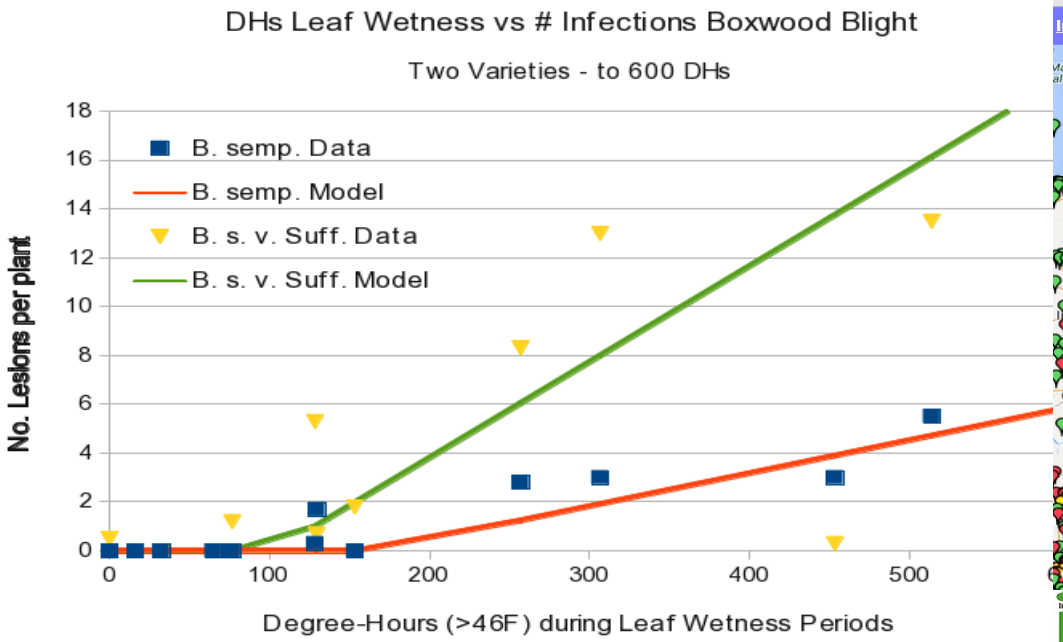
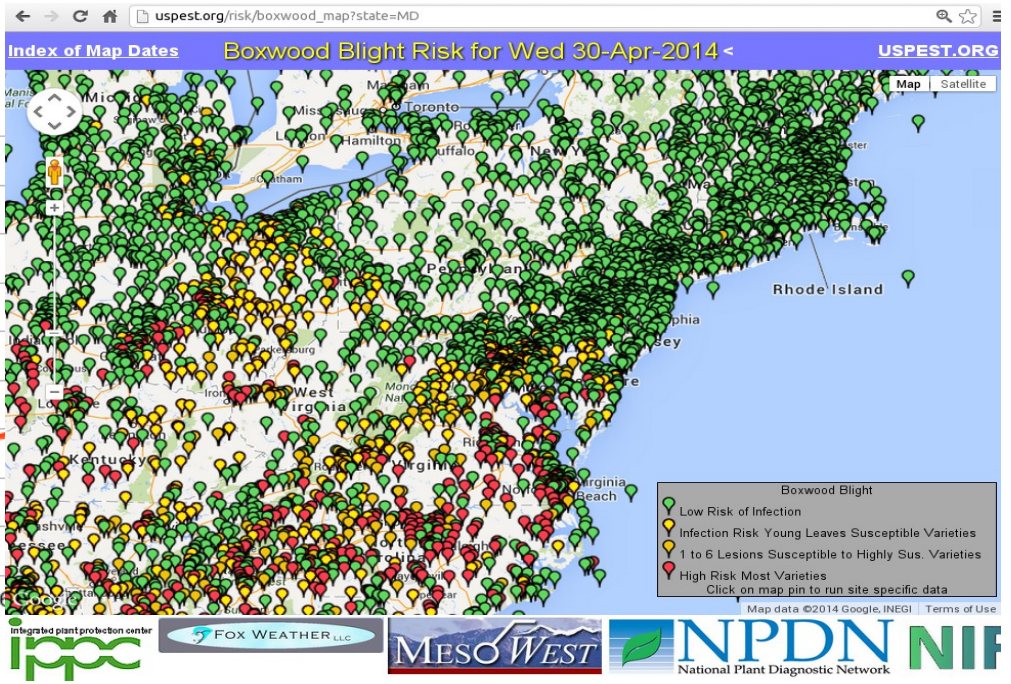
Developing a Predictive Boxwood Blight Model for the U.S.

Len Coop
Integrated Plant Protection Center & Botany and Plant Pathology Dept.
Oregon State University, Corvallis OR
May 13, 2014





OSU integrated plant protection center Western IPM Center MESO WEST NIFA ipmPIPE

USPEST.ORG Website

- Serving weather-driven pest models since 1996
- Now with 104 models (mostly degree-day and hourly weather-driven)
- Support for several invasive pests, working with USDA APHIS PPQ, ipmPIPE, NPDN, Western IPM Centers, NIFA funded grants

MyPest Page - IPM Pest and Plant Disease Models and Forecasting

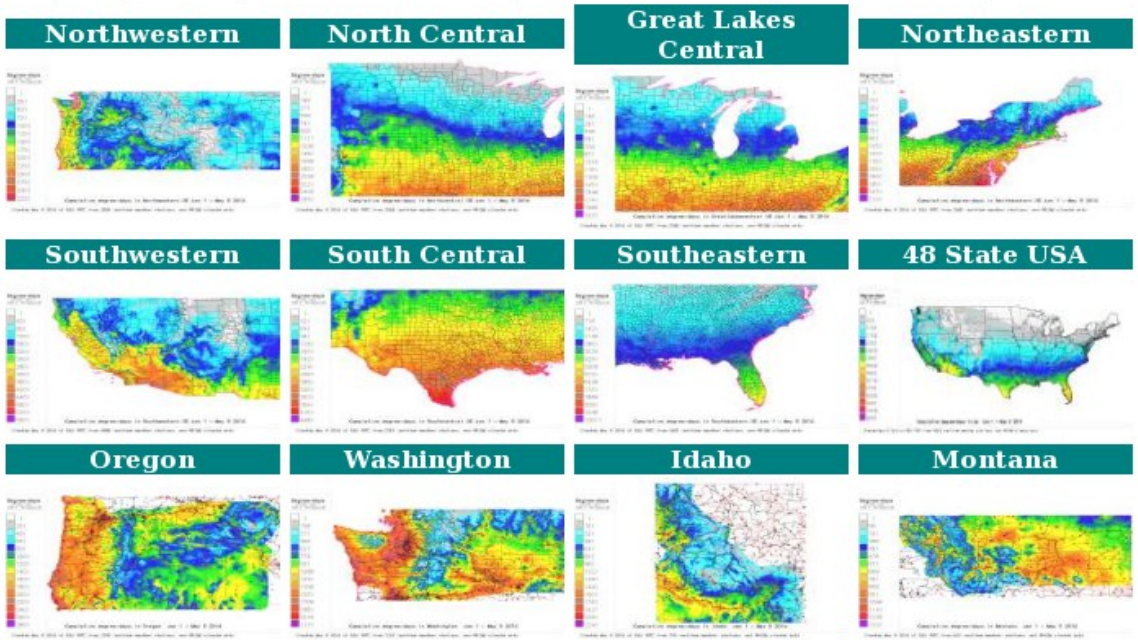
USPEST.ORG

for Agricultural, Pest Management, and Plant Biosecurity Decision Support in the US

Introduction | Quick Start | Map Index | Shortcut Links | Degree-day Maps

Custom degree-day mapmaker for 48 US states - use your own settings:
new server (fastest), 2nd server

Daily degree-day accumulation maps - click on a region for more maps:



Use these maps to track heat unit build-up using the temperature thresholds 32°, 41°, and 50° F, and for GIS interface to calculate degree-days at specific locations.

integrated plant protection center IPPC OSU | PRISM GROUP | Western IPM Center | ipmPIPE | NPDN National Plant Diagnostic Network | NIFA

Plant Disease/Other Hourly Driven Models

- **Fireblight**
  - Fire Blight (Cougarblight older version)
  - Fire Blight (Cougarblight 2010EZ)
  - Fire Blight (Cougarblight 2010 hourly)
- **Powdery Mildew**
  - Cherry Powdery Mildew
  - Cleistothecial Powdery Mildew
  - GT Powdery Mildew
  - Hop Powdery Mildew
  - Pearson-Gadoury (1987) Ascospore release Model
  - Strawberry Powdery Mildew
- **Scab**
  - Apple Scab
  - Pear Scab
- **Tomcast and Melcast**
  - Muskmelon Melcast
  - Tomcast DSV
  - Watermelon Melcast
- **Other**
  - Anjou Pear Scald
  - Botrytis
  - ☑ Boxwood Blight Infection Risk
  - Chilling Units (Simple)
  - Chilling Units (Utah)
  - Custom Degree-Hour Accumulation Model
  - Tomato Potato Late Blight

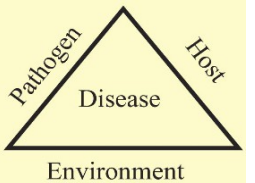
Degree-day/Phenology Models

Available Models		Selected Models
Apple Maggot 1st Emerge	--- Add --->	Asian Citrus Psyllid
Apple Maggot Percent Emerge	<--- Remove ---	Brown Marmorated Stink Bug
Apple Scab		Cereal Leaf Beetle
Barley		Emerald Ash Borer
Bertha Armyworm		European Grapevine Moth
Black Cutworm		Gypsy Moth Sheehan-Simplifie
Cabbage Looper		Light Brown Apple Moth
Cabbage Maggot		Spot. Wing Dros. OW Mortal.
Canary		Spotted Wing Drosophila
Canola-Argentine		

Uspest.org Boxwood Blight Infection Risk Models

Some considerations:

- A goal is to provide a risk warning system for when the environment is conducive to infection events
- We plan to keep the model or series of models as up to date as time and funding allows
- The current model is derived almost entirely from the Belgian work team including Kurt Heungens, Bjorn Gehesquiere, et al.



A Decade Plus of Boxwood Blight Research

Bjorn Gehesquière, Johan Van Huylenbroeck, Filip Rys, Kurt Heungens

18th Ornamental Workshop on Diseases and Pests

September 25, 2012

Institute for Agricultural and Fisheries Research
Plant Sciences Unit
www.ilvo.vlaanderen.be

Werkgroep Buxus

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

	6.0°C	12.0°C	17.6°C	22.4°C
7D	0,0	3,0	29,5	40,2
48H	0,0	1,7	10,2	17,3
24H	0,0	0,0	3,0	5,5
12H	0,0	0,0	0,0	2,8
6H	0,0	0,0	0,0	0,3

Buxus sempervirens 'Suffruticosa'

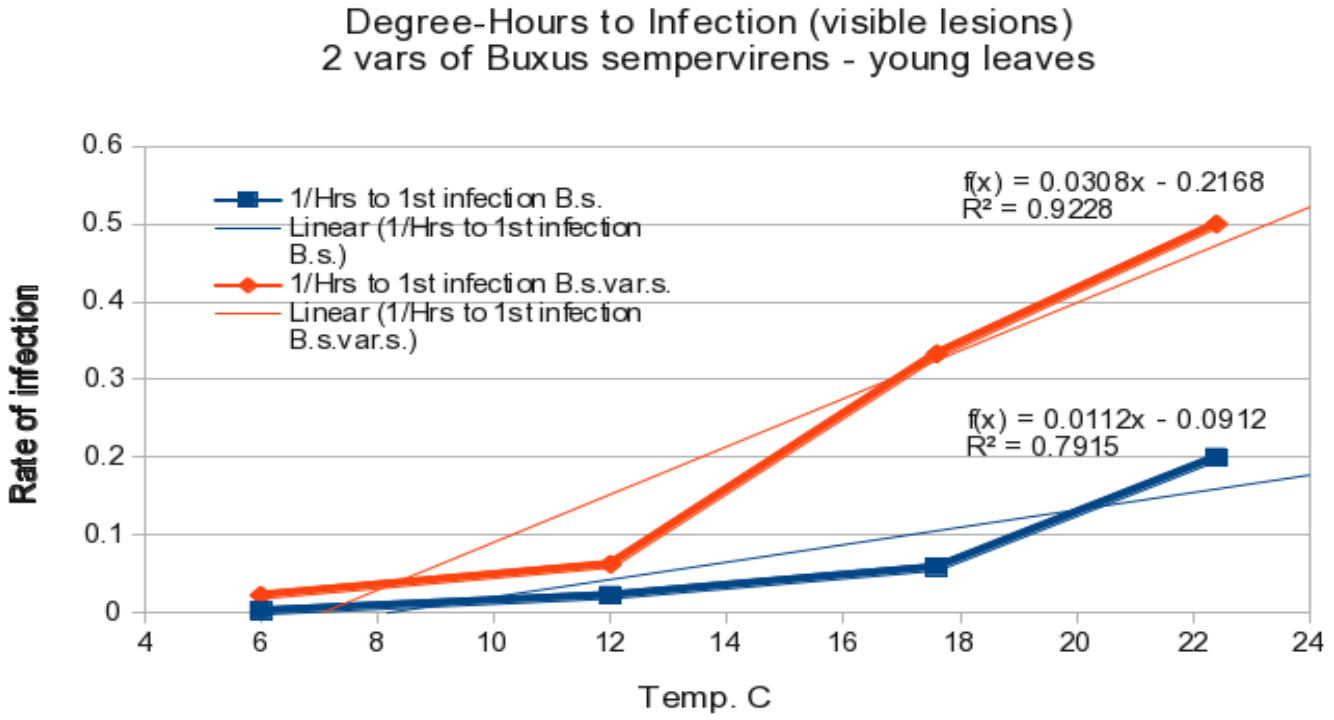
	6.0°C	12.0°C	17.6°C	22.4°C
7D	0,0	0,3	91,2	101,8
48H	0,5	0,7	34,3	48,7
24H	0,0	0,0	13,0	13,5
12H	0,0	0,0	1,8	8,3
6H	0,0	0,0	1,2	5,3

