Plant Disease Infection Risk Model Analysis - July 2026. By Len Coop and Brittany S. Barker,
Oregon IPM Center (OIPMC), Oregon State University for implementation at uspest.org (OIPMC) as a DDRP model and the National Phenology Network (NPN)

Brown rot (stone and pome fruits) ***Monilinia* spp. (*M. fructicola*, *M. Laxa*, and *M. fructigena*)**

Fig. 3. Blossom blight of peach following infection by *Monilinia fructicola*. Note sporulation on the twig below the infected blossom.

Fig. 4. Infection of ripening peach fruit by *Monilinia fructicola*. Note the infected, nonabscised, aborted fruit immediately above the infected ripening fruit.

Fig. 5. Blighted blossom and shoot and infected fruit of wild plum collected 200 m from a peach orchard.

Images from: Zehr, E.I. 1982. Control of brown rot in peach orchards. Plant Dis. 66:1101-1105.

Model synopsis: All sources listed below were reviewed and compared for development/adaptation for our implementation of a Monilinia spp. brown rot infection risk model. This model is similar to other infection risk models at uspest.org in that temperatures are summed over time (similar to degree-hour and degree-day concepts) during periods of sufficient moisture (in the form of humidity, precipitation, or calculated leaf wetness) until sufficient germination, elongation, penetration, and infection for visible disease symptoms to eventually occur on the plant. As the Australian model (Source 1) has been implemented and is well documented, we rely on that primarily. The temperature range was extended based on results of Casals et al. 2010 (Source 2), who compared time to infection vs. temperature in the laboratory for all three species. Based on these results, the resulting model at uspest.org should serve to forecast brown rot for the native M. fructicola (brown rot of stone fruits) and the invasive (not yet reported in the U.S.) M. fructigena equally well. The third species, M. laxa, also native to the U.S. takes ca 30% longer for infection to occur during favorable temperatures. Therefore, the model may be interpreted a bit more conservatively if this species is present. This model assumes that inoculum is present in the orchard, and that the host(s) are in a susceptible development stage, which is highest during bloom, then low during young fruit development, gradually increasing until harvest and even in post-harvest storage.

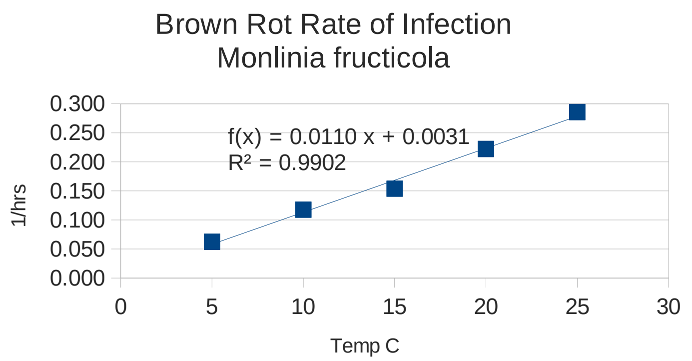
Model availability (hourly weather driven version): https://uspest.org/risk/models?mdl=brownrot
Daily weather driven version (DDRP): https://uspest.org/CAPS/BROT_cohorts
USA NPN version: https://www.usanpn.org/

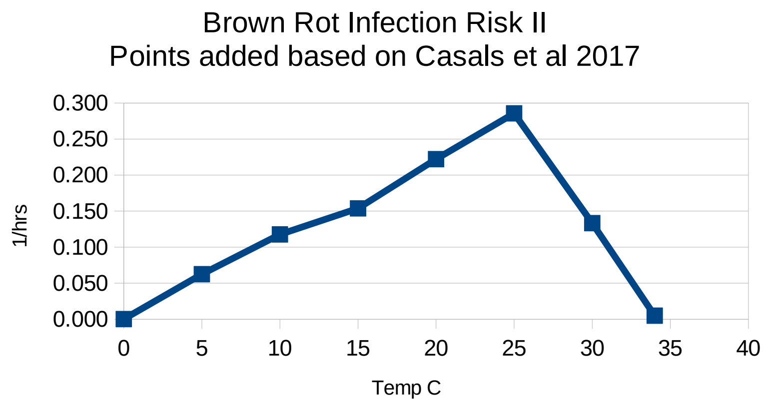
Sources:

1. State of Victoria, Australia (Villalta, O., R. Holmes, and S. Kreidl). 2015. Best Practices for Brown Rot Management - Booklet
https://www.hin.com.au/__data/assets/pdf_file/0006/19437/Brochure-Brown-Rot-Best-Practices-HIA-SF12004-Aug-2015.pdf

M. fructicola (primarily) M. laxa (less common)
Adapted from Table 1:

Temp C	1/hrs	hrs to high risk
5	0.063	16
10	0.118	8.5
15	0.154	6.5
20	0.222	4.5
25	0.286	3.5





	Temp C	1/hrs	hrs to high risk
	0	0.000	4000
	5	0.063	16
	10	0.118	8.5
	15	0.154	6.5
	20	0.222	4.5
	25	0.286	3.5
from Casals→	30	0.133	7.5
et al 2010→	34	0.005	200

Our piecewise regression model based on these data→

Temps below and up to 25C	
Temp C	1/hrs
0	0.000
5	0.063
10	0.118
15	0.154
20	0.222
25	0.286
slope	0.0111
y-intercept	0.002
R2	0.994

Temps 25 to 35C		
Temp C	1/hrs	hrs to high risk
25	0.286	3.5
30	0.133	7.5
34	0.005	200
slope	-0.0312	
y-intercept	1.066	
R2	1.000	

Results: we combined the Australian model for temperatures between 5 and 25 deg. Celsius with source #2 (Casals et al. 2010) for temperatures between 25 and 35C using two linear piecewise regression models to predict infection risk based on temperature during periods of sufficient moisture.

2. Casals, C., I. Vinas, R. Torres, C. Griera, and J. Usall. 2010. Effect of temperature and water activity on in vitro germination of Monilinia spp. J. Appl. Microbiol. 108:47-54. doi:10.1111/j.1365-2672.2009.04402.x

Notes: 1. At 38C no germination was observed (so consider this as above the upper threshold)

Data from Fig. 3 M. fructigena

35 C		30 C		25 C		15 C	
Hours	Germ %	Hours	Germ %	Hours	Germ %	Hours	Germ %
2.10	8.61	2.2	54.9	2.09	79.99	3.30	79.93
4.06	64.56	3.5	79.9	2.28	87.00	4.00	95.49
7.77	80.25	3.9	86.9	4.01	90.62	7.90	95.66
7.98	81.77						
23.76	84.56						

5 C		0 C	
Hours	Germ %	Hours	Germ %
24.16	56.89	24.48	13.75
46.69	80.48	48.00	71.43
48.00	81.97	60.00	80.23
		72.00	90.19

Hours to 80% germination vs Temp C

Temp C	1/hrs	Hrs
0	0.016666667	60
5	0.021551724	46.4
15	0.301204819	3.32
25	0.4784689	2.09
30	0.285714286	3.5
35	0.129032258	7.75

Temp C	1/hrs	Hrs
0	0.016666667	60
5	0.021551724	46.4
15	0.301204819	3.32
25	0.4784689	2.09

