CocciWatch: Understanding temporal and spatial drivers of *Coccidioides* exposure risk

Impact and Control of Valley Fever
NASEM
November 2022

Dr. Dave Engelthaler
Professor, Director
tgen® NORTH
AN AFFILIATE OF City of Hope.

Coccidioides exposure risk is complicated

- Severe weather events, climate, and human factors are thought to influence abundance of arthroconidia within air and drive valley fever cases.

- Great epidemiological investigations examples.
  - Northridge earthquake (1994)
  - Tempest from Tehachapi (1977)
  - Highway construction outbreaks

Stochasticity of *Coccidioides* soil introduction

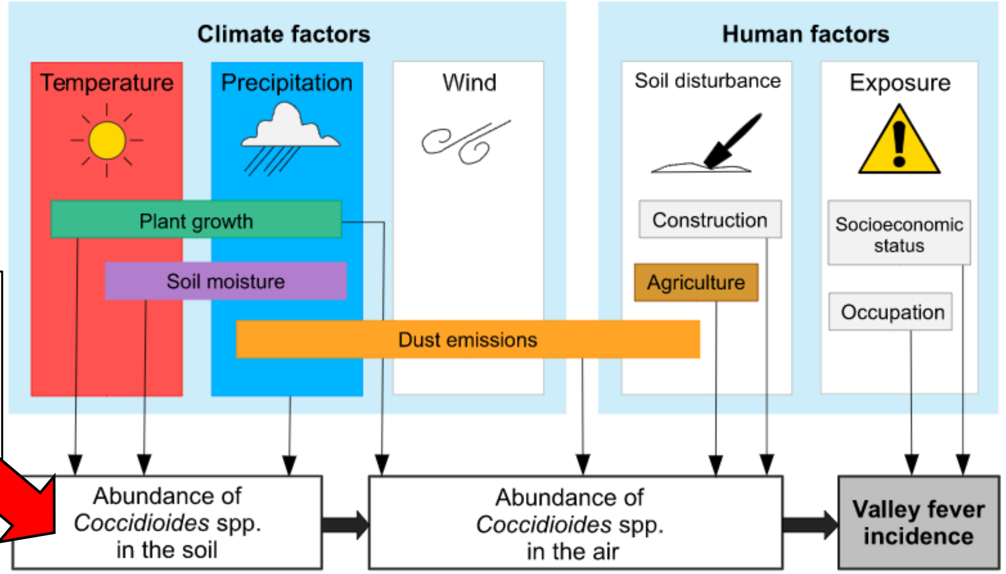

Figure 1. Climate, environmental, and human factors may modulate the abundance of *Coccidioides* spp. in the soil and air and therefore influence the temporal and spatial patterns of valley fever incidence.

(Gorris et al. 2018)

Wind and Dust Storms

Refer to: Pappagianis D, Einstein H: Tempest from Tehachapi takes toll or Coccidioides conveyed aloft and afar (Medical Information). West J Med 129:527-530, Dec 1978

Medical Information

Tempest From Tehachapi Takes Toll or Coccidioides Conveyed Aloft and Afar

DEMOSTHENES PAPPAGIANIS, MD, PhD, *Davis, California, and*
HANS EINSTEIN, MD, *Los Angeles*

New cases of acute primary coccidioidomycosis in large numbers resulted from a windstorm that blew through Kern County, California, on December 20, 1977. In most of these cases clinically apparent infections developed in early and mid-January 1978 and occurred not only in persons exposed directly to

The NEW ENGLAND JOURNAL of MEDICINE

MEDICAL INTELLIGENCE ARCHIVE

An Unusual Outbreak of Windborne Cocc

Neil M. Flynn, M.D., Paul D. Hoeprich, M.D., Mildred M. Kawachi, M.D., Kenneth K. Lee, M.D., Ruth M. Lawrenc
Ronald S. Kundargi, M.B., B.S., and Gordon A. Wong, M.D

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NEWS | 01 August 2022

Dust-up over dust storm link to 'Valley Fever' disease

Researchers are divided over whether rising cases of the fungal infection in the United States can be linked to dust storms.

GeoHealth

COMMENTARY
10.1029/2022GH000642

Dust Storms, Valley Fever, and Public Awareness

Daniel Q. Tong[1], Morgan E. Gorris[2], Thomas E. Gill[3], Karin Ardon-Dryer[4], Julian Wang[1], and Ling Ren[1]

[1]Department of Atmospheric, Oceanic and Earth Sciences, Center for Spatial Information Science and Systems,

Key Points:

- Contradicting common perception, the Storm Events Data are from diverse

GeoHealth

RESEARCH ARTICLE
10.1029/2021GH000504

No Consistent Link Between Dust Storms and Valley Fever (Coccidioidomycosis)

Andrew C. Comrie[1]

[1]University of Arizona, Tucson, AZ, USA

Key Points:

- It is often asserted that large dust storms like haboobs generally lead to increases in cases of Valley fever

AGU PUBLICATIONS

Geophysical Research Letters

RESEARCH LETTER
10.1002/2017GL073524

Intensified dust storm activity and Valley fever infection in the southwestern United States

Daniel Q. Tong[1,2,3], Julian X. L. Wang[2], Thomas E. Gill[4], Hang Lei[1,2], and Binyu Wang[1]

Key Points:

- The frequency of locally originated

Goal: use a multidisciplinary approach to understand and predict relative exposure risk in the Phoenix area across time and space

What do we need to do this?

- Real-time ongoing surveillance (air filters)
- Weather data
- Model to predict risk
- Understanding of what the “risk” means from a public health perspective.

Current datasets:

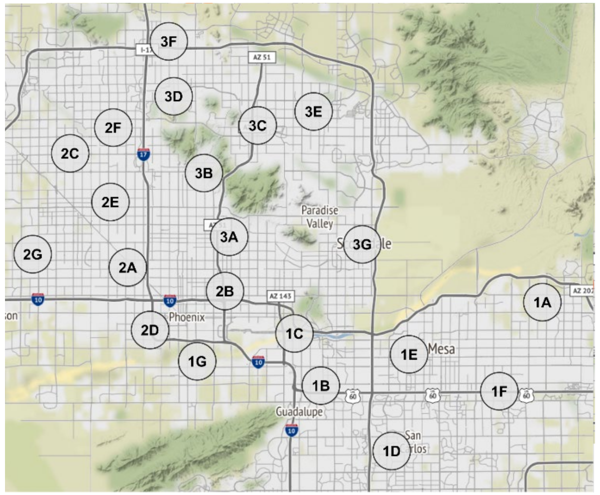
- Reported cases (ADHS)
- Air filters from Phoenix area (ADHS, DHS)
- Processed air filters (TGen, CDC)
- Weather data (TGen, NOAA)

Additional datasets to include:

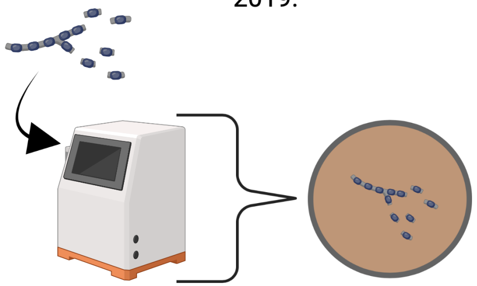
- Clinical testing data (positive/negative tests)
- Valley fever cases in dogs
- Veterinarian testing data

CocciWatch – The System

1.



