Valley Fever Public Health Decision Support System Based on Climate and Environmental Changes

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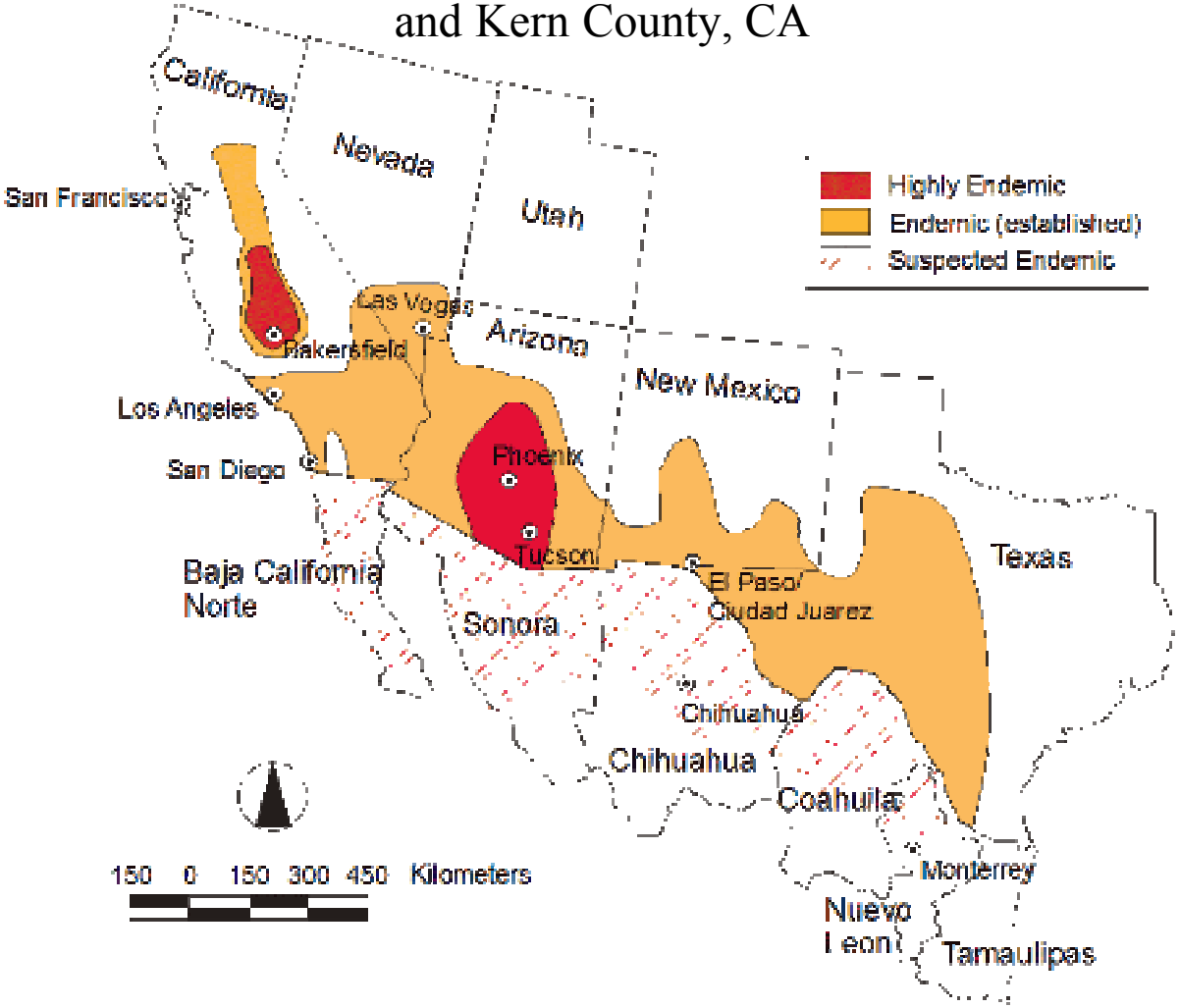
Cocci Background

- Valley fever (coccidioidomycosis) caused by soil-dwelling fungi, *Coccidioides immitis & Coccidioides posadasii*
  - Fungus responds to changes in climate conditions
- When fungal spores become airborne and are inhaled, infection may occur
  - Flu-like symptoms (fever, cough, etc.) in early stages
  - May disseminate from lungs to other parts of body
- Range of cases
  - Asymptomatic/Inapparent - 60%
  - Mild to Moderate - 30%
  - Complications - 5% to 10%
  - Fatal - less than 1%
- Greater regional mortality/morbidity than Hanta or West Nile viruses