25	0.4784689	2.09
30	0.285714286	3.5
35	0.129032258	7.75

Fig. 2 M. fructicola

35 C

Hrs	1/hrs	% germination
2.095	0.477	13.710
4.952	0.202	42.500
8.000	0.125	70.806
21.238	0.047	80.726
23.810	0.042	85.081

30 C

Hrs	1/hrs	% germination
2.243375648	0.446	75.14893617
2.956981942	0.338	79.74468085
4.287216163	0.233	91.23404255

25 C

Hrs	1/hrs	% germination
2.091993038	0.478	80.20301166
2.294745263	0.436	86.24731101
4.142086545	0.241	94.67780817

15 C

Hrs	1/hrs	% germination
3.25494368	0.307	80.47058824
3.809887359	0.262	92.70588235
7.727158949	0.129	97.88235294

5 C

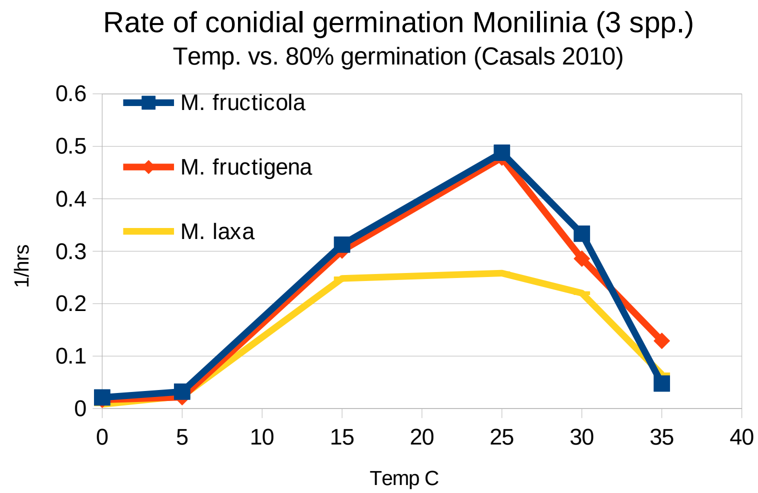
Hrs	1/hrs	% germination
24	0.042	74.09448819
31.57894737	0.032	80.78325736
32.84210526	0.030	81.50435143
48	0.021	95.11811024

0 C

Hrs	1/hrs	% germination
23.03820014	0.043	0.070307007
47.35880009	0.021	79.99531287
49.75298805	0.020	80.72181861
71.72814624	0.014	93.82704476

Hours to 80% germination vs Temp C - all three species

Temp C	Avg cola+gen	M. fructicola	M. fructigena	M. laxa	Hrs
0	0.018890766	0.021114865	0.016666667	0.008	47.36
5	0.026853032	0.032154341	0.021551724	0.0236	31.1
15	0.30685241	0.3125	0.301204819	0.248	3.2
25	0.483136889	0.487804878	0.4784689	0.258	2.05
30	0.30952381	0.333333333	0.285714286	0.22	3
35	0.088325653	0.047619048	0.129032258	0.065	21



M. laxa
(from Fig. 1)

35 C

Hrs	1/hrs	% germination
2.910	0.343646482	19.921
4.090	0.244485294	37.582
8.277	0.120813341	74.461
12.413	0.080563494	79.048
21.441	0.04664065	81.519

30 C

Hrs	1/hrs	% germination
3.294	0.303550832	40.103
4.612	0.216837335	79.910
4.486	0.222897762	80.893
8.901	0.112346018	90.457

25 C

Hrs	1/hrs	% germination
2.303	0.434157446	23.387
3.870	0.25840365	79.926
4.050	0.246943324	89.474

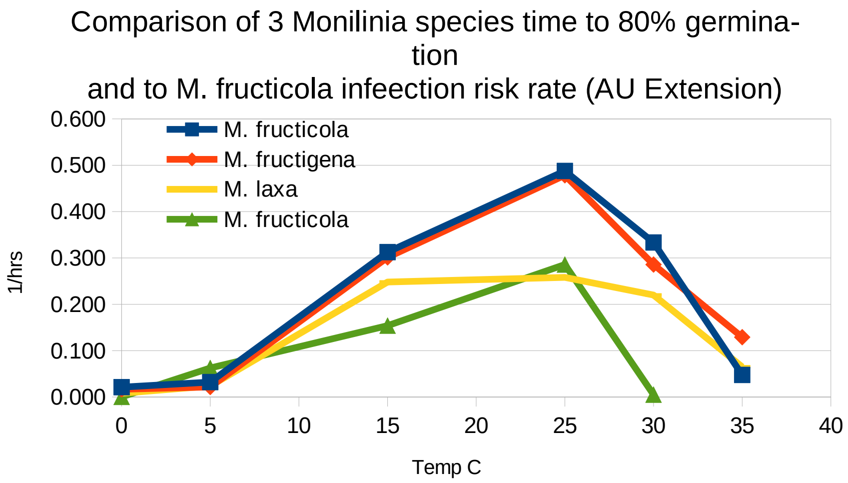
15 C		
Hrs	1/hrs	% germination
2.498	0.400290378	43.729
4.030	0.248127068	80.141
4.640	0.215501944	93.859

5 C		
Hrs	1/hrs	% germination
12.192	0.082021066	9.563
23.700	0.042194206	57.438
36.333	0.027523096	72.924
41.855	0.023891977	80.660

0 C		
Hrs	1/hrs	% germination
47.520	0.021043771	30.645
72.000	0.013888889	64.516
96.480	0.010364842	71.290
122.400	0.008169935	78.548

Comparison with Source #1
AU Extension – M. fructicola

			Hours to 80% germination vs Temp C						**1/hrs (Casals et al. 2010)**			**AU model**
Temp C	1/hrs	hrs to high risk	Temp C	M. fructicola	M. fructigena	M. laxa	M. fructicola	Temp C	M. fructicola	M. fructigena	M. laxa	M. fructicola
0	0.000	4000	0	47.4	60.0	125.0	150	0	0.021	0.017	0.008	0.000
5	0.063	16	5	31.1	46.4	42.4	16	5	0.032	0.022	0.024	0.063
10	0.118	8.5					8.5					0.118
15	0.154	6.5	15	3.2	3.3	4.0	6.5	15	0.313	0.301	0.248	0.154
20	0.222	4.5					4.5					0.222
25	0.286	3.5	25	2.1	2.1	3.9	3.5	25	0.488	0.478	0.258	0.286
29	0.005	200	30	3.0	3.5	4.5	150	30	0.333	0.286	0.220	0.005
			35	21.0	7.8	15.4		35	0.048	0.129	0.065	



		hrs 15C	**hrs 25C**	**average**
AU	hi inf. risk	6.5	3.5	
Casals	80% germination	3.25	2.09	
	Casals/AU ratio:	0.5	0.60	**0.55**
	AU/Casals ratio:	2	1.67	**1.84**

So the 80% germination measure (Casals) is about 55% of the degree-hours needed to reach the high risk rating used by the AU model. This could be attributed to infection steps post-spore germination.

