.



Field-grown plants with symptoms and leaf debris.

Symptoms and leaf debris.

Infected field-grown boxwood in North Carolina.

Photo courtesy of Kelly Ivors, NC State

Symptoms in potted plants.

Infected potted plants in NC nursery.

Photos courtesy of Kelly Ivors, NC State

Excessive leaf debris in pots.

Foliar symptoms: note leaf debris.

Symptoms in propagation flat.

Infected cuttings in propagation bed in VA.

Photo courtesy of Norm Dart
Virginia Department of Agriculture and Consumer Services

Foliar symptoms and canker on cuttings.

Infected liners.

Symptoms (cont'd)

- Plants attempt to regrow, but repeated infection and defoliation weakens the root system and leads to plant death, especially for young plants or new transplants.

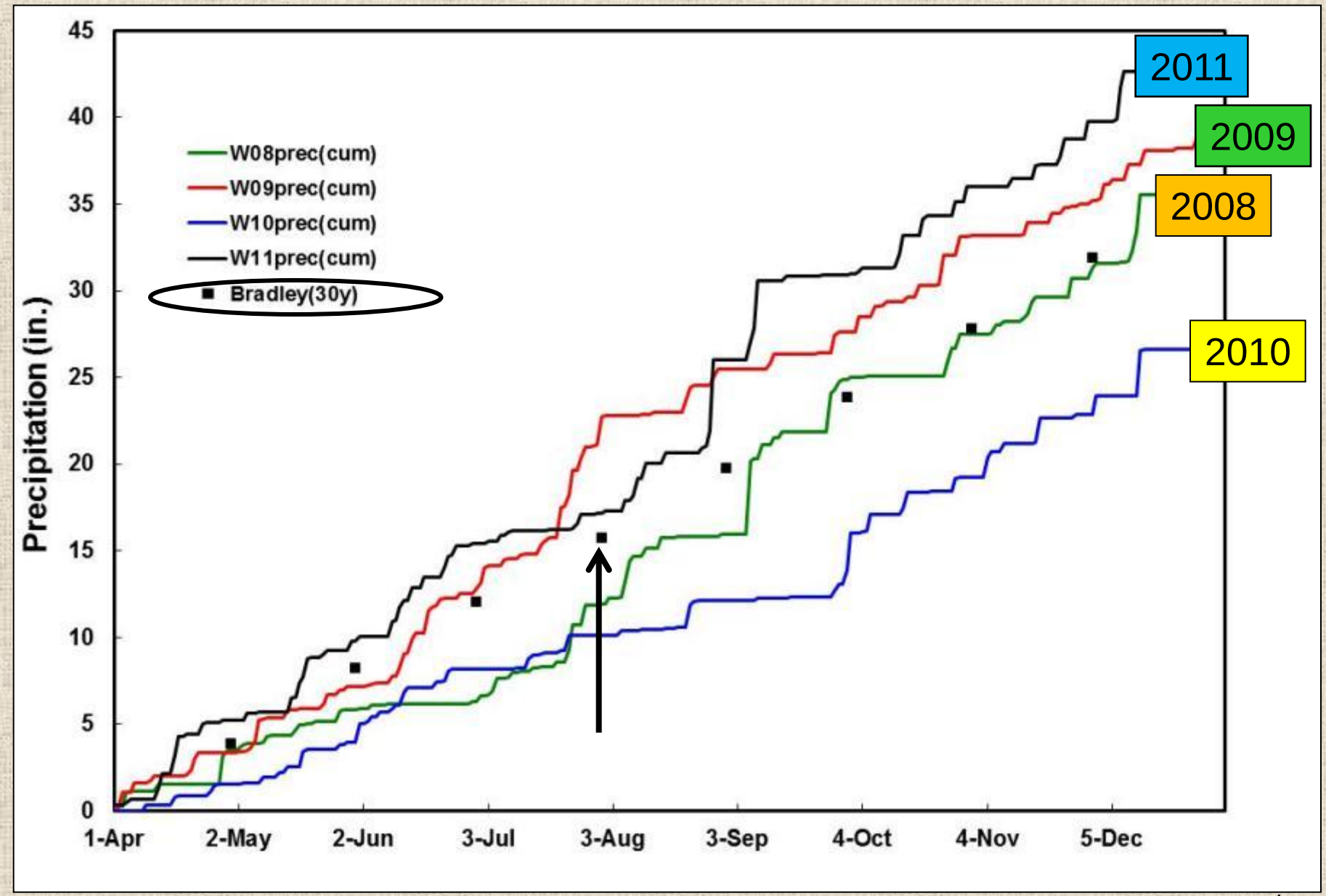
Disease Cycle and Spread

- Boxwood blight can spread very rapidly under warm and humid conditions.
- In 2011, established boxwood plantings in Connecticut landscapes were apparently killed in one season following the introduction of infected plants.
  - 2011 was a particularly moderate, wet year that included several violent rain events.

Weather

- 2011- Warm, cloudy, and wet
- 2010- Hot, sunny, and dry
- 2009- Cool, cloudy, and wet