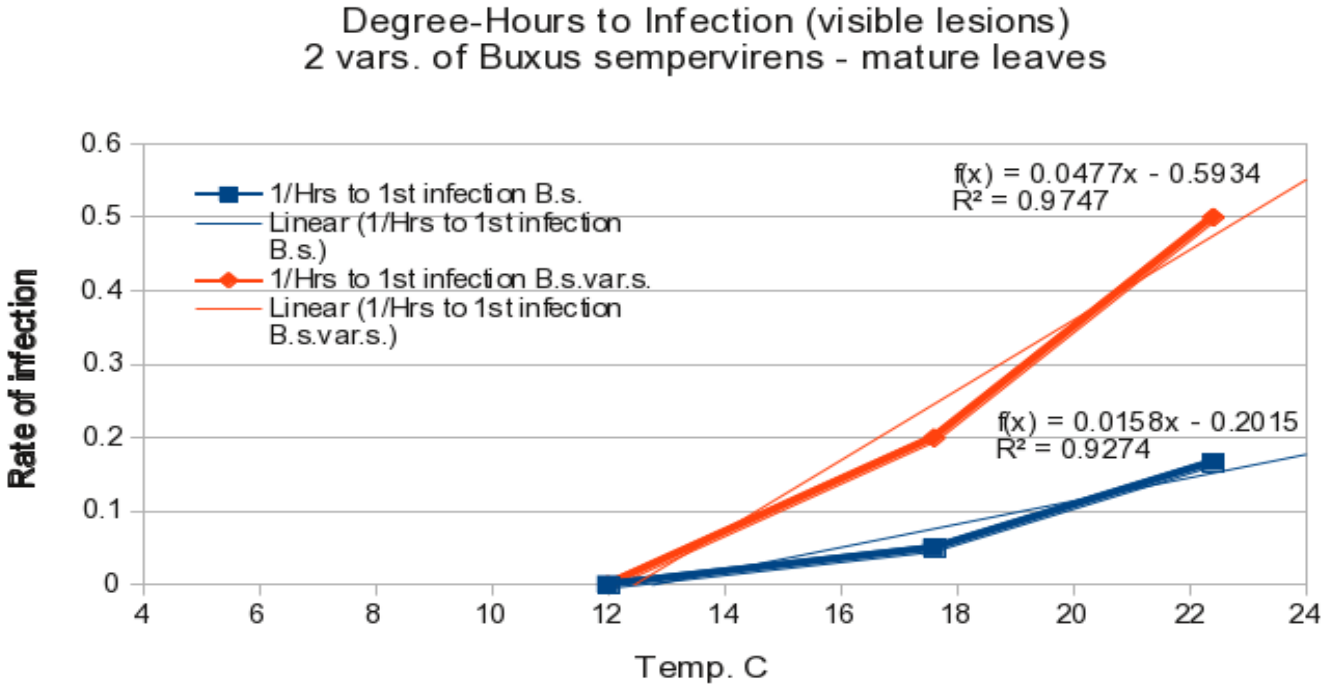
Observations

- 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)

Uspest.org Boxwood Blight Infection Risk Models

- The first question for building one or more models: as the temperature threshold seems to be much lower for young vs. mature leaves, do we need separate models with different thresholds?



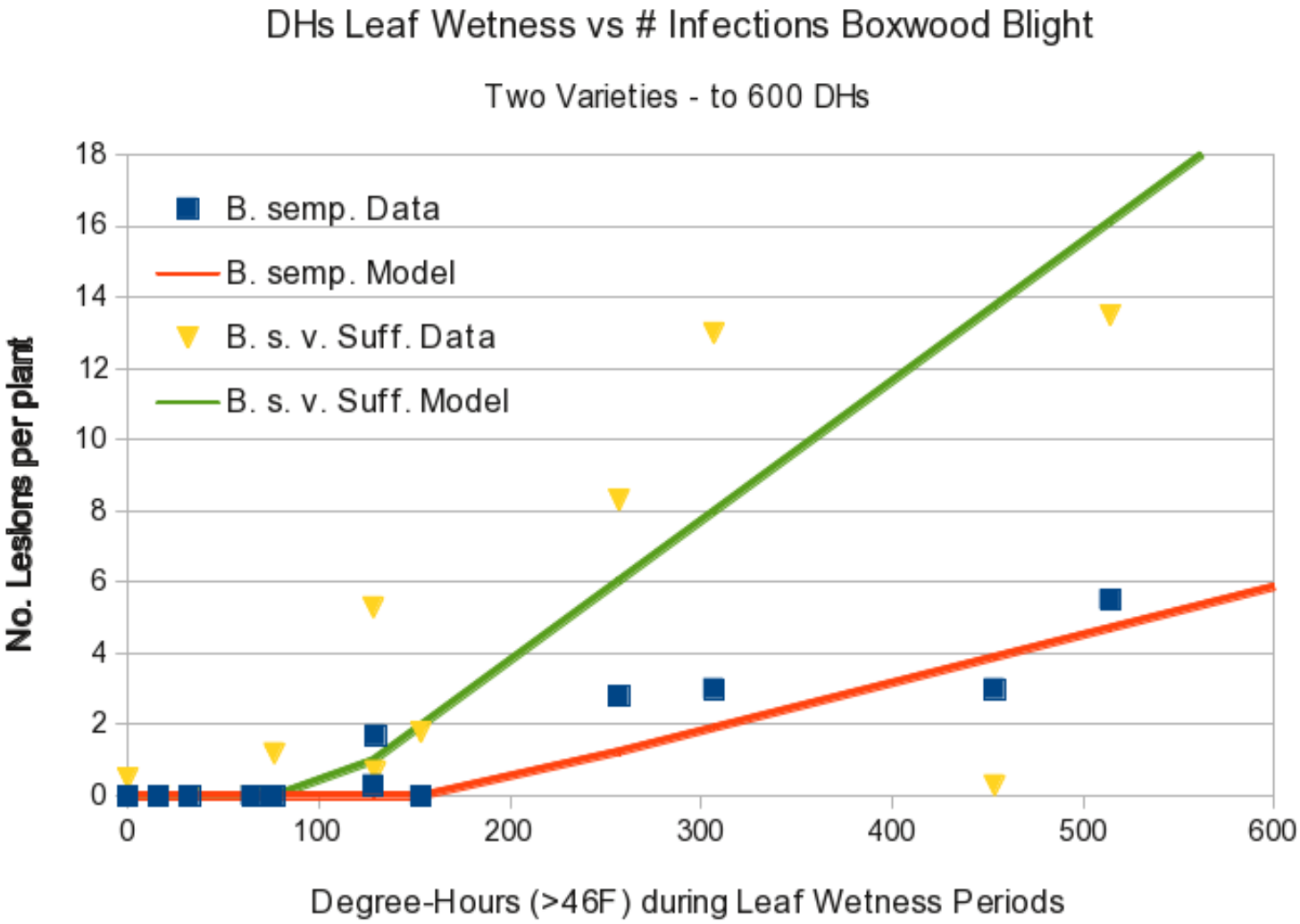


Uspest.org Boxwood Blight Infection Risk Models

- The 2nd question for building model(s):

Do we want to model just first infection risk or (also) the number of lesions or severity of the disease?

We used this method to help settle on a single model with a lower threshold of 7.78 C (46 F)



Summary of Parameters for Modeling Boxwood Blight (Vers 1.0):

Name of model: **Boxwood blight infection risk**
Model type: **Degree-hours (DHs)** accum. during **leaf wetness** periods
"inverse Mills table approach"
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**

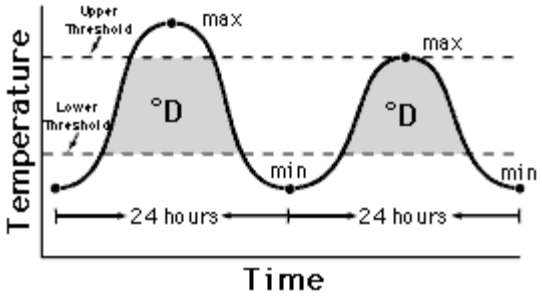
Model assumptions: 1. Spores from microsclerotia generally require rainfall to spread and initiate the infection process, thus the model conservatively does not require rainfall events, as spores may also be present from existing lesions.

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.

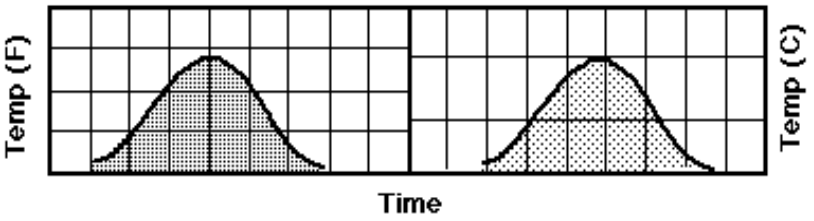
What is a degree-hour?

Like a degree-day, which is a thermal unit that integrates temperature over time spanning 1 day...



Simple formula DDs = (daily max+min/2) - Tlow

A degree-hour integrates temperature over 1 hour...



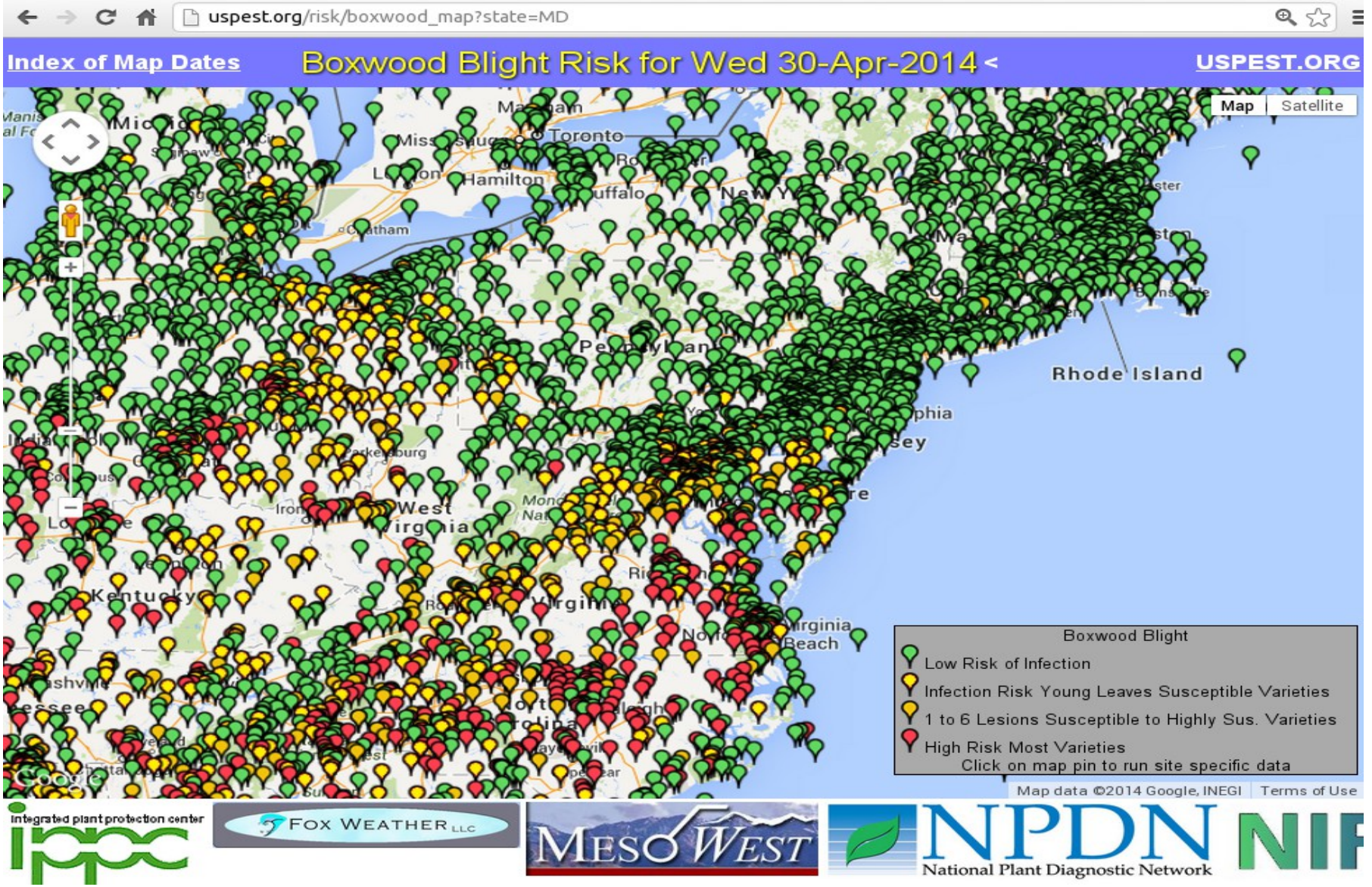
Used in plant disease management because the infection process can take just hours rather than days...