3. RIMpro brown rot model
https://rimpro.cloud/platform/brown-rot-monilinia-spp/

- This model serves regions in N. Europe
- It looks pretty similar to AU model but details of the algorithm are not available

4. Michigan State University Extension website: (dated April 2014)
https://www.canr.msu.edu/news/considerations_for_pre_bloom_and_bloom_sprays_for_american_brown_rot

George Sundin and Nikki Rothwell

These mummies serve as the initial inoculum source for American brown rot in the subsequent spring. Mummies are the source of conidia (spores), which develop at a temperature range of 55-77 degrees Fahrenheit and are disseminated by wind and rain.
The spores have the potential to infect flowers, particularly at the optimal temperature range of 72-77 F.

Blossom blight infection only occurs with a wetting event accompanied by prolonged conditions of high humidity.
Typically, sustained relative humidity values of 90 percent or above for 24 hours or more are associated with optimal infection events

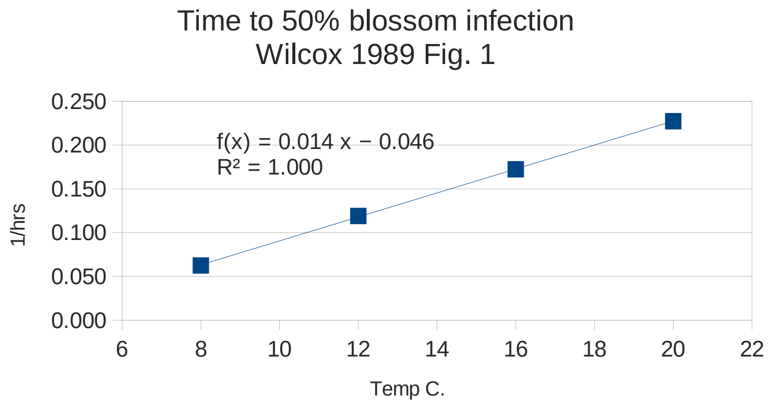
Highest risk of blossom blight occurs when:
- Presence of overwintering mummies.
- Warm temperatures in the 70s during bloom.
- Rain event during bloom followed by a sustained period where the relative humidity remains high.

5. Wilcox, W. F. 1989. Influence of environment and inoculum density on the incidence of brown rot blossom blight of sour cherry. Phytopathology 79:530-534.

- Monilinia fructicola on sour cherry
- Work performed in Geneva, NY Cornell Univ.

From Table 1 first column (Disease incidence vs. temperature)

Temp C	1/hrs	Time hrs	Temp C	1/hrs	conidial germ hrs
8	0.14	7.143	8	0.091	11
12	0.48	2.083	12	0.111	9
16	0.68	1.471	16	0.143	7
20	1	1	20	0.2	5



From Fig. 1 inoc rate 5,000 conidia/ml

Temp C	1/hrs	conid germ	Time to 50% blossom infec hrs	From text: 50% freq of germ conidial germ tube growth (3x)
8	0.063	0.091	16	11
12	0.119	0.111	8.4	9
16	0.172	0.143	5.8	7
20	0.227	0.200	4.4	5
25				

- Infection rates similar to AU model above
- limited temperature rage

6. Holmes, R., O. Villalta, S. Kreidl, D. Partington, A. Hodson, and T.A. Atkins. 2008. A weather-based model implemented in HortPlus MetWatch with Potential to forecast brown rot infection risk in Stone Fruit. Acta Horticulturae. DOI: 10.17660/ActaHortic.2008.803.1

- This is the peer-reviewed publication from which the AU model (source #1) is based upon.
- Actually it cites an earlier publication (Tate et al. 1995; next source) as the model source.

7. Tate, K.G., P.N. Wood, and D.W. Manktelow. 1995. Development of an improved spray timing system for process preaches in Hawke's Bay. Proc. 48th N.Z. Plant Prot. Conf. p. 101-106.

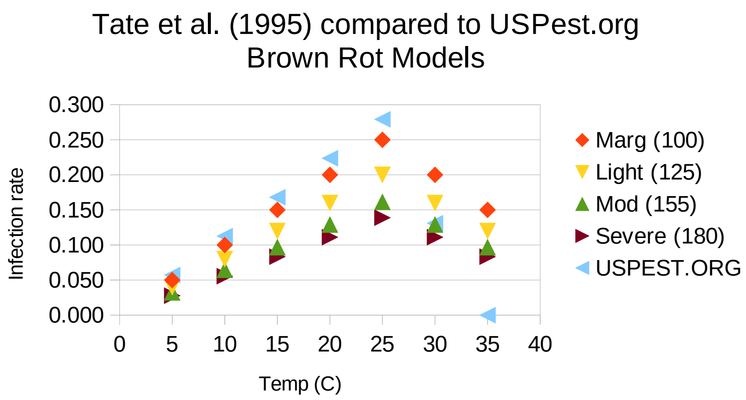
Implementation of Tate 1995 model

- Model is: multiply hours of wetness times the avg (mean) T (assume C) during the wet period.
- Used a 4 hour dryness interval to separate wet events
- Also tested a 12 hour dryness interval to separate wet events, resulting in one additional severe infection period and some sites **(**Swan Hill and Shepparton North**)**
- noted several infection periods from Dew (Shepparton can have long foggy periods), so extending required dryness interval based on RH>85% makes sense

Risk categories:
Marginal: 90-120 Deg-Hrs
Light: 121-150 Deg-Hrs
Moderate: 151-180 Deg-Hrs
Severe: >181 Deg-Hrs

Notes: We convert this to regular hourly time step degree-hour model as per other works above, calibrate severity based on this set of ranges. Use their proposed dry period reset time of 4 hrs.

	hrs LW to:			
	Marg (100)	Light (125)	Mod (155)	Severe (180)
Temp C	100	125	155	180
5	20.0	25.0	31.0	36.0
10	10.0	12.5	15.5	18.0
15	6.7	8.3	10.3	12.0
20	5.0	6.3	7.8	9.0
25	4.0	5.0	6.2	7.2
30	5.0	6.3	7.8	9.0
35	6.7	8.3	10.3	12.0



Convert to rates (1/hrs)

Temp C	Marg (100)	Light (125)	Mod (155)	Severe (180)	USPEST.ORG
5	0.050	0.040	0.032	0.028	0.057105264
10	0.100	0.080	0.065	0.056	0.112610613
15	0.150	0.120	0.097	0.083	0.168115961
20	0.200	0.160	0.129	0.111	0.223621309
25	0.250	0.200	0.161	0.139	0.279126658
30	0.200	0.160	0.129	0.111	0.130962139
35	0.150	0.120	0.097	0.083	0

USPest.org (from #1 above)

	Temp C range 0-25	Temp C range 25-35
slope:	0.01110107	-0.031
intercept	0.001599916	1.066
R2	0.99436974	1.000

Results: The infection rates predicted by the implemented USPest.org model compare closely with the Tate et al. model for the lightest infection category (marginal), which suggests that the former is using a rather conservative approach.

