Bringing Plant Disease Forecasting Science to the 21st Century Farm

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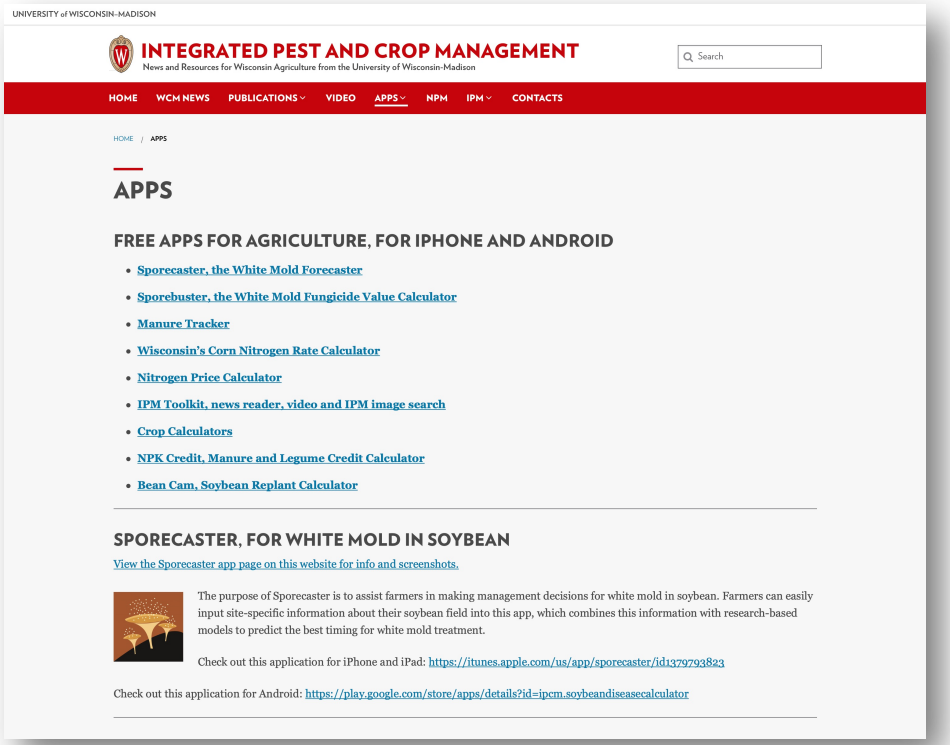
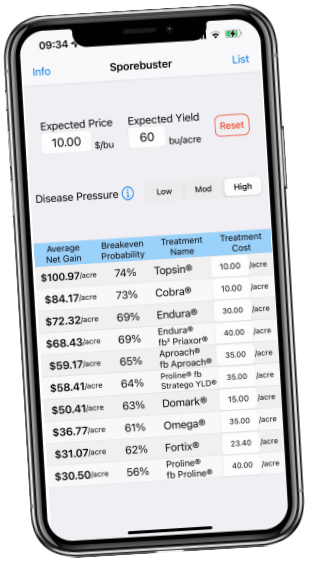
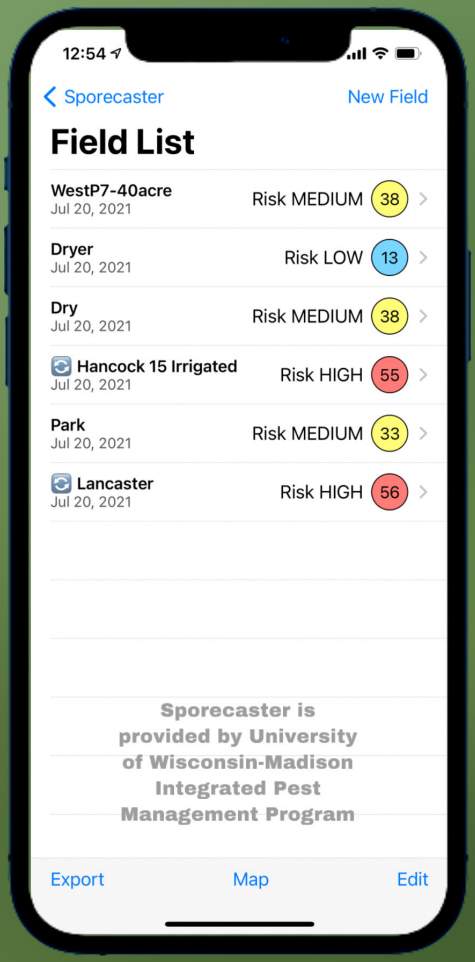
The Apps



https://ipcm.wisc.edu/apps/





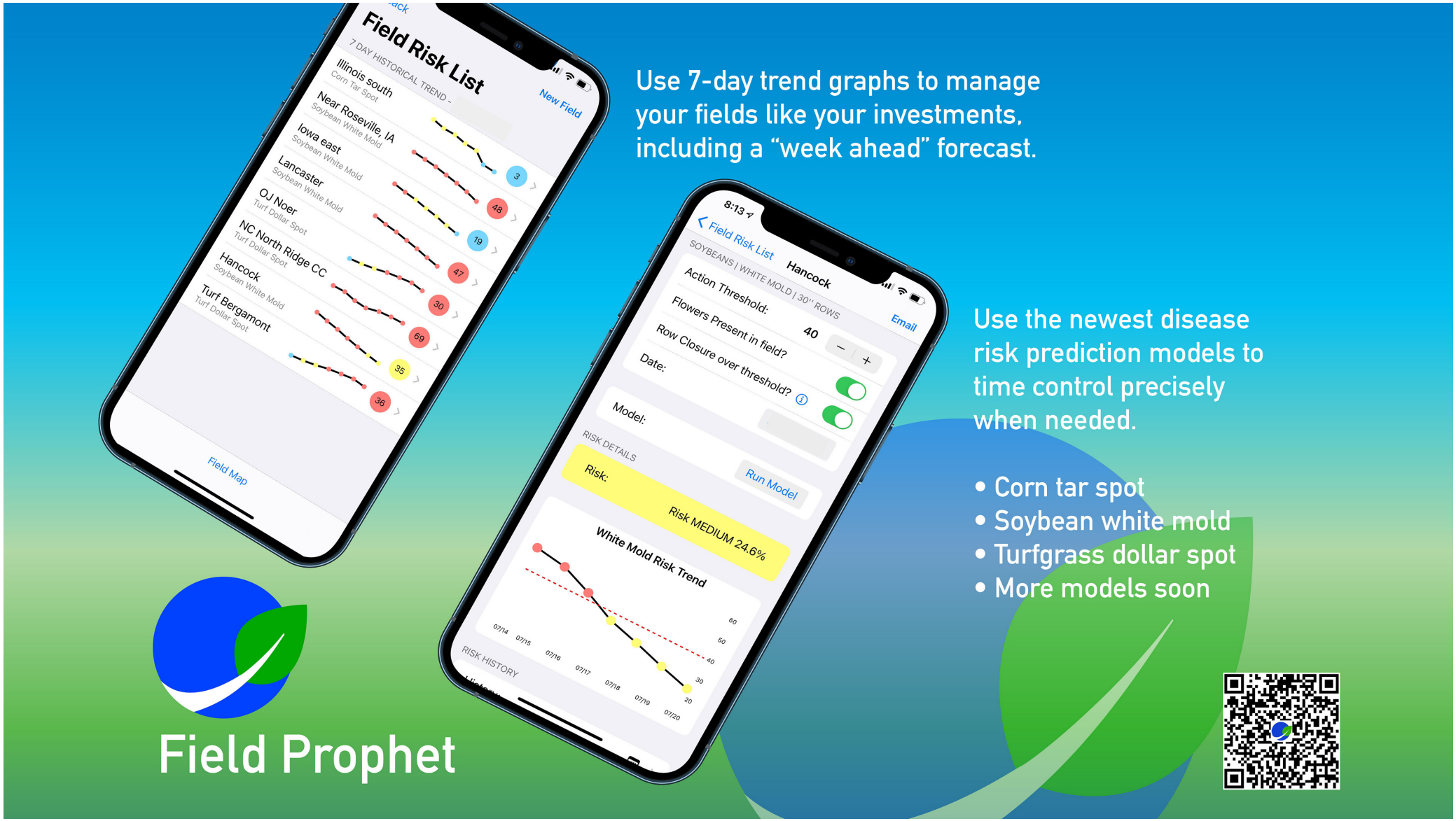
Free app!

"Sporecaster" calculates daily risk of infection during flowering for white mold on soybean crops

Free app!

"TarSpotter" calculates daily risk of tar spot infection before symptoms, giving you time to control.

For Android versions, Visit http:ipcm.wisc.edu/apps


Field Risk List
7 DAY HISTORICAL TREND
New Field
Illinois south
Corn Tar Spot
Near Roseville, IA
Soybean White Mold
Iowa east
Soybean White Mold
Lancaster
Soybean White Mold
OJ Noer
Turf Dollar Spot
NC North Ridge CC
Turf Dollar Spot
Hancock
Soybean White Mold
Turf Bergamont
Turf Dollar Spot
3
48
19
47
30
69
35
36
Field Map
Use 7-day trend graphs to manage your fields like your investments, including a “week ahead” forecast.
8:13
Field Risk List
Hancock
SOYBEANS | WHITE MOLD | 30" ROWS
Email
Action Threshold:
40
Flowers Present in field?
Row Closure over threshold?
Date:
Model:
RISK DETAILS
Run Model
Risk:
Risk MEDIUM 24.6%
White Mold Risk Trend
60
50
40
30
20
07/14
07/15
07/16
07/17
07/18
07/19
07/20
RISK HISTORY
Use the newest disease risk prediction models to time control precisely when needed.
• Corn tar spot
• Soybean white mold
• Turfgrass dollar spot
• More models soon
Field Prophet

A Quote That Changed My Career at UW

From a Wisconsin Soybean Marketing Board

“You can do all the research in the world - if it stays stuck in the scientific literature, never being delivered to the public, you can’t change behavior. Don’t let your research collect dust.”

This is the foundational premise of the “Wisconsin Idea”

What better way to deliver research-based information, than through smartphone apps – Validate, deliver, and keep it free

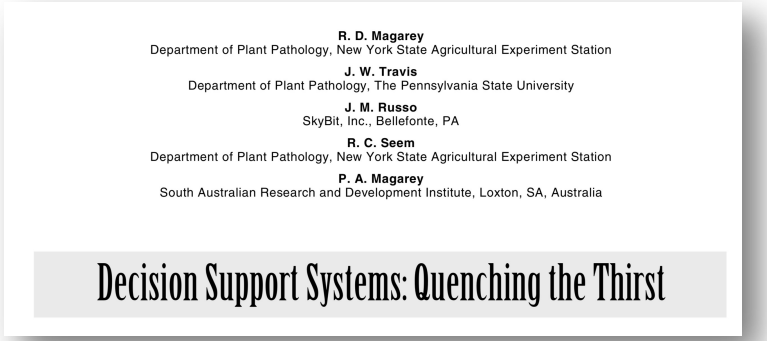
Smartphone-based Disease Forecasting Challenges

- Specificity of Forecasts? (Can't generate forecasts remotely below 2 Km grid)
- Accuracy – Initial efforts have shown 80% accuracy
  - Have identified misses of Sporecaster and Tarspotter over the years
  - Forecasting systems are a constant work in progress – Currently working on identifying areas of improvement in the app
  - Expensive to maintain, especially if you want the app to remain free
- Cell phone coverage and slow rural internet speeds
- Adoption? – Average age of farmers is **57.5 years of age**
  - Average age of new farmers (those who have farmed less than 10 years) is **46.3**

Farmprogress.com (April 11, 2019)

How Do We Get Farmers and Practitioners to Use Research-based Apps?

