Integrating Short and Long Term Risk Models for Boxwood Blight

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ABSTRACT

Boxwood blight, caused by the ascomycete fungus, *Calonectria pseudonaviculata* (*Cps*) is an invasive disease of boxwood (*Buxus* spp.) and related genera (*Sarcococca, Pachysandra*, others) in the family Buxaceae. We present several models that can be used at varying spatial and temporal scales to predict *Cps* infection and outbreak risk, along with climatic suitability for long-term establishment risk, based upon weather and climate data. A short-term infection risk model has been available since 2014, with numerous updates, that uses hourly temperature and moisture data to predict risk. This model can be run at single sites using a web page integrated with 150 other pest, crop, and plant disease models, at uspest.org. A new mobile-adapted app version has recently been updated with email notification "push" capabilities, according to schedules of user's selection. A North American synoptic version of the model is updated online daily, which provides a regional-to-national view of current, forecast, and past infection risk levels.

We also developed a new spatialized, daily time-step model that integrates short term infection risk predictions, which were calibrated based upon the hourly weather-driven models, with long term infection risk, based on climatic suitability. The DDRP-BOXB (Degree-Days, establishment Risk, and Phenological event maps – Boxwood Blight) climatic suitability model was calibrated using the process-based CLIMEX platform, and an ensemble of correlative risk models, which were all developed using global *Cps* occurrence data (Barker et al, submitted). This model, an expansion of the published DDRP platform (Barker et al. 2020), provides stakeholders with short and long term estimates of both when and where boxwood blight is likely to occur and affect boxwood plantings, whether in nurseries or landscape settings.

CREDITS

The Oregon IPM Center at Oregon State University works closely with and gives thanks and appreciation to: funding agencies USDA NIFA CPPM ARDP (Applied Research and Development Program), W. IPM Center, APHIS PPQ, NOAA NWS, MESOWEST Utah, and the OSU PRISM Climate Data Group. We thank numerous sources of free and public weather data including WSU AgWeatherNet, AGRIMET, ADCON, CIMIS, Daymet, and numerous other public and agricultural networks. The system was built using open source software tools such as GNU/LINUX, GRASS GIS, and the R, Python, and Perl programming languages. This poster (P118) presented at: International IPM Symposium, Feb. 28-Mar. 3, 2022.

Short Term (hourly): infection risk

Temperature vs. infection rate. We combined data from Gehesquière (2014) and Avenot et al. (2017) to develop a lookup-table approach to determining degree-hours during leaf wetness periods for infection rate of boxwood blight, for the susceptible cultivars including *Buxus simpervirens* and *B. simpervirens* "Suffruticosa". **(Fig. 1)**

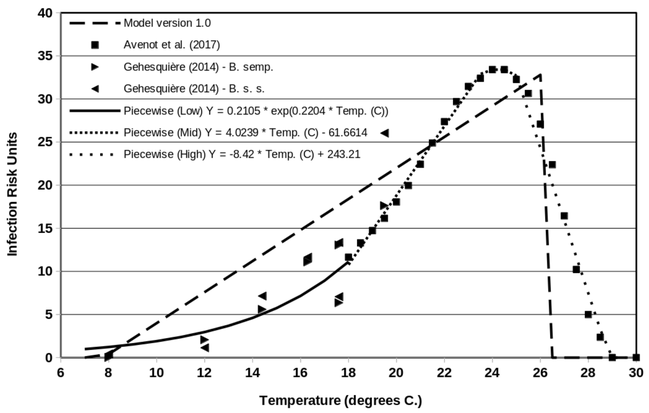

Fig. 1. The effect of temperature on rate of Infection used for boxwood blight model.

Boxwood blight model app

The model app was developed with mobile devices in mind. It includes a tab-based interface. I**nputs:** 1) find nearest weather station, 2) start date if checking past outbreaks, otherwise not required, 3) time frame of interest. **Outputs:** both Graph and Table formats. A short introduction section is also included. Model results can also be delivered as automated email notifications as a free subscription service.