And happens typically during periods of sufficient moisture such as when RH > 95% or when leaf wetness occurs

Simple formula DHs = hourly avg temp - Tlow

Uspest.org Boxwood Blight Infection Risk Mapping
uspest.org/risk/boxwood_map

Some considerations:
- Hourly risk accumulated over past several days
- Numerous public weather networks of varying quality/citing standards

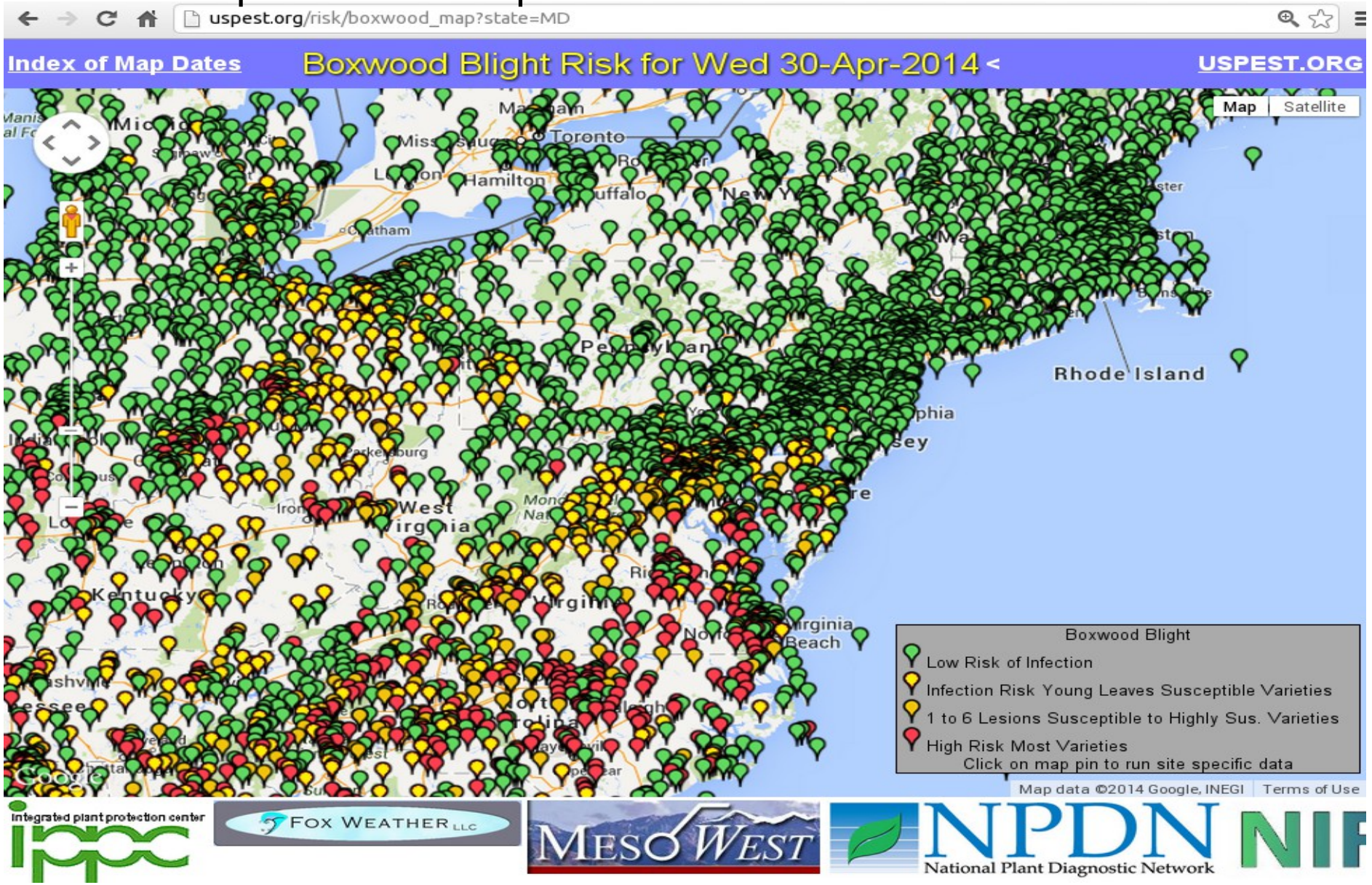


Uspest.org Boxwood Blight Infection Risk Mapping

uspest.org/risk/boxwood_map

Some considerations:

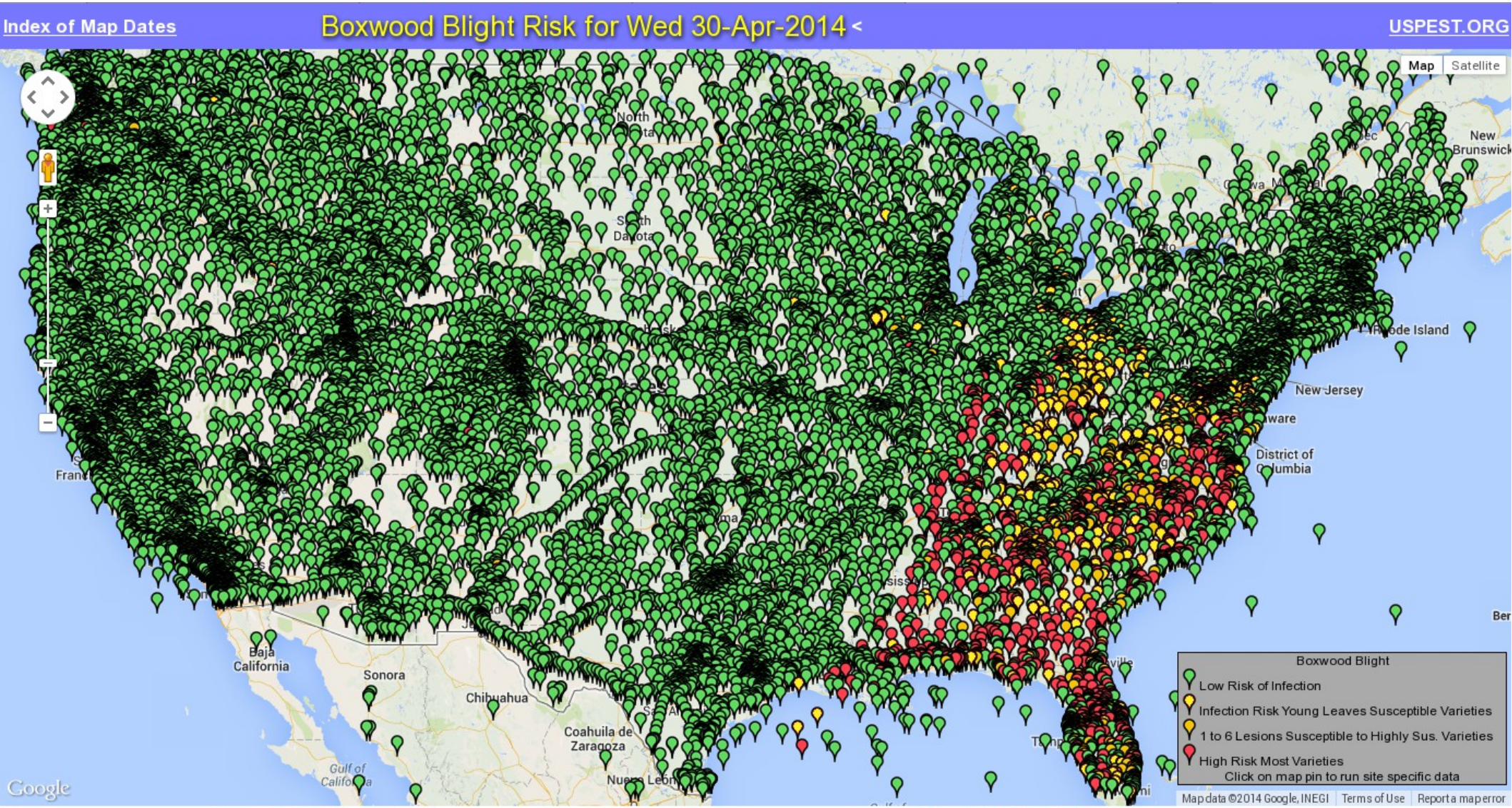
- Click on a pin to run the model w/7-day forecast for that weather station
- Current maps do not incorporate a forecast themselves



Uspest.org Infection Risk Mapping

Some considerations:

- Computed daily over 18,000 locations US and outlying areas



Integrated plant protection center

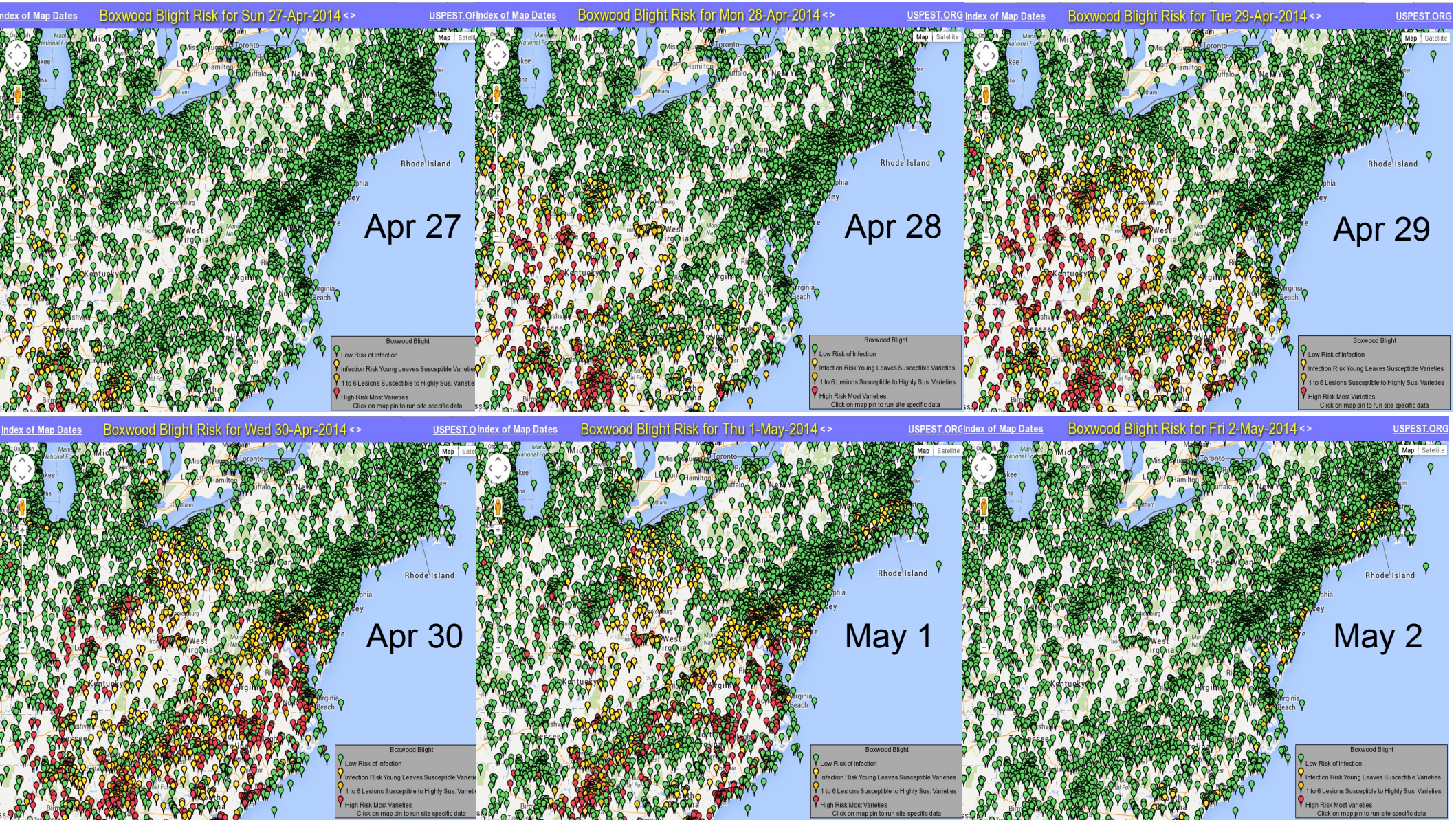
FOX WEATHER

MESO WEST

NPDN National Plant Diagnostic Network

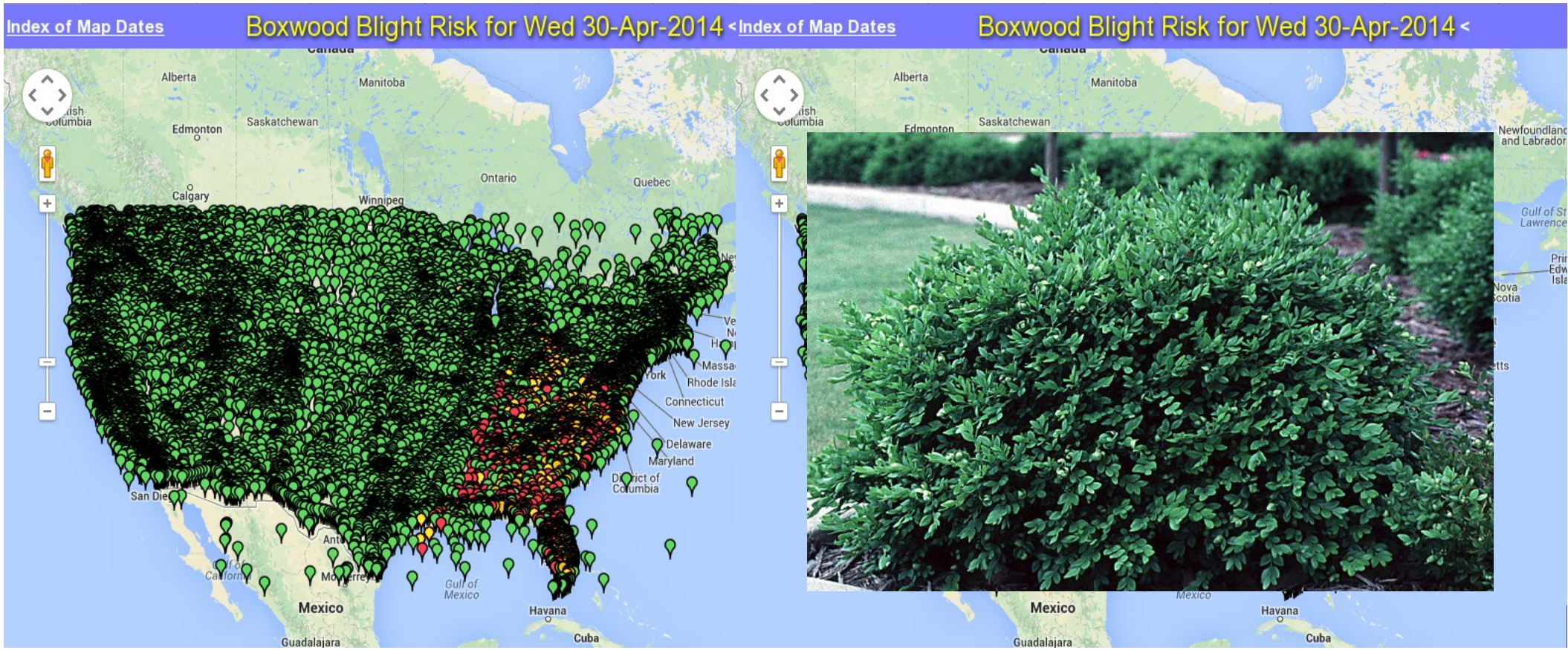
NIFA

Uspest.org Infection Risk Mapping – stepping day by day – a recent infection event cycle (Apr 27-May 2)