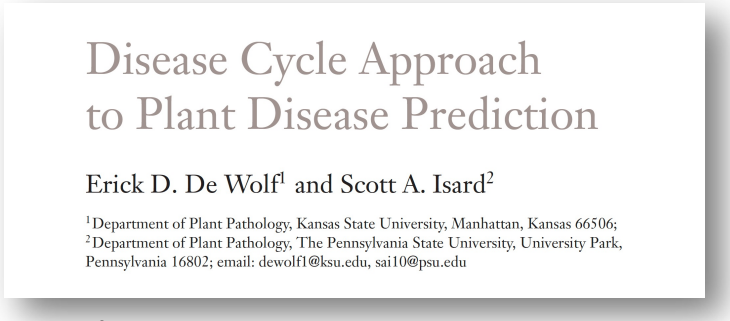
Adoption might increase with improvements in accuracy, accessibility, and profitability



R. D. Magarey
Department of Plant Pathology, New York State Agricultural Experiment Station
J. W. Travis
Department of Plant Pathology, The Pennsylvania State University
J. M. Russo
SkyBit, Inc., Bellefonte, PA
R. C. Seem
Department of Plant Pathology, New York State Agricultural Experiment Station
P. A. Magarey
South Australian Research and Development Institute, Loxton, SA, Australia

Decision Support Systems: Quenching the Thirst

Magarey et al. 2002, Plant Disease



Disease Cycle Approach to Plant Disease Prediction

Erick D. De Wolf[1] and Scott A. Isard[2]

[1]Department of Plant Pathology, Kansas State University, Manhattan, Kansas 66506; [2]Department of Plant Pathology, The Pennsylvania State University, University Park, Pennsylvania 16802; email: dewolf1@ksu.edu, sai10@psu.edu

DeWolf and Isard 2007, Ann. Rev. Phytopath.

- Lots of Disease Forecasting models out there, but adoption historically is low
  - Needed specialized equipment (e.g. leaf wetness sensor)
  - Need to consider many diseases and pests, not just one
- Better predictive models are increasingly complicated
- Farmers seek site-specific forecasts
- Farmers are busy, need quick recommendations
  - The "Cup of Coffee Rule"
- The invention of the smartphone has helped facilitate solving some of these issues
  - GPS
  - Fast calculations
  - Weather Model Aggregation - openly available
  - Sporecaster can deliver site-specific (local grid), daily forecasts for multiple locations in seconds, accounting for crop physiology and pathogen biology

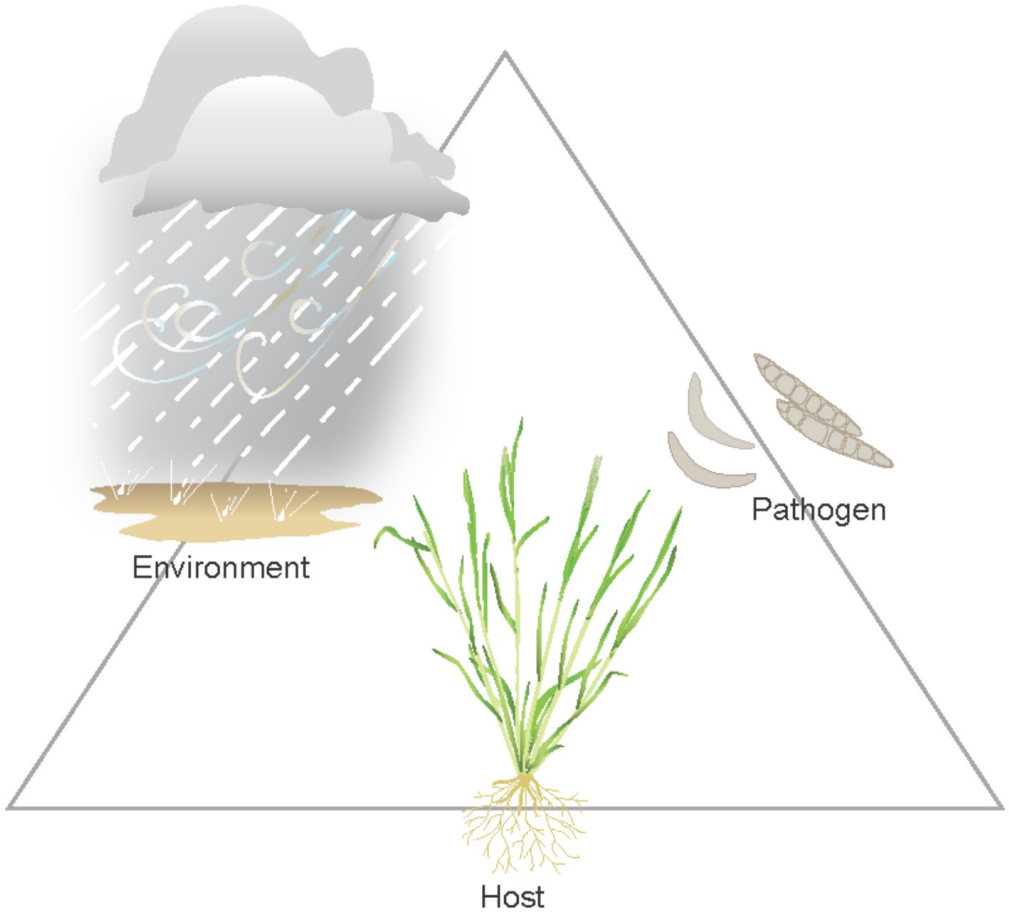
Remote-Accessed, Site-Specific Weather in an Application Programming Interface (API)

The Dark Sky API as an example

- Pulls weather data (historical and real-time forecasts) from multiple sources
- Site-specific (uses GPS) down to 2.5 – 5.0 km grids
- Aggregated into one usable format
- Can eliminate the need for on-site weather station
  - -Lower weather data accuracy?
  - -Lack of use of biologically relevant weather variables (e.g. leaf wetness)?

ID	Source
`cmc`	The USA NCEP's Canadian Meteorological Center ensemble model, available globally.
`darksky`	Dark Sky's own hyperlocal precipitation forecasting system, backed by radar data from the USA NOAA's NEXRAD system, available in the USA, and the UK Met Office's NIMROD system, available in the UK and Ireland.
`ecpa`	Environment and Climate Change Canada's Public Alert system, available in Canada.
`gfs`	The USA NOAA's Global Forecast System, available globally.
`hrrr`	The USA NOAA's High-Resolution Rapid Refresh Model, available in the continental USA.
`icon`	The German Meteorological Office's icosahedral nonhydrostatic, available globally.
`imo`	The Icelandic Meteorological Office's Severe Weather Alerting system, avaialble in Iceland.
`isd`	The USA NOAA's Integrated Surface Database, available near populated areas globally for times greater than two weeks in the past.
`madis`	The USA NOAA/ESRL's Meteorological Assimilation Data Ingest System, available near populated areas globally.
`meteoalarm`	EUMETNET's Meteoalarm weather alerting system, available in European Union countries and Israel.
`nam`	The USA NOAA's North American Mesoscale Model, available in North America.
`nwspa`	The USA NOAA's Public Alert system, available in the USA.
`sref`	The USA NOAA/NCEP's Short-Range Ensemble Forecast, available in North America.

The Disease Triangle Matters!



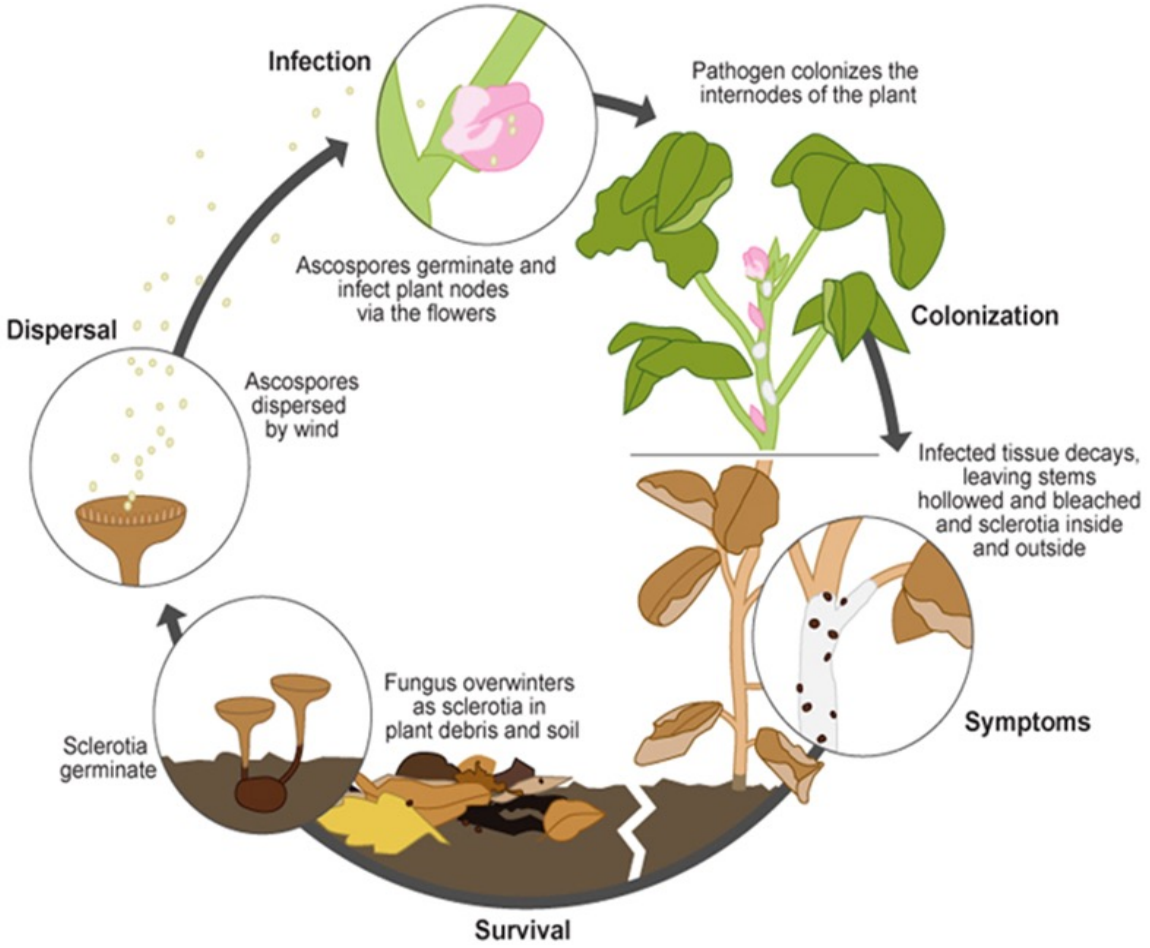
How does Sporecaster work?

- Based on Research From 3 publications
  1. Willbur, J.F., Fall, M.L., Blackwell, T., Bloomingdale, C.A., Byrne, A.M., Chapman, S.A., Holtz, D., Isard, S.A., Magarey, R.D., McCaghey, M., Mueller, B.D., Russo, J.M., Schlegel, J., Young, M., Chilvers, M.I., Mueller, D.S., and Smith, D.L. 2018. Weather-based models for assessing the risk of Sclerotinia sclerotiorum apothecial presence in soybean (*Glycine max*) fields. Plant Disease. DOI:10.1094/PDIS-04-17-0504-RE
  2. Willbur, J.F., Fall, M.L., Byrne, A.M., Chapman, S.A., McCaghey, M.M., Mueller, B.D., Schmidt, R., Chilvers, M.I., Mueller, D.S., Kabbage, M., Giesler, L.J., Conley, S.P., and Smith, D.L. 2018. Validating *Sclerotinia sclerotiorum* apothecial models to predict Sclerotinia stem rot in soybean (*Glycine max*) fields. Plant Disease. https://doi.org/10.1094/PDIS-02-18-0245-RE.
  3. Fall, M., Willbur, J., Smith, D.L., Byrne, A., and Chilvers, M. 2018. Spatiotemporal distribution pattern of Sclerotinia sclerotiorum apothecia is modulated by canopy closure and soil temperature in an irrigated soybean field. Phytopathology. https://doi.org/10.1094/PDIS-11-17-1821-RE.
- Available for the U.S. and Canada
- Can be run in the field or at the desk
- Uses a combination of user inputs and GPS-referenced weather information (DarkSky API) to provide a risk of white mold so you can make a spray decision
- As of Summer, 2021 (Released May 2018)
  -Updated on over **6,000 devices**
  -**1,000** forecasts per day during July (Peak Period)
- Awarded the 2018 American Society of Agronomy (ASA) Extension Education Community Educational Award in the category of digital decision aids (software, web-based, smartphone and tablet apps)

White Mold Cycle (Soybean)

Process requires:

- -moderate temperatures (≤21 C averages; Nighttime temps matter a lot!)
- -high humidity (not necessarily excessive rain)
- -Between row canopy closure of 40% or more



How Important Are Apothecia?