Valley Fever Endemic Zone

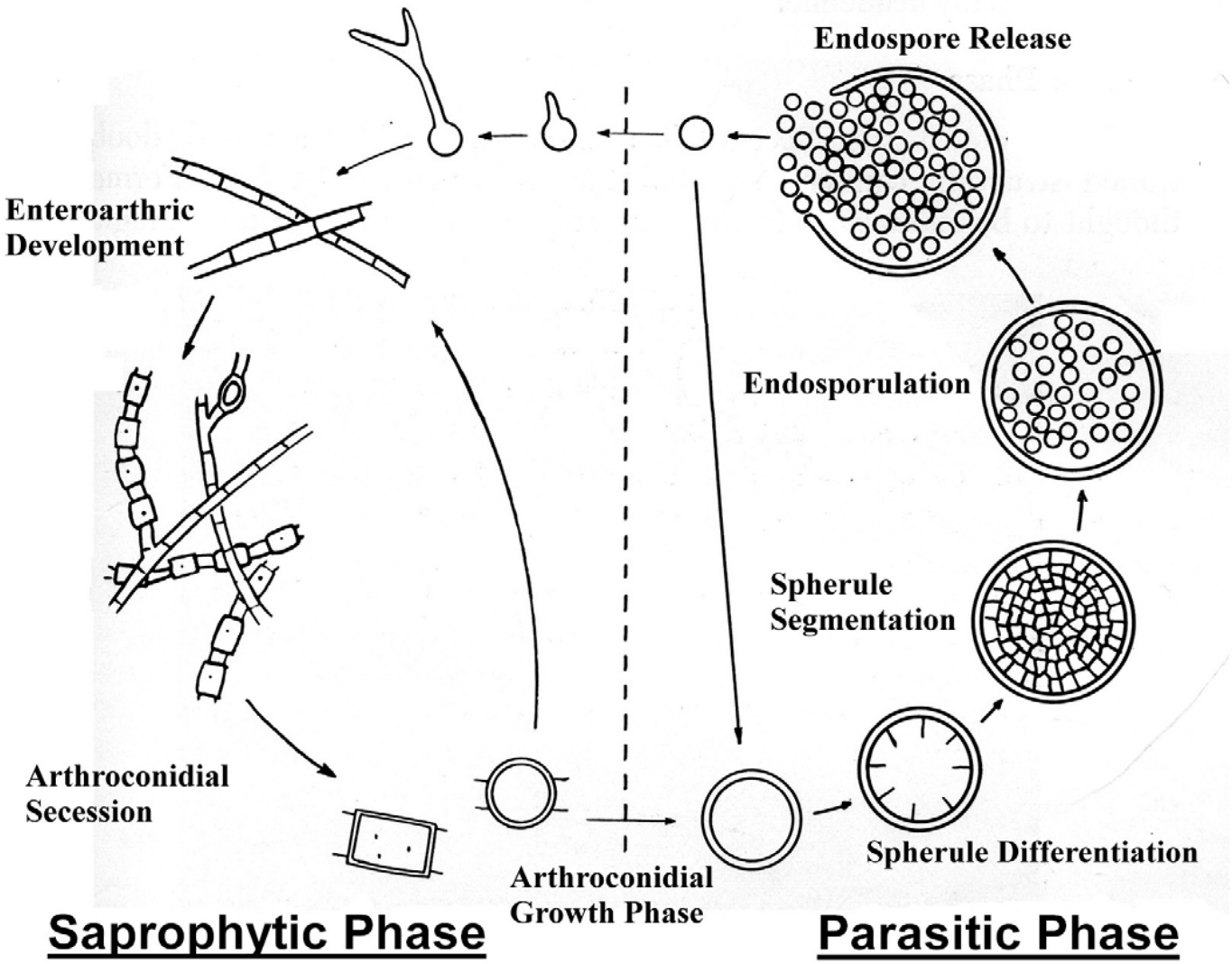
- Named originally for the San Joaquin Valley, CA
- Highly endemic in Pima and Maricopa Counties, AZ and Kern County, CA