Uspest.org Boxwood Blight Infection Risk Mapping

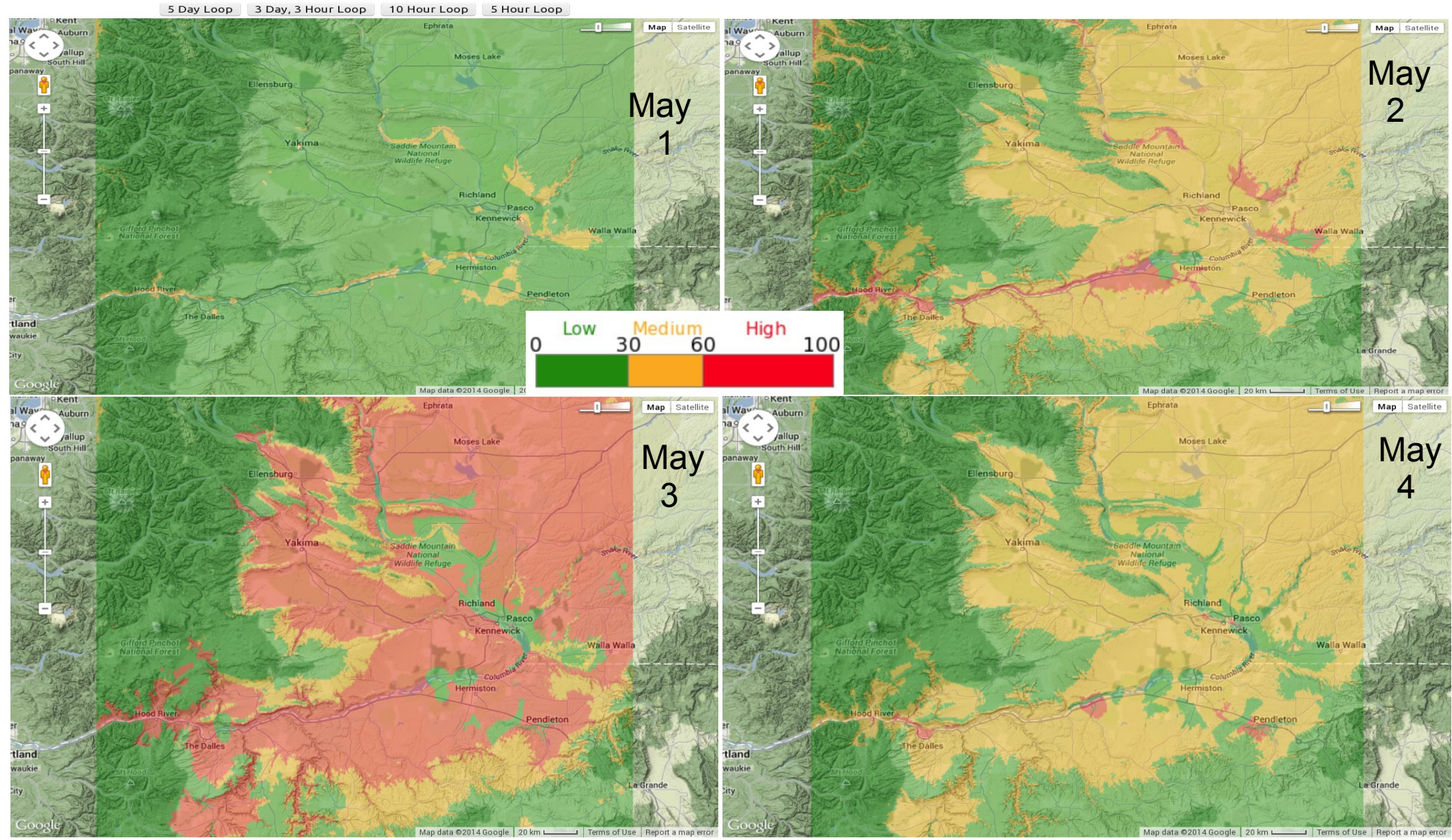
Coincidence?
- Zoom out far enough the map kind of looks like boxwood ;-)



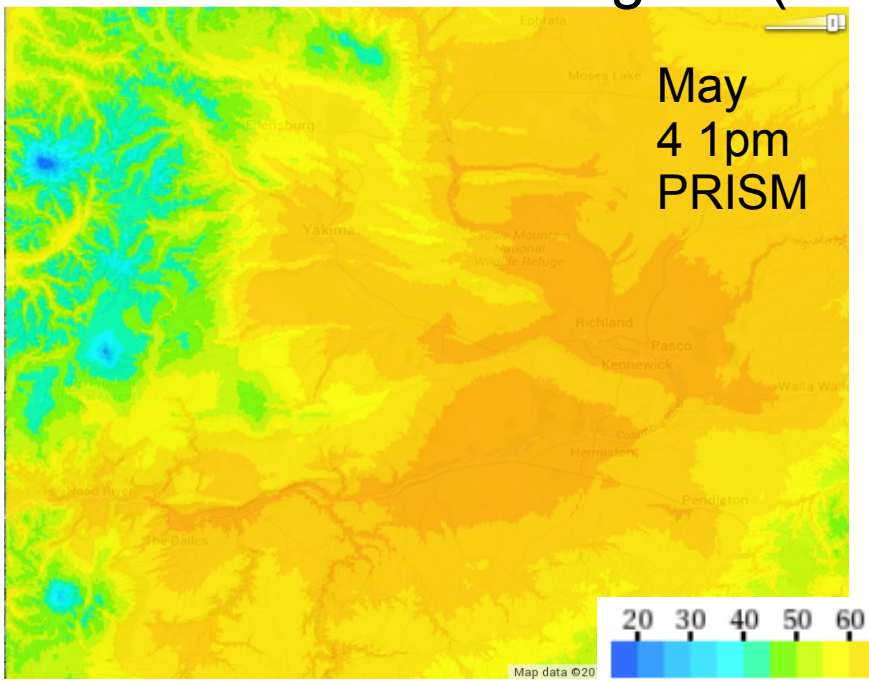
Optional infection risk mapping – Infrastructure built for 4 regions, 4 diseases – 800m resolution, PRISM data interpolation, loops

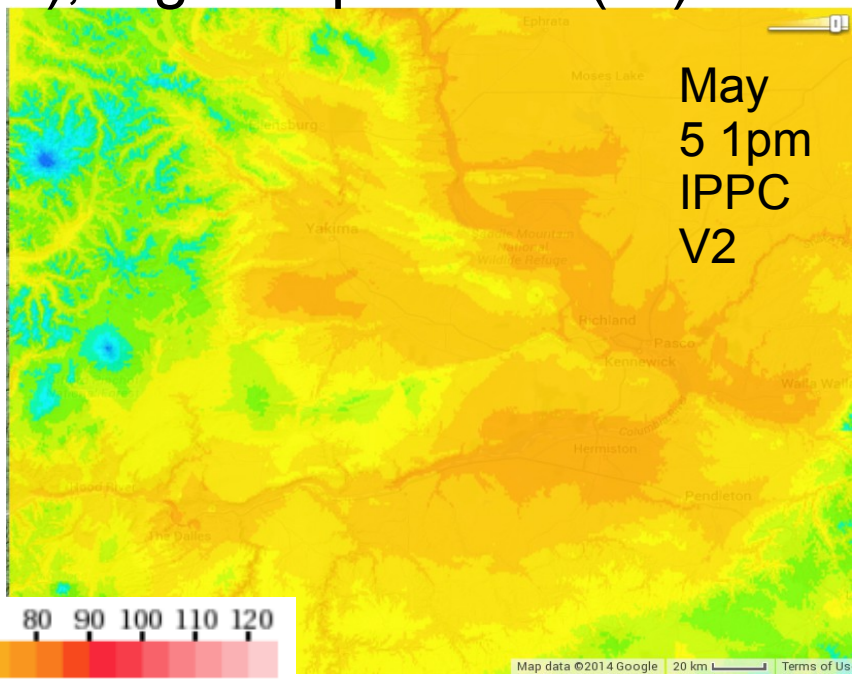
uspest.org/risk/grid_display

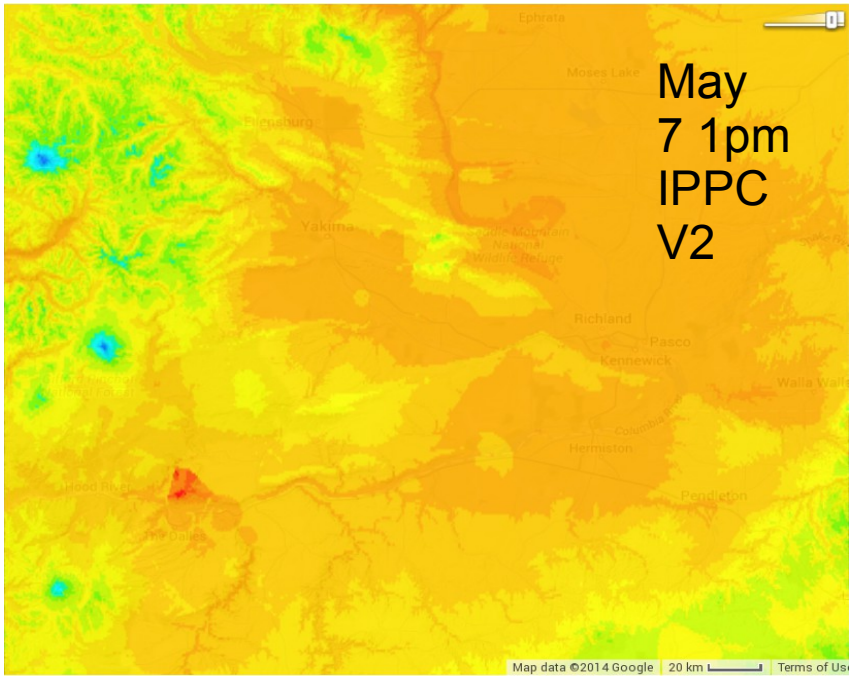
ex. Columbia Basin hop powdery mildew

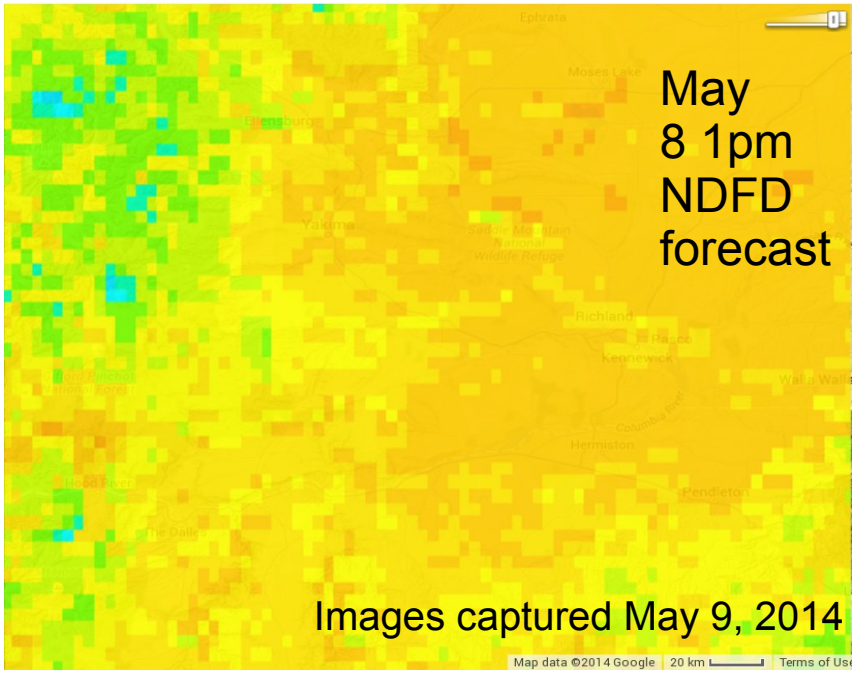


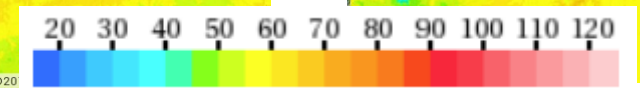
Disease grids based on hourly PRISM (800m), IPPC V2 (800m) and NDFD forecast grids (2.5km), e.g. temperature (°F)