CT Rainfall 2008-2011



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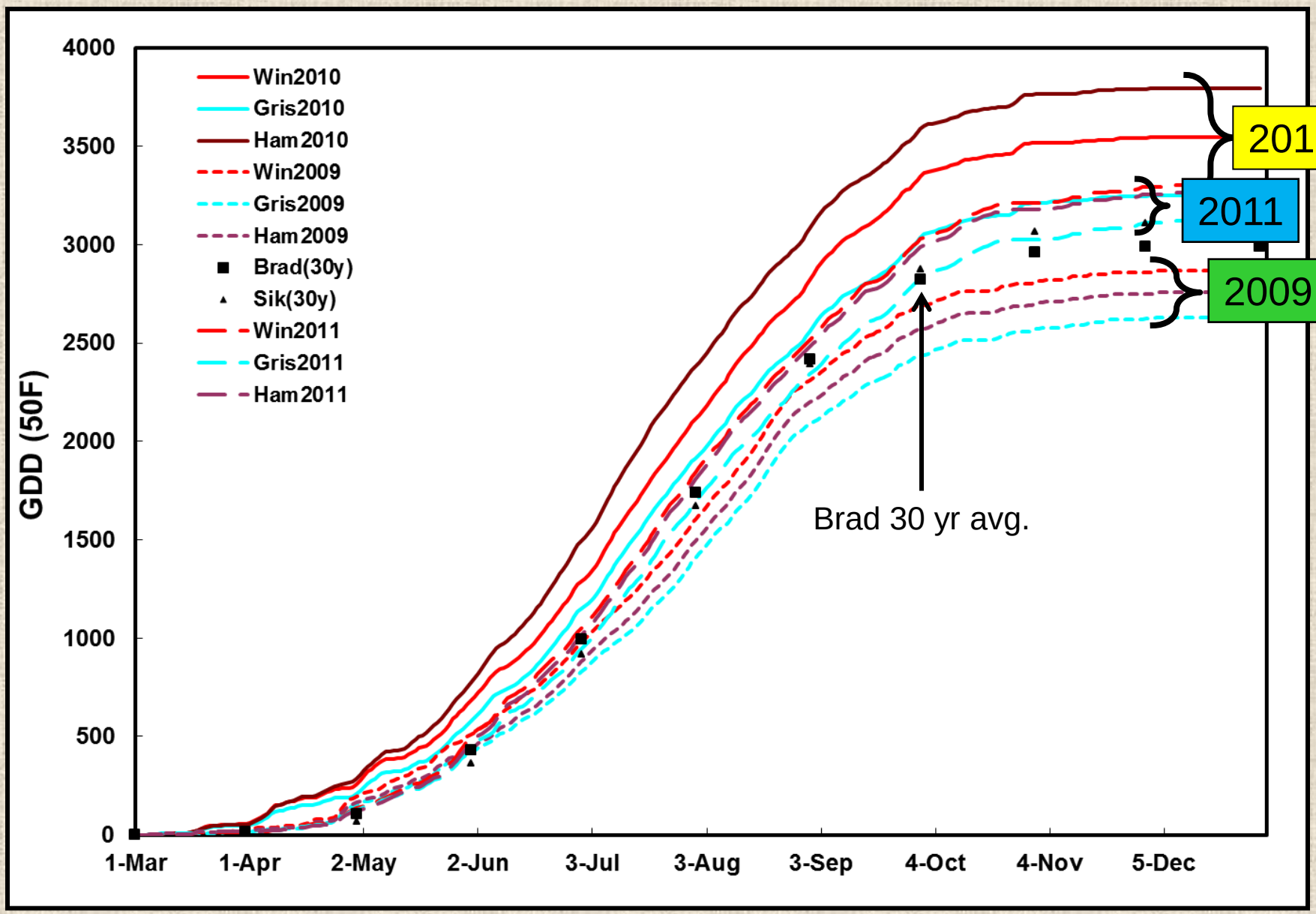
CT Growing Degree Days 2009-2011



Boxwood blight in a residential property.

One new plant installed in 2011.

Boxwood blight in a residential property.

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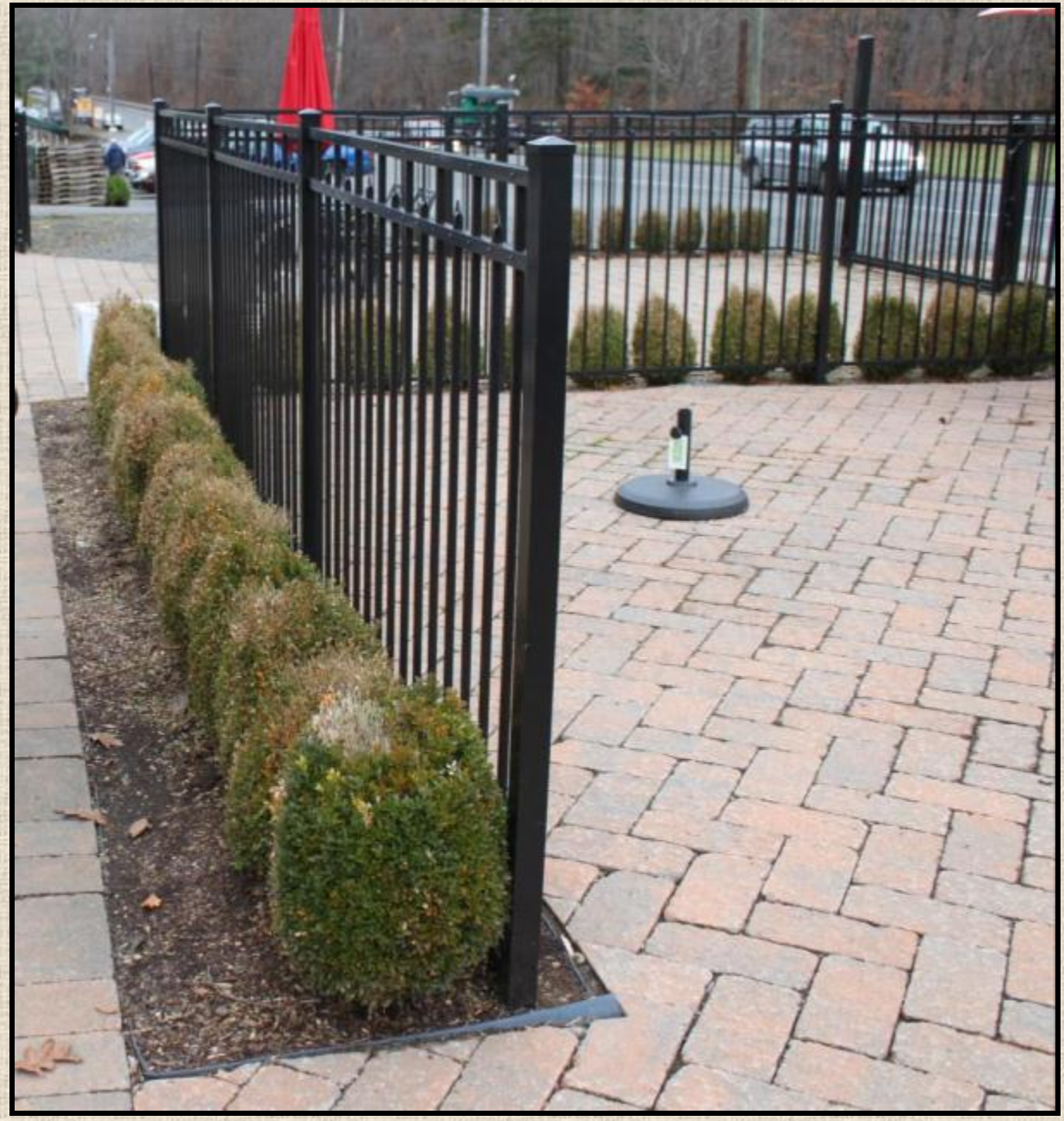
Boxwood blight in a residential property.

