Brief Documentation for Boxwood Blight Infection Risk Model at Uspest.org

Version 1.0 - Mar. 6, 2013

Leonard Coop, coopl@science.oregonstate.edu
Associate Director for Decision Support Systems
Integrated Plant Protection Center
Oregon State University
http://uspest.org/wea

Once reviewed and sufficiently verified, the model will be officially released and added to the multi-pest modeling website as per the link:
http://uspest.org/risk/models?mdl=bxwd_s
(note bxwd_s is the key standing for “boxwood blight – susceptible varieties”)

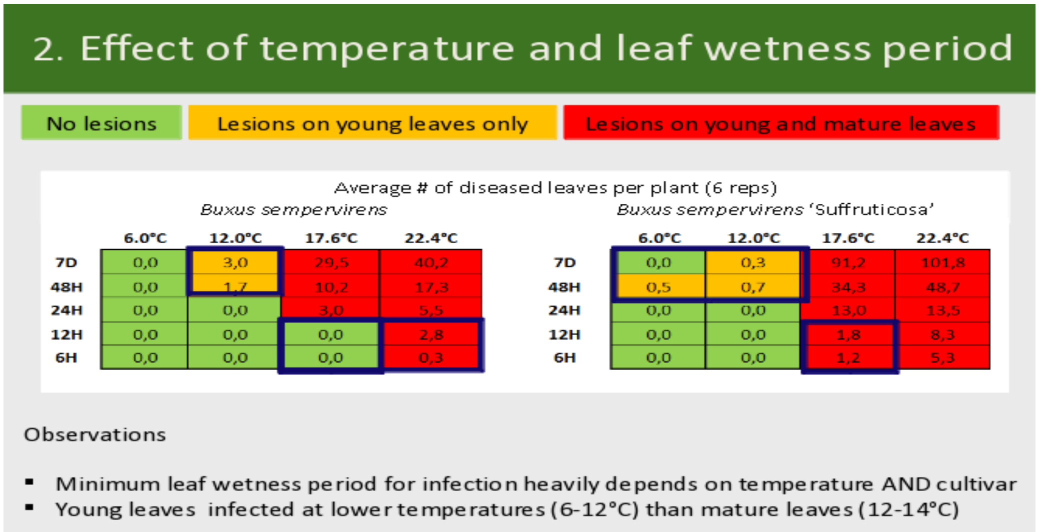
This is a summary of key modeling information developed within the spreadsheet: model_boxwood_blight_v1.xls and PDF version: model_boxwood_blight_v1.pdf

Abstract

The recently introduced pathogen, *Cylindrocladium pseudonaviculatum* (also *C. buxicola*) causes boxwood blight on boxwood, *Buxus sempervirens.* Models to predict infection and severity of this disease are urgently needed. As part of the IPPC/USPEST.ORG commitment to IPM and tools to mitigate the impact of invasive pests in the US, an infection risk model using the “degree-hours (DH) during periods of leaf wetness” approach was developed in order to better predict environmental conditions conducive to infection. This model was developed from recently presented data, thus far from two main sources; 1) a presentation by Belgian researchers Gehesquiere, Huylenbroeck, and Heungens (Sept. 2012), for two varieties of *Buxus*; *B. sempervirens* (Common or American boxwood), which has been classified as susceptible, and *B. sempervirens var. Suffruticosa* (English or true dwarf boxwood), which was found to be among the most highly susceptible varieties assessed (see http://go.ncsu.edu/boxwood_blight_links); and 2) boxwood blight webinars available (Mar. 2012 & Mar. 2013) from http://www.anla.org, including presentations by Sharon Douglas (Conn. Agric. Exp. Sta.) and others. The model will be revised as additional data become available. Two lower temperature thresholds were fit using the x-intercept regression method: 46F (7.78C), for first infections on young foliage; and 51F (10.56C), for first infections on mature foliage. First infection DH values (in Fahrenheit) were: Young leaves (Tlow=46F): B. s. var. Suff.: 56 DHs, B. s.: 160 DHs; Mature leaves (Tlow=51F): B. s. var. Suff.: 41 DHs, B. s.: 144 DHs. Since our goal for this infection risk model is to provide early warning of first infections of most sensitive plants (in this case to young foliage), the 46F/7.78C threshold was used for the single model developed and implemented at the website thus far. The model was also extended to include the relative degree of infection (measured as the number of lesions per plant reported by Gehesquiere et al.). Linear regression models were fitted to these data (young plus mature foliage combined) using the 7.78C threshold. Selected additional predictions (in Fahrenheit) of this extended model include: at 250 DHs: B. s. var. Suff.: 6 lesions, B. s.: 1 lesion; at 400 DHs: B. s. var. Suff.: 12 lesions, B. s.: 3 lesions; at 550 DHs: B. s. var. Suff.: 18 lesions, B. s.: 5 lesions. The model was implemented as version 1.0 at http://uspest.org/risk/models?mdl=bxwd_y. Early tests indicate that DH values accumulate in a pattern similar to apple scab, ranging from a bit less rapidly in central VA to significantly less rapidly in W. Oregon. The model needs improvements as additional results are made available, including to cover a wider range of susceptibilities beyond the two varieties included thus far.