8. Luo et al 2001

- stone fruit risk of infection in California
- data not presented in readily extractible forms **(**e.g. Fig 5 would be useful but range and variance of results is too wide or large**)**
- final decision aid chart (Fig. 9) may be useful (partial):

Stage:			Wetness Duration (h)					
popcorn to	Temp C		4	8	12	16	20	24
full bloom		10	0	1	1	1	1	2
low inoc. Pot.		15	0	1	1	1	1	2
		20	1	1	2	2	2	3
		25	0	1	1	2	2	3

0= no risk, 1= low risk, 2= mod. risk, 3= high risk

9. Koball, D. C. W. F. Wilcox, and R. C. Seem. 1997. Influence of incubation-period humidity on the development of brown rot blossom blight of sour cherry. Phytopathology 87:42-49.

- Work performed on sour cherry in NY State.
- Found that the higher the RH (post inoculation), the higher incidence of blossom blight.
- Fig. 2 shows a linear trend RH range 57% - >90% results in 20%-100% blossom blight.
- this relationship could be used to show increasing risk of brown rot (blossom blight) post infection event which depends upon T and leaf wetness.
- possibly reduce to a simple threshold of ca. 85% RH that could either "bridge" infection events (use as proxy for LW), or just use to continue to increase a risk index of some sort (probably degree-hours during periods of LW)
- 8 hours of wetting at 20C for all treatment blocks resulted in high blossom infection rates (Fig. 3)

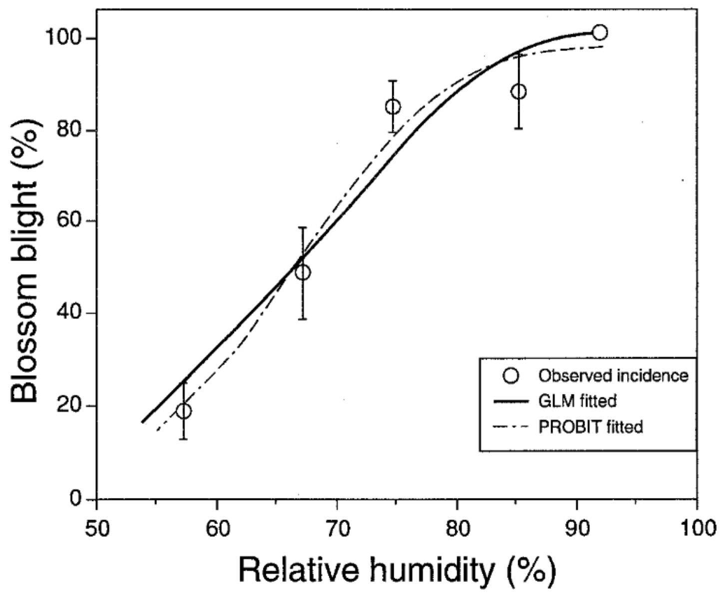
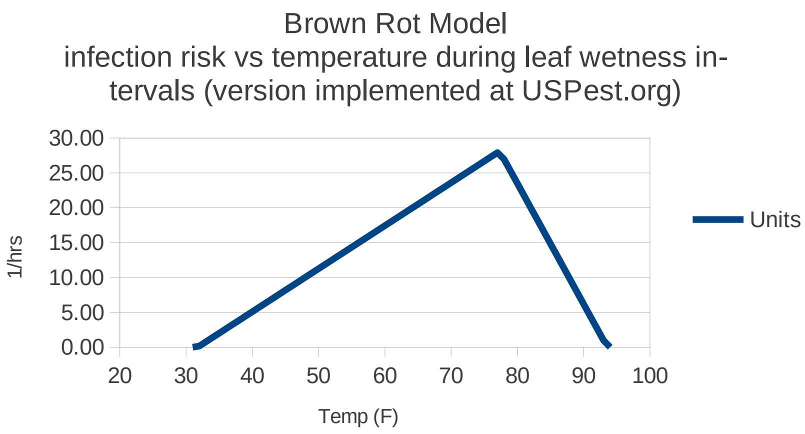


Fig. 2. Percentage of sour cherry blossoms blighted by *Monilinia fructicola* as a function of relative humidity (RH) during incubation. Excised blossoms

10. Conversion of the USPest.org model to Fahrenheit as a lookup table.

Units meaning: 1.0 is “high infection risk”

	Model Celsius Scale				Model Fahrenheit Scale				
	Temp C	units	Range 1 to 25 deg C		Temp C	Temp F	Units	Range 32 to 77	
	0	0.002	slope	0.011101	-0.6	31	0.00	slope	0.616726092
33.8	1	0.013	intercept	0.001600	0	32	0.16	intercept	-19.5752433
	2	0.024	rsq	1.00000000	0.6	33	0.78		
	3	0.035			1.1	34	1.39		
	4	0.046			1.7	35	2.01		
	5	0.057			2.2	36	2.63		
	6	0.068			2.8	37	3.24		
	7	0.079			3.3	38	3.86		
	8	0.090			3.9	39	4.48		
	9	0.102			4.4	40	5.09		
	10	0.113			5.0	41	5.71		
	11	0.124			5.6	42	6.33		
	12	0.135			6.1	43	6.94		
	13	0.146			6.7	44	7.56		
	14	0.157			7.2	45	8.18		
	15	0.168			7.8	46	8.79		
	16	0.179			8.3	47	9.41		
	17	0.190			8.9	48	10.03		
	18	0.201			9.4	49	10.64		
	19	0.213			10.0	50	11.26		
	20	0.224			10.6	51	11.88		
	21	0.235			11.1	52	12.49		
	22	0.246			11.7	53	13.11		
	23	0.257			12.2	54	13.73		max units boxblt model:
	24	0.268			12.8	55	14.34		temp C
77	25	0.279	Range 26 to 34 deg C		13.3	56	14.96		24.9
	26	0.256	slope	-0.0311612	13.9	57	15.58		35.0148
	27	0.224	intercept	1.065798205	14.4	58	16.19		32.875
	28	0.193	rsq	1	15.0	59	16.81		
	29	0.162			15.6	60	17.43		
	30	0.131			16.1	61	18.05		121.8637993
	31	0.100			16.7	62	18.66		
	32	0.069			17.2	63	19.28		
	33	0.037			17.8	64	19.90		
93.2	34	0.006			18.3	65	20.51		
	35	0.000			18.9	66	21.13		
	36	0.000			19.4	67	21.75		
	37	0.000			20.0	68	22.36		
					20.6	69	22.98		
					21.1	70	23.60		