Boxwood blight in a commercial property.



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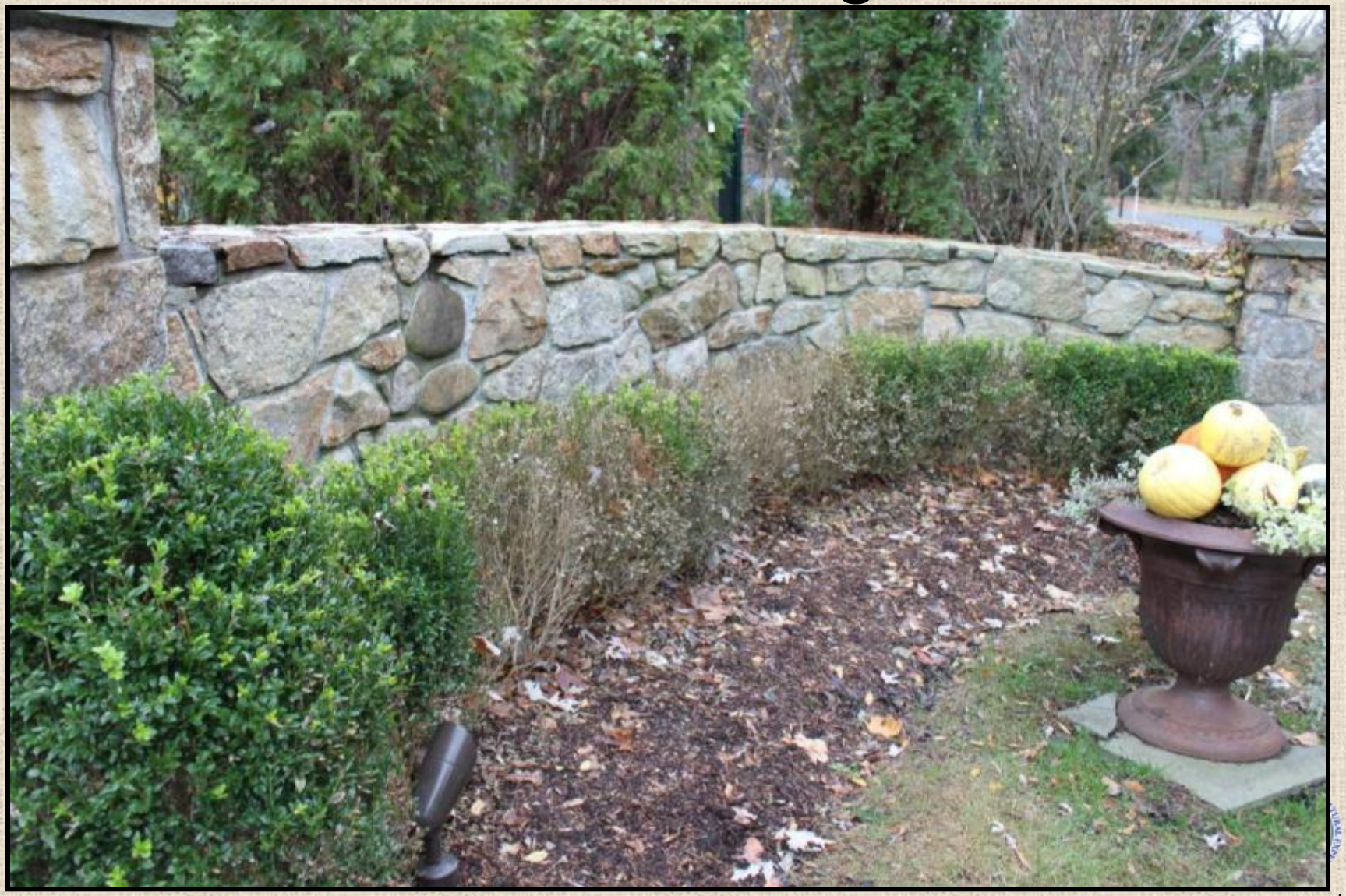
Boxwood blight in a commercial property.

Before: established planting with boxwood blight.



After: infected plants were removed.

Disease Cycle

- Boxwood blight pathogen has a rapid disease cycle: can be completed in one week.
- Temperature range: 41-86 ºF.
- Optimum temperature for growth: 77 ºF.
- Fungus is sensitive to high temperatures: killed after 7 days at 91 ºF.
- Infections can occur very quickly under warm (64-77 ºF), humid conditions.

Disease Cycle (cont'd)

- Spores germinate 3 hours after inoculation and penetrate plant host tissues within 5 hours.
- The fungus does not require a wound to infect--can penetrate directly through the plant cuticle or can enter the leaf through stomata.
- High humidity levels or free water on plant tissues are necessary for successful infection.

4 Days after Inoculation

Photo courtesy of Kelly Ivors, NC State

Photos courtesy of Kelly Ivors, NC State

The Boxwood Blight Fungus

- Readily forms fruiting structures on infected plants.
  - These structures (**sporodochia**) are visible with a hand lens on the undersides of infected leaves and on the black lesions on stems.
- **Sporodochia** contain large numbers of sticky, cylindrical spores (**conidia**), which give the sporodochia an angular or crystalline appearance.

Boxwood Blight Fungus (cont'd)

- Structures of the fungus called **vesicles** form in the sporodochia and protrude from the main fruiting body.
- Spores (**conidia**) are cylindrical and hyaline, and usually have one septation (2-celled).