Models of First Infection

Time of first symptoms of infection (lesions on leaves), (data from Gehesquiere et al. 2012, Fig. 1) were plotted vs. temperature (C) to determine potential lower thresholds, both for infection of young leaves and mature (less susceptible) leaves, for the two varieties of *Buxus* studied, *B. sempervirens* and *B. s. var. Suffruticosa* (Fig. 2).



2. Effect of temperature and leaf wetness period

No lesions | Lesions on young leaves only | Lesions on young and mature leaves

Average # of diseased leaves per plant (6 reps)

	Buxus sempervirens				*Buxus sempervirens* 'Suffruticosa'			
	6.0°C	12.0°C	17.6°C	22.4°C	6.0°C	12.0°C	17.6°C	22.4°C
7D	0,0	3,0	29,5	40,2	0,0	0,3	91,2	101,8
48H	0,0	1,7	10,2	17,3	0,5	0,7	34,3	48,7
24H	0,0	0,0	3,0	5,5	0,0	0,0	13,0	13,5
12H	0,0	0,0	0,0	2,8	0,0	0,0	1,8	8,3
6H	0,0	0,0	0,0	0,3	0,0	0,0	1,2	5,3

Observations

- Minimum leaf wetness period for infection heavily depends on temperature AND cultivar
- Young leaves infected at lower temperatures (6-12°C) than mature leaves (12-14°C)

Fig. 1. Data of Gehesquiere et al. 2012 used to develop *Buxus* infection risk models.