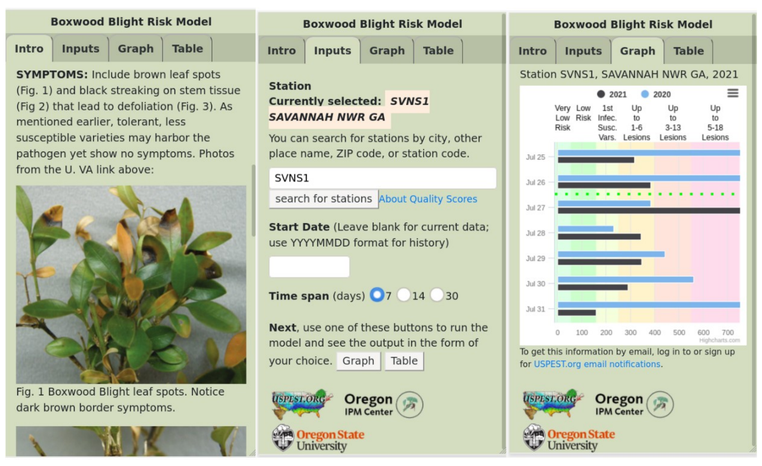

Fig. 2. Boxwood blight model app, https://uspest.org/risk/boxwood_app user interface. **(Left)** Introduction to boxwood blight and model usage, **(Middle)** Inputs including weather station, optional start date, and ouput preferences, **(Right)** Model output graph showing infection risk over time including use of a 5-day weather forecast.

Short Term (spatial): infection risk

We modified the existing DDRP modeling platform (Barker et al. 2020) to incorporate leaf wetness estimates based on average relative humidity (RH) combined with precipitation using daily PRISM data. This algorithm was calibrated using the synoptic version of our hourly-weather driven infection risk model output (Fig. 3).

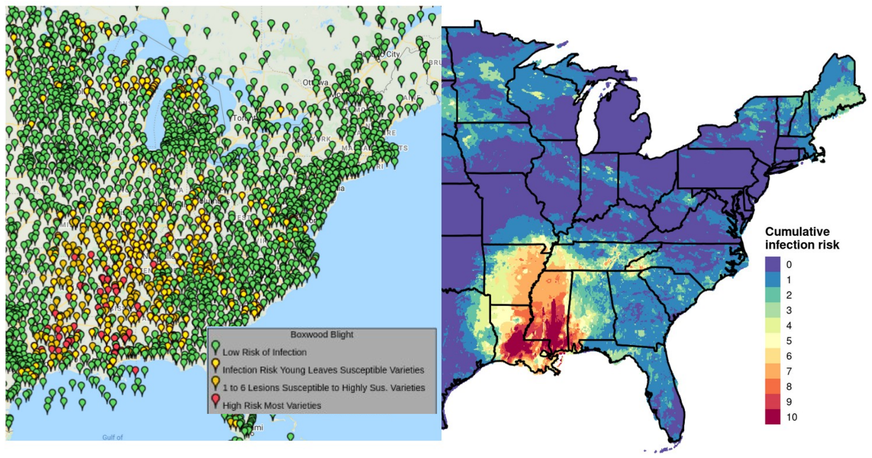

Fig. 3. (Left) Synoptic version of hourly weather driven infection risk model output (July 15, 2019). **(Right)** DDRP-BOXB short term infection risk (July 12-15, 2019) illustrating how daily parameters were calibrated, and model output for real-time decision support.

Long Term (spatial): climate suitability

We calibrated cold, heat, and dry stress parameters in DDRP-BOXB based on CLIMEX (Fig 4) and correlative "climate envelope" models (not shown).