Boxwood Blight Fungus

Sporulation on undersurfaces of leaves.

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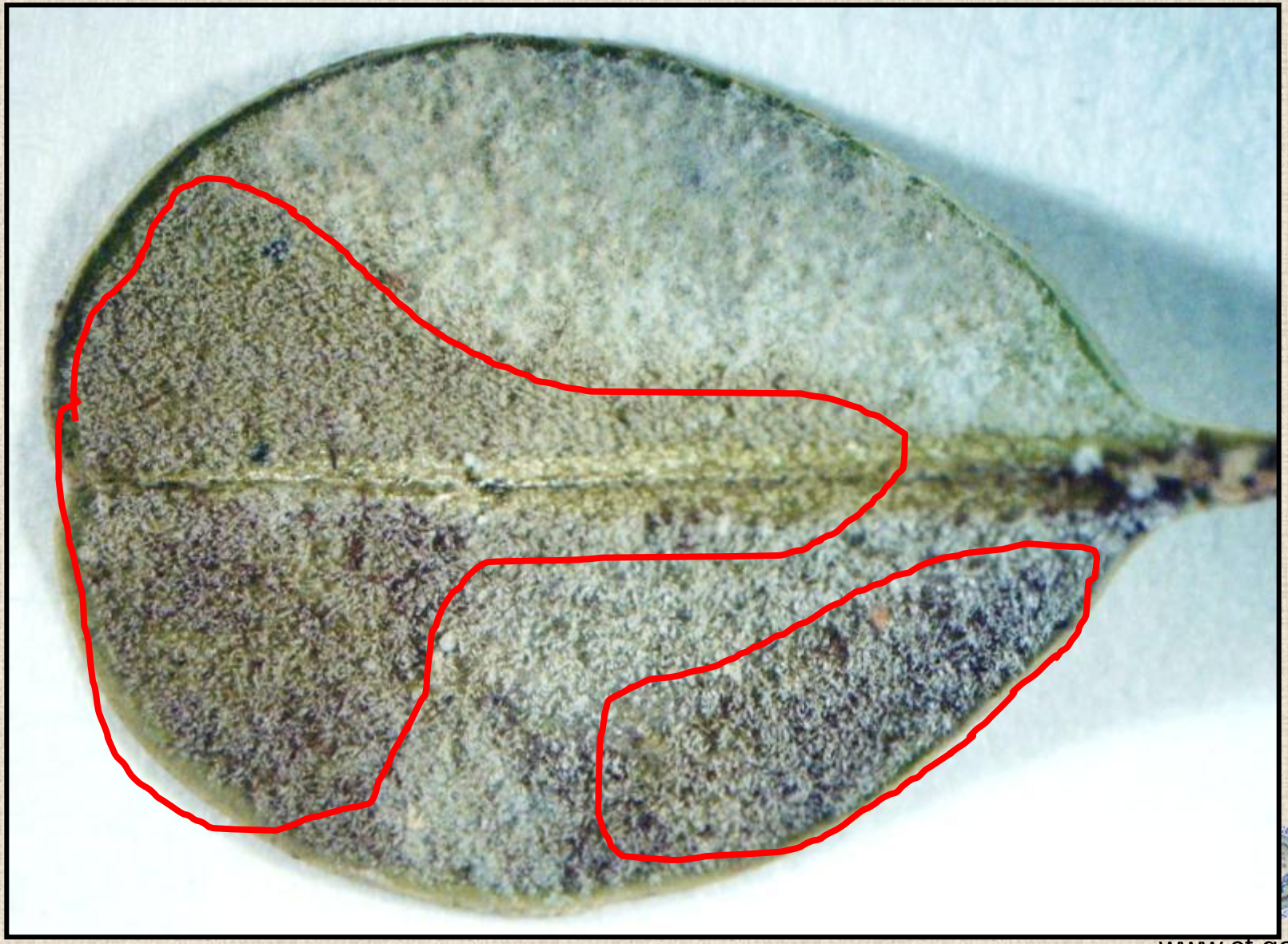
Lesions with sporulation.

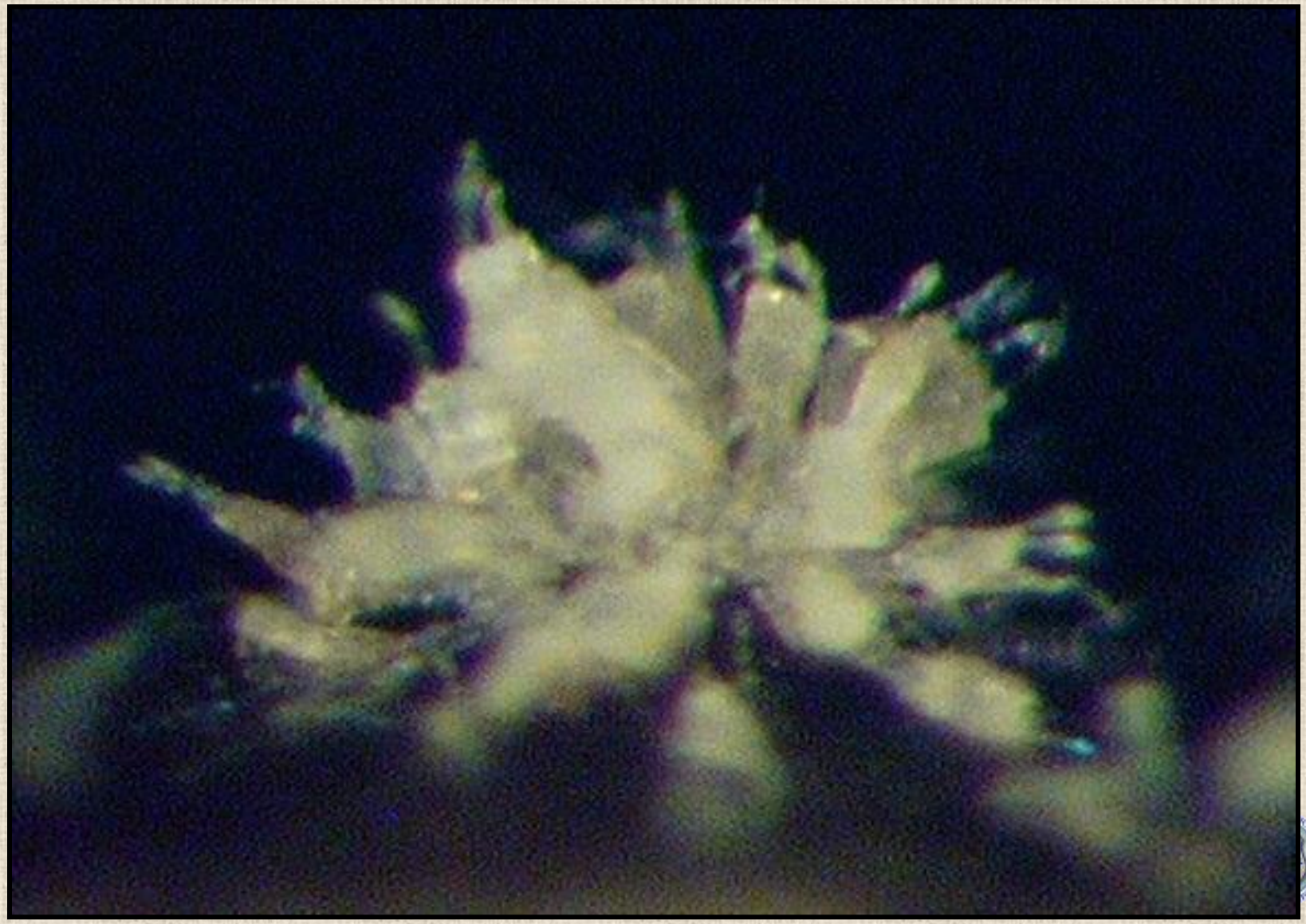
Distinctive appearance of sporulating colonies--mixed infection on leaf.