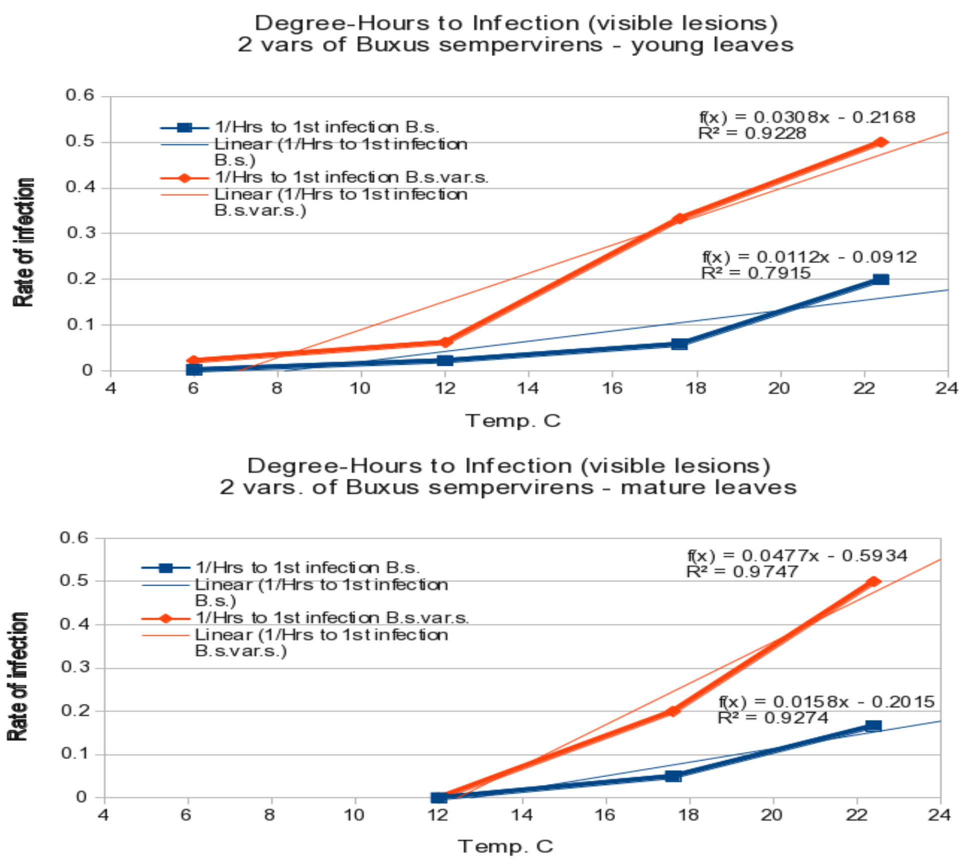


Fig. 2. Regression of rate of first lesion development (1/hours) vs. Temperature (C) for two varieties of boxwood, and for young leaves (Top), and mature leaves (Bottom).

These models indicated low temperature thresholds (using the x-intercept method) for first lesions of between 7.0 and 8.1 C for young leaves, and 12.4 and 12.8 C for mature leaves for the two varieties of boxwood. When combined, and forced to the nearest whole integer (in F) and extended past initial infections (see below), these models were modified to a low threshold of 7.78 C (46 F) for young leaves, and to 10.56 C (51 F) for mature leaves. The modified regression equations retained a reasonably good fit to the data for first infection models (r^2 =0.92 and 0.79, young leaves; 0.93 and 0.97, mature leaves). The resulting DHs to first lesions were: Young leaves (Tlow=46 F): B. s. var. Suff.: 56 DHs, B. s.: 160 DHs; Mature leaves (Tlow=51F): B. s. var. Suff.: 41 DHs, B. s.: 144 DHs.

Degree of Infection Models

From the data of Gehesquiere et al. (2012), we regressed the number of leaf lesions per plant (reflecting the number of infections) vs. DH during leaf wetness periods. Varying the low temperature threshold (Tlow) for DH calculation and recording r^2 values to indicate best fit indicated that a Tlow in the range of 10.5-11 C was best for the data when the young leaves, shown above to be more susceptible at lower temperatures, were included in the analysis, and 11.5-12 C when young leaves were excluded. This degree-of-fit analysis was repeated after dropping the 3 data points with highest number of lesions (due to a leveling off/non-linear effect). Highest r^2 values were obtained for Tlows of 11-11.5 C when including young leaves, and 12 C excluding young leaves.

While these higher Tlow values provide a better fit when infection of mature leaves is modeled, we set an overall common threshold for all models to the lower value of 7.78 C (46 F) to meet the following objectives: 1) Develop a single (pair of) conservative models that best predict first infections on young, more susceptible leaves (for both varieties), 2) Include additional degree of infection risk estimates for young plus mature leaves, 3) Working with the data revealed that the experimental conditions went far beyond the leaf wetness/degree-hour duration expected under natural outdoor conditions, so the highest levels of infection (>500 DHs) were dropped from the analysis, 4) Provide a whole number Tlow when converted to degrees F to facilitate implementation of the model. Using the 7.78 C low threshold, two models of disease build up were then fit to the data (Fig. 3):

B. semp.: Degree of infection (#lesions/plant) = 0.0243 x DH – 2.2275; r^2 = 0.946
B. s. v. Suff.: Degree of infection (#lesions/plant) = 0.0706 x DH – 4.0446; r^2 = 0.877