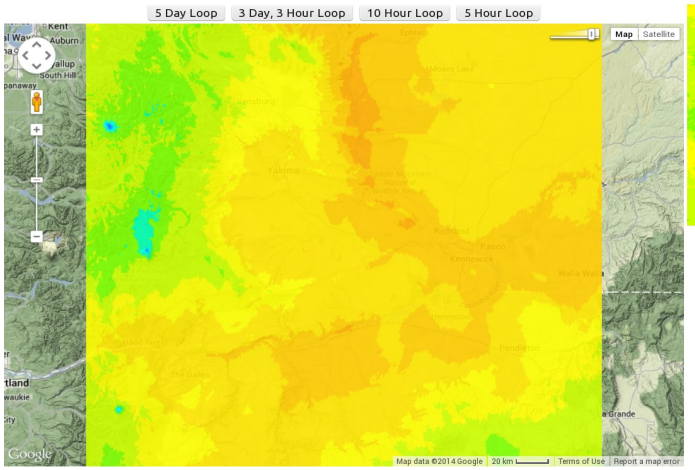




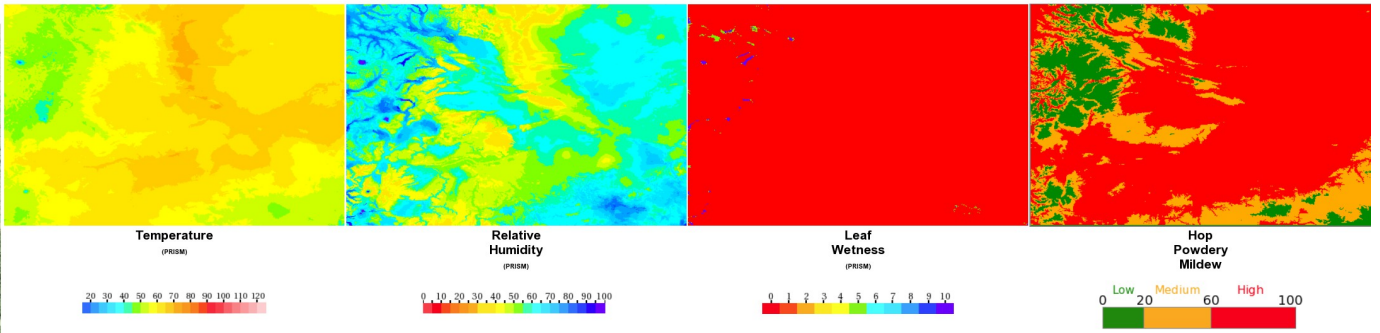


PRISM (800m), IPPC V2 (800m) interpolated weather observations & NDFD gridded forecast (2.5km)

Fri 2-May-2014 07 am

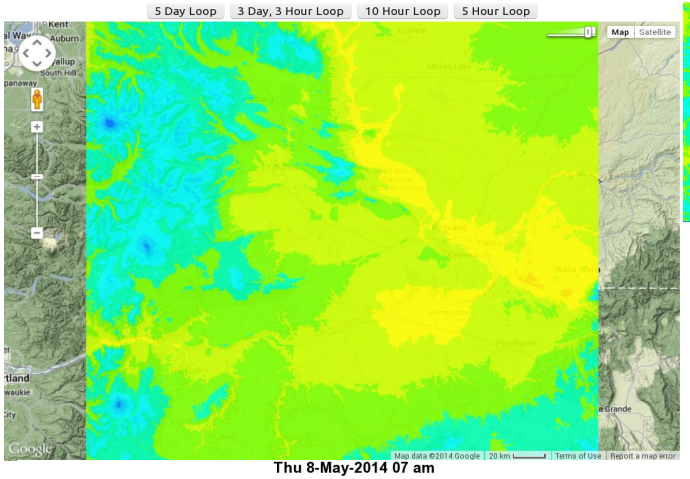


click on any image to overlay on left



May 2 7am PRISM

Mon 5-May-2014 07 am



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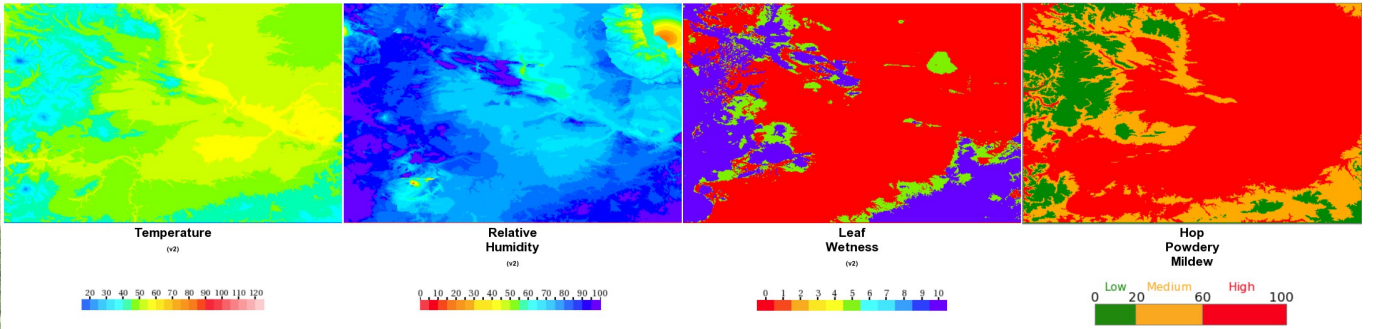
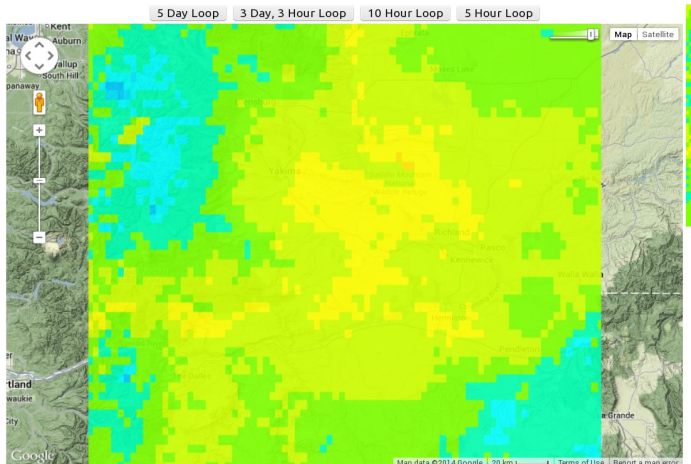


May 5 7am IPPC V2

Thu 8-May-2014 07 am



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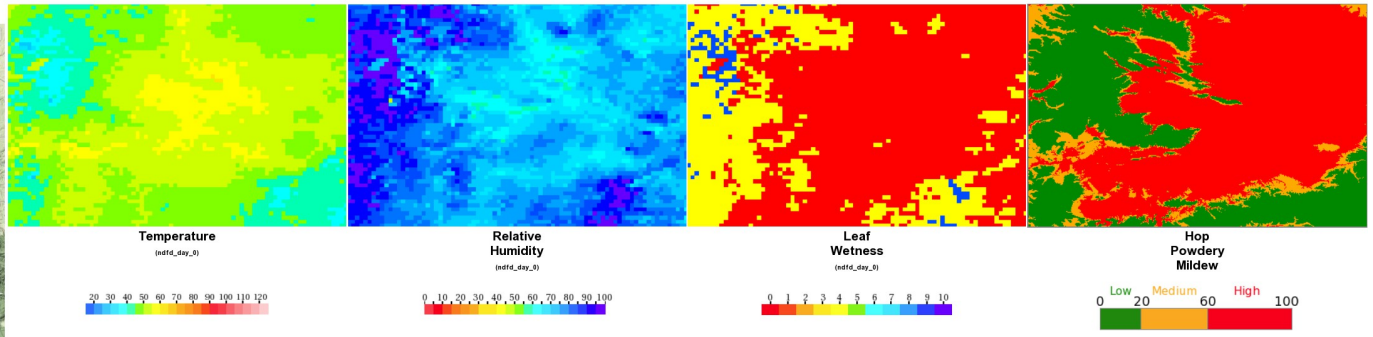


May 8 7am NDFD forecast

Uspest.org Example Simulation model for epidemiology and management of a plant disease – model by Bill Pfender et al.

STEMRUST_G Grass Stem Rust Decision Aid 2014

Required inputs: Location: Hyslop OSU Cmpbll

Rust scouting date: Mar 10

Number of pustules found: 0.2

per: ft. of row 10 tillers

Date of flag sheath emergence:

(leave blank for unknown)

Fungicide application date and type:

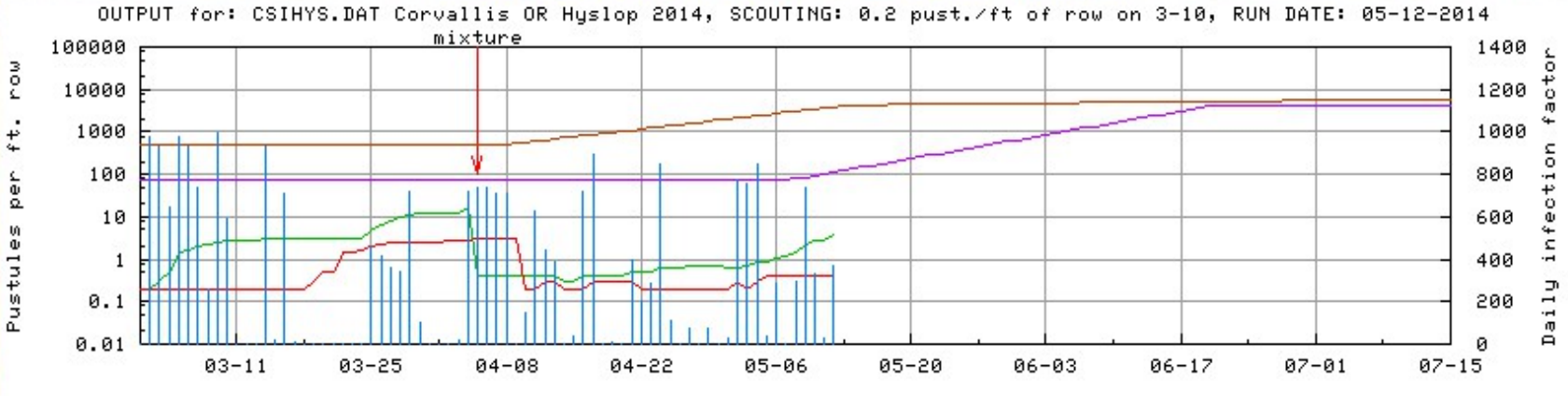
Apr	5	DMI	Strob	mixture	none
Apr	1	DMI	Strob	mixture	none
Apr	1	DMI	Strob	mixture	none
Apr	1	DMI	Strob	mixture	none
Apr	1	DMI	Strob	mixture	none

Compute new graphs Compute

Help/Comments:

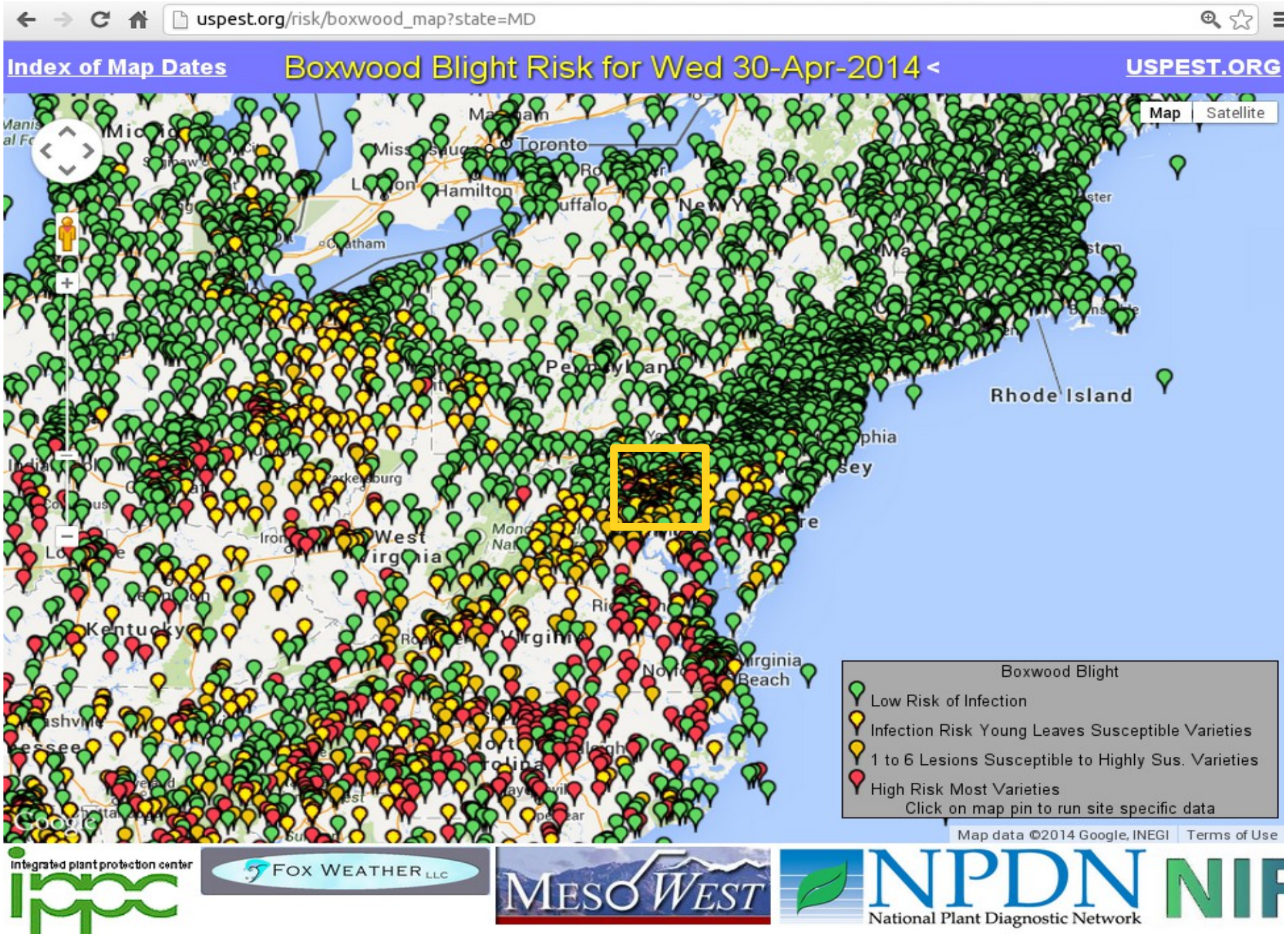
The lower graph shows the model's calculation for plant growth, which is very important in rust development. The graph shows the lengths, in inches, of: (red line) sheath number 2, (green line) flag sheath, and (blue line) flowerhead plus stem. Dates refer to the time when approximately 25% of tillers show the indicated development. The modeled timing of emergence for these plant parts should match approximately your field observations. If they don't, you can improve the model results by adjusting the date you put into the 'Date of flag