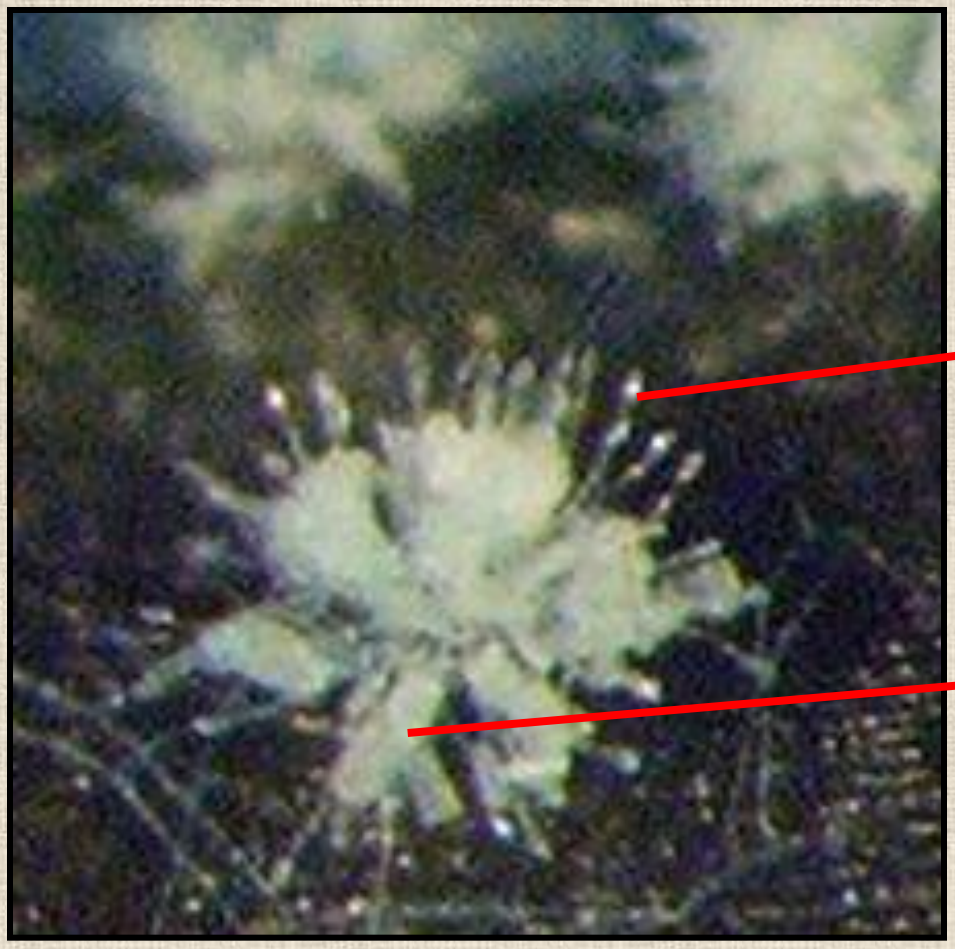
Sporulating colonies have a distinctive angular, “blocky” appearance.

Sporodochia on stem lesion.

Sporodochium with protruding vesicles.