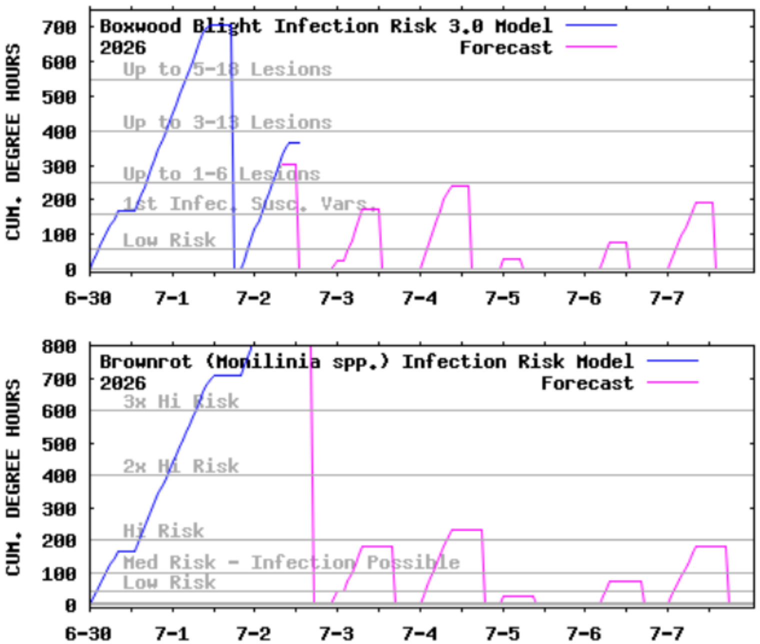


21.7	71	24.21		
22.2	72	24.83		
22.8	73	25.45		
23.3	74	26.06		
23.9	75	26.68	Range 78 to 94:	
24.4	76	27.30	slope	-1.7311779
25.0	77	27.91	intercept	161.9775132
25.6	78	26.95	r2	1
26.1	79	25.21		
26.7	80	23.48		
27.2	81	21.75		
27.8	82	20.02		
28.3	83	18.29		
28.9	84	16.56		
29.4	85	14.83		
30.0	86	13.10		
30.6	87	11.37		
31.1	88	9.63		
31.7	89	7.90		
32.2	90	6.17		
32.8	91	4.44		
33.3	92	2.71		
33.9	93	0.98		
34.4	94	0.00		

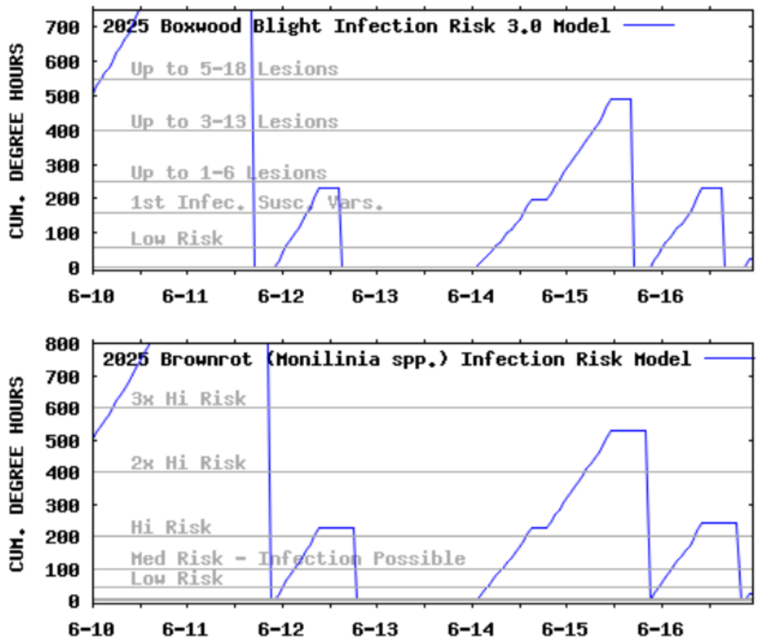
11. Calibrate USPest.org hourly temperature/leaf wetness model to DDRP/CAPS daily weather (temperature, RH, precipitation model):

Notes: As the hourly Monilinia model is very similar to our boxwood blight model implementation, we calibrated the daily brown rot model version to hourly box blight model, as shown below:

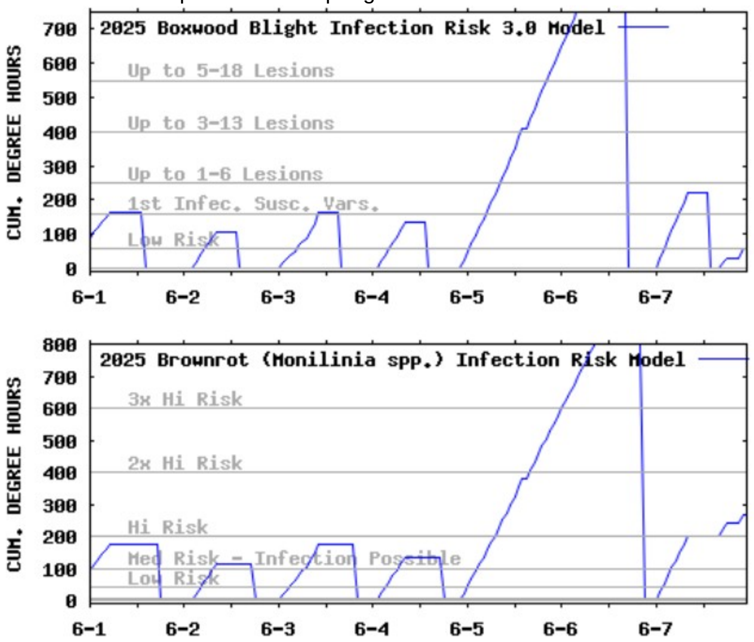
Example 1. Malta. NY 2026



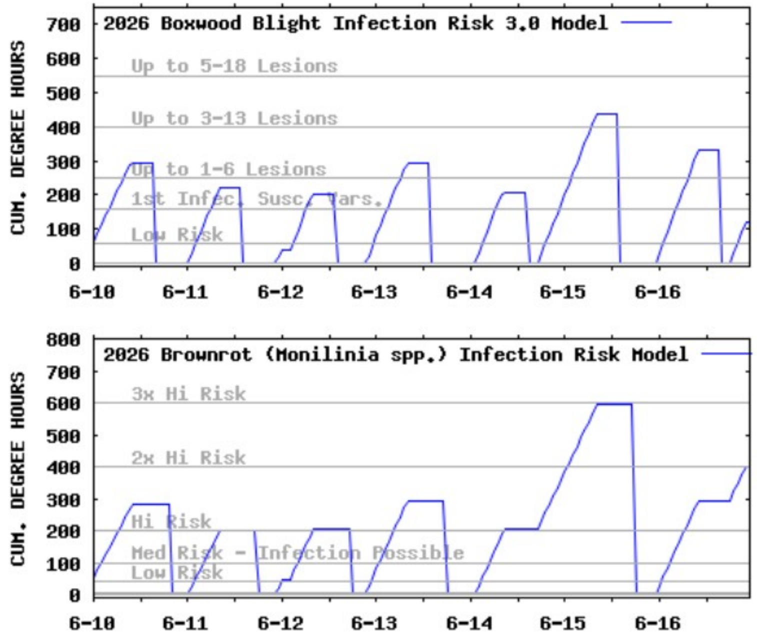
Example 2. Ballston Lake, NY 2025



Example 3. Seven Springs NC 2025

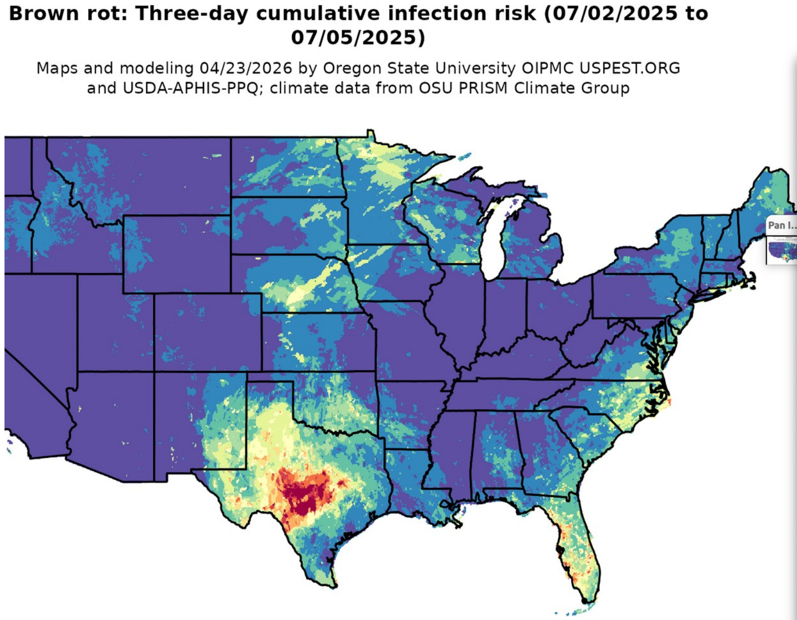


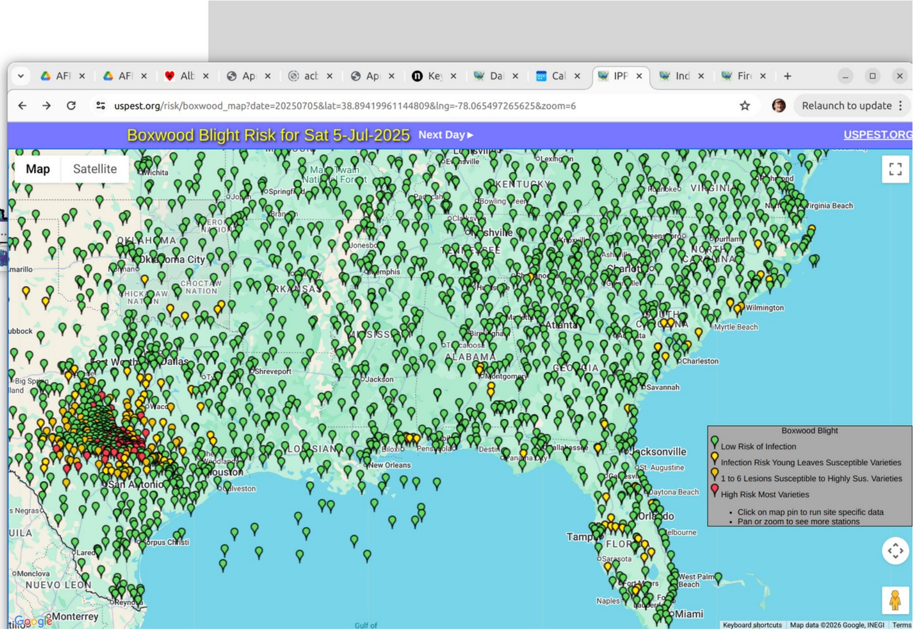
Example 4.Metter GA 2026



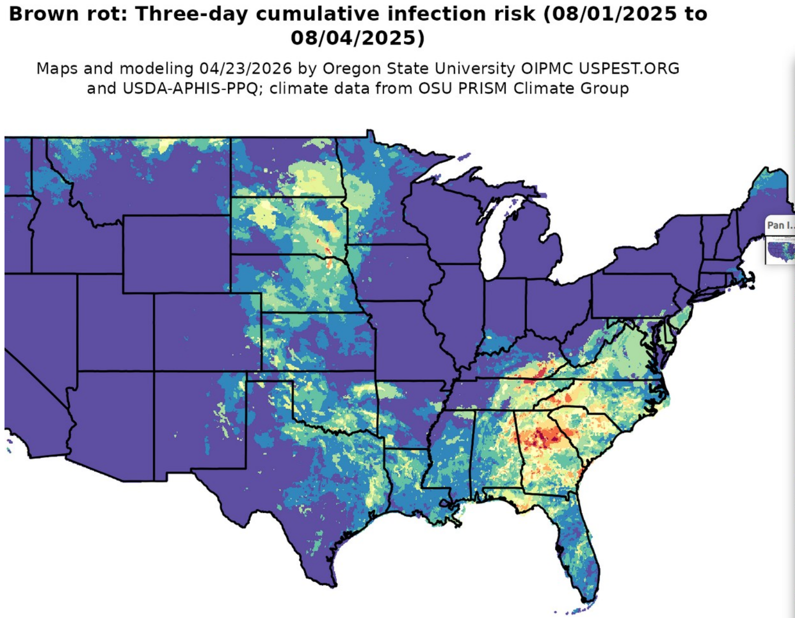
Based upon this close similarity between the two hourly driven models, we elected to use the box blight hourly driven synoptic maps to help calibrate the parameters for the daily DDRP Monilinia model, with several representative examples shown below:

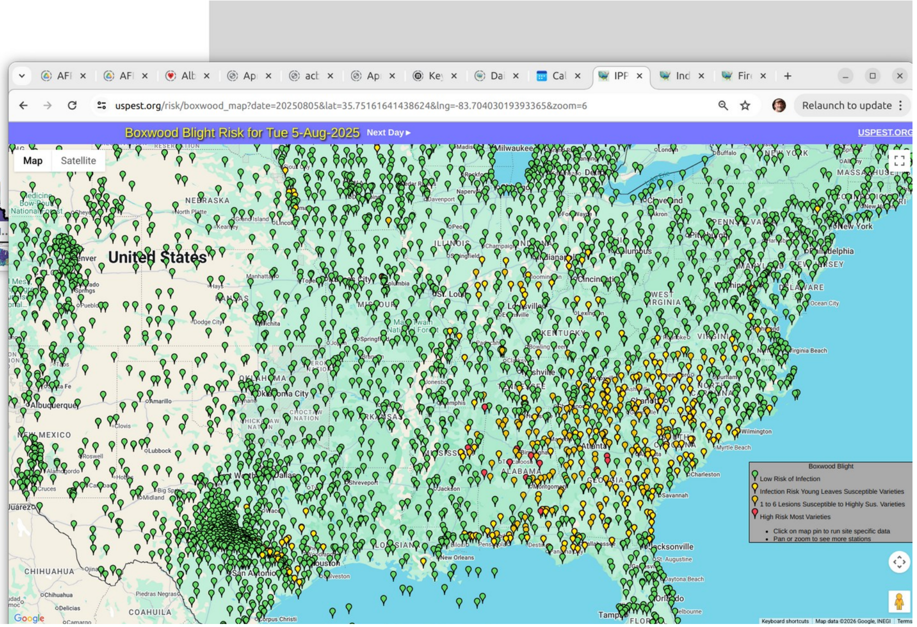
Example 1 – SE US July 2025 with central Texas having highest risk.