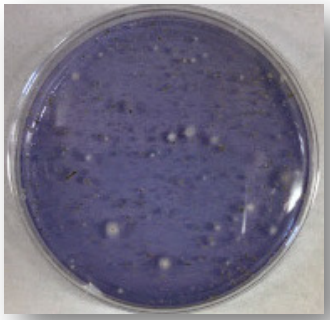
- Formation of apothecia critical for SSR development in soybean

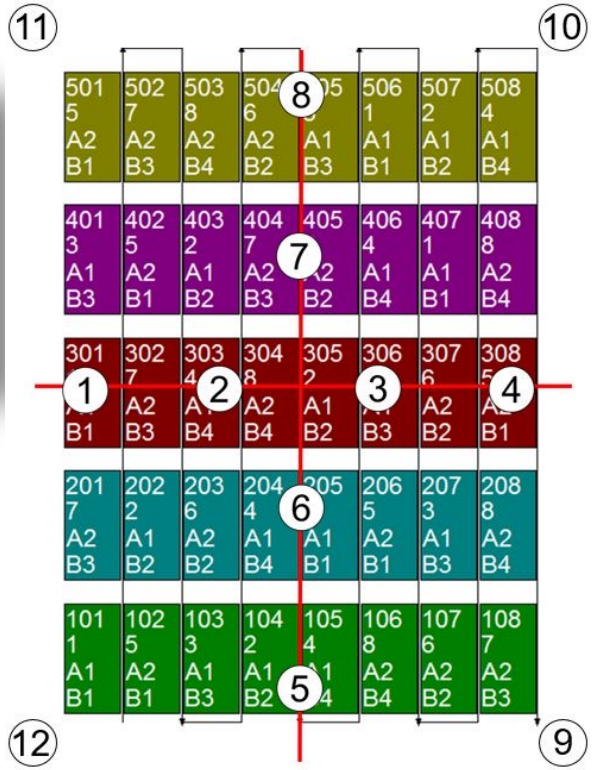
- Majority of infections in soybean occur due to ascospore release from apothecia within the field

Boland and Hall, 1988, Plant Pathology , 37:329-336
Wegulo, Sun, Martinson, and Yang, Can. J. Plant Sci., 80:389-402

Apothecial Mapping and Spore Trapping

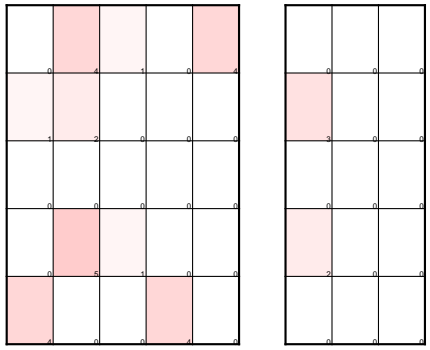
- Using semi-selective media:
- Exposed plates under canopy facing prevailing winds for 3 consecutive hours between 09:00 and 14:00
- Used 8 spore traps placed evenly along transects (shown at right)



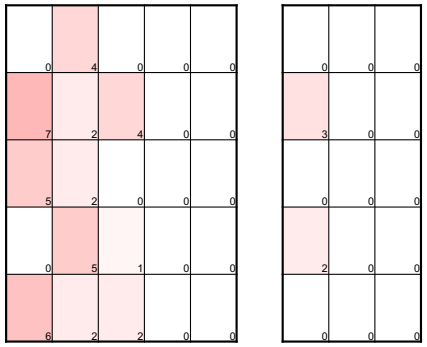


Foster, A. J., Kora, C., McDonald, M. R., & Boland, G. J. (2011). Development and validation of a disease forecast model for Sclerotinia rot of carrot. *Canadian Journal of Plant Pathology*, *33*(2), 187–201. doi:10.1080/07060661.2011.563753

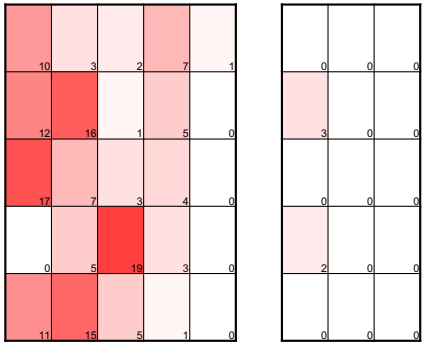
2015 Apothecial Scouting



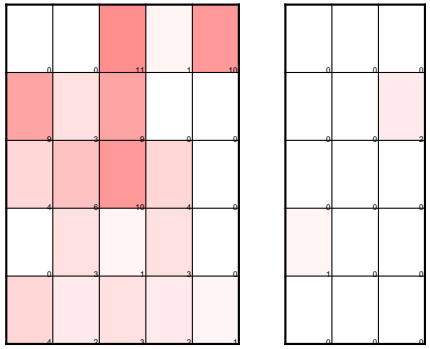
48 DAS (V4/5)



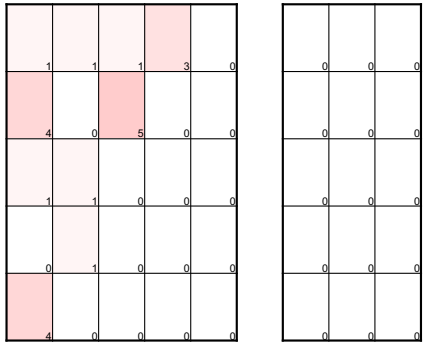
58 DAS (R1)



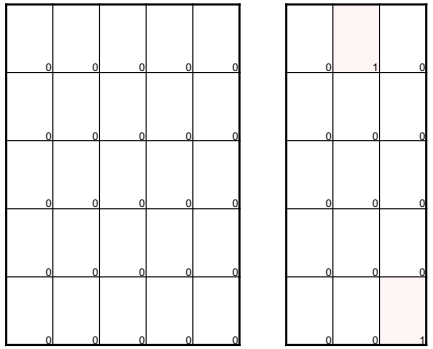
62 DAS (R2)



69 DAS (R2)



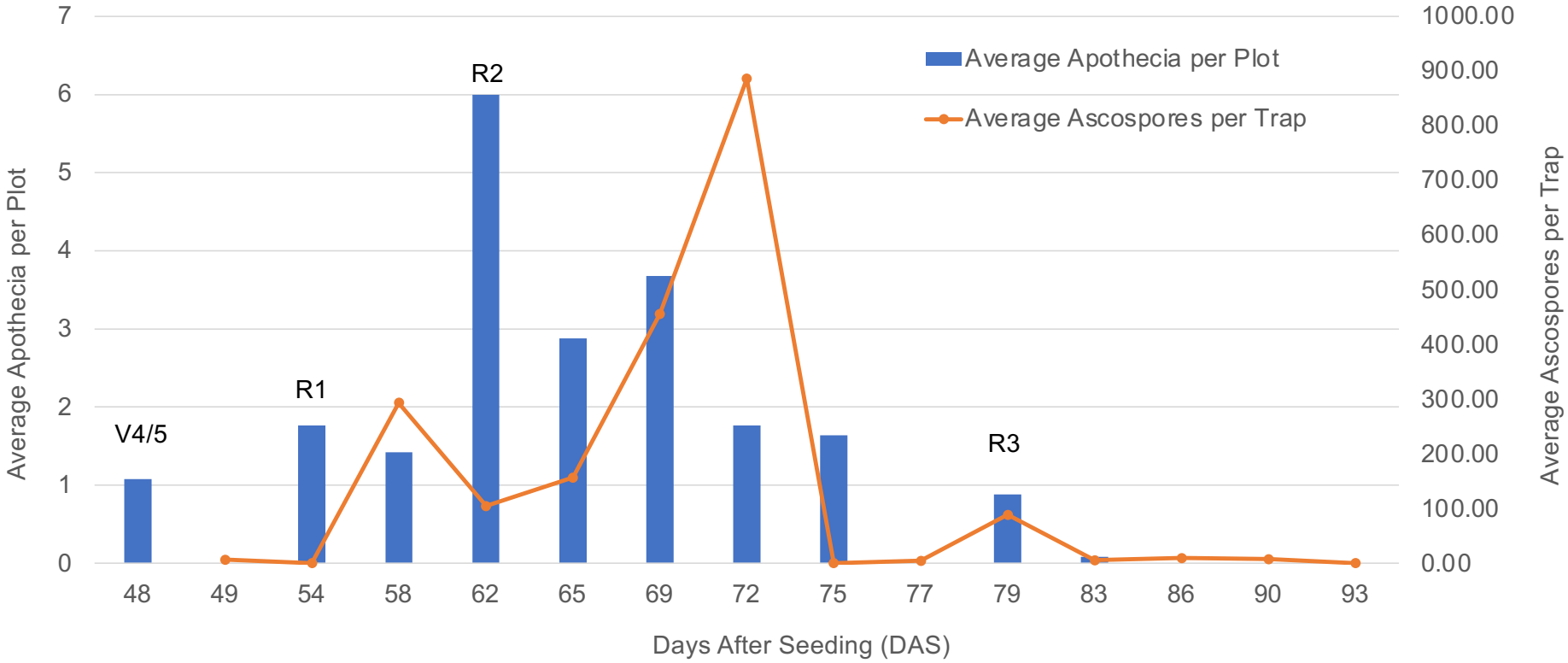
79 DAS (late R3)



86 DAS (R4)

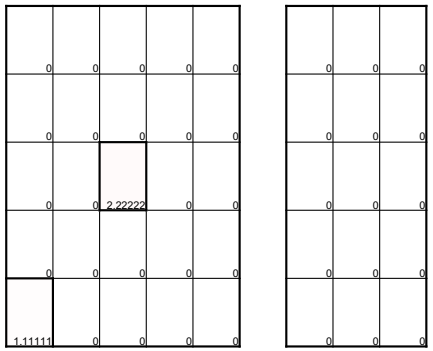
0	Total # Apothecia	25

Apothecia and Trap Data

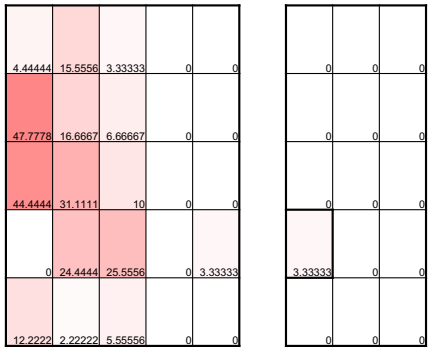


2015 Disease Severity Index

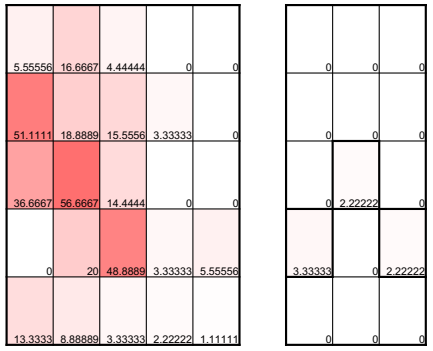
late July to late August (6 ratings)



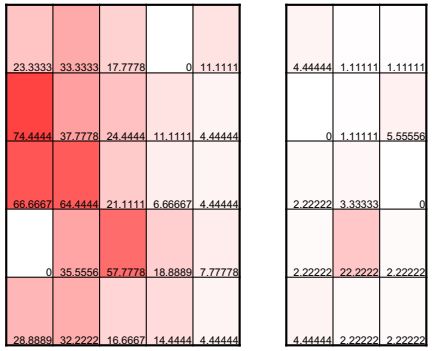
75 DAS (R3)



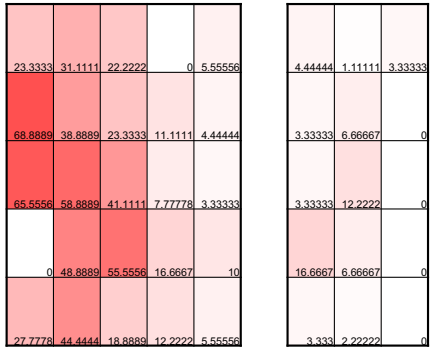
90 DAS (R5)



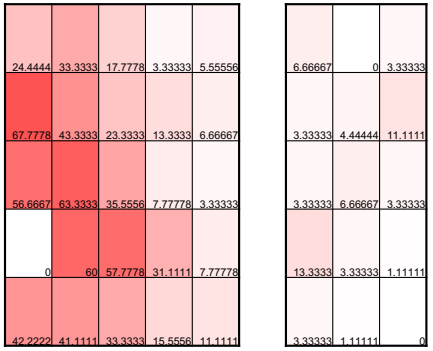
93 DAS (R5)



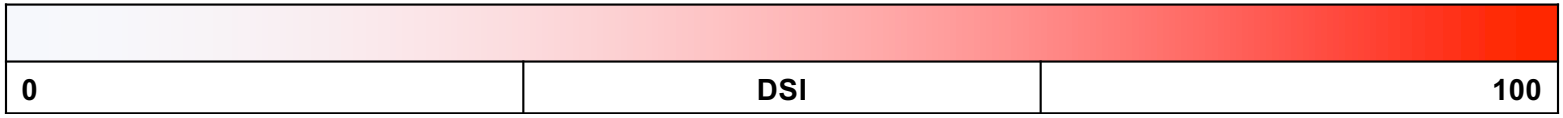
97 DAS (R5)



99 DAS (late R5)

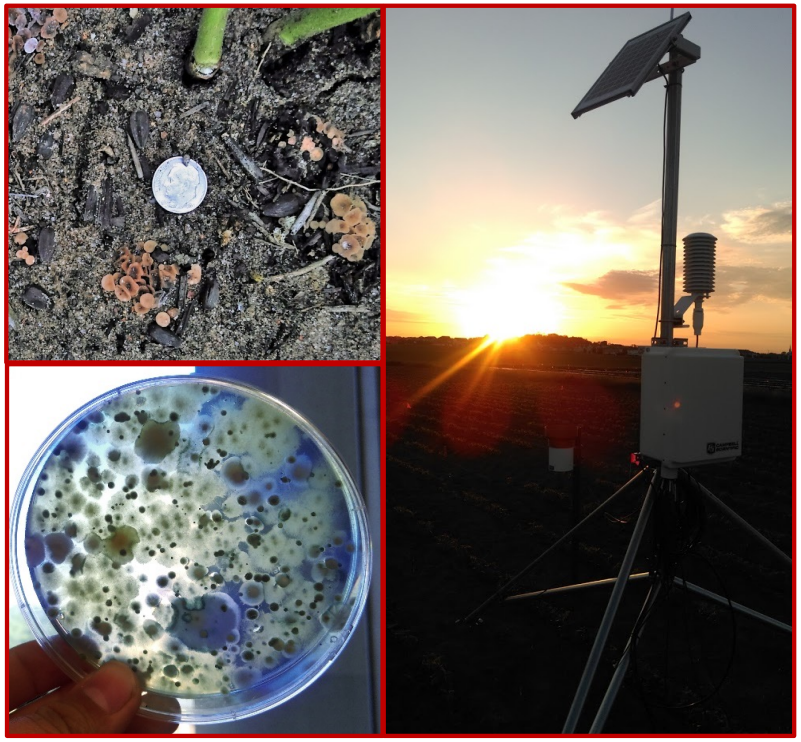


105 DAS (R6)



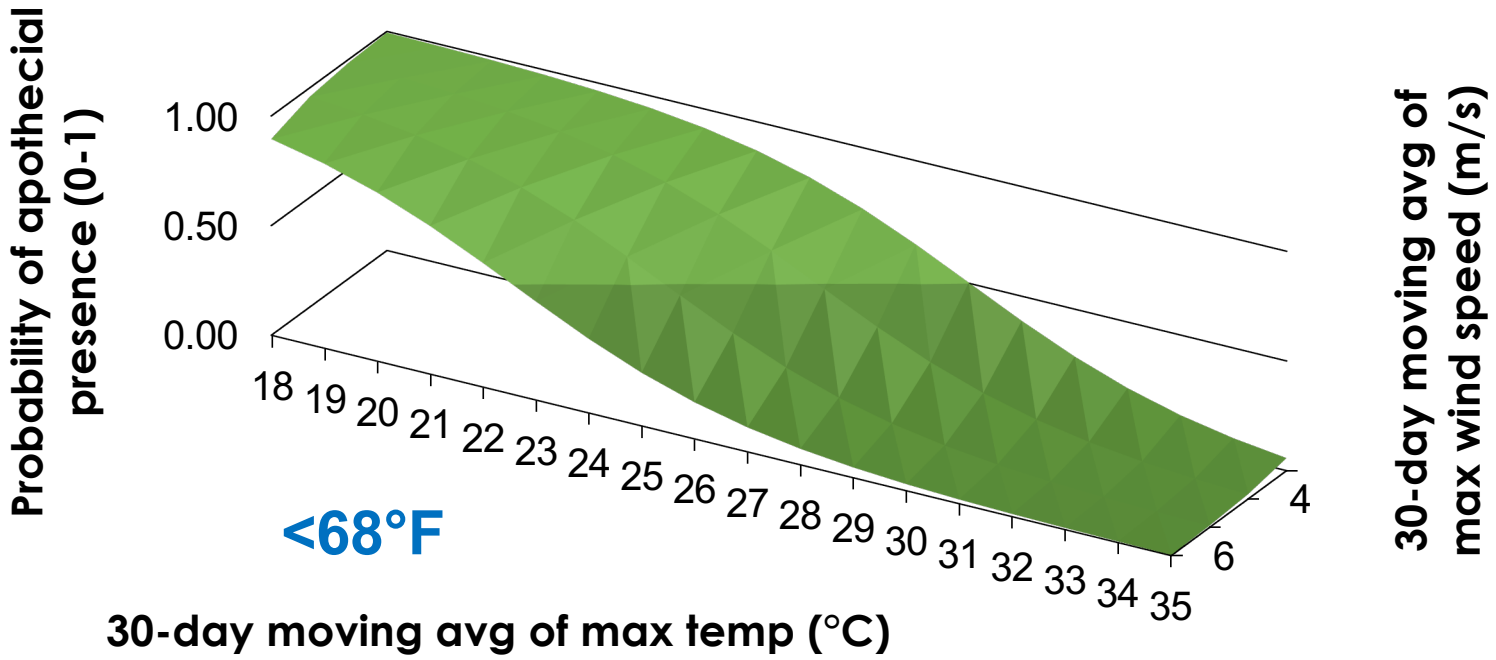
Data Collection

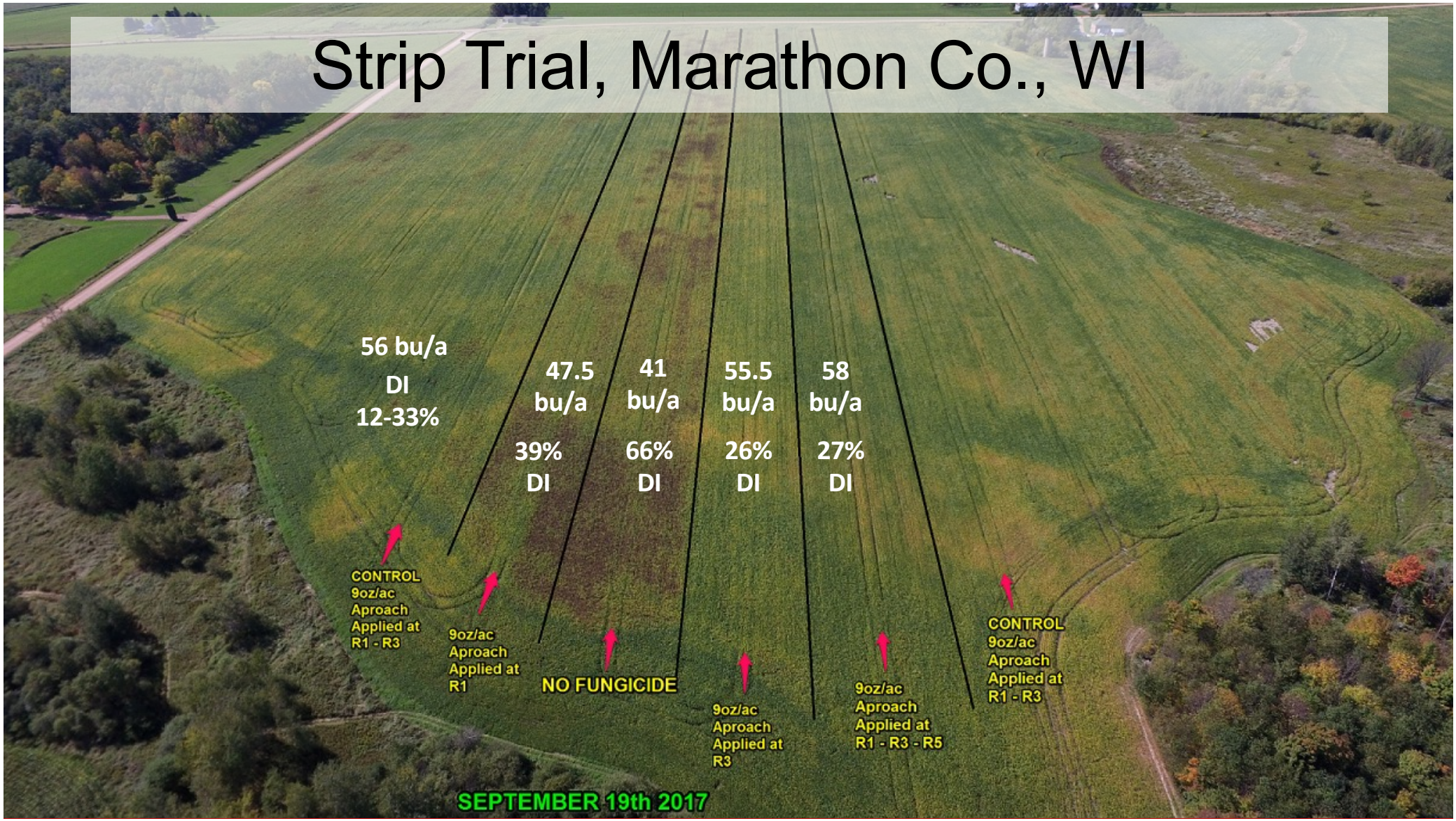
- Developed standardized protocols for intensive, multi-state apothecial and ascospore monitoring
- Scouted research trials for apothecia in Iowa, Michigan, and Wisconsin
  - **9 site-years (n = 3,866)**
- Monitored ascospores using *Sclerotinia* semi-selective media
- Accessed high-resolution gridded weather data and validated with an on-site Campbell weather station



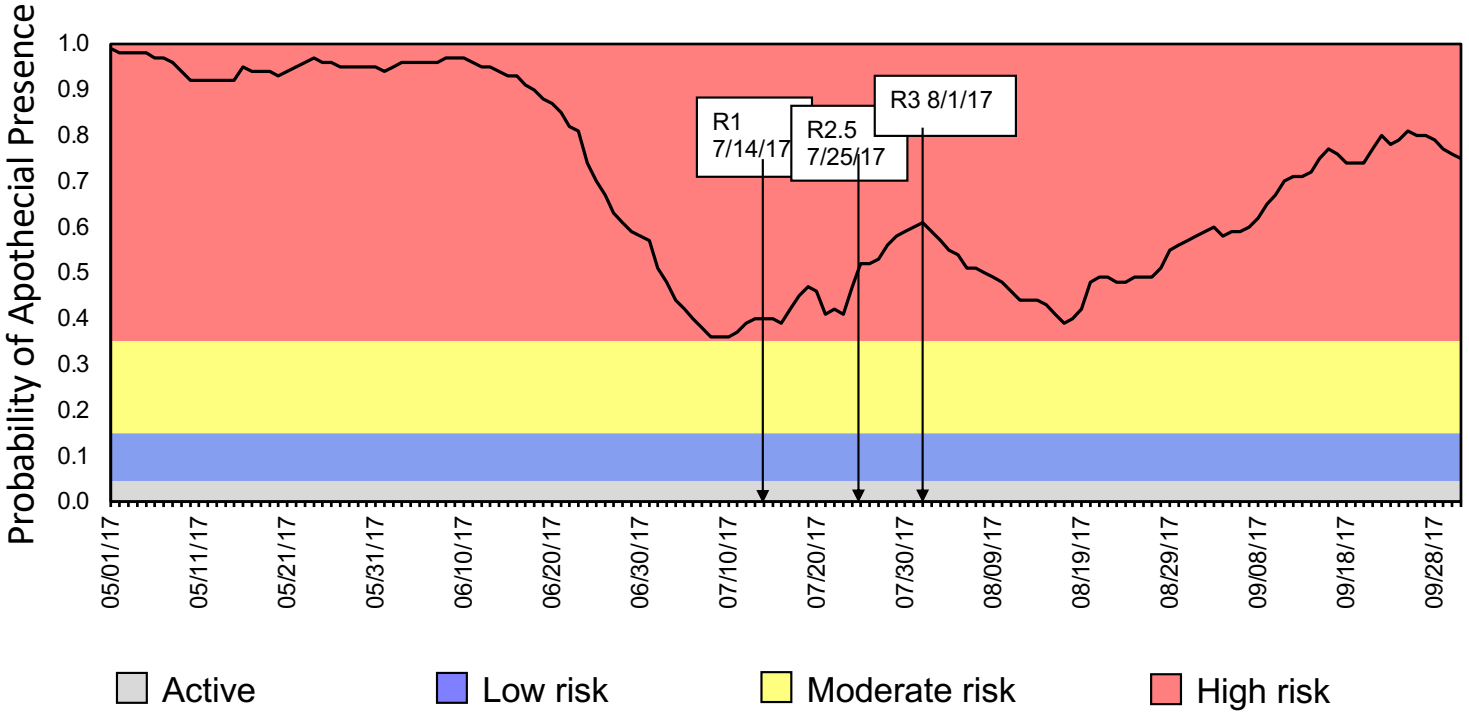
Model for Non-Irrigated Fields

Logit (P) = -0.47*MaxAT – 1.01*MaxWS + 16.65




Strip Trial, Marathon Co., WI
56 bu/a
DI
12-33%
47.5
bu/a
39%
DI
41
bu/a
66%
DI
55.5
bu/a
26%
DI
58
bu/a
27%
DI
CONTROL
9oz/ac
Aproach
Applied at
R1 - R3
9oz/ac
Aproach
Applied at
R1
NO FUNGICIDE
9oz/ac
Aproach
Applied at
R3
9oz/ac
Aproach
Applied at
R1 - R3 - R5
CONTROL
9oz/ac
Aproach
Applied at
R1 - R3
SEPTEMBER 19th 2017

2017 Risk Probabilities Based on the Model, Marathon Co. Strip Trial

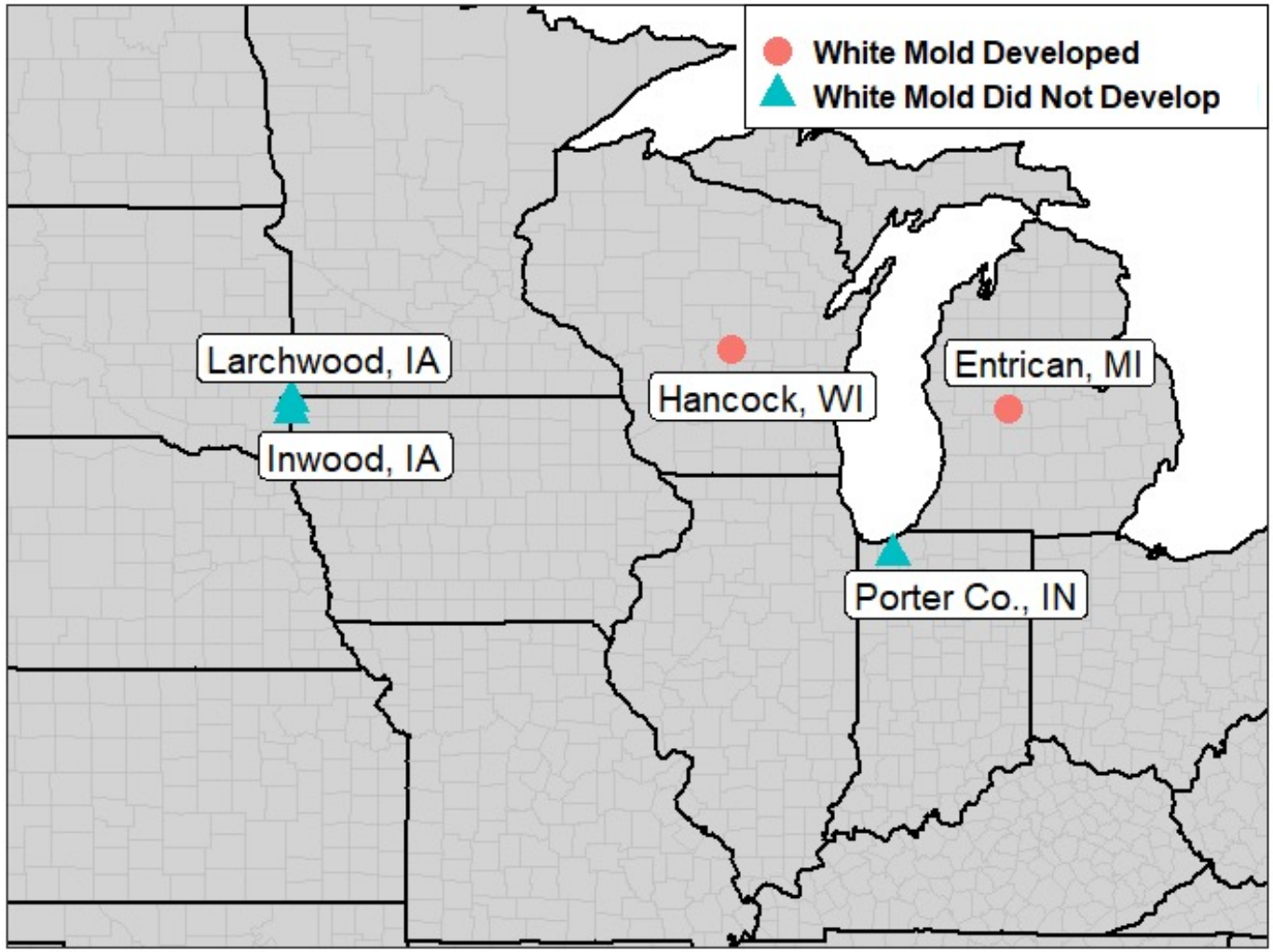


CROP PROTECTION NETWORK
A Product of Land Grant Universities

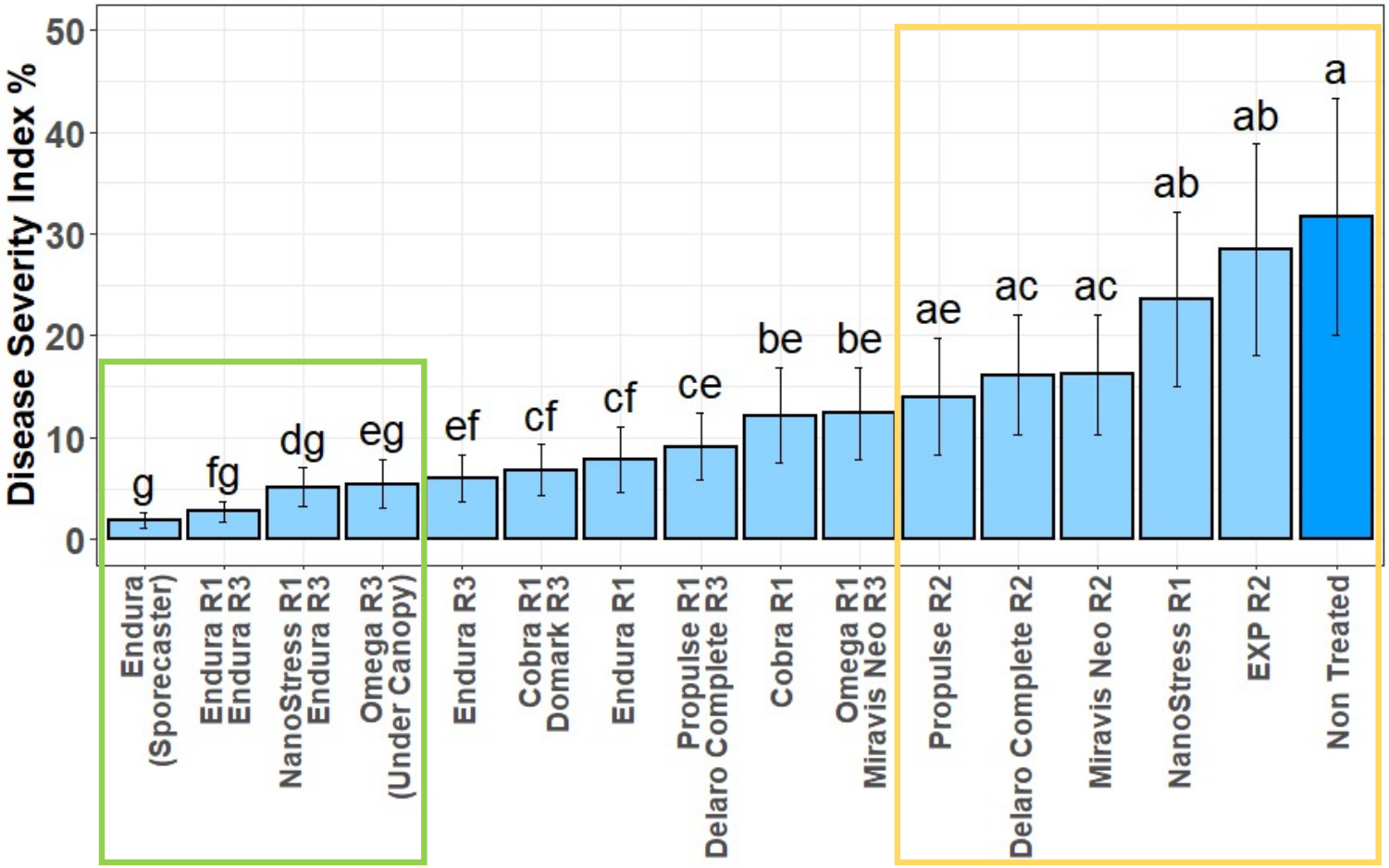
Coordinated White Mold Fungicide Trials 2021

Richard Wade Webster, Martin I. Chilvers, Daren S. Mueller, Darcy E. P. Telenko, and Damon L. Smith

- 5 site-years
- White mold developed in 2 of the 5 site-years
  (average disease incidence >1%)

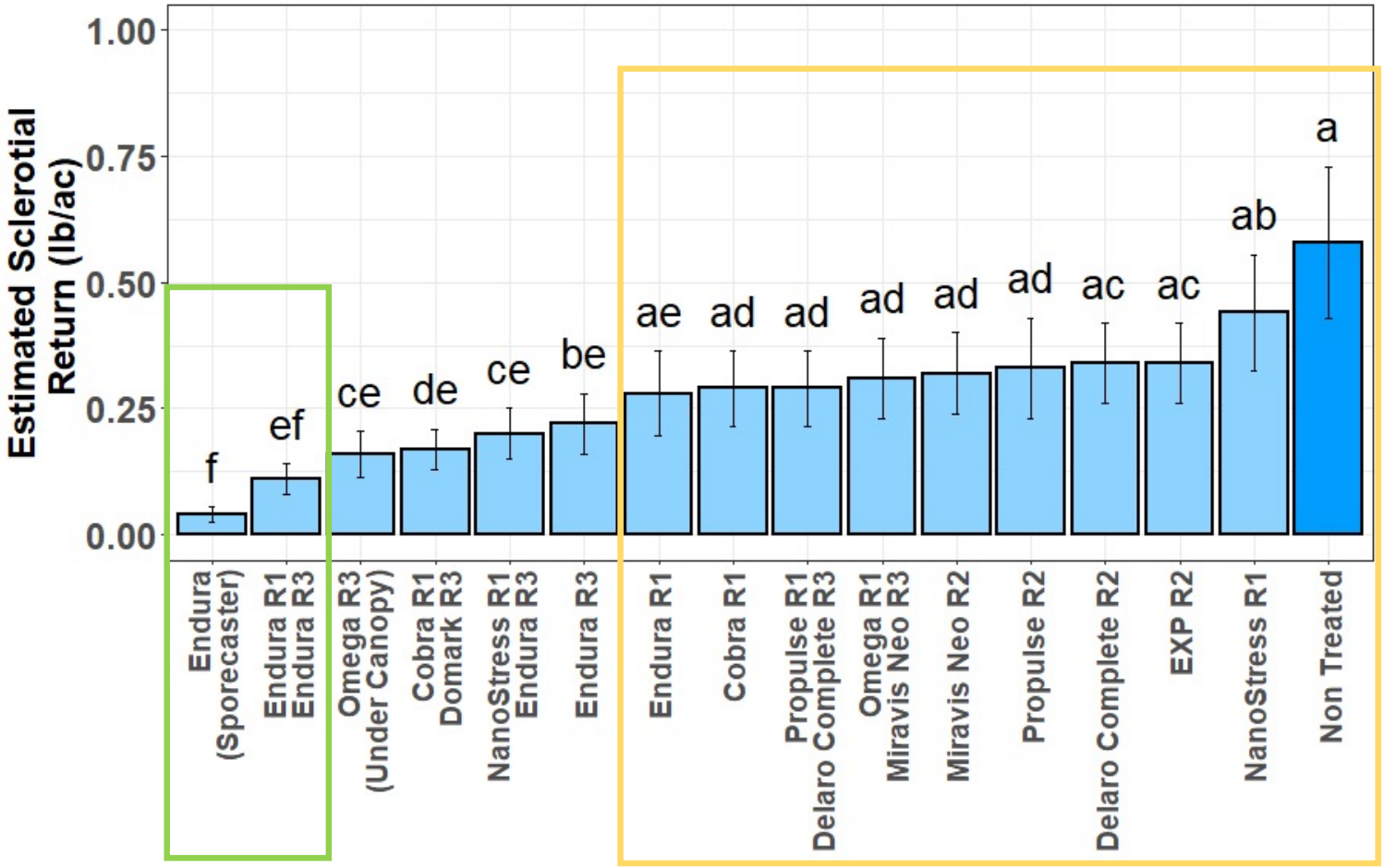


White Mold Disease Severity Index



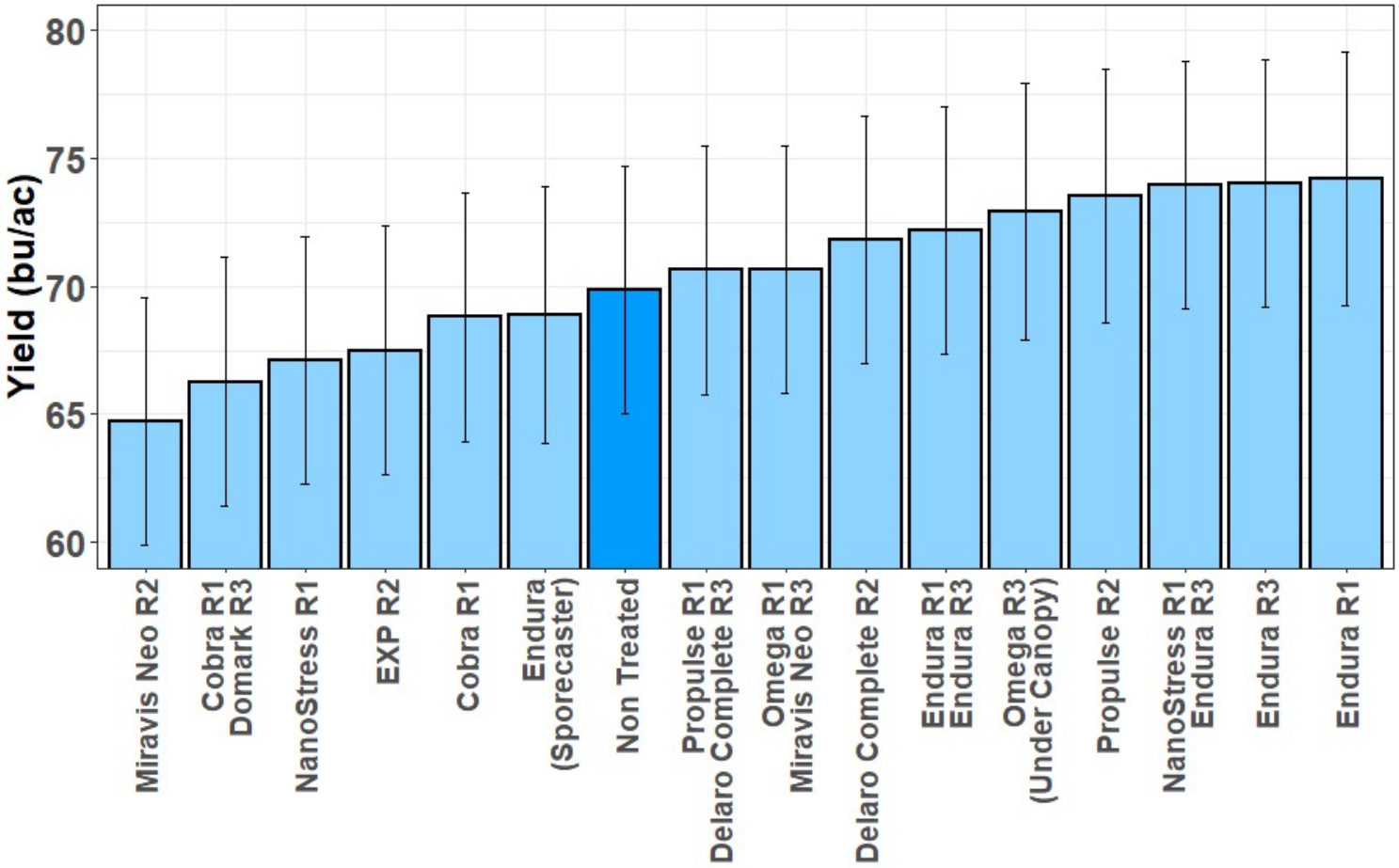
***P* < 0.001**

Predicted White Mold Sclerotial Return



P **< 0.001**

Yield – Site-years with White Mold



2 Site-years

***P* = 0.11**

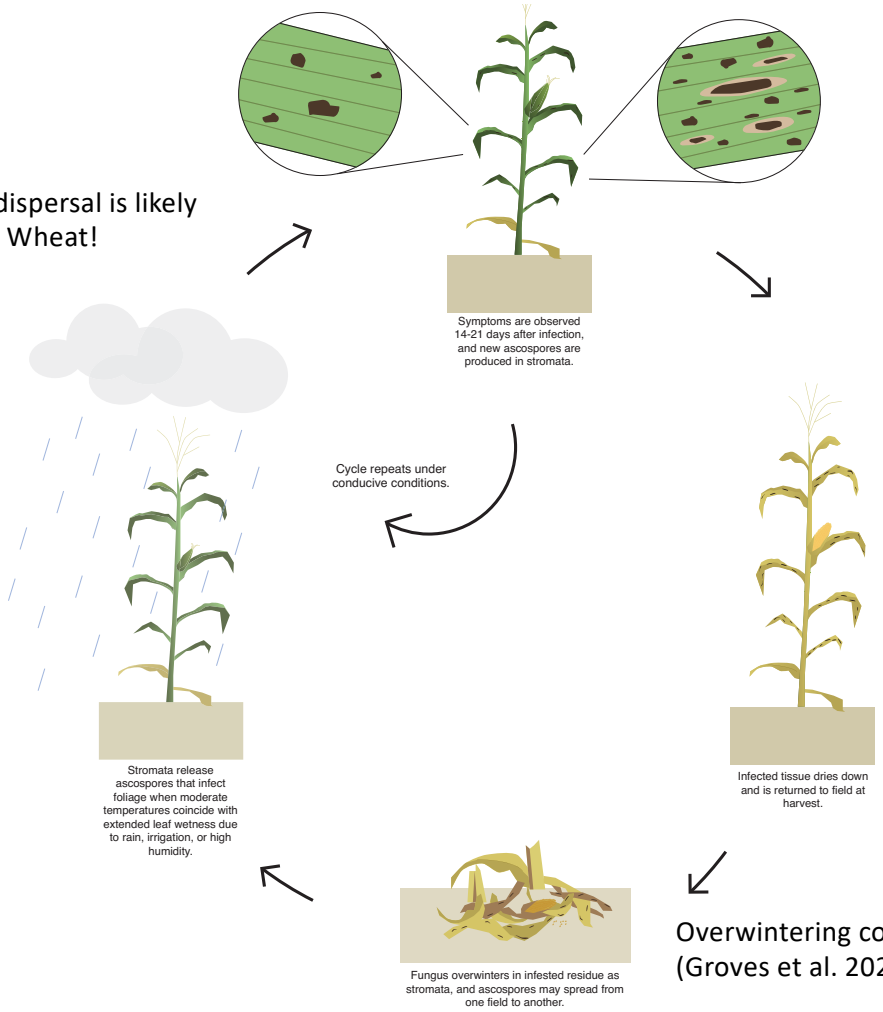
How Are We Integrating Sporecaster into the Management Plan?

*Two site-years in 2020; The Sporecaster application of Endura was performed **ONLY** in Michigan
**Only the treatment main effect was significant at $\alpha = 0.05$

Let’s Take a Look at Sporecaster

Let's Talk Tar Spot!

Long-distance dispersal is likely
– Think FHB on Wheat!



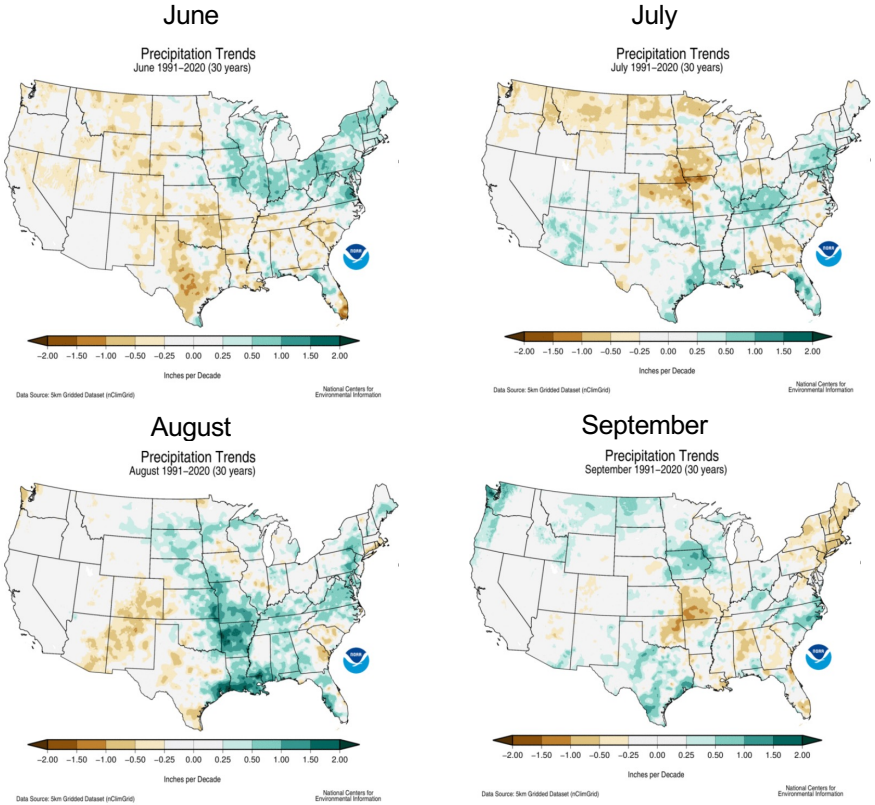
-Moisture and extended periods of leaf wetness are VERY important for the tar spot pathogen

-Temperature is important, but short-lived high temperatures are not lethal

Overwintering confirmed in the Midwest (Groves et al. 2020)

Why Are Diseases Like Tar Spot Emerging in the Upper Midwest?

- Short Rotations
  - -Corn-Corn and Corn-Soybean are not long rotations!
- No-Till Cropping Systems
  - -Good for soil conservation
  - -Downside = Lots of crop surface residue where pathogens can overwinter
- Wetter Seasons
  - -30-year NOAA precipitation trends increasing During Growing season
  - -Especially true for June, August, and September (Drier July adding a stress component?)



What We Know About Weather and Tar Spot

Figure From Mottaleb et al., 2018

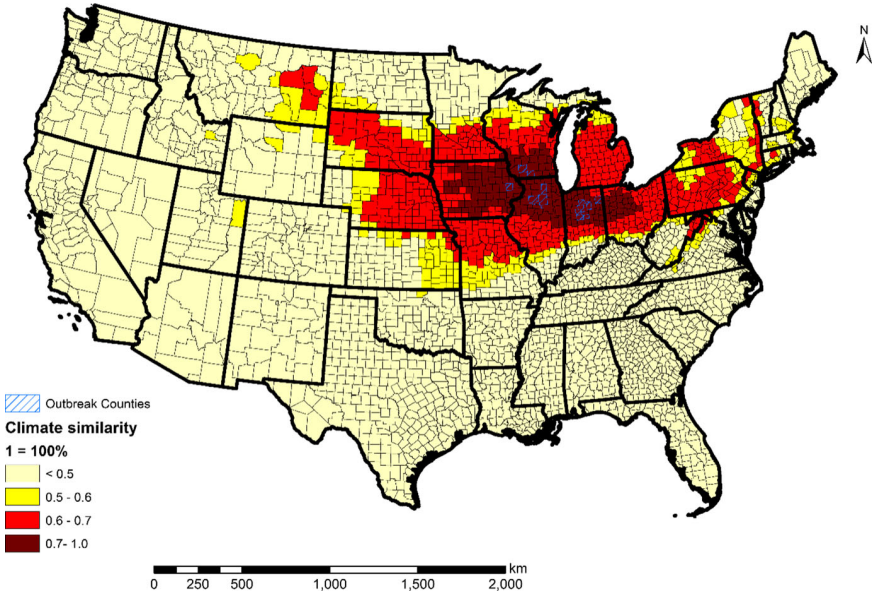


Fig. 4 Maize-producing counties vulnerable to tar spot complex (TSC) calculated based on climate similarity indices using historic climatic data from the counties where TSC has been detected. Source: developed by authors

Hock et al. 1995

- Monthly average temp of 63 F – 72 F
- Average RH greater than 75%
- Average of 7h/night of leaf wetness
- 10-20 foggy days per month
- Monthly rainfall total of at least 5.9 inches

Major Lesson of 2019: Irrigation Drives Tar Spot

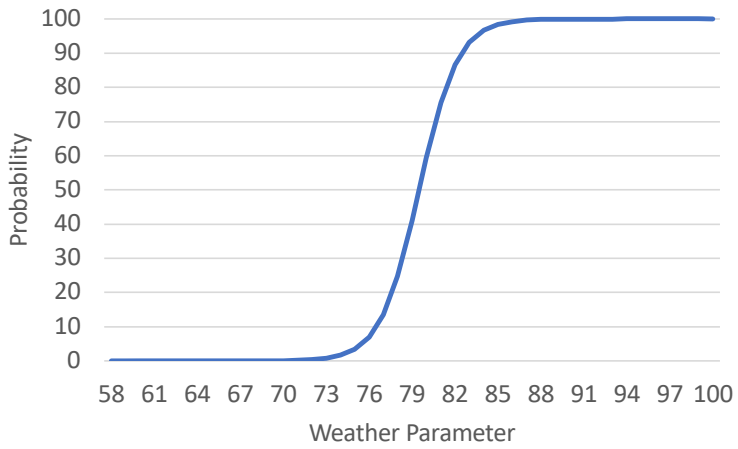
- Image from Michigan Courtesy of Dan Heasley and Martin Chilvers, MSU
- Entire Field Treated with Headline AMP at R1
- Environment may be so favorable that fungicide nearly ineffective.

Image courtesy: Dan Heasley, 2019

Disease Prediction is Key - Tarspotter

- **Development and validation work supported by Wisconsin Corn Promotion Board and National Corn Growers Association**
- Sporecaster set the framework to build on for deploying models for other diseases
- Platform is easy to use and flexible – Uses Logistic regression models (think probabilities!)
- Simply retrain the models using the biologically appropriate weather variables and moving averages
- Validate, retrain, validate – this is an iterative process (Machine Learning)

2021 Model – Version 3.0

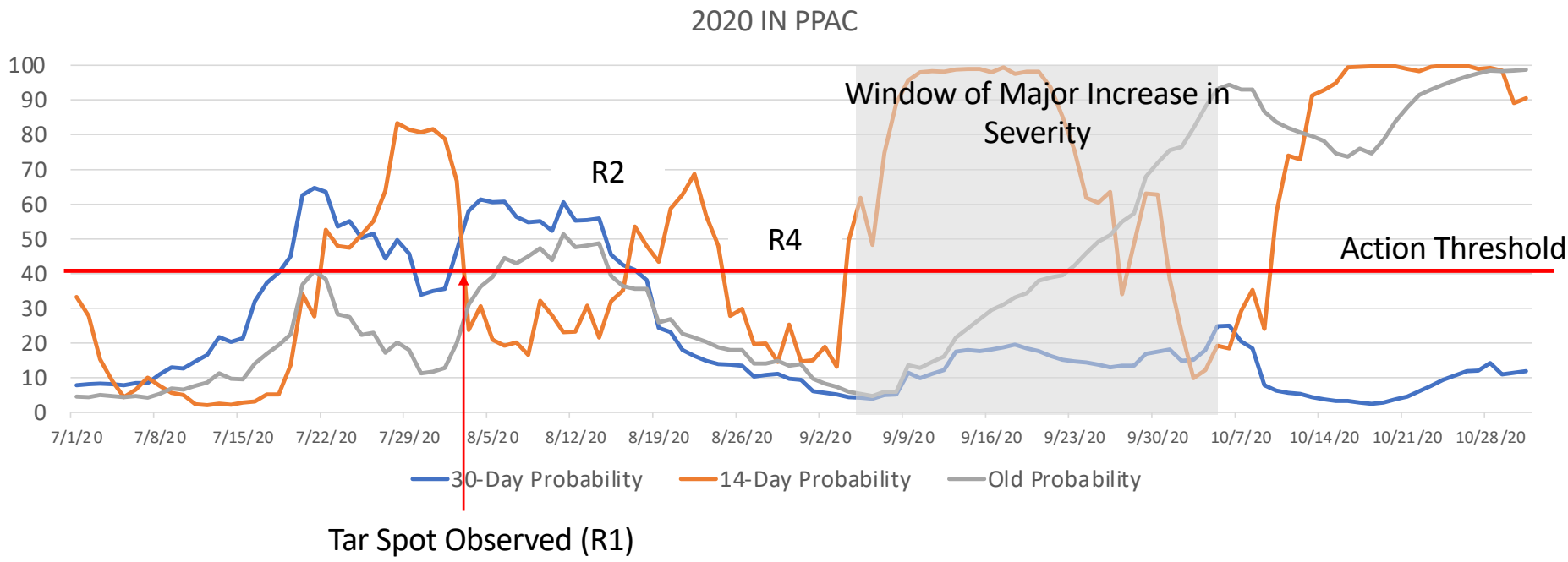


- Intercept model
- 14-day moving average of **Mean Temperature**
- 14-day moving average of **Min Relative Humidity**
- 14-day moving average of **Min Dew Point**
- 14-day **Total Rainfall**

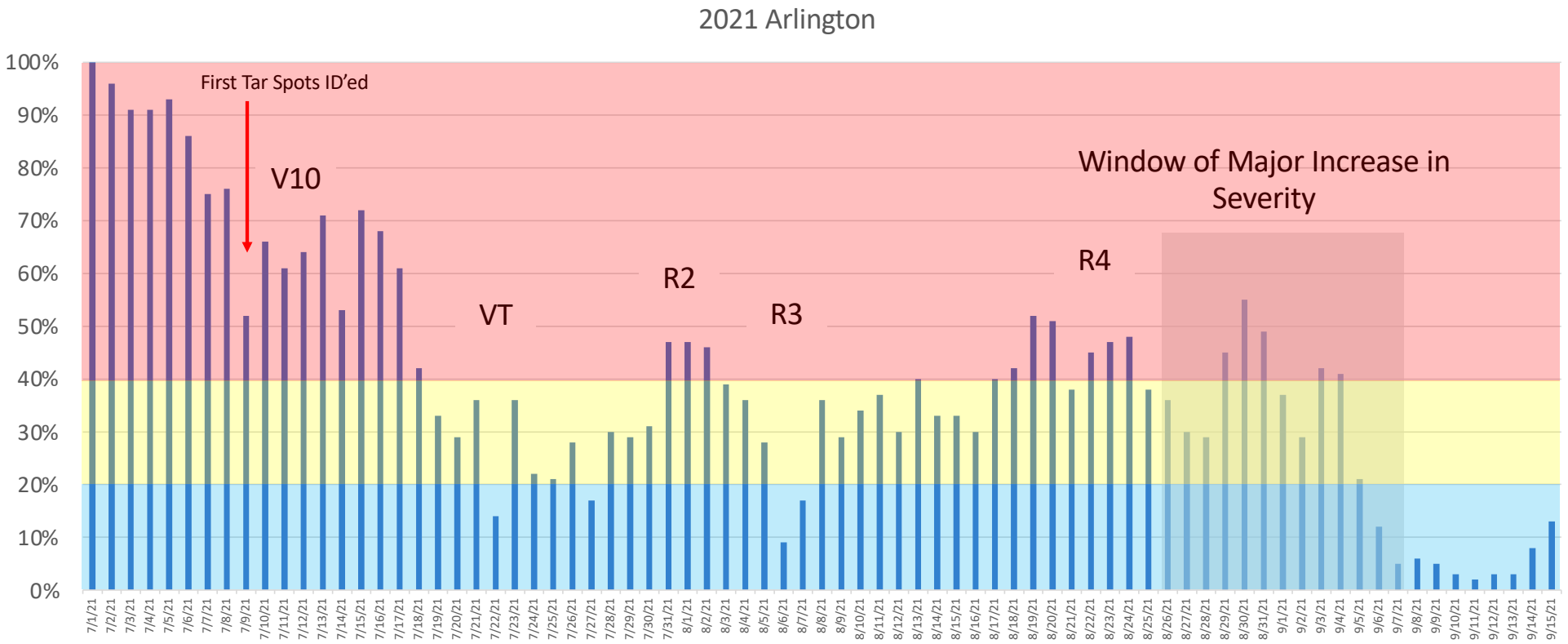
*All weather is gridded, GPS-referenced, cloud-based weather

Association of Predicted Probabilities and Observed Responses			
Percent Concordant	90.2	**Somers' D**	0.823
Percent Discordant	8.0	**Gamma**	0.838
Percent Tied	1.8	**Tau-a**	0.394
Pairs	31317	**c**	0.911

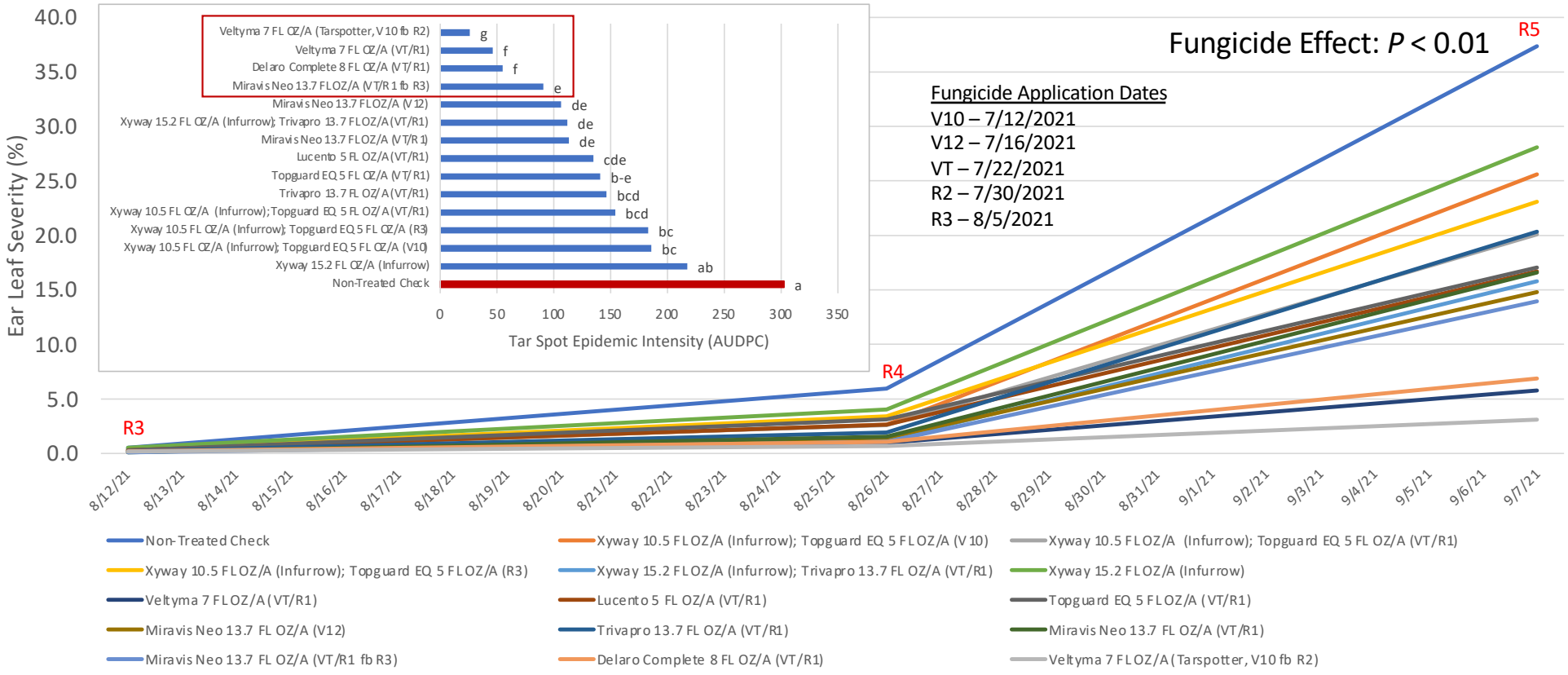
2020 Validation of Models Indiana - High Disease Location



Arlington 2021 Tarspotter Probabilities



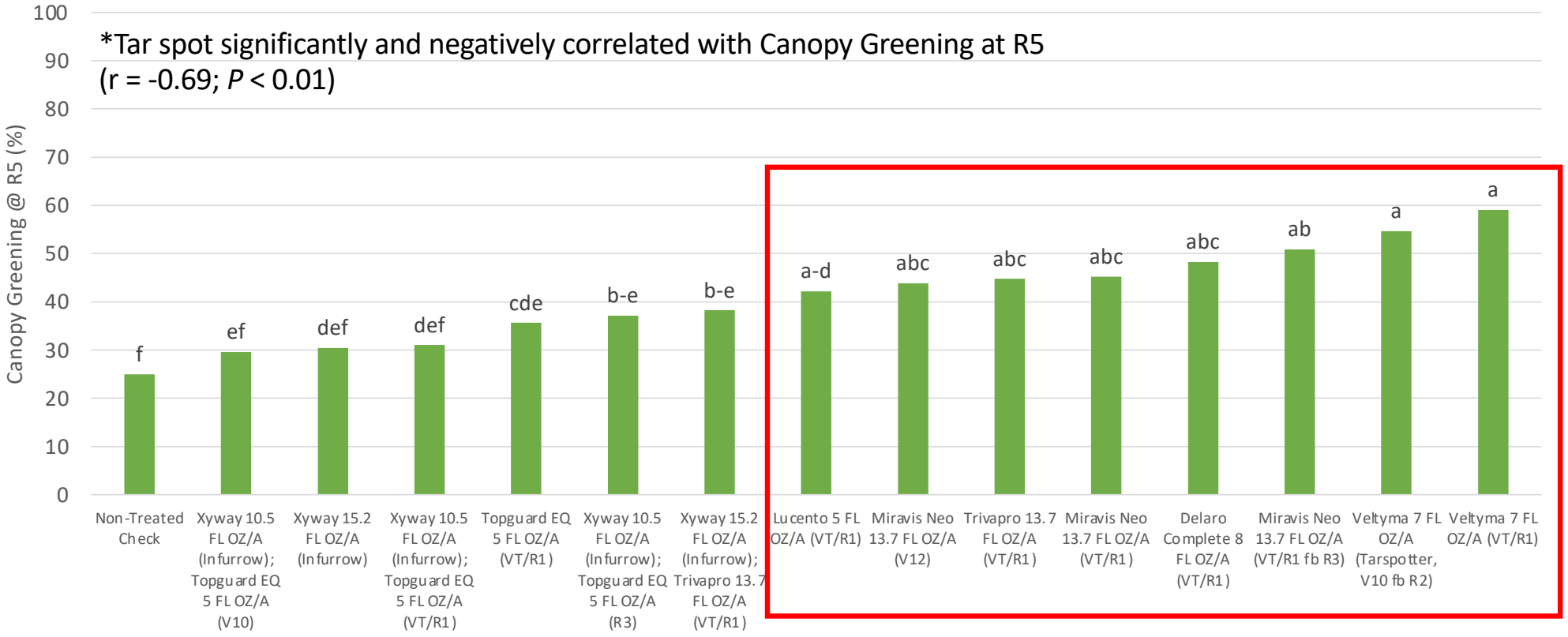
2021 Wisconsin Corn Fungicide 'Rodeo'



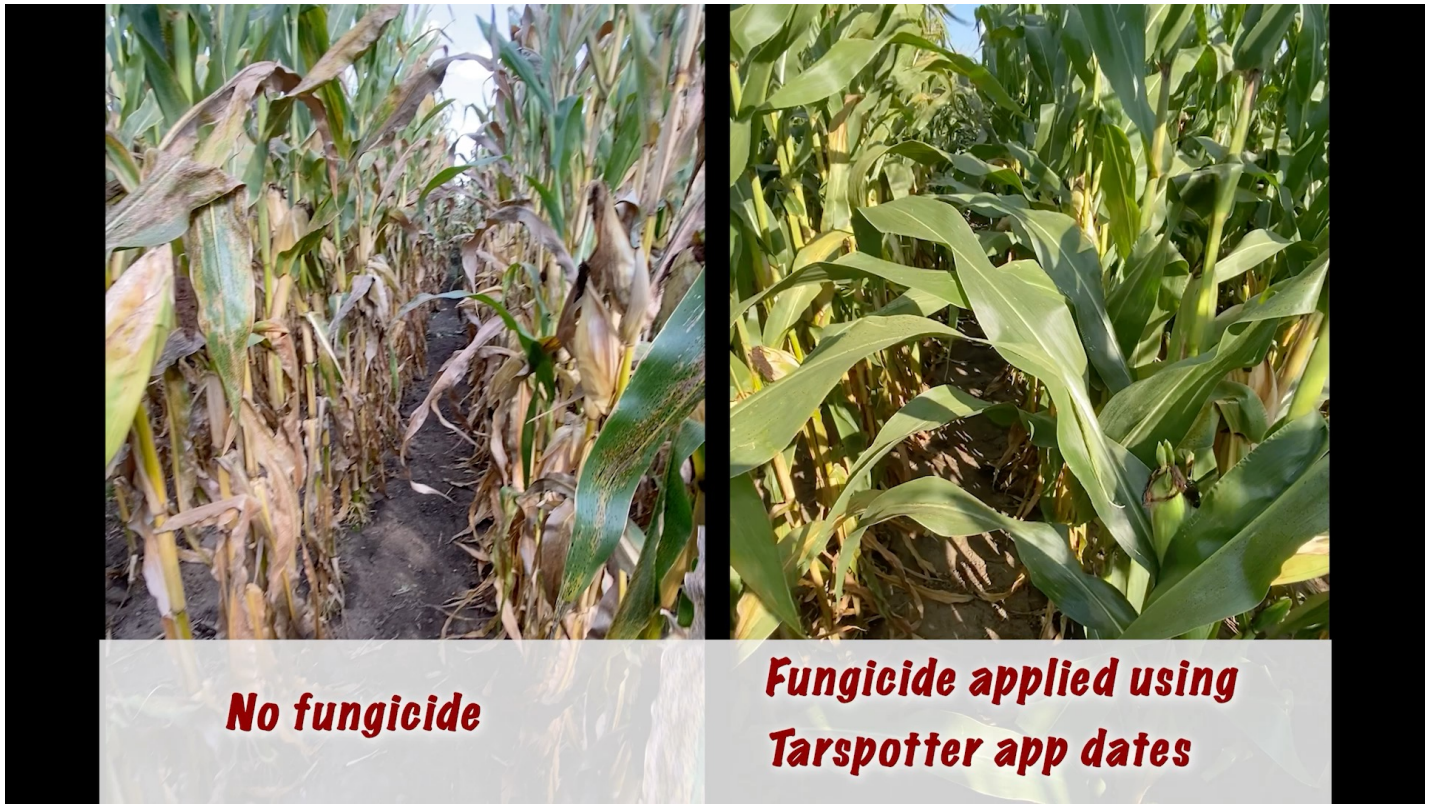
2021 Wisconsin Fungicide 'Rodeo'

Canopy Greening Score

Fungicide Effect: $P < 0.01$



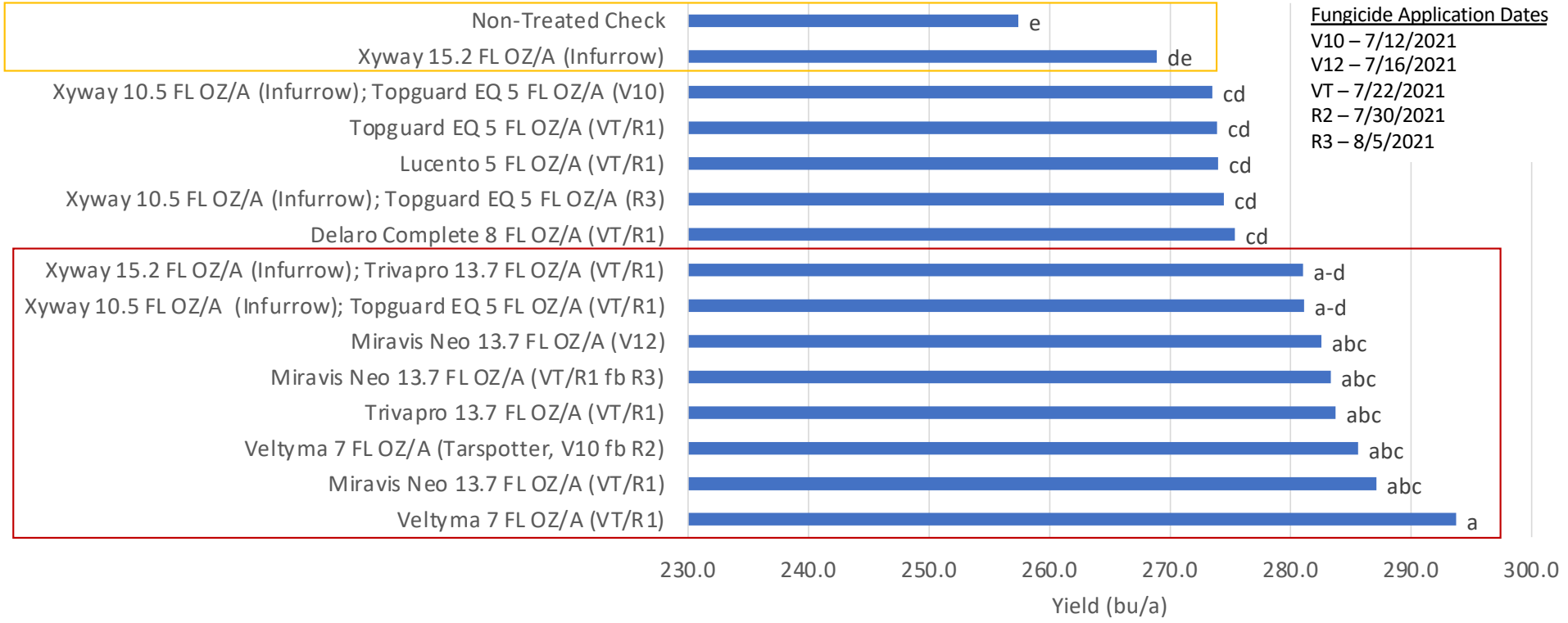
Tarspotter Sprays vs. Not Treating



R5 Growth Stage – September 7, 2021

2021 Wisconsin Corn Fungicide 'Rodeo'

Fungicide Effect: $P < 0.01$



*Test Weights all between 58 and 59 lbs/bu

Let’s Look At Field Prophet

Field Prophet

fieldprophet.com

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Thank You!

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