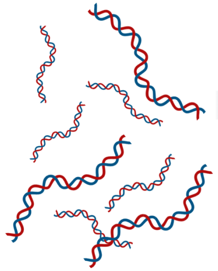
Daily air filter collections from across 21 sites in Phoenix, AZ collected between 2018 and 2019.



*Filters are split between TGen and CDC

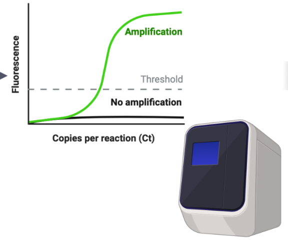
2.

DNA Extraction of air filters.

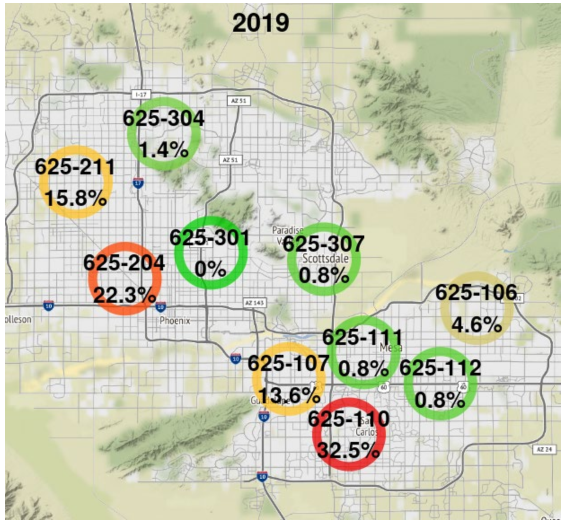


3.

Real-time PCR for presence absence detection of *Coccidioides.*



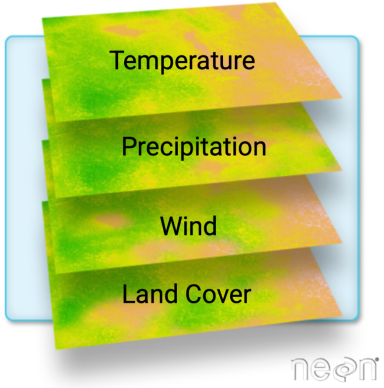
4.



Characterize prevalence across space and time at the study sites.

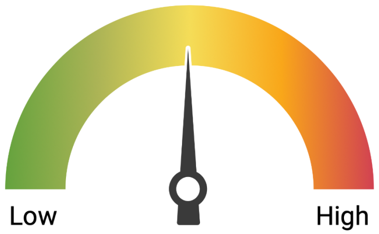
5.

Environmental correlation and modeling to identify drivers of *Coccidioides* presence.



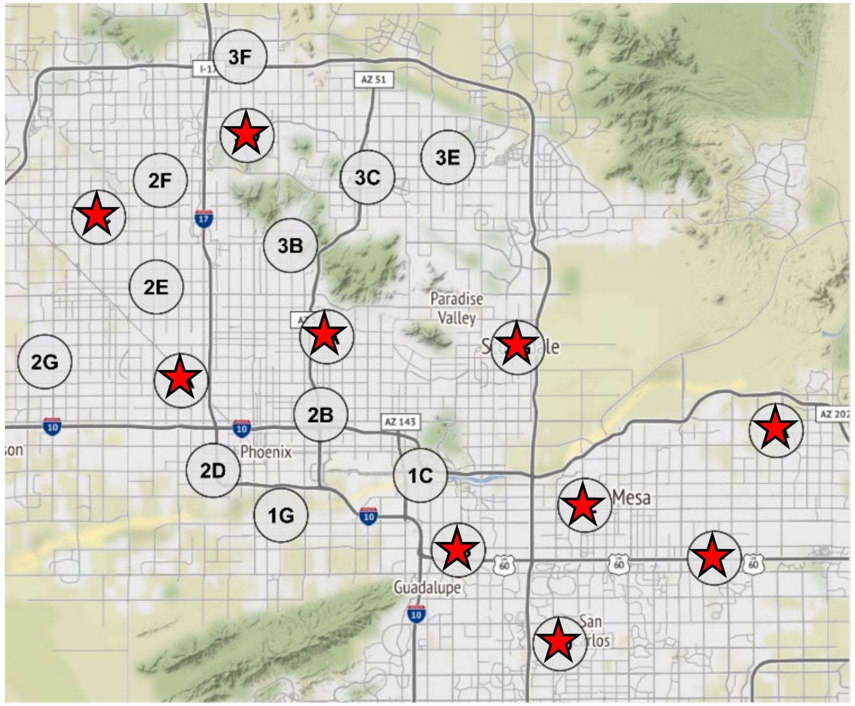
6.