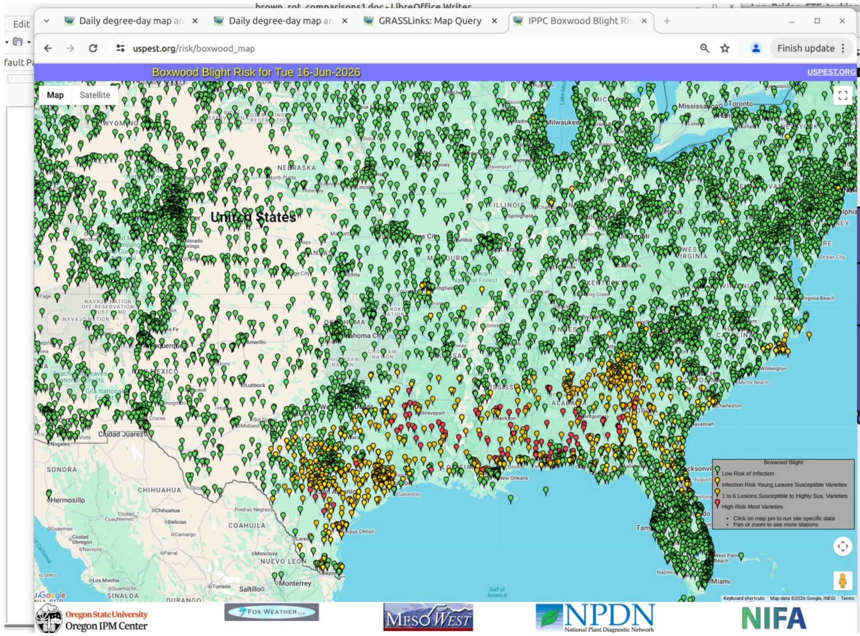


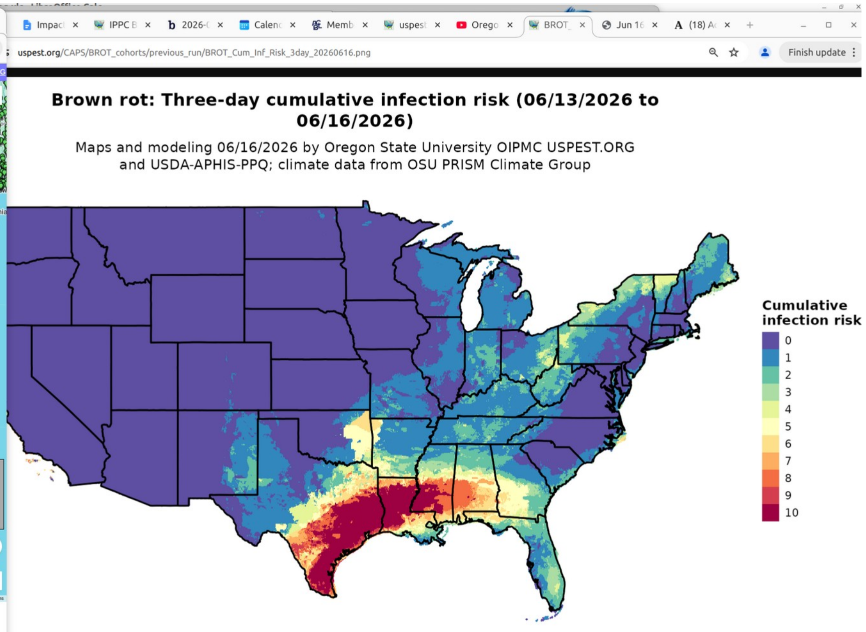
Example 2 – SE US Aug 2025 showing greater risk in SE states of NC, SC, GA, and FL panhandle.



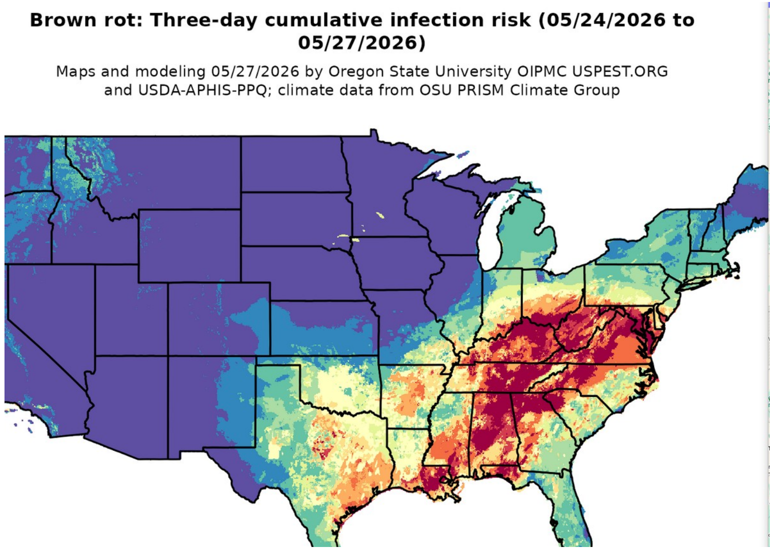


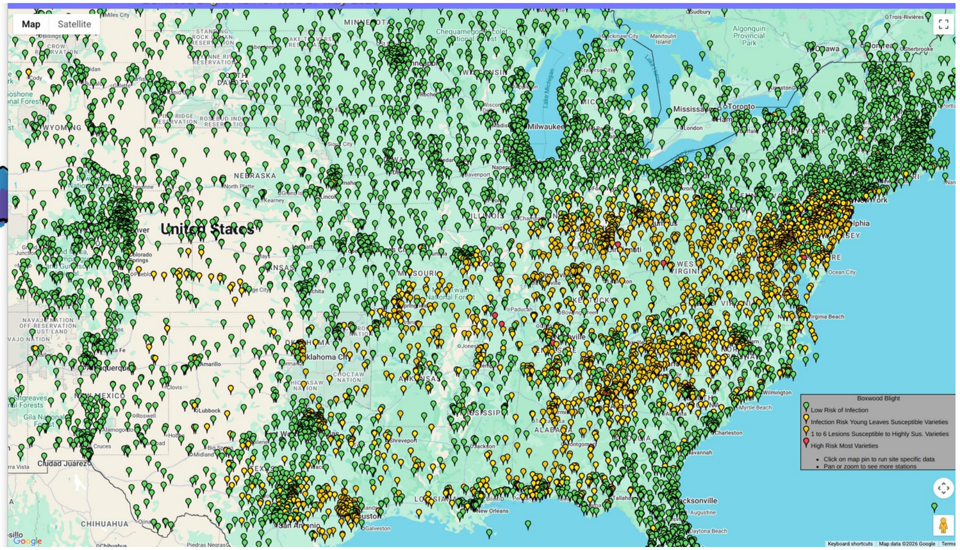
Example 3. June 2026 with portions of S. TX, LA, AL, and MS having high risk.





Example 4. May 2026 showing broad risk throughout and surrounding Appalachian states to the Gulf coast.