Graphs of rust activity and plant growth



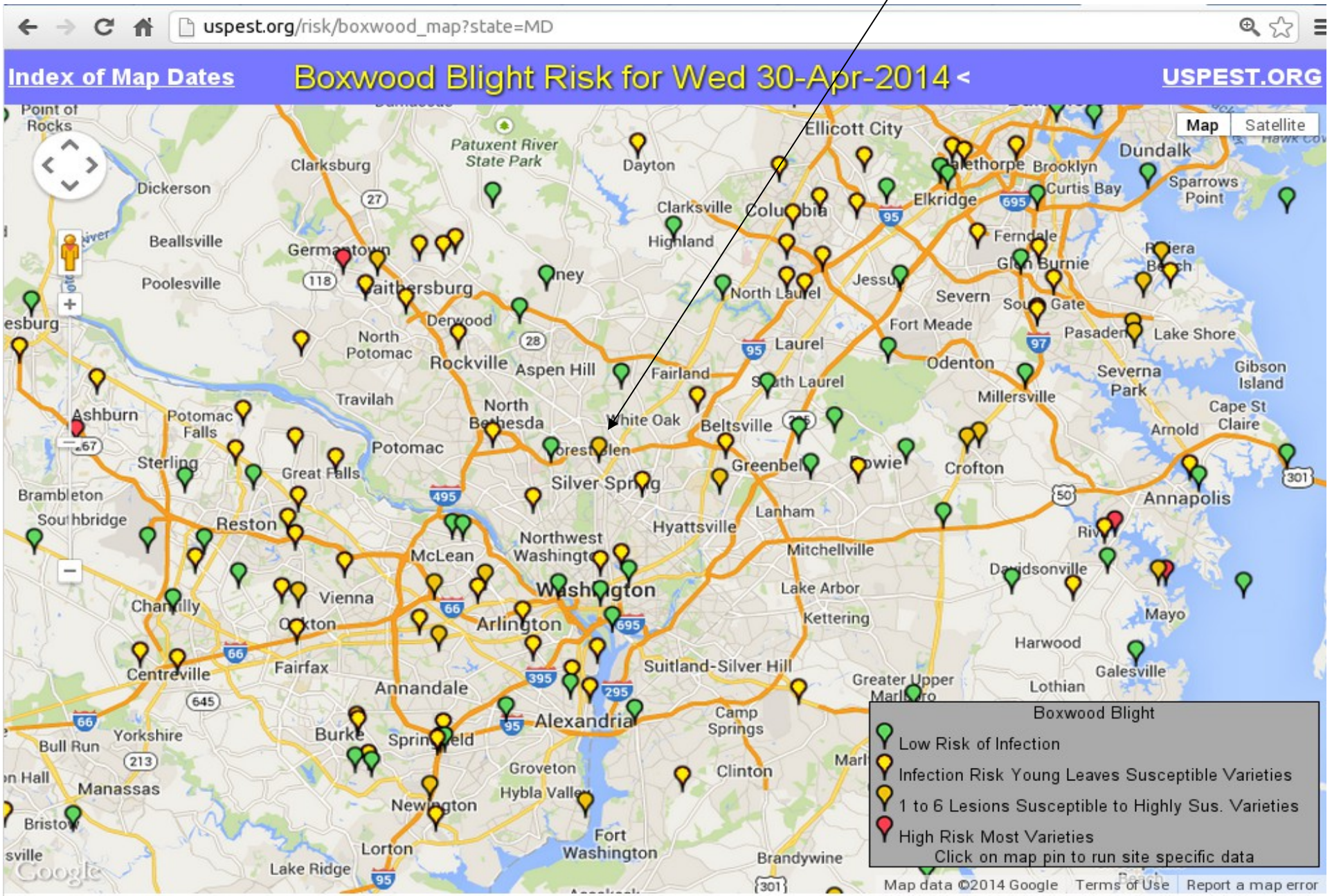
Uspest.org Infection Risk Mapping

uspest.org/risk/boxwood_map, zoom to local region



Uspest.org Infection Risk Mapping –

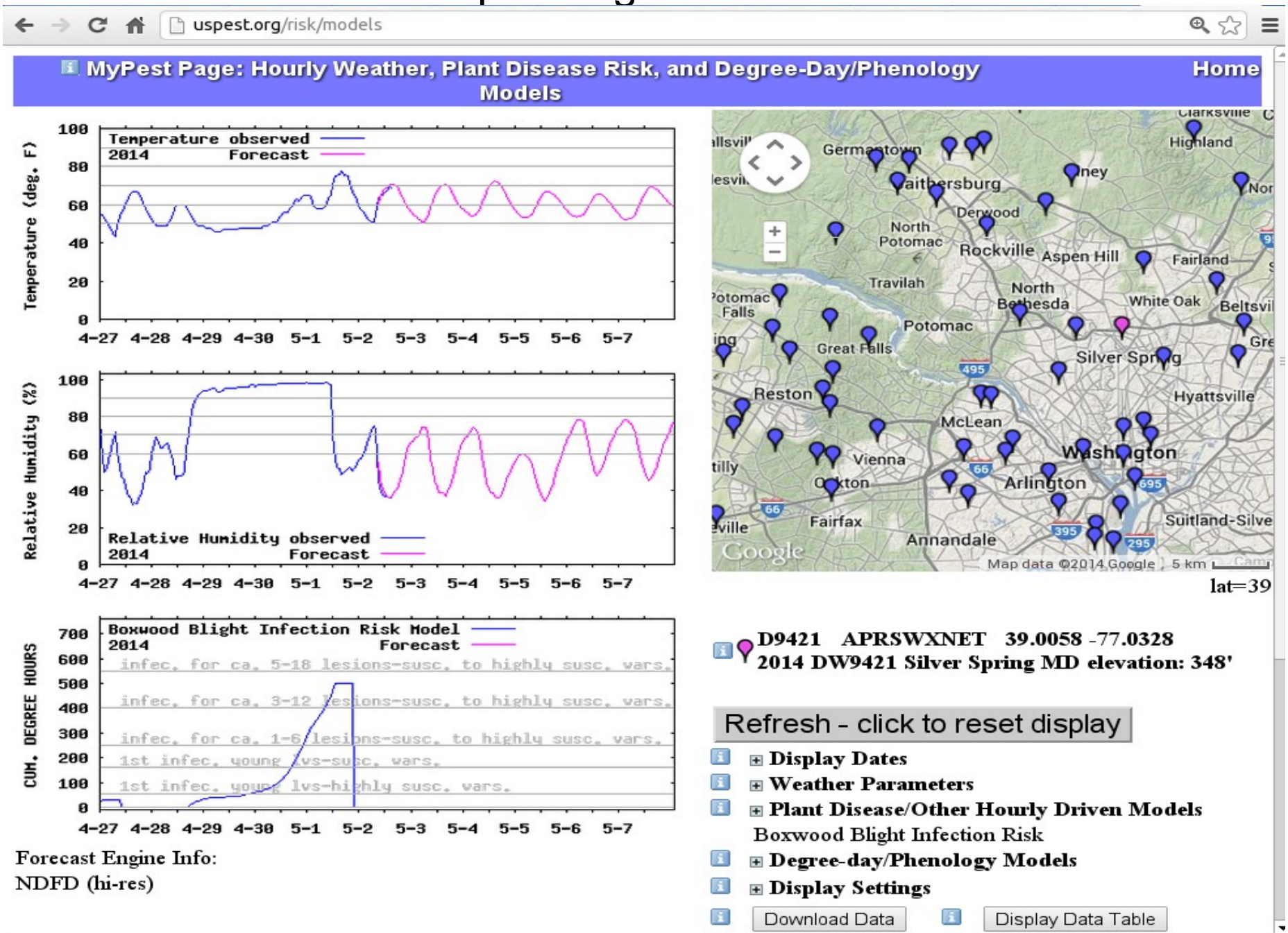
Zoom to Beltsville/Silver Spring, click on pin



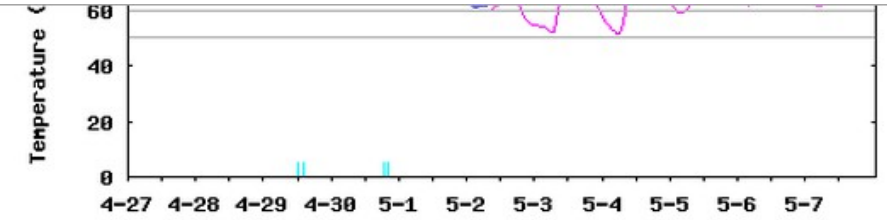
Uspest.org Infection Risk Mapping –> “MyPest Page” Model

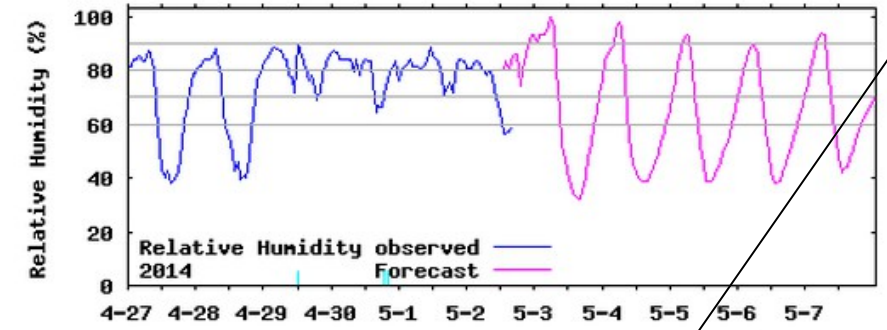
click on Silver Spring (weather station D9421)

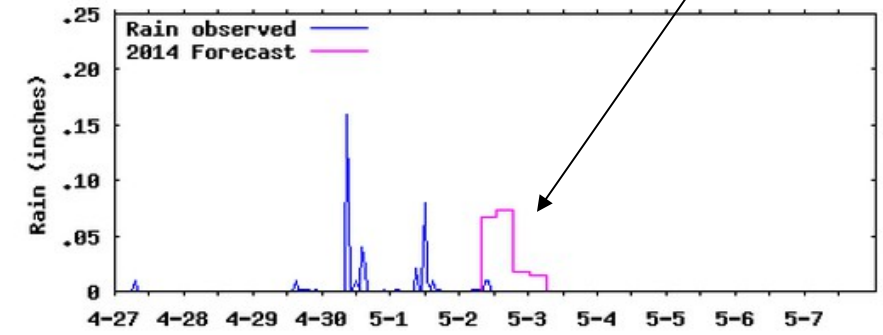
uspest.org/risk/models

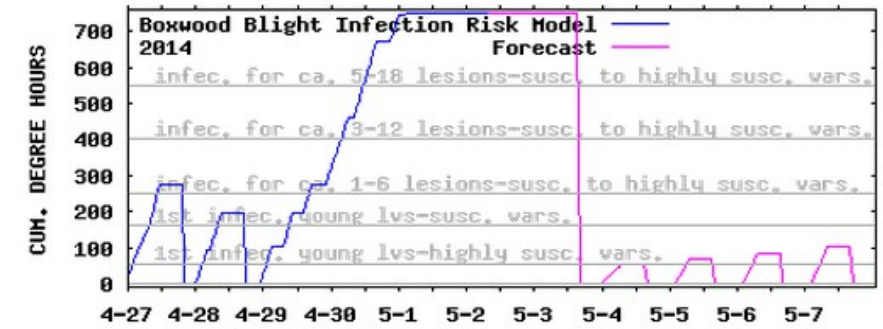


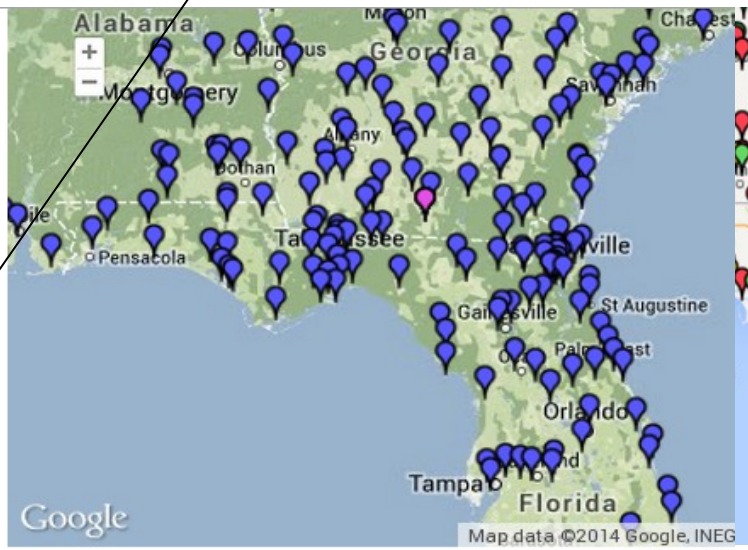
Uspest.org Infection Risk Model – high risk forecast S. Georgia