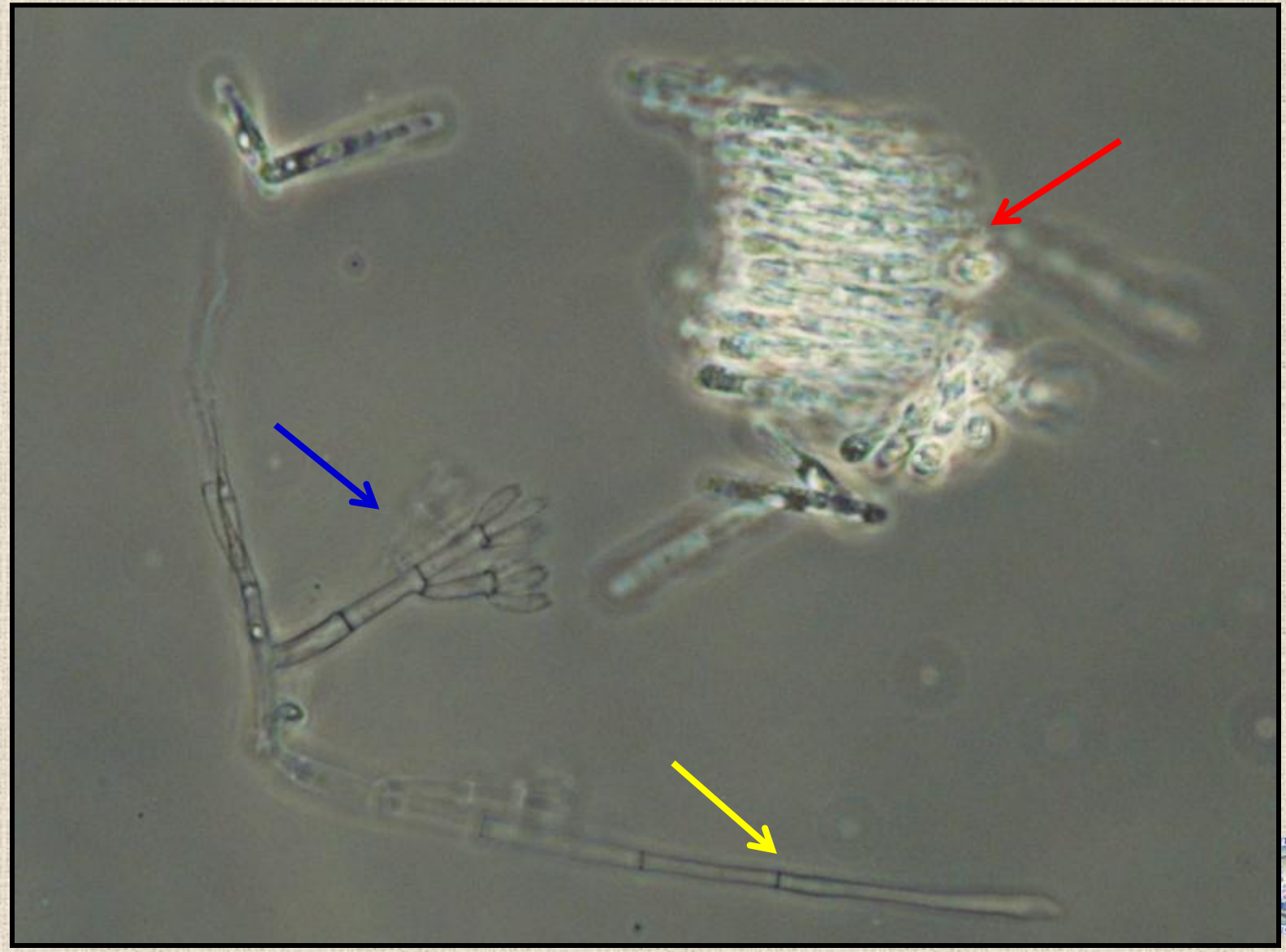


Sporodochium with vesicles and spores.



Vesicles and spores.

Vesicle, spore-bearing structure, and cluster of spores held together by a slimy matrix.



Two-celled spores (conidia).

Genotypes of the Boxwood Blight Fungus

- **Genotype 1 (G1)**
  - Identified in United Kingdom, New Zealand, and North Carolina.
  - Considered the “common” strain.
- **Genotype 2 (G2)**
  - Identified in Belgium and several other European countries.
  - Has some fungicide resistance—this has important implications for control.

Genotypes (cont'd)

- There are substantial differences between G1 and G2, but very little genetic diversity within each group.
- Suggests two separate introductions of the exotic boxwood blight fungus into Europe.

Diagnosis

- Microscopy.
- Incubation of 24-48 hours under high humidity.
- Culture on artificial media.
- We do not diagnose boxwood blight based on leaf and stem symptoms.

Sporulation in lesion after 24 h incubation.

Disease Spread

- **Short Distance:**
  - Spores are splash-dispersed and can be carried short distances by wind or wind-driven rain.
- **Medium Distance:**
  - Occurs as a result of the activities of humans (e.g., contaminated boots, clothing, and equipment), animals, and birds, since the spores are sticky.
  - Movement of debris in runoff water.

Disease Spread (cont'd)

- **Long Distance:**
  - Movement of infected plants (commerce).
  - Contaminated trucks and shipping containers.
  - Unintentional movement of asymptomatic but infected plants.
    - Shipping apparently "healthy" boxwood (infected, but asymptomatic or having very limited outward symptoms) or boxwood treated with fungicides that suppress, but do not kill or eradicate the fungus, to nurseries and landscapes.
    - "Trojan horse" or "Typhoid Mary" syndrome.