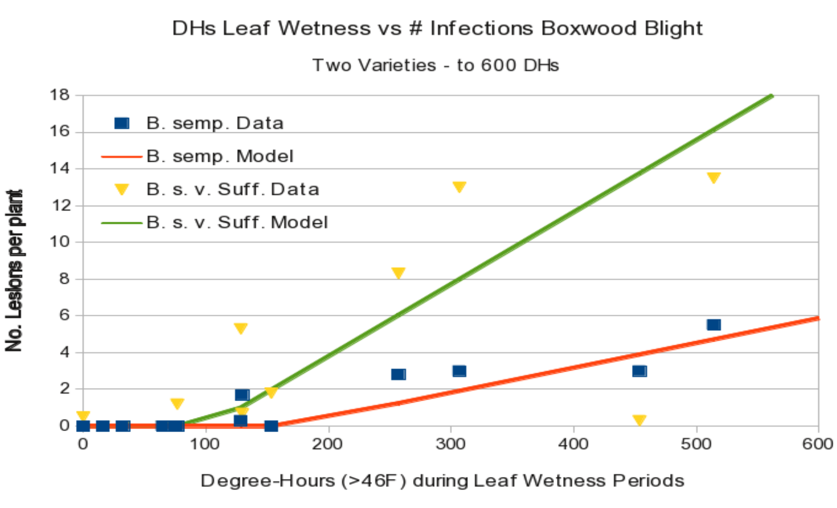


Fig. 3. Degree of infection models (converted to Fahrenheit) and data out to 600 DH.

Model Implementation at USPEST.ORG/WEA

The above models describing first infection risk and degree of infection have been combined and implemented for review and testing at the multi-pest modeling website http://uspest.org/risk/models. It is, like the implementation of apple and pear scab, a standard "degree-hours during periods of leaf wetness" model. The degree of infection model is subject to interpretation of events relevant to management needs, and therefore should be reviewed especially by potential end-users of the model. The combined model currently uses the following selected events and parameters drawn from the two degree of infection models:

Summary of Parameters for Modeling Boxwood Blight :

Name of model: Boxwood blight infection risk
Model type: Degree-hours (DHs) accum. during leaf wetness periods
Lower temp. threshold: 46F (7.78C)
Upper temp. threshold: 85F (29.4C)
No. of dry hours to stop the infection cycle: more than 8.0
DHs to first infection of young leaves (highly susc. Var.): 56
DHs to first infection of young leaves (susc. Var.): 160
DHs for infection resulting in: 6 lesions, highly susc. Var., 1 lesion, susc. Var: 250
DHs for infection resulting in: 12 lesions, highly susc. Var., 3 lesions, susc. Var: 400
DHs for infection resulting in: 18 lesions, highly susc. Var., 5 lesions, susc. Var: 550
Model assumptions: 1. Spores from microsclerotia generally require rainfall to spread and initiate the infection process, thus the model conservatively does not require rainfall events, as spores may also be present from existing lesions.
2. The model should reflect a range of infection conditions most likely to occur in typical N. America climates; it was adjusted to reflect needs in the humid mid-latitudes (such as NC, VA, WV, PA, and MD).
3. These results reflect work performed on one highly susceptible (English boxwood) and one susceptible (American boxwood) variety; lower infection risk levels would be expected for less susceptible varieties.

Initial tests of model parameters were compared to the apple scab model using the website at http://uspest.org/risk/models:

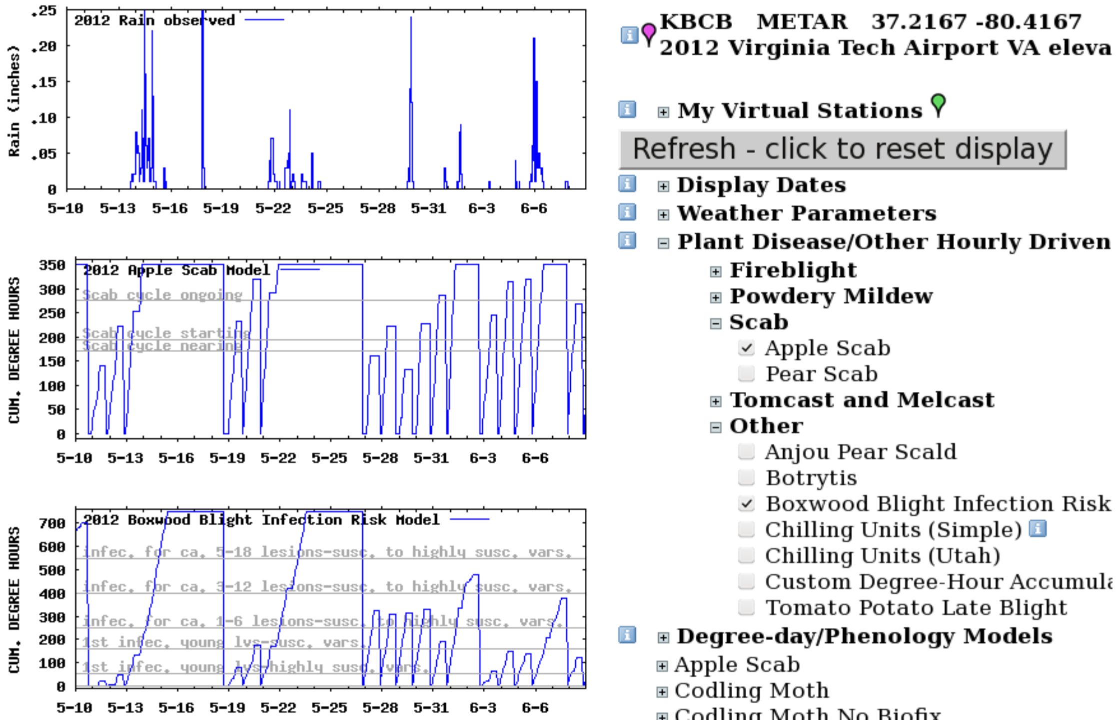


Fig. 4a. Comparison of preliminary infection risk model online at http://uspest.org/risk/models for boxwood blight (bottom plot) vs. apple scab infection risk model (middle plot), May 10-Jun 9, 2012, Blacksburg, VA. Note that the boxwood blight reset threshold was arbitrarily set to 8 dry hours as used for apple scab model, one reason the two plots are similar.

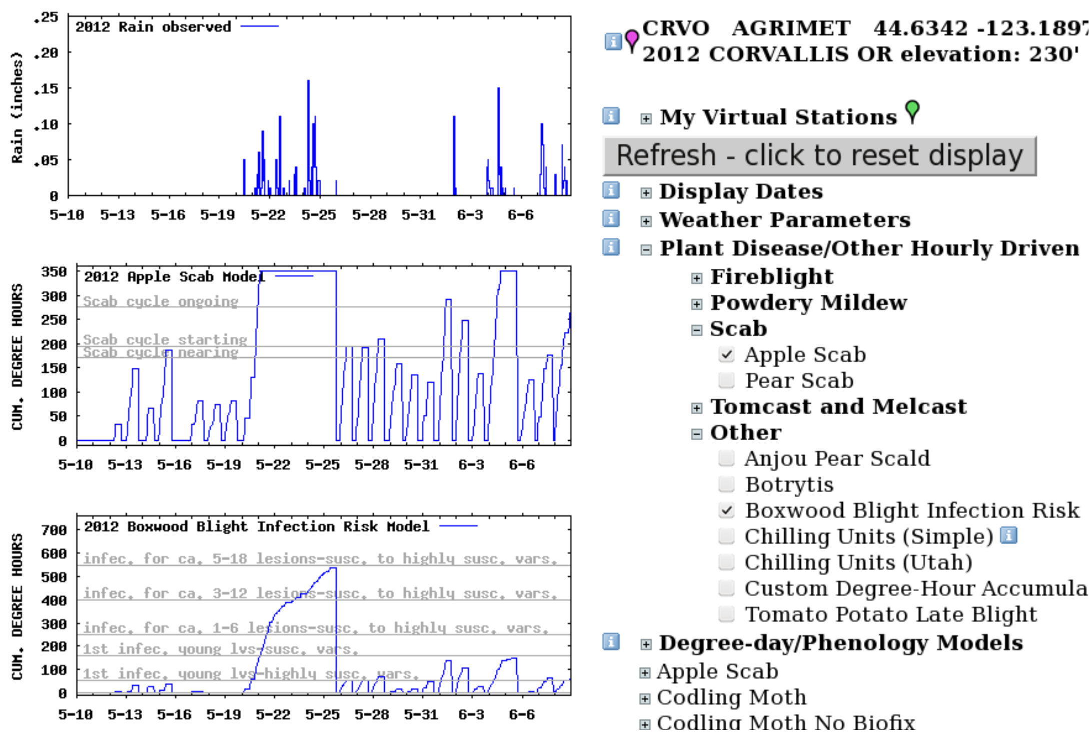
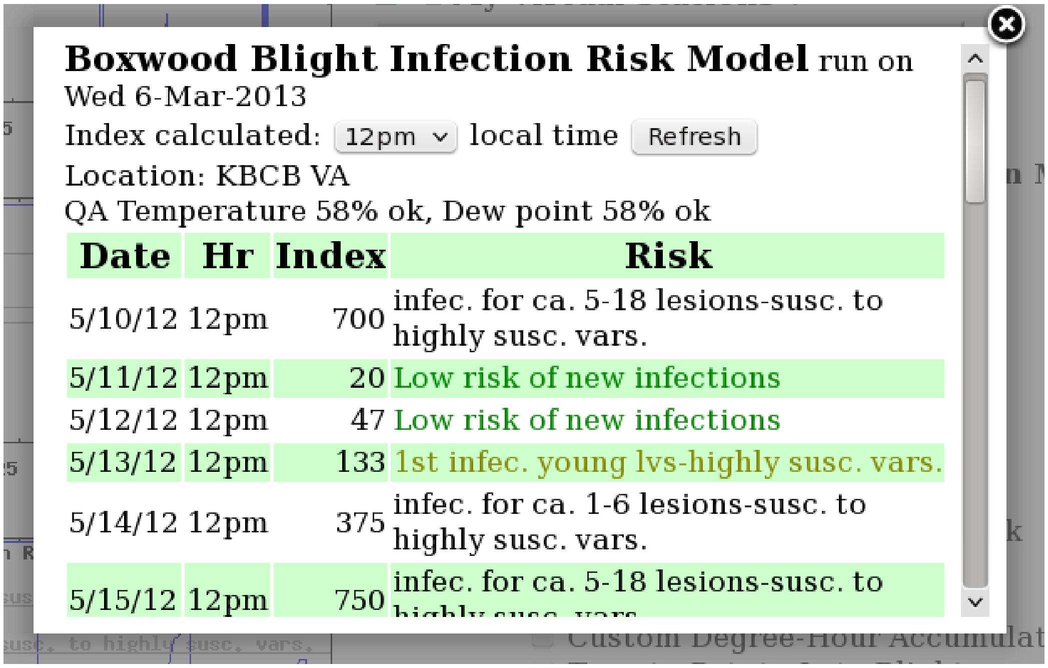


Fig. 4b. Same time interval model output for CRVO Corvallis, Oregon. Note conditions that favor apple scab do not suggest similar infection conditions for boxwood blight as seen for the example location in Virginia.



Boxwood Blight Infection Risk Model run on Wed 6-Mar-2013
Index calculated: 12pm local time Refresh
Location: KBCB VA
QA Temperature 58% ok, Dew point 58% ok

Date	Hr	Index	Risk
5/10/12	12pm	700	infec. for ca. 5-18 lesions-susc. to highly susc. vars.
5/11/12	12pm	20	Low risk of new infections
5/12/12	12pm	47	Low risk of new infections
5/13/12	12pm	133	1st infec. young lvs-highly susc. vars.
5/14/12	12pm	375	infec. for ca. 1-6 lesions-susc. to highly susc. vars.
5/15/12	12pm	750	infec. for ca. 5-18 lesions-susc. to

Fig. 4c. The same preliminary model example output (as in Fig. 4a) in tabular format (requires clicking on the plot for the table to pop-up, note scroll bar indicating only partial results are displayed), at http://uspest.org/risk/models.

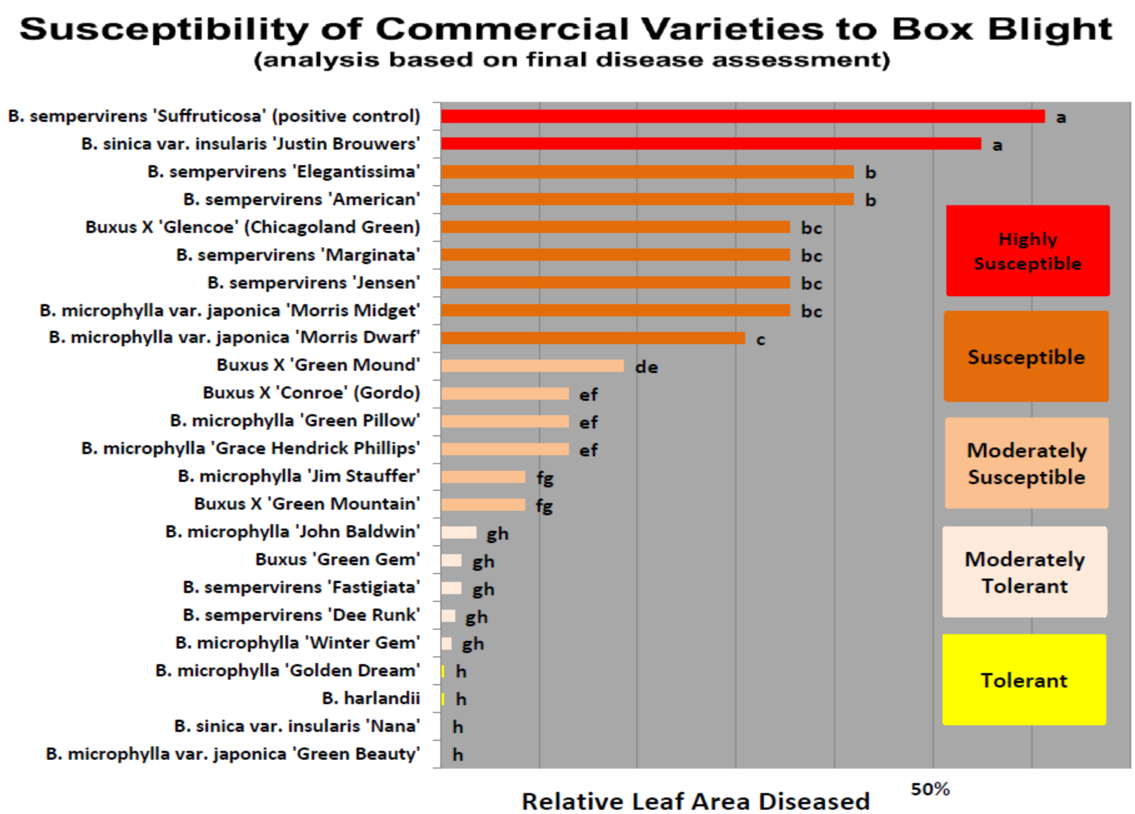


Fig. 5. Information on relative susceptibility of varieties of boxwood to boxwood blight. From NCSU website, http://go.ncsu.edu/boxwood_blight_links. For reference in interpreting current model outputs.

Areas for Potential Model Improvement

This model is preliminary and requires additional research results to verify the findings it is based upon. However this model is likely to be conservative for the most part in predicting infection risk, based on assumptions noted above. In addition, the model requires local validation for any region where it is used. New sources of data relating environmental conditions to infection risk are expected to improve the model in the near future. In addition, the several other varieties of *Buxus*, as well as other susceptible plant groups should be compared to these results and perhaps the model can be revised or split for several categories of susceptibility, such as moderately tolerant, moderately susceptible, susceptible, and highly susceptible (as shown in Fig. 5.).