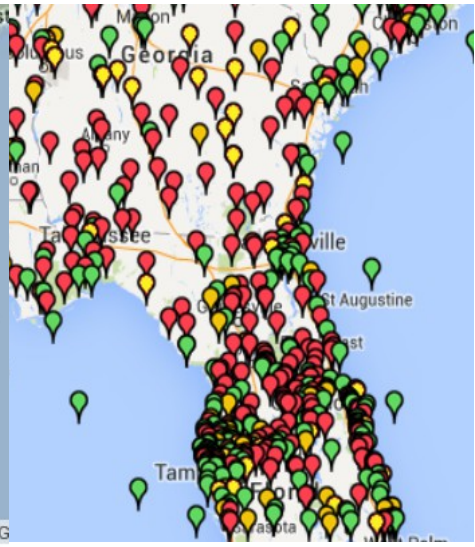












lat=27

KVLD METAR 30.7831 -83.2831
2014 Valdosta Reg Apt GA elevation: 203'

Refresh - click to reset display

- **Display Dates**
- **Weather Parameters**
  - Temperature (°F)
  - Dew Point (°F)
  - Relative Humidity (%)
  - Wind Speed (mph)
  - Rain (inches)
  - Leaf Wetness (0=dry, 10=wet)
- **Plant Disease/Other Hourly Driven Models**
  - Boxwood Blight Infection Risk
- **Degree-day/Phenology Models**
- **Display Settings**

Download Data | Display Data Table

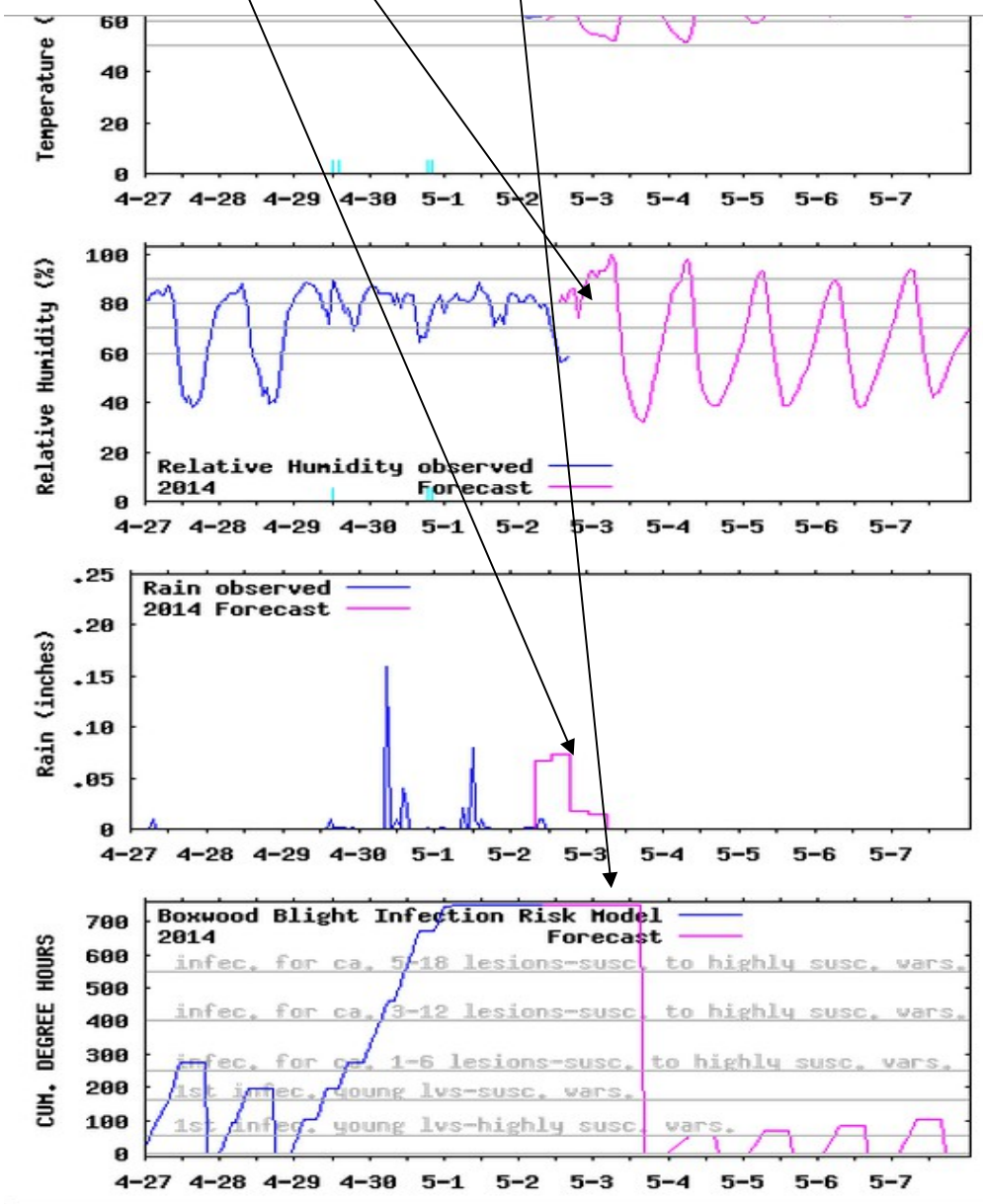
Uspest.org Infection Risk Model – high risk S. Georgia
National Weather Service NDFD forecast

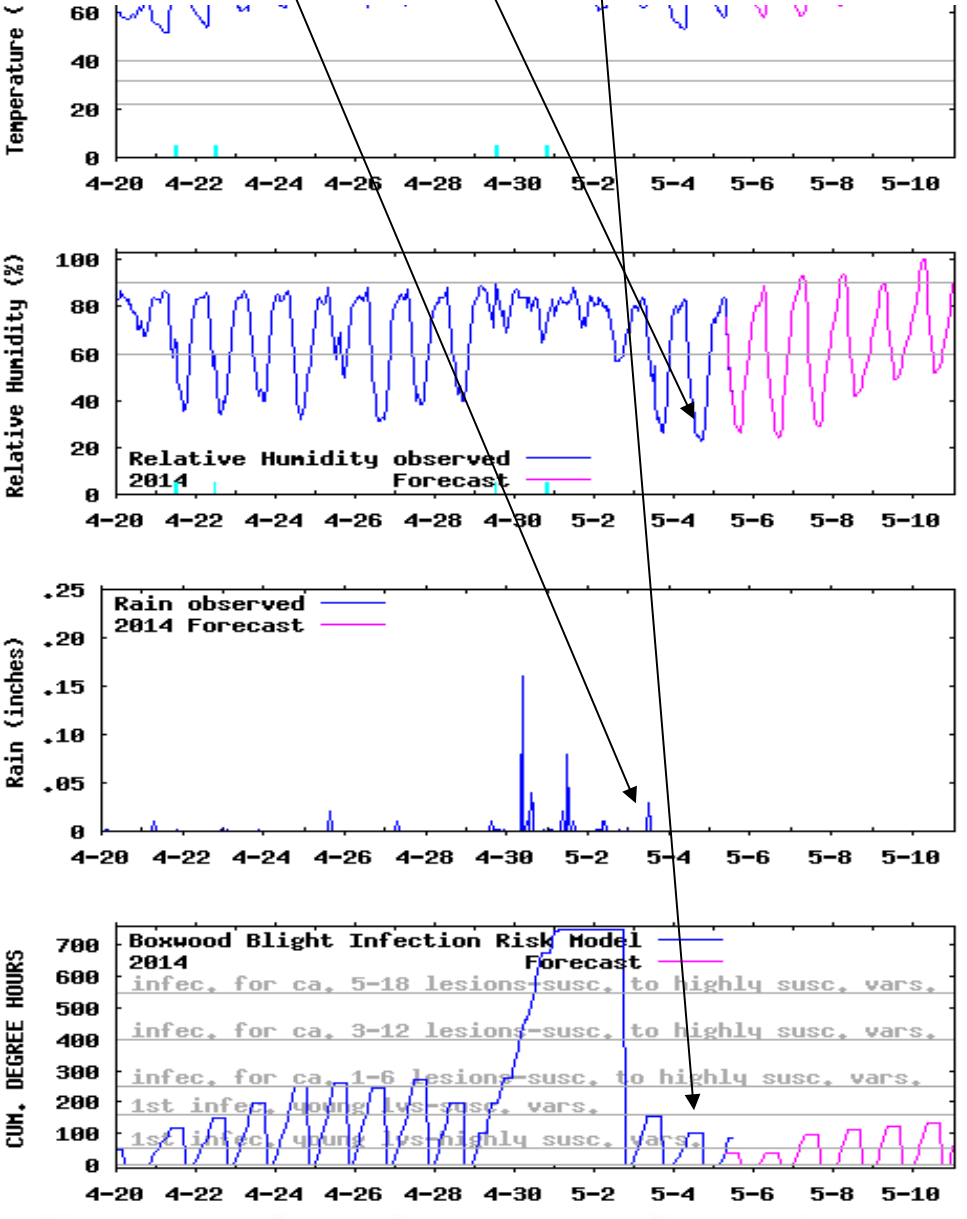
May 2 model run w/NDFD:

High: rainfall, RH, disease risk *forecast*

May 5 model run:

Low: rainfall, RH, disease risk *observed*

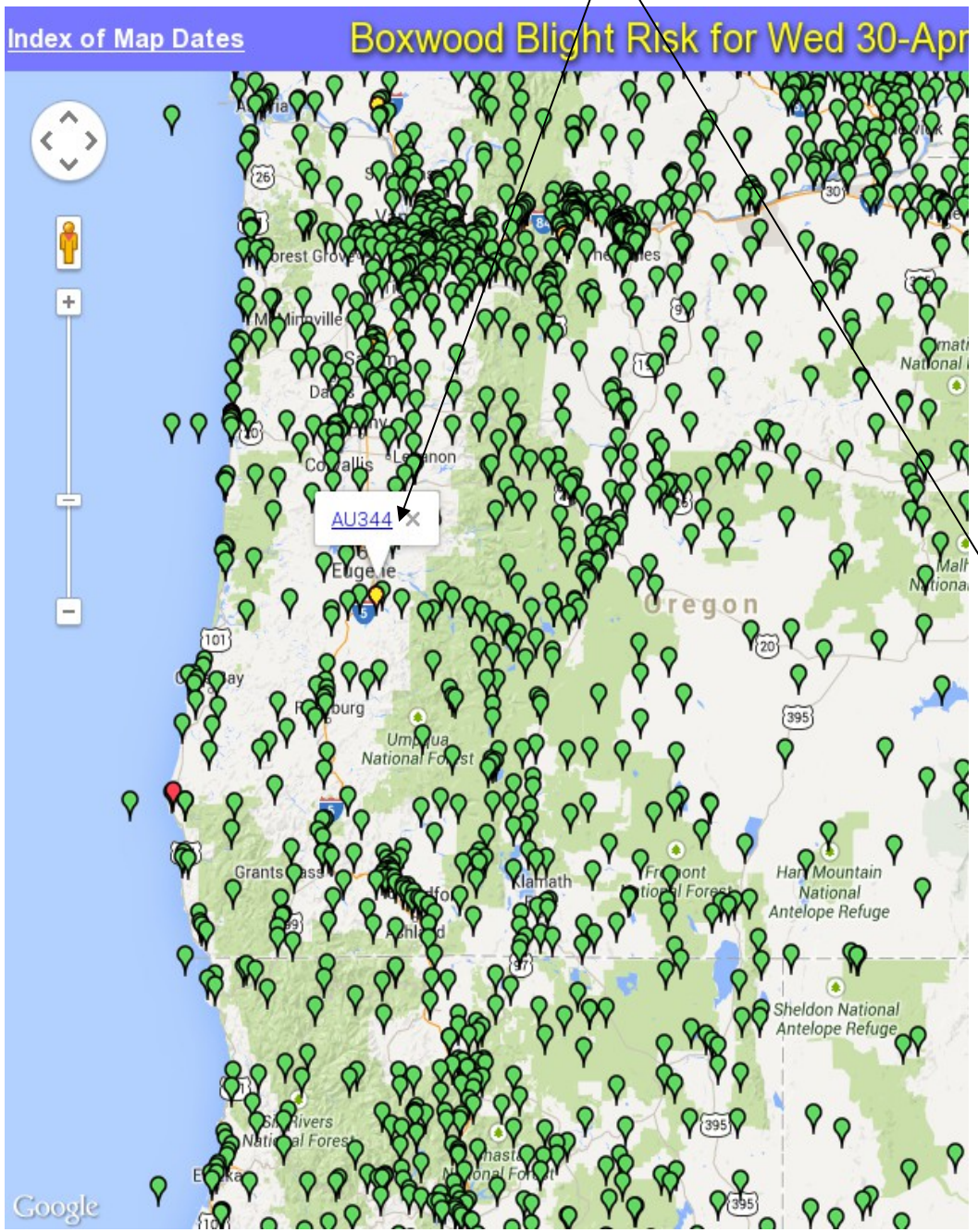


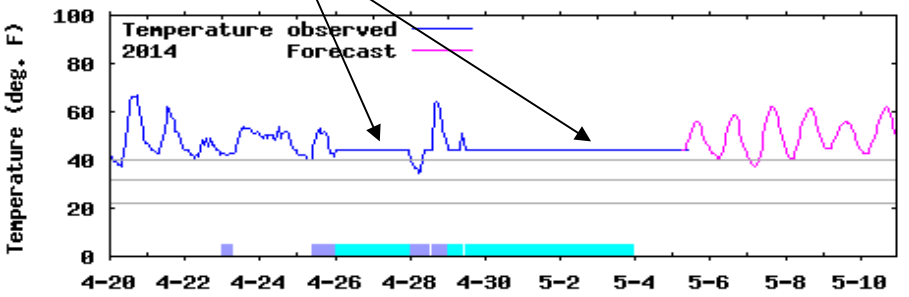


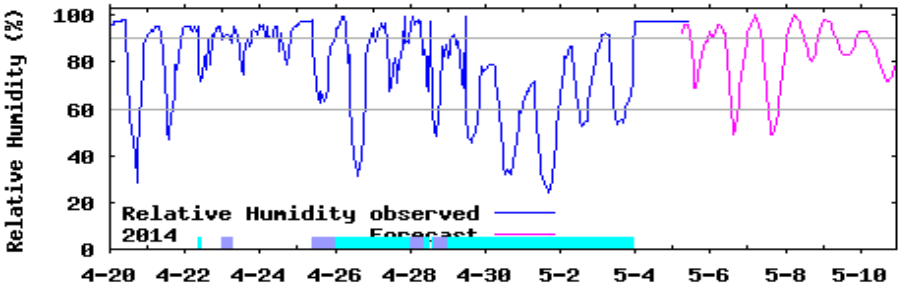
Uspest.org Infection Risk Mapping/Modeling –data QA considerations