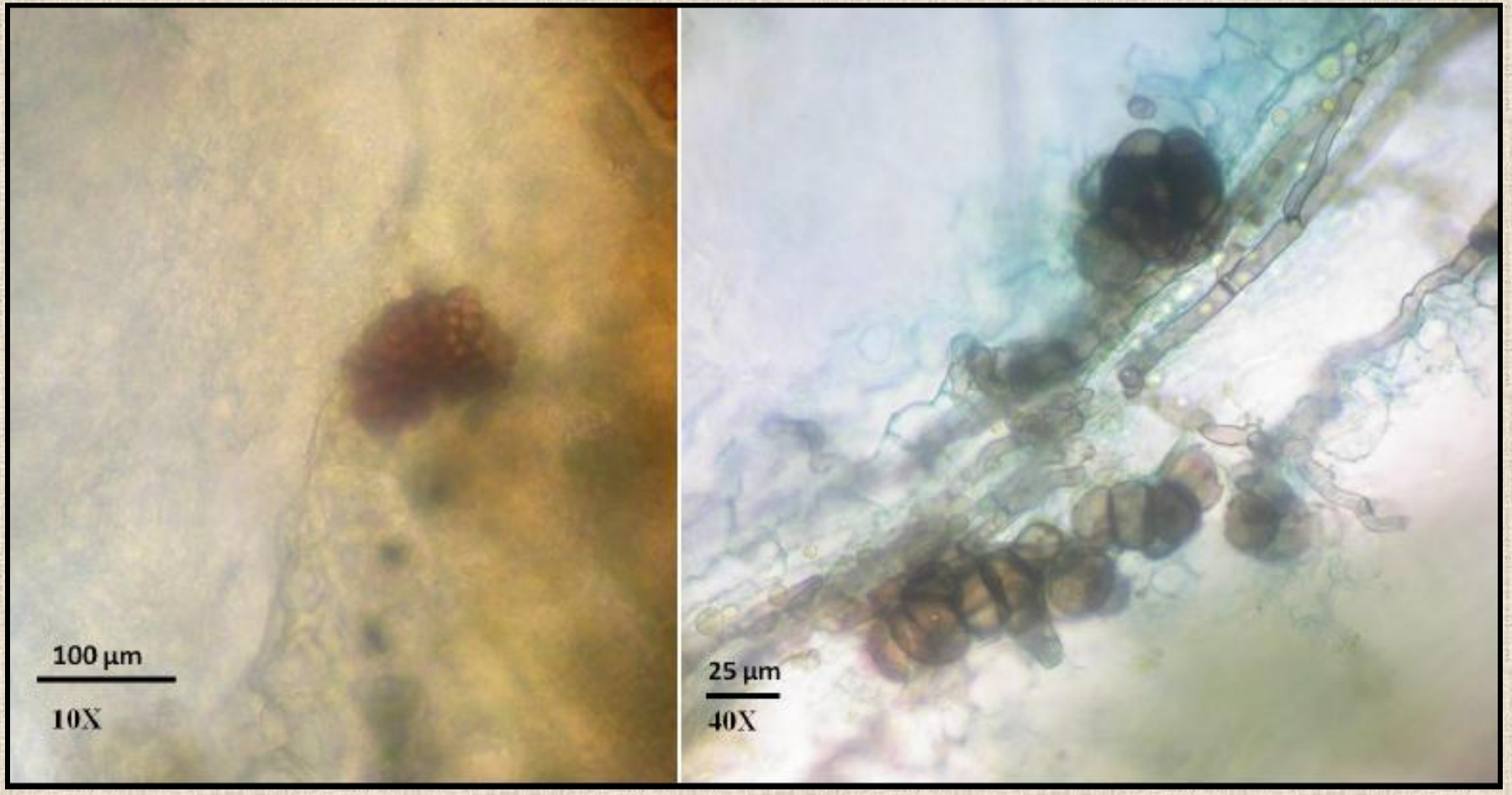
Disease Spread--In Production

- Infected plant material.
- Conditions during propagation.
- Pruning and grooming.
- Overhead watering.
- Runoff water.
- Pot-to-pot spacing.
- Contaminated tools, flats, equipment, clothing, and boots.
- Leaf debris.
- And many more….

Survival

- *Cylindrocladium pseudonaviculatum* survives as **mycelium** and resting structures (**microsclerotia**) in leaves and cankers on infected plants and in leaf debris (fallen, infected leaves).
  - Reported to survive for at least 5 years in decomposing boxwood leaves.

Microsclerotia in tissues.



Photos courtesy of Norm Dart
Virginia Department of Agriculture and Consumer Services

Regulatory Status of Boxwood Blight

- Not federally regulated.
- USDA-APHIS-PPQ is investigating the situation to determine if they will take any action.
- Regulatory actions in CT are under the statutory authority of The Connecticut Agricultural Experiment Station (CAES).
  - Sec. 22-84 and Sec 22-98 of the Connecticut General Statutes.

Regulatory Status of Boxwood Blight (cont'd)

- When Boxwood Blight is detected, a "Stop Sale Notice" is given to nursery or business.
  - Prevents the sale and movement of infected plants from quarantined property.
  - Many CT properties are voluntarily disposing of infected plants by burial on the quarantined property or transporting them to incinerators (under supervision by CAES inspectors).

What has been happening in Connecticut?

- Voluntary burial or incineration of infected plants.
  - Under observation by CAES nursery inspectors.
- Significant financial losses.

Infected boxwood bagged for incineration.

Infected plants put into dumpster for incineration.

Dumpster filled with infected boxwood.

Field-grown plants prior to destruction.

Infected plants dug and roots exposed prior to burial: note healthy root systems.

Burial of infected boxwood.

Infected, potted boxwood readied for burial.

Burial of potted boxwood.

Infected boxwood in NC nursery “holding area” for incoming/outgoing plants.

Photo courtesy of Kelly Ivors, NC State

Burning leaf debris in NC holding area.

Photo courtesy of NC Department of Agriculture

Photo courtesy of NC Department of Agriculture

Tossing infected boxwood into pit for burning in NC.

Photo courtesy of NC Department of Agriculture

Burning infected plants in NC.

Photo courtesy of NC Department of Agriculture

Current and Future Work at CAES: *Determine Genotype*

What genotype(s) is present in CT?

- CAES has over 40 isolates of the fungus collected from locations throughout the state.
- Using molecular techniques (PCR-RFLP) to determine the genotype(s) present in CT.

Current and Future Work at CAES: *Biology*

Can the fungus colonize the roots?

- Roots appear healthy, but if the fungus colonizes the roots, could this be a source of infection?

How does the fungus survive in CT and New England?

- Environmental requirements for survival and infection.

Current and Future Work at CAES: *Fungicide Efficacy*

What fungicides are most effective?

- CAES has begun testing registered and experimental fungicides to determine if more efficacious products are available.
- Develop a fungicide regime for managing the disease.

Current and Future Work at CAES: *Best Management Practices*

What BMPs should the industry follow?

- CAES is developing BMPs for managing boxwood blight.
- Can highly susceptible varieties be used as indicator or trap plants?
- What are the most effective sanitizing agents for containers or equipment?

Other Boxwood Diseases

- Volutella Leaf Blight and Canker
- Macrophoma Leaf Spot

Volutella Leaf Blight and Canker

- Causal Agent: *Volutella buxi (Pseudonectria rousseliana)* (fungus)

Volutella Blight-distinctive salmon-pink sporulation.

Macrophoma Leaf Spot

- Causal Agent: *Macrophoma candolleri* (fungus)

Macrophoma Leaf Spot

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Managing Boxwood Blight

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Management Strategies

1. Start with pathogen-free material by purchasing from reputable suppliers, nurseries, or garden centers.
   - Avoid purchasing from infested areas.
   - Request a history of fungicide treatments with each shipment (fungicide name, application rate and time).
   - Carefully inspect plants or cuttings for symptoms at the time of purchase or when received from supplier.