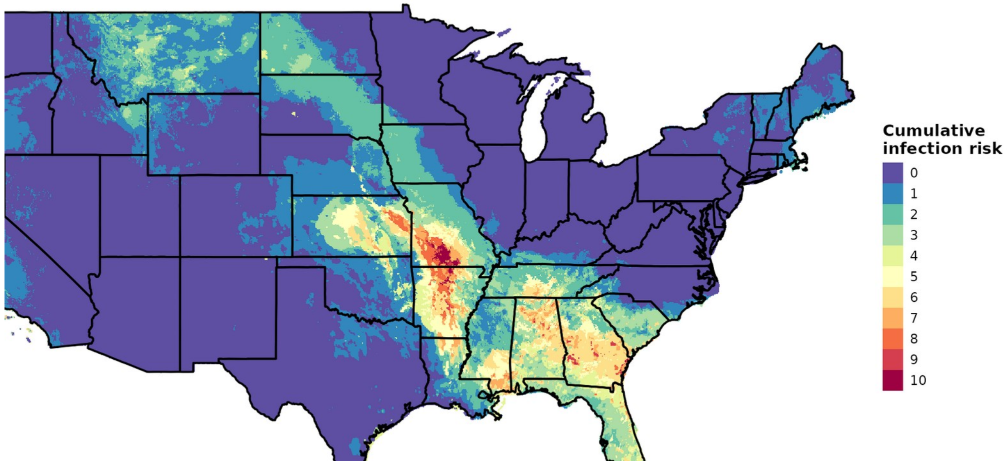


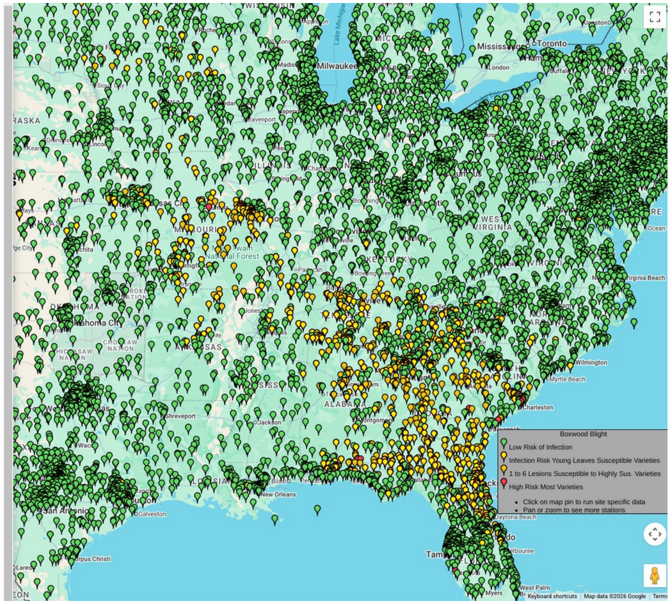


Example 5. May 2026 showing a NW to SE band of moderate to high risk.

Brown rot: Three-day cumulative infection risk (05/28/2026 to 05/31/2026)

Maps and modeling 05/31/2026 by Oregon State University OIPMC USPEST.ORG and USDA-APHIS-PPQ; climate data from OSU PRISM Climate Group

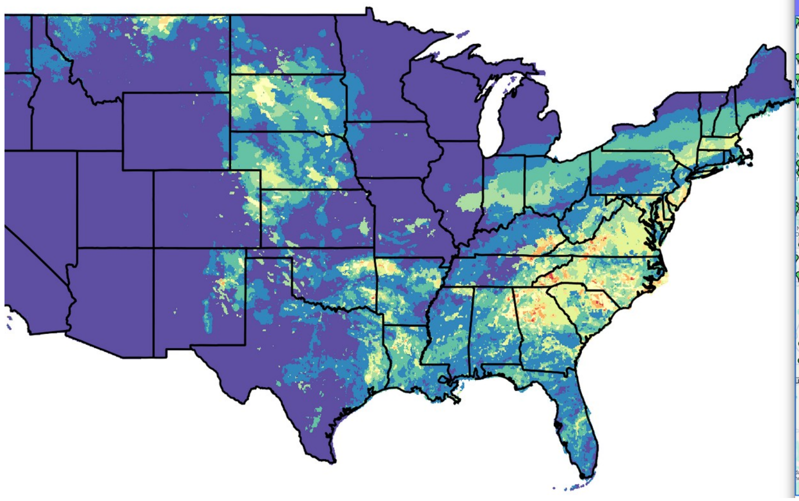


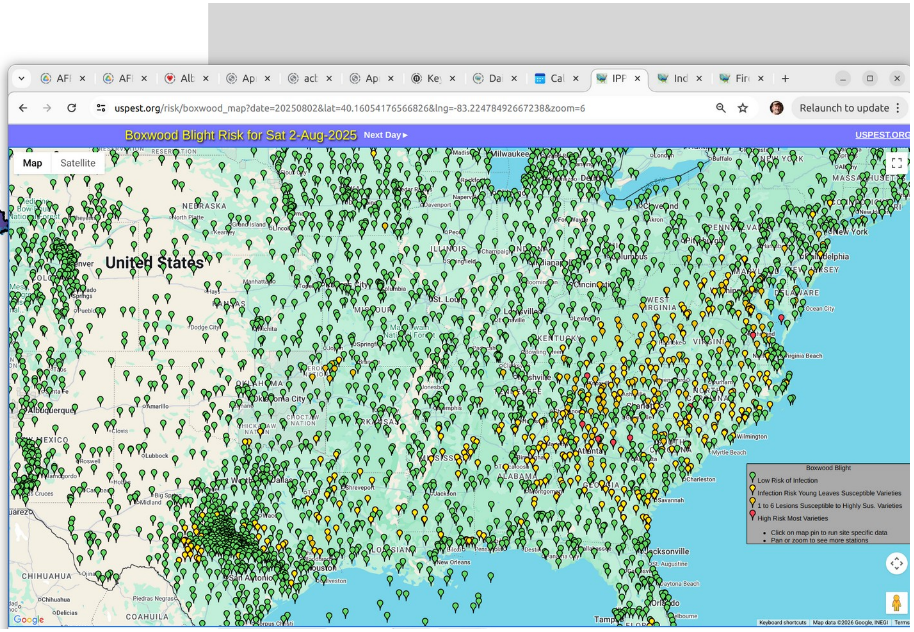


Example 6. Light to moderate risk in several SE regions. Note Monilinia model is slightly "hotter" or more sensitive than box blight, so very low Monilinia risk in NE, SD, IN, OH, and New England is not reflected in the box blight risk map.

Brown rot: Three-day cumulative infection risk (07/31/2025 to 08/03/2025)

Maps and modeling 04/23/2026 by Oregon State University OIPMC USPEST.ORG and USDA-APHIS-PPQ; climate data from OSU PRISM Climate Group





Notes: These are close but not exact comparisons, as the time scales cannot be matched precisely and timing of storms may impact hourly and daily climate records differently. Also, many of the weather stations in our hourly database have issues with moisture parameters so that they never represent plant disease risk accurately, for example they could always display as green due to a lack of having sensors for precipitation. Also, the 4 day risk DDRP maps are based upon 2 prior days of PRISM data followed by 2 days of NWS NDFD forecast grids, while the synoptic maps are based solely on recent observed weather rather than using forecasts, which will introduce forecast error into the comparisons.

Results – in general the daily PRISM climate plus NDFD forecast driven DDRP maps do reflect the higher resolution (hourly weather station) locations quite well on temporal and geographic scales.