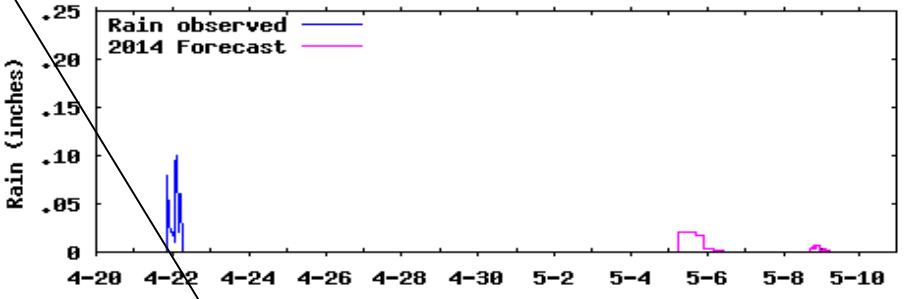
"moderate risk" shown

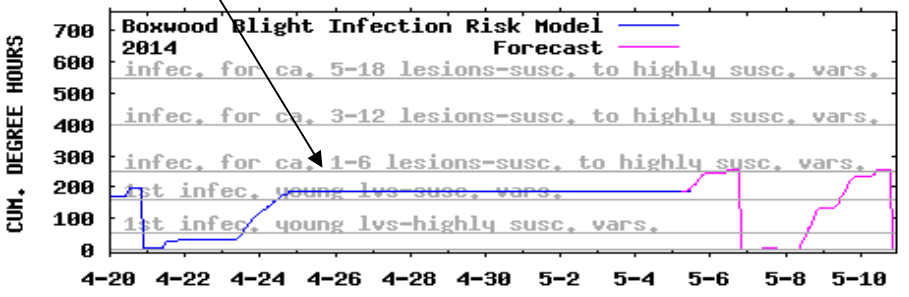
Temperature outage responsible





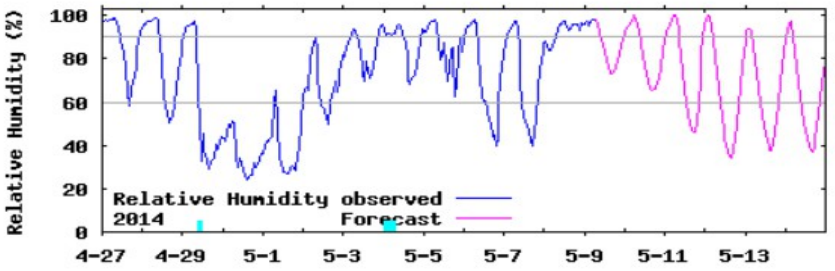


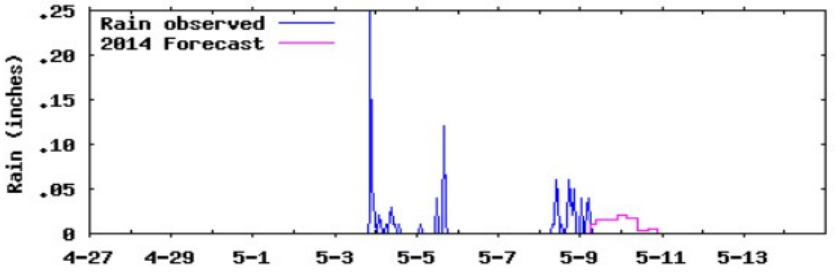


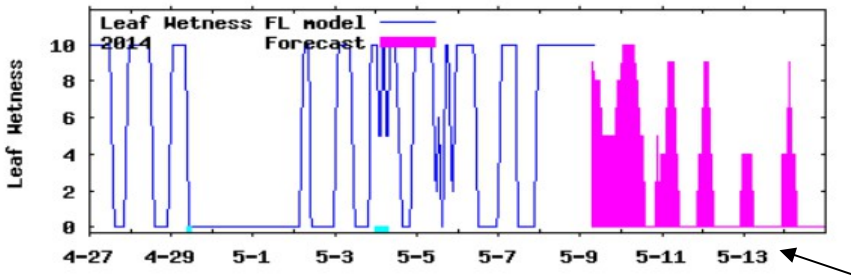


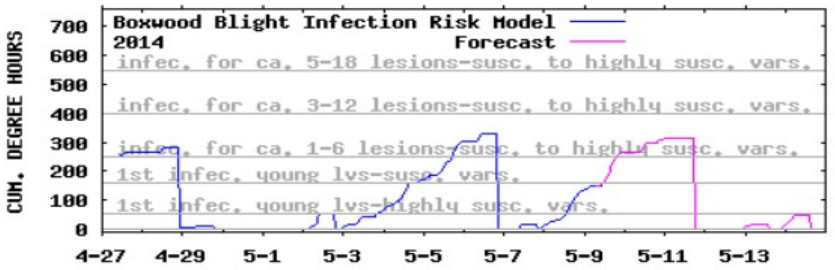
Uspest.org Infection Risk – rainfall contributes to leaf wetness & risk Portland (Nursery is #1 commodity Oregon $745m 2012)

Model run Friday May 9, 2014









Forecast Engine Info:
NDFD (lo-res)

lat=45.44632long=-122.592

E1145 APRSWXNET 45.5328 -123.1447
2014 EW1145 Forest Grove OR elevation: 262'

My Virtual Stations

Refresh - click to reset display

Display Dates

Weather Parameters

- ☑ Temperature (°F)
- ☐ Dew Point (°F)
- ☑ Relative Humidity (%)
- ☐ Wind Speed (mph)
- ☑ Rain (inches)
- ☑ Leaf Wetness (0=dry, 10=wet)

Plant Disease/Other Hourly Driven Models

Boxwood Blight Infection Risk

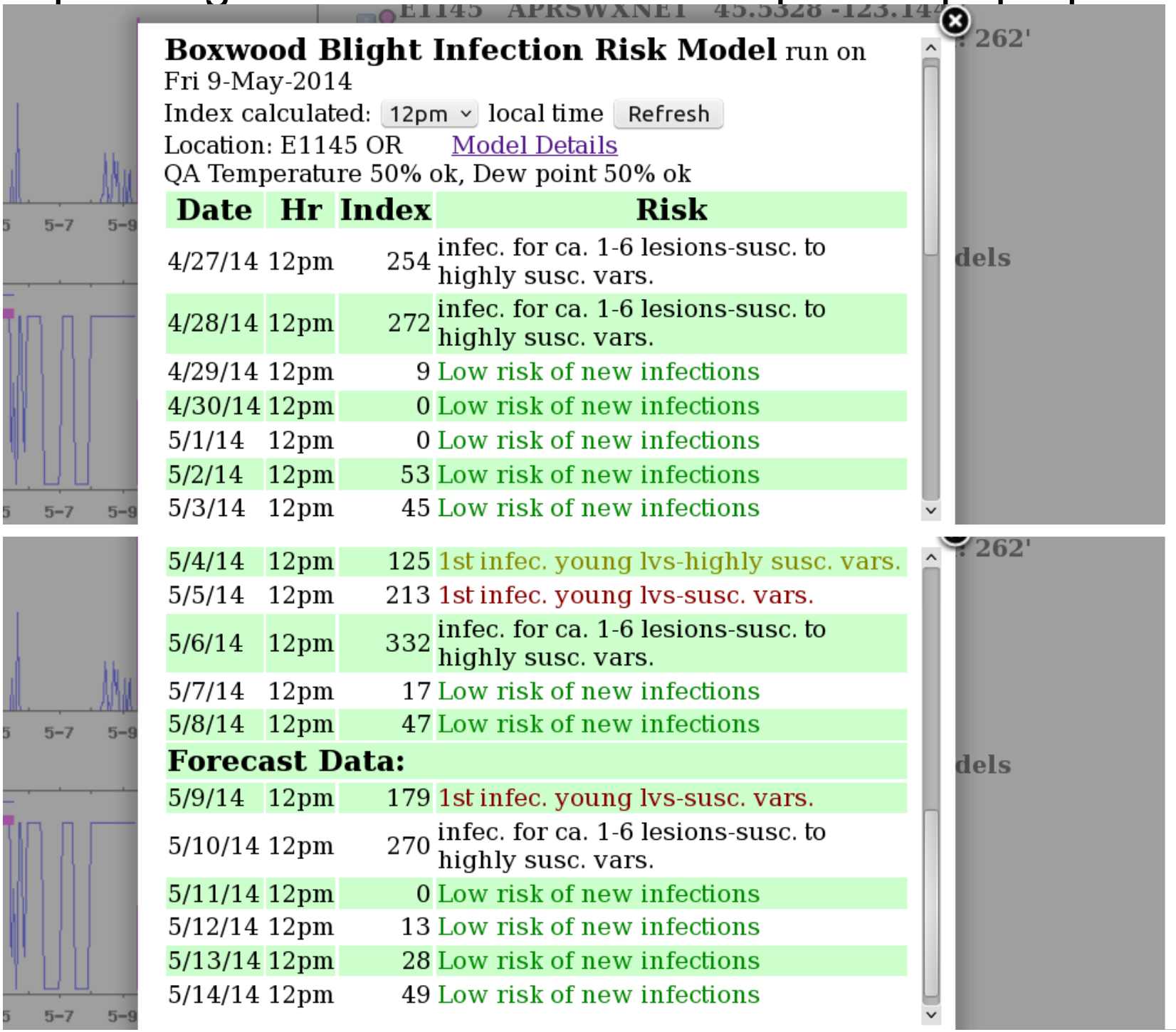
Degree-day/Phenology Models

Display Settings

Download Data Display Data Table

Leaf wetness calculated using Iowa State (Kim et al 2004, 2005, 2010) Fuzzy Logic algorithm with addition of rainfall wetness

Uspest.org Infection Risk – click on plot for pop-up table



Boxwood Blight Infection Risk Model run on
Fri 9-May-2014
Index calculated: 12pm local time Refresh
Location: E1145 OR Model Details
QA Temperature 50% ok, Dew point 50% ok

Date	Hr	Index	Risk
4/27/14	12pm	254	infec. for ca. 1-6 lesions-susc. to highly susc. vars.
4/28/14	12pm	272	infec. for ca. 1-6 lesions-susc. to highly susc. vars.
4/29/14	12pm	9	Low risk of new infections
4/30/14	12pm	0	Low risk of new infections
5/1/14	12pm	0	Low risk of new infections
5/2/14	12pm	53	Low risk of new infections
5/3/14	12pm	45	Low risk of new infections
5/4/14	12pm	125	1st infec. young lvs-highly susc. vars.
5/5/14	12pm	213	1st infec. young lvs-susc. vars.
5/6/14	12pm	332	infec. for ca. 1-6 lesions-susc. to highly susc. vars.
5/7/14	12pm	17	Low risk of new infections
5/8/14	12pm	47	Low risk of new infections
Forecast Data:			
5/9/14	12pm	179	1st infec. young lvs-susc. vars.
5/10/14	12pm	270	infec. for ca. 1-6 lesions-susc. to highly susc. vars.
5/11/14	12pm	0	Low risk of new infections
5/12/14	12pm	13	Low risk of new infections
5/13/14	12pm	28	Low risk of new infections
5/14/14	12pm	49	Low risk of new infections

Summary Points for Modeling Boxwood Blight (Vers 1.0) :

Questions remain:

Lower temp. threshold: **46F (7.78C)** <-- **1. Need research on this**

Upper temp. threshold: **85F (29.4C)** <-- **2. Need research on this**

Under high humidity/rainfall/leaf wetness conditions, at temperatures above 46F and below ca. 85F, if inoculum is present and you have susceptible hosts, infection is likely to occur with sufficient time as measured using degree-hours (DH).

No. of **dry hours** to stop the infection cycle: **more than 8.0**

3. Need research on this

DHs to first infection of young leaves (highly susc. Var.): **56**

DHs to first infection of young leaves (susc. Var.): **160**

4. Should we build a separate model with a lower threshold for young leaves?

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**

5. Should we build a separate model with a higher threshold for mature leaves?

What's next for Boxwood Blight infection risk/other models:

Questions remain:

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.

6. Should we study type of rain drops in spore dissemination?

7. Does Oregon drizzle count as rain?

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).

8. How do we design the model to be as robust as possible?

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.

9. To what extent do we need more work on varieties with different levels of susceptibility?

10. Are there other types of models (establishment risk, overwintering survival, short and long distance spore dissemination, other types of risk, management including fungicidal residual activity) that we should be focusing on?

Low hanging fruit vs. research grant proposals...