Management Strategies (cont'd)

2. Newly purchased plants or rooted cuttings should be isolated from existing boxwood plantings or production areas in nurseries for at least one month, but preferably for several months.
   - Keep plants labeled or barcoded to be able to track the source.
   - Avoid co-mingling of plant material from different sources.
   - Holding area should have a surface that can be cleaned of plant debris.

Management Strategies (cont'd)

3. Keep accurate, detailed records of:
   - Plants received and complete history while in the nursery;
   - Propagation of plant material;
   - Mortality due to any cause;
   - All chemical/fertilizer applications;
   - Weather records, if available.

Management Strategies (cont'd)

4. Space plants to maximize air circulation and minimize conditions favorable for disease development, when possible.

Management Strategies (cont'd)

5. Avoid overhead watering or working with plants when they are wet.
   - Water is important for the spread and development of boxwood blight.

Management Strategies (cont'd)

6. Sanitation is critical for eliminating and reducing inoculum, since the fungus can survive in plant debris for up to five years.
   - Accomplished by raking, vacuuming, and removing leaf debris.
   - In commercial field plantings, burning plant debris with a propane torch is an option.
   - Monitor plant debris in run-off water.
   - Work in blocks with infected plants last and after completing work with healthy plants.
   - Sanitize all shipping containers, benches, and equipment.

Propane torch used to burn infected boxwood and leaf debris in field in NC.

Photo courtesy of NC Department of Agriculture

Management Strategies (cont'd)

7. Scout and inspect all boxwood plants daily or weekly.
   - **As soon as boxwood blight symptoms are detected, immediately pull and remove whole plants and place them in plastic bags to avoid carrying infected material through a nursery or landscape.**
   - Infected plant material should NOT be composted.

Management Strategies (cont'd)

8. If you observe suspicious symptoms on boxwood, it is important to have the disease accurately identified by a specialist (plant pathologist).
   - For example, in CT:
     - *The Plant Disease Information Office* (CAES): http://www.ct.gov/caes/pdio.
     - *UCONN Home & Garden Center*: http://www.ladybug.uconn.edu/.

Management Strategies (cont'd)

9. Use indicator plants to monitor disease levels or to detect new infections.
   - Place highly susceptible plants, such as *B. sempervirens* 'Suffruticosa,' in propagation areas or blocks to use as "trap" plants.

Management Strategies (cont'd)

10. Planting less susceptible species of boxwood or alternatives to boxwood can reduce the potential for disease.
    - Examples of alternative plants include some dwarf cultivars of *Ilex crenata, Pieris japonica, Rhododendron* spp., and *Taxus baccata.*

Management Strategies (cont'd)

11. Fungicides.
    - *FUNGICIDES ARE NOT CURATIVE.*
    - Follow a preventative program that includes different products with different modes of action (FRAC groups).
    - Products differ significantly in their mode of action (e.g., some are more effective in inhibiting spore germination; others are more effective at inhibiting mycelial growth).

Management Strategies (cont'd)

- For commercial producers:
  - Azoxystrobin (Heritage**)
  - Boscalid + pyraclostrobin (Pageant**)
  - Chlorothalonil (Bravo Ultrex, Daconil, Docket)
  - Fludioxonil (Medallion**)—some phytotoxicity?
  - Mancozeb (Dithane, Fore, Protect)
  - Pyraclostrobin (Insignia**)
  - Triflumizole (Terraguard**)

** Effective for other *Cylindrocladium* species.

Management Strategies (cont'd)

- For homeowners:
  - Chlorothalonil
  - Mancozeb

CAES “Boxwood Blight Team”

- Mary K. Inman, Technician, Plant Disease Information Office
- Dr. Sharon M. Douglas, Plant Pathologist
- Dr. Victoria L. Smith, Deputy State Entomologist
- Tia Blevins, Jeff Fengler, Steve Sandrey, and Peter Trenchard, CAES Inspectors

Acknowledgements

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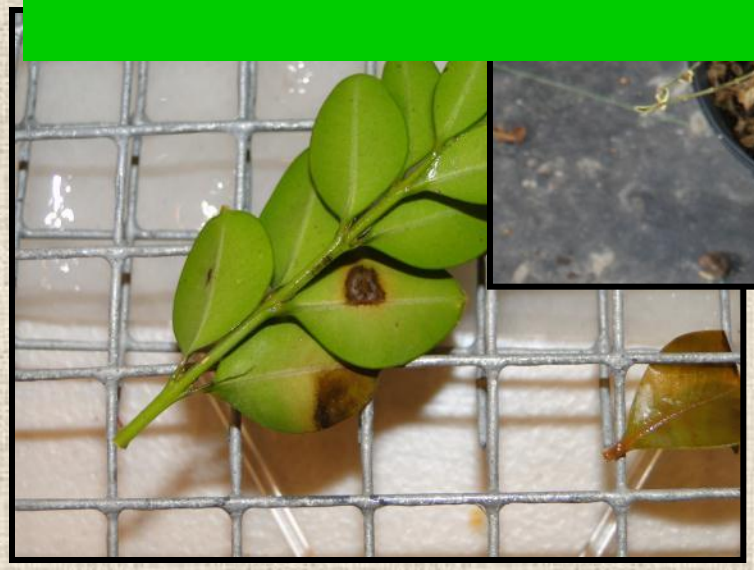
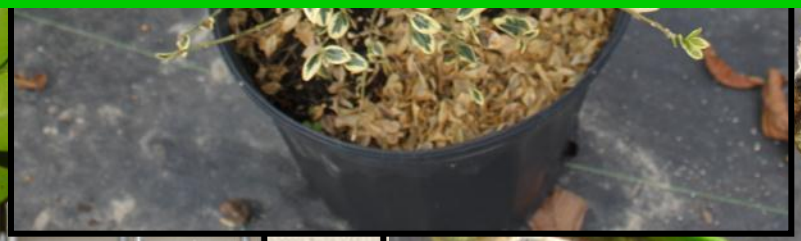
Thank you! Questions?





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