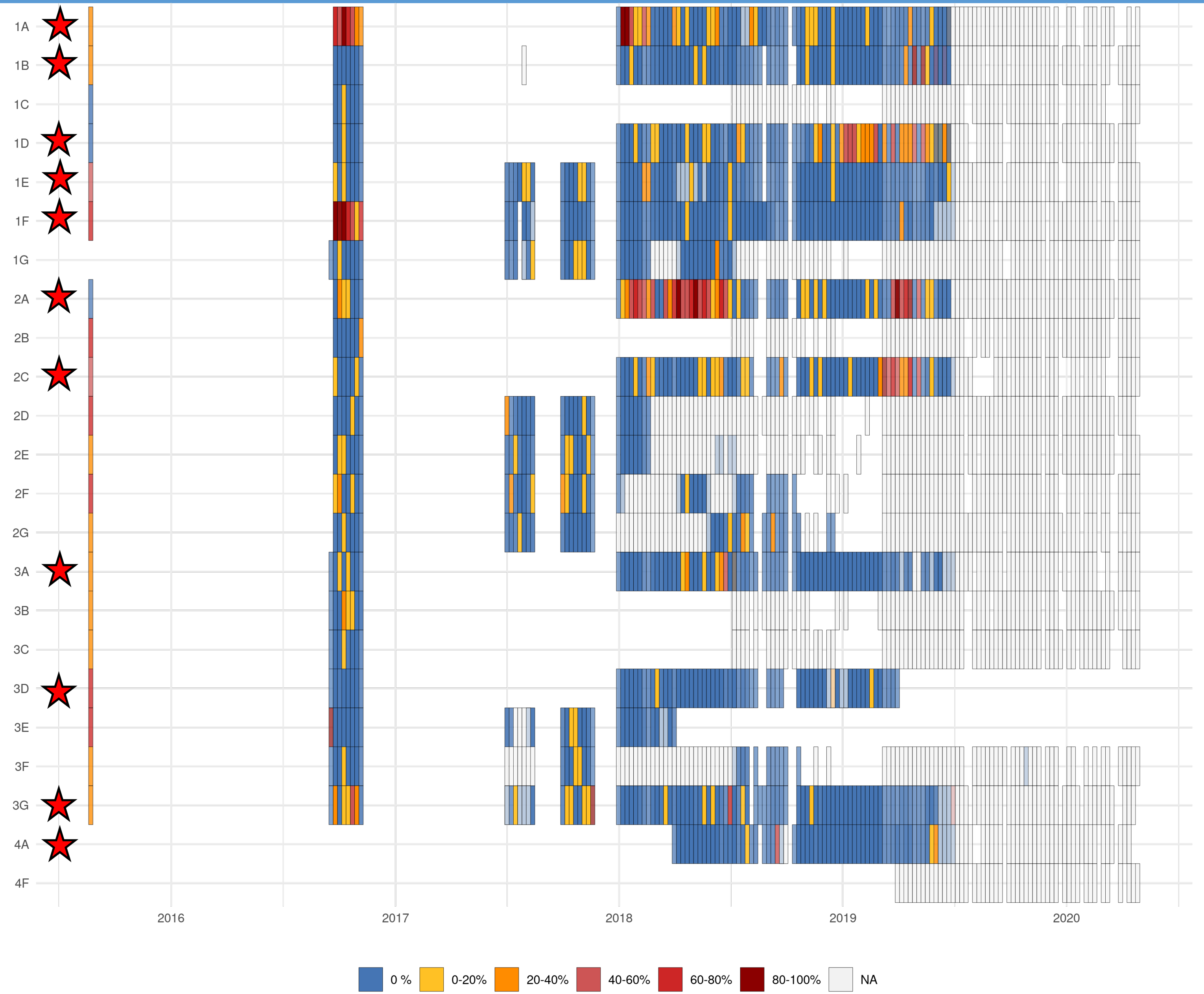
Using a spatial temporal model and weather predictions we plan to produce a Valley Fever Risk Index.



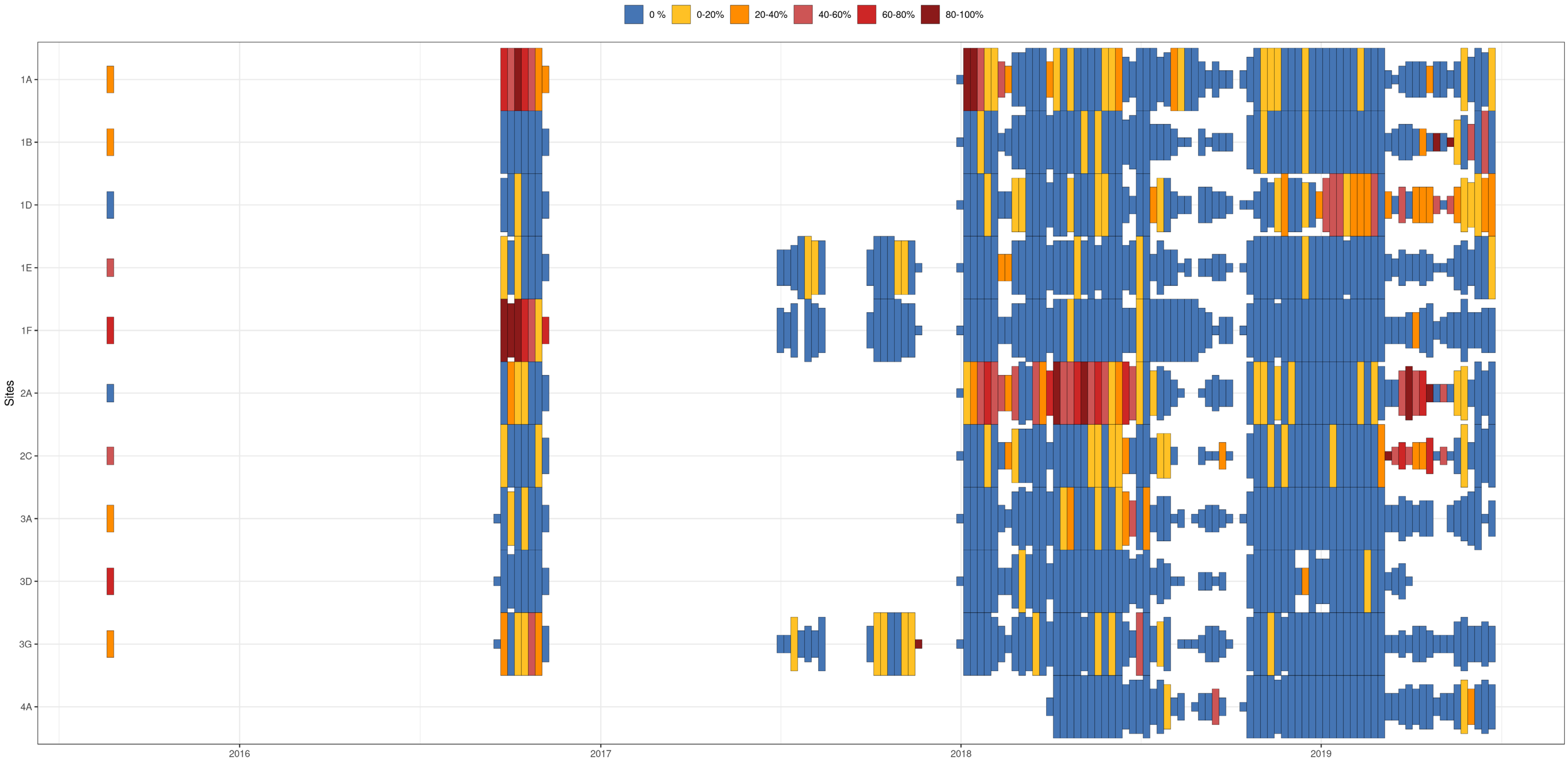
CocciWatch

- Filter collections from 23 sites (n = ~10K).
- Processing has focused on 11 of 23 sites, up to July 2019 (n = 5,055).





CocciWatch- Current Data



CocciWatch- Current Data

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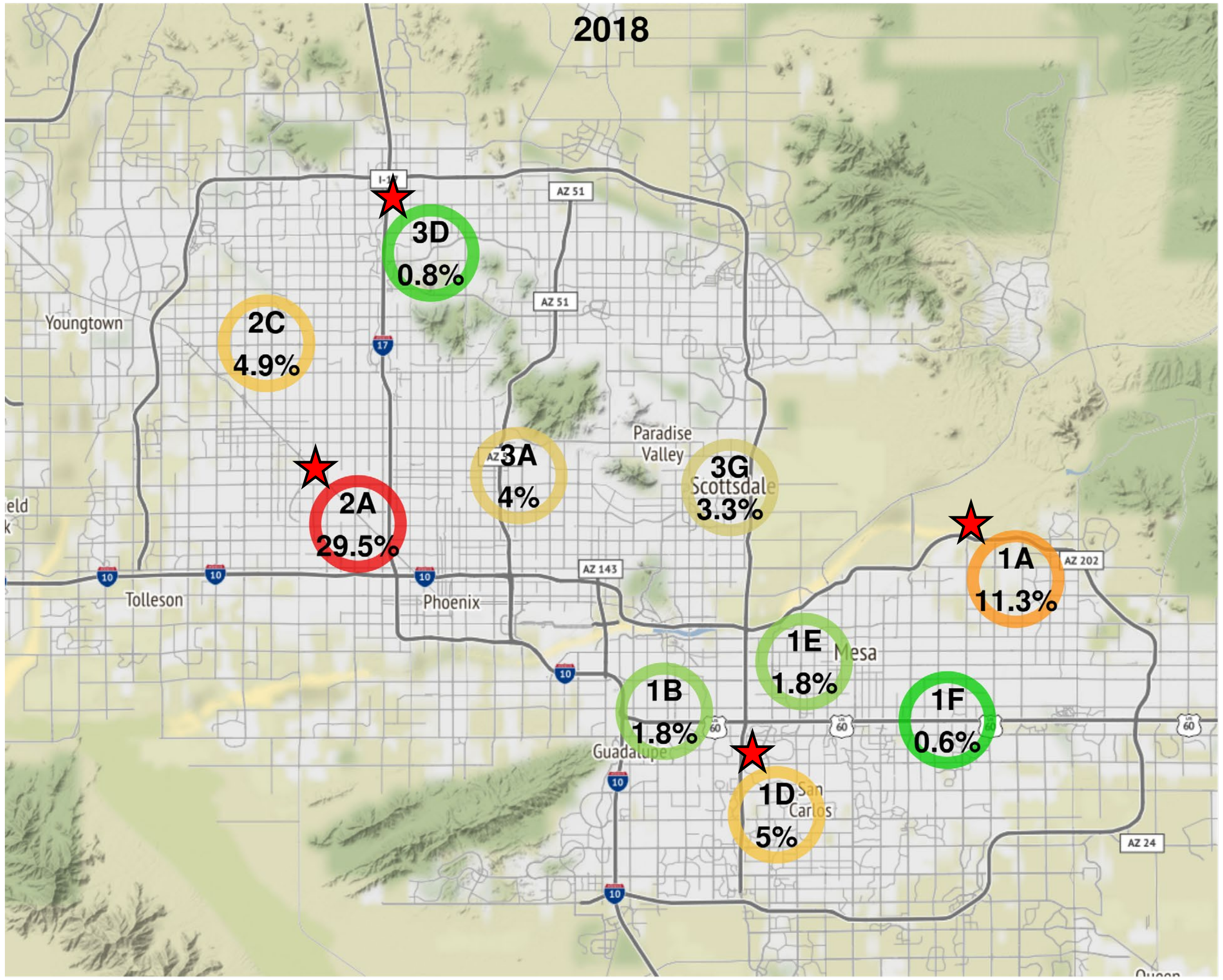
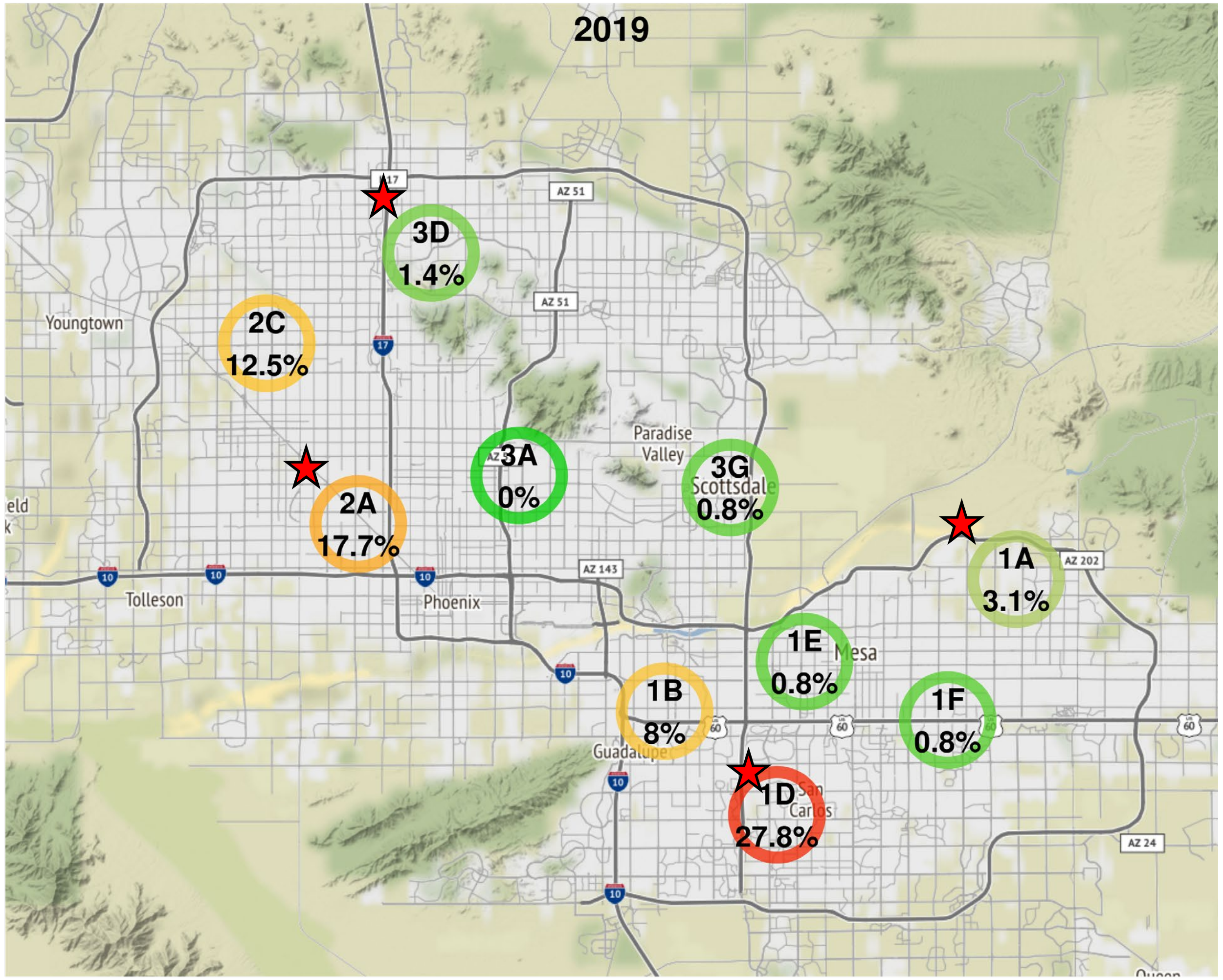
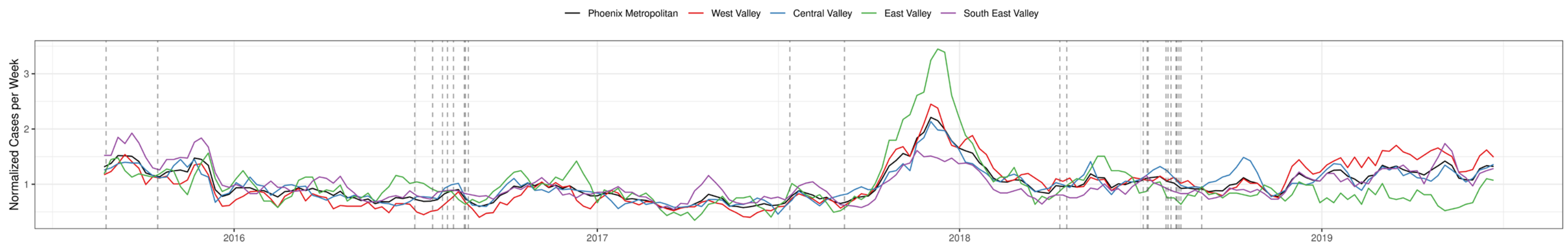




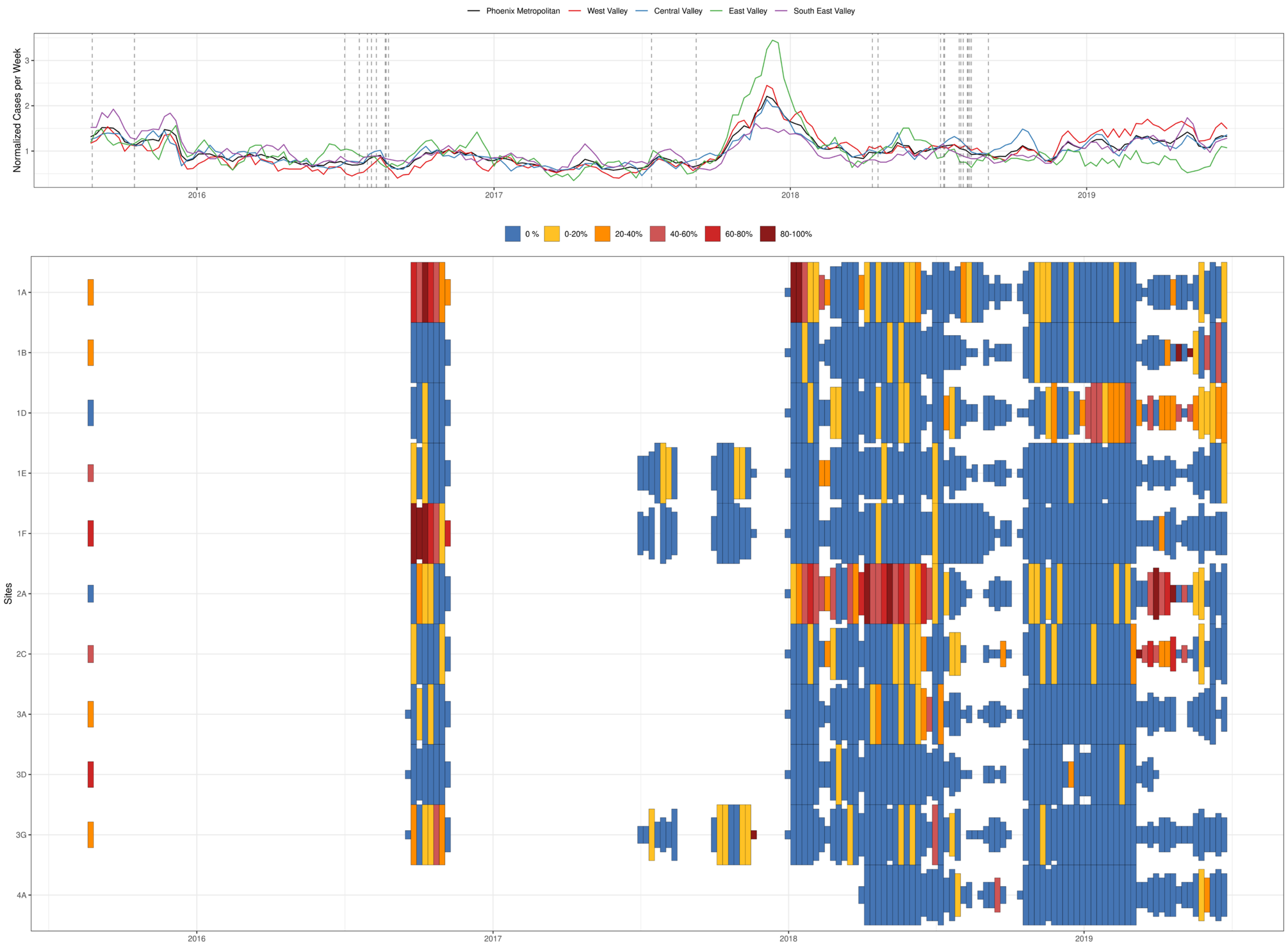
CocciWatch - How does air surveillance relate to dust storms?

- Dust storm data were downloaded from National Oceanic & Atmospheric Administration Storm Event's Database (vertical dotted lines on case panel).
- Days with reported dust storms had a 5% prevalence (13/260) while days without reported dust storms had 7% prevalence (358/4,948).
- No statistical difference in prevalence observed between days with reported dust storms and days without (p=0.21).
- Challenges:
    - Opportunistic filter sampling
    - Dust storm collection databases



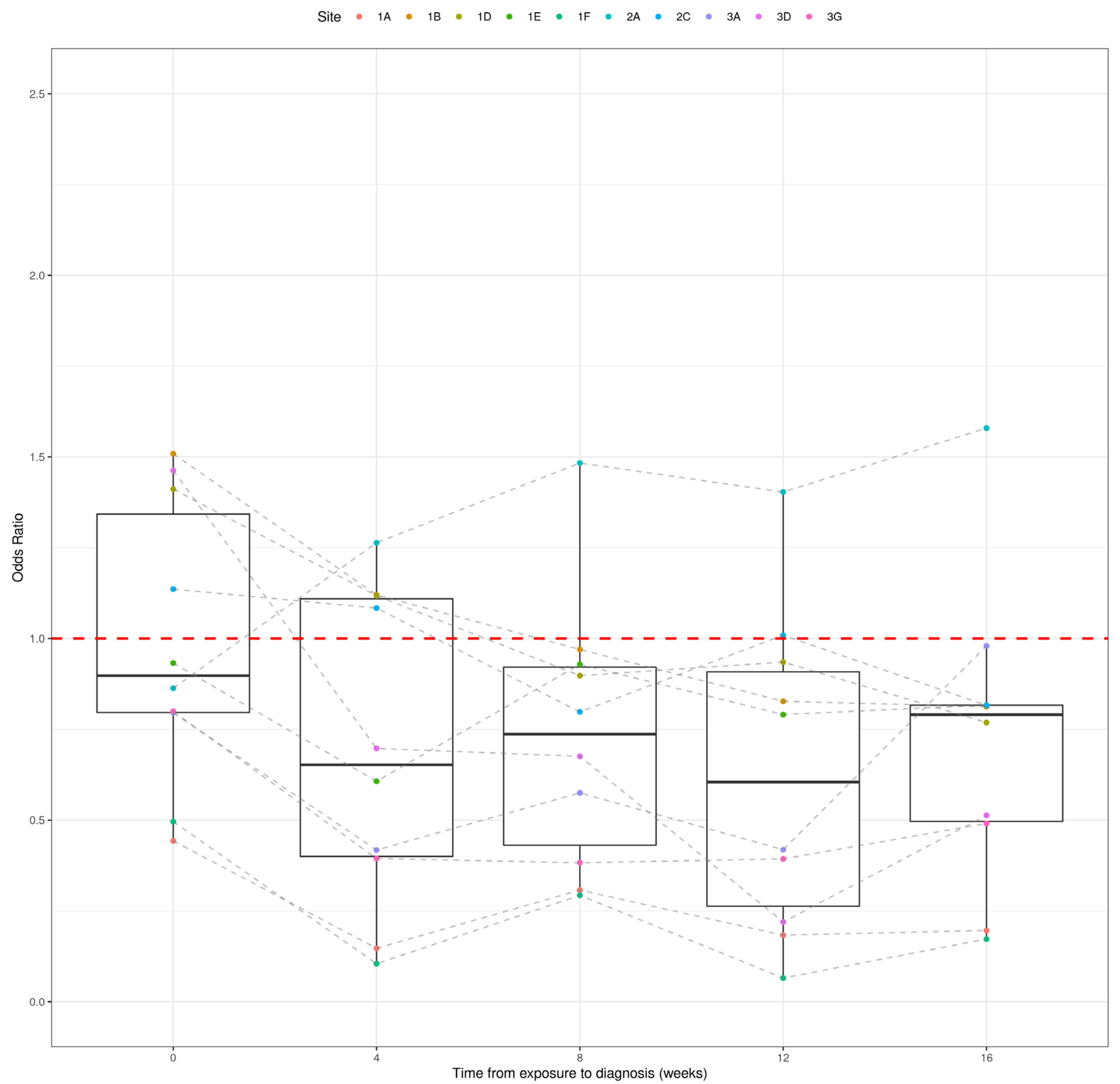
CocciWatch - How does air surveillance relate to clinical cases?

- No obvious seasonality across study period or relationship to filter prevalence.
- Previously documented increase in cases in late 2017.
- Further statistical analyses needed for statistical correlation analyses.
    - Binomial mixed effects models



CocciWatch - How does air surveillance relate to cases?

- Binomial mixed effects model was used to investigate association of *Coccidioides* presence/absence and clinical cases.
- *Coccidioides* presence/absence data was compared to valley fever case averages for the greater Phoenix area across 5 incubation periods (0, 4, 8, 12, 16 weeks).
- Hypothesized that *Coccidioides* presence/absence data would be positively associated with clinical cases at 12 and 16 weeks.
- Results suggest negative relationship at majority of sites across all lead periods (exception being Site 2A which had a strong positive association).
- Challenges:
    - Case reporting (under reporting, spatial resolution)
    - Local population movement

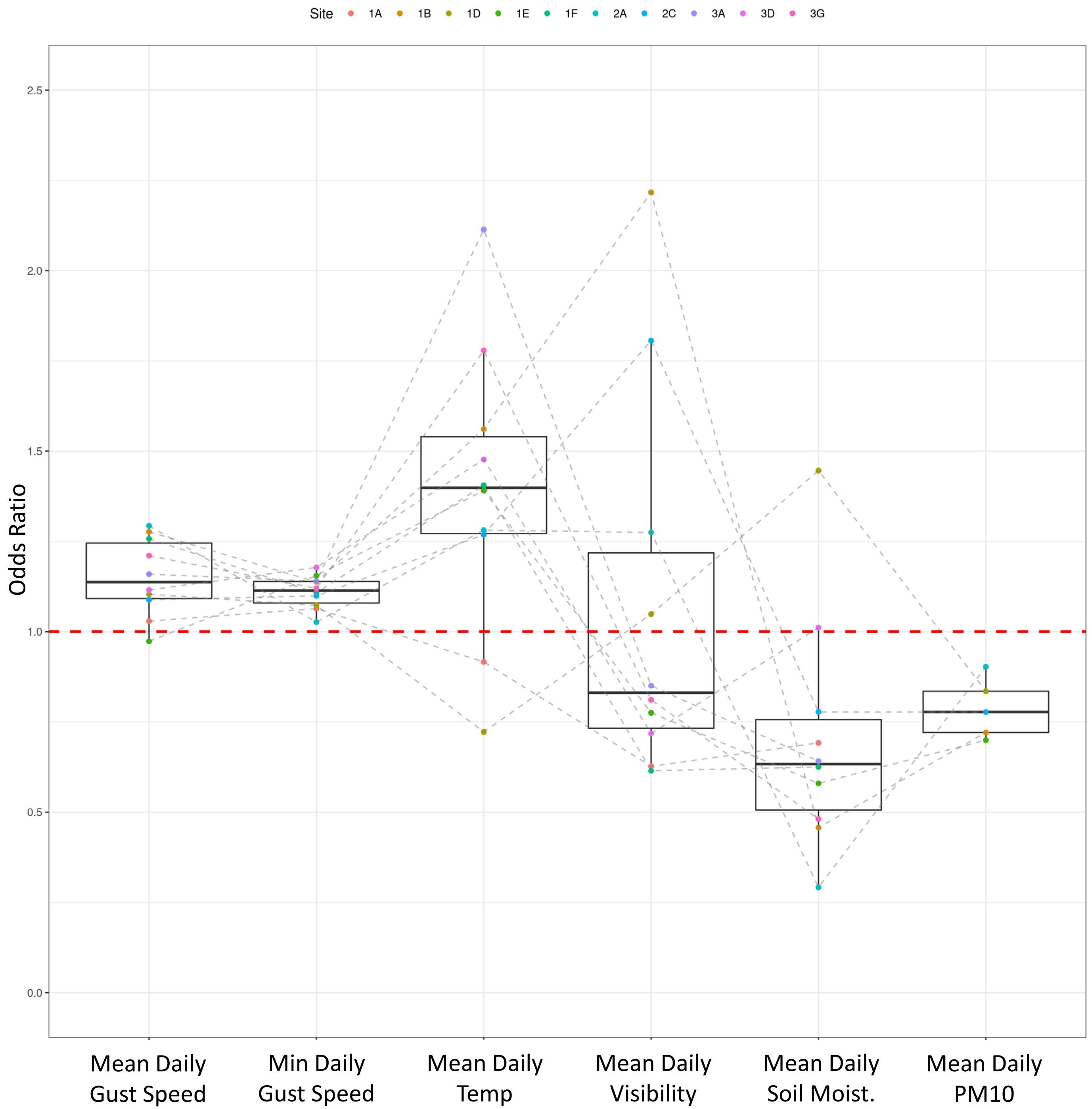


CocciWatch- How does air surveillance relate to daily weather*?

Results

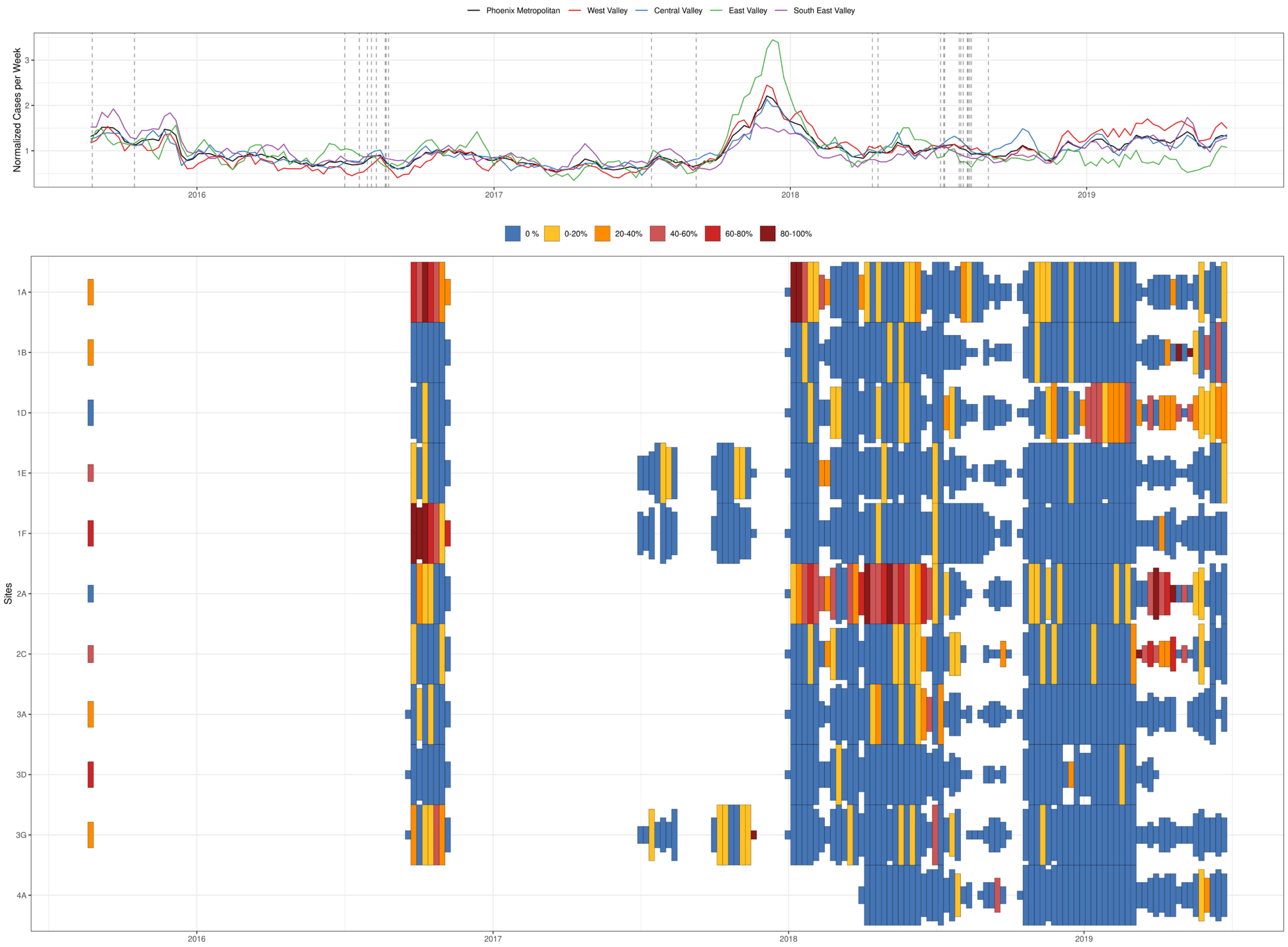
- **Wind speeds** were positively (OR > 1) correlated with *Coccidioides* prevalence
- **Temperature** was generally positively (OR > 1) correlated with *Coccidioides* prevalence.
- **Soil moisture** was negatively (OR < 1) correlated with *Coccidioides* prevalence.
- **Visibility** was not correlated with *Coccidioides* prevalence.
- **PM10 levels** were negatively (OR < 1) correlated with *Coccidioides* prevalence.

*NOAA's High Resolution Rapid Refresh



CocciWatch - Surveillance conclusions

- **High variance in prevalence across space and time suggesting that risk is spatially and temporally variable.**
  - Supported by ecology- *Coccidioides* must be introduced into the soil and then aerosolized.
  - Several environmental factors have associations with *Coccidioides air* presence.
- **Local drivers influence site prevalence.**
  - Specific weather patterns?
  - Soil disturbance?
  - Land cover around sites?

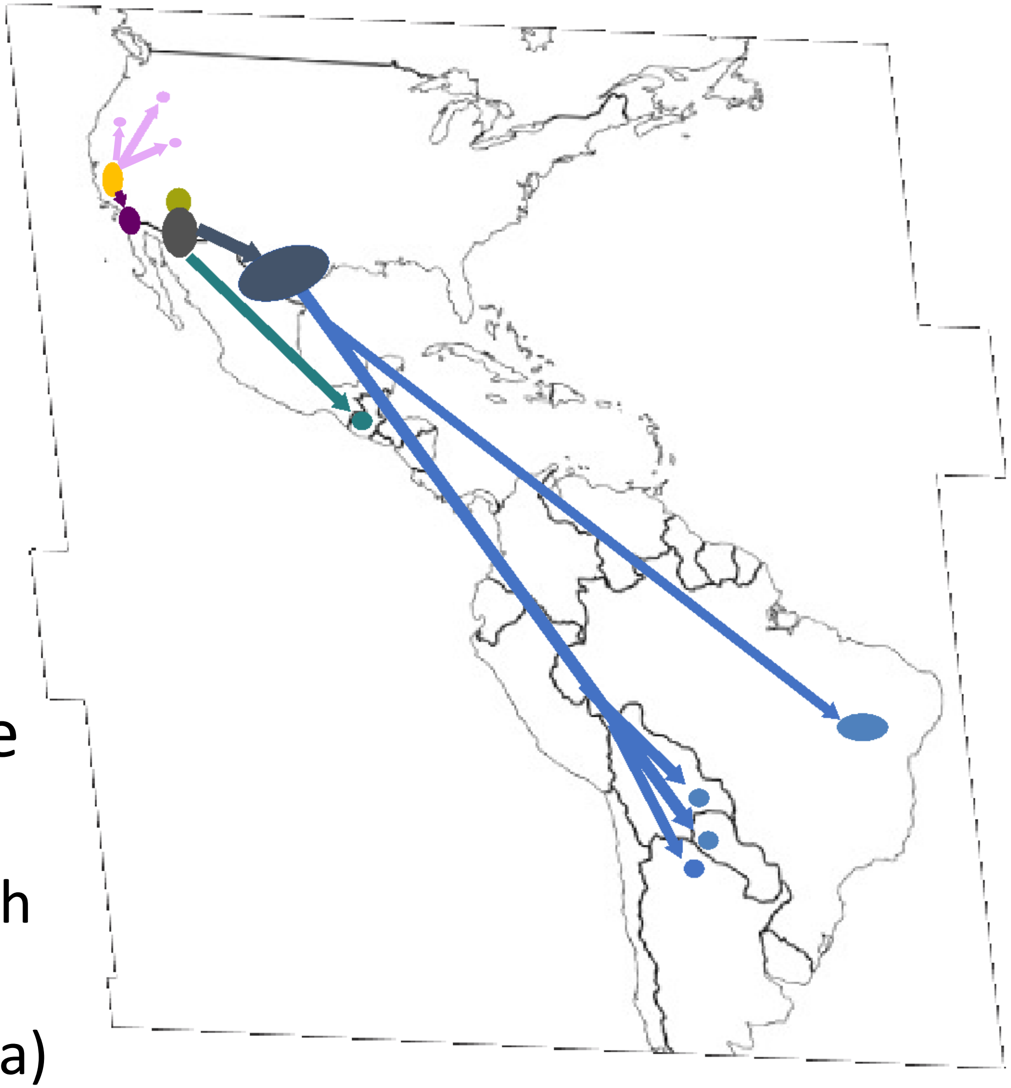


What Drives Dispersal?

- Wind?
- Haboobs?
- Natural disasters?
- Climate change?
- Animals?
- Humans?

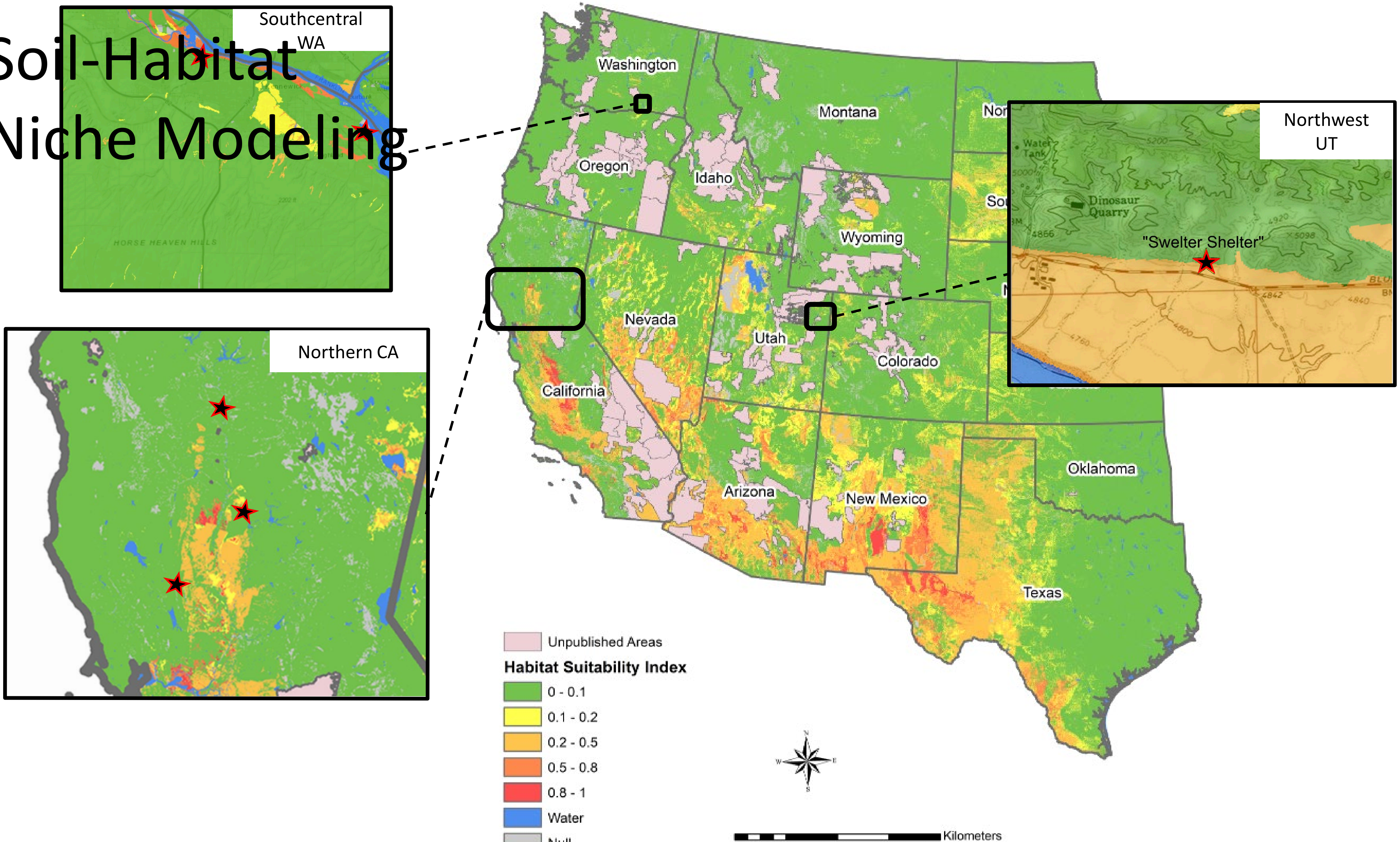
A Couple Thoughts on Cocci Dispersal

- Wind clearly moves cocci in the air
  - Can result in dispersed cases, but maybe not dispersed ecology
  - Distinct phylogeography belies continual wind driven dispersal
- Climate change can make conditions more favorable for growth and transmission
  - But cannot disperse the pathogen
- Humans and animals are the likely long range dispersal vectors
  - Animals have dispersed Cocci southward to South and Central America (>100kya)
  - Humans likely dispersed Cocci northward (<10kya)



Engelthaler et al, mBio, 2016

Soil-Habitat Niche Modeling



(Dobos, et al, 2021)

The CocciWatch Collaboration

This work would not have been possible without the contributions from many institutions and individuals!

- **TGen**
  - Tanner Porter
  - Jolene Bowers
  - Parker Montfort
  - Dave Engelthaler
- **CDC**
  - Anastasia Litvintseva
  - Lalitha Gade
  - Nancy Chow
  - Malavika Rajeev
  - Tom Chiller
- **ADHS**
  - Ken Komatsu
  - Shane Brady
  - Guillermo Adame
- **Johns Hopkins Unv.**
  - Arturo Casadeval
- **Department of Homeland Security**
  - Andrew Willman
- **National Oceanic and Atmosph. Admin**
  - Dr. Brian Klimowski
- **Northern Arizona University**
  - Dr. Joseph Mihaljevic
- **The University of Arizona**
  - Dr. Bonnie LaFleur

Funding: NIH NIAID, ABRC

"Valley Fever"
R. Dillon, 2008