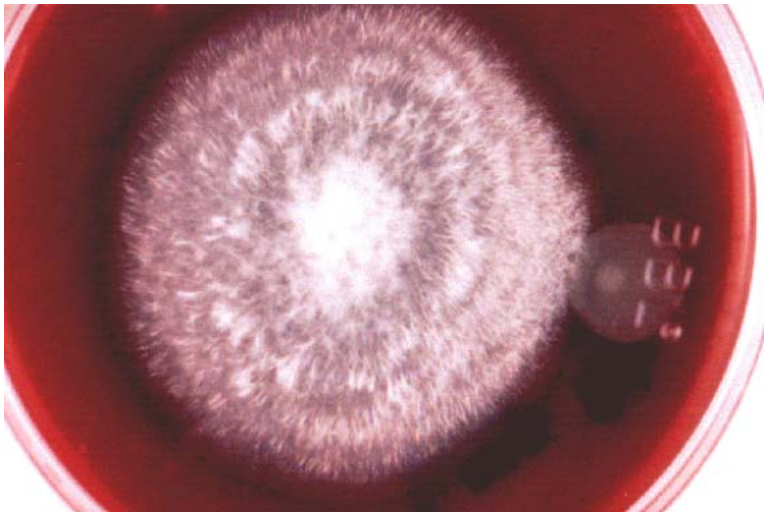
- Also endemic to parts of Central and South America (only found in dry climates of the Western Hemisphere, not in other deserts)

Source: http://health.usgs.gov/geohealth/images/v03_n01_fig4.png

Lifecycle of *Coccidioides spp.*

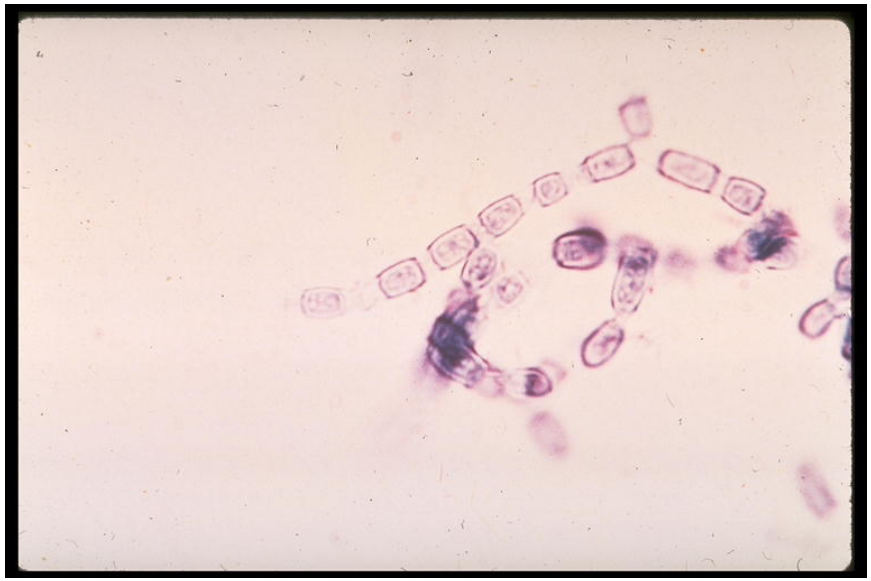


Coccidioides

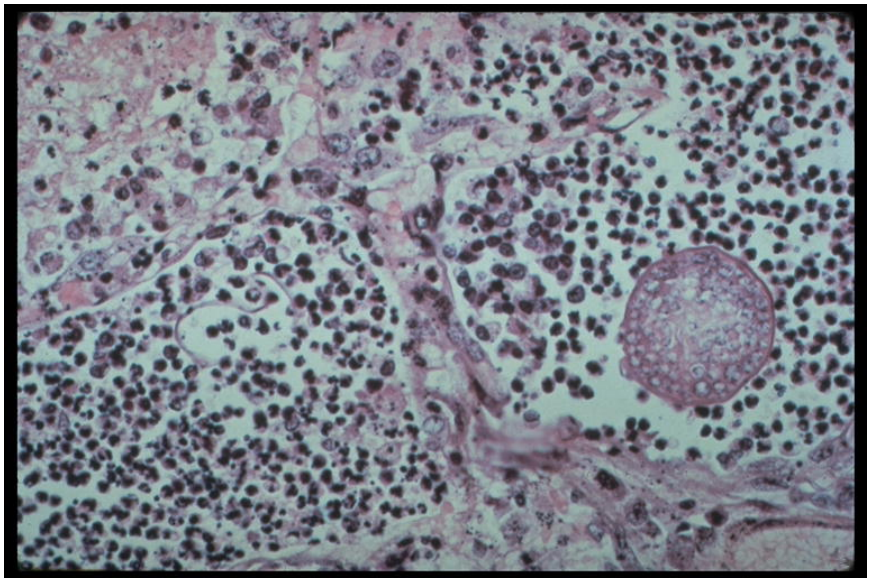


Mycelial form of mature Coccidioides colony growing on blood agar culture medium

Photos: VFCE



Arthroconidia (spores)