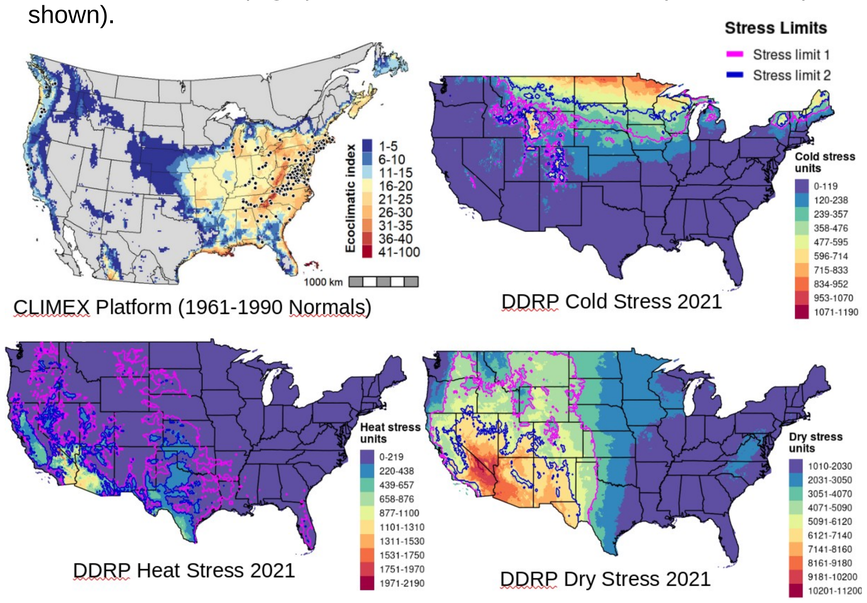

Fig. 4. Comparison of climate suitability models for boxwood blight: **(Upper left)** CLIMEX model developed using global location records and older 30-year average data. **(Other maps)** DDRP-BOXB model stress factors for 2021, when combined, provide similar climate suitability predictions to CLIMEX.

Example model outputs and applications

The DDRP-BOXB model is integrated to predict plant disease infection risk (short term, Fig. 3, right) and both infection risk and establishment risk (long term) for the conterminous US (Fig. 5).

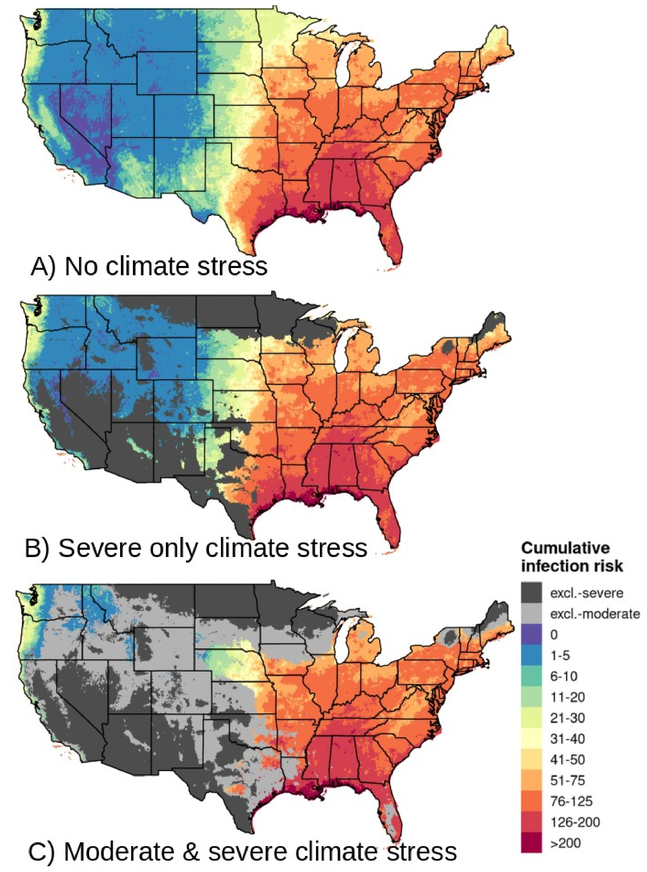

Fig. 5. A) Year-long cumulative boxwood blight infection risk for 2021, B) Same as (A) with climate suitability (establishment risk, severe stress only), C) Same with both moderate and severe climate stress.

Plans for future work

Our next step is to develop an online model interface for real-time decision support. Funding has also been secured for further expansion of the DDRP platform beginning with a suite of invasive insect, plant disease, and weed pests. We also are exploring how photoperiod interacts with phenology in support of predictive models to aid in weed biological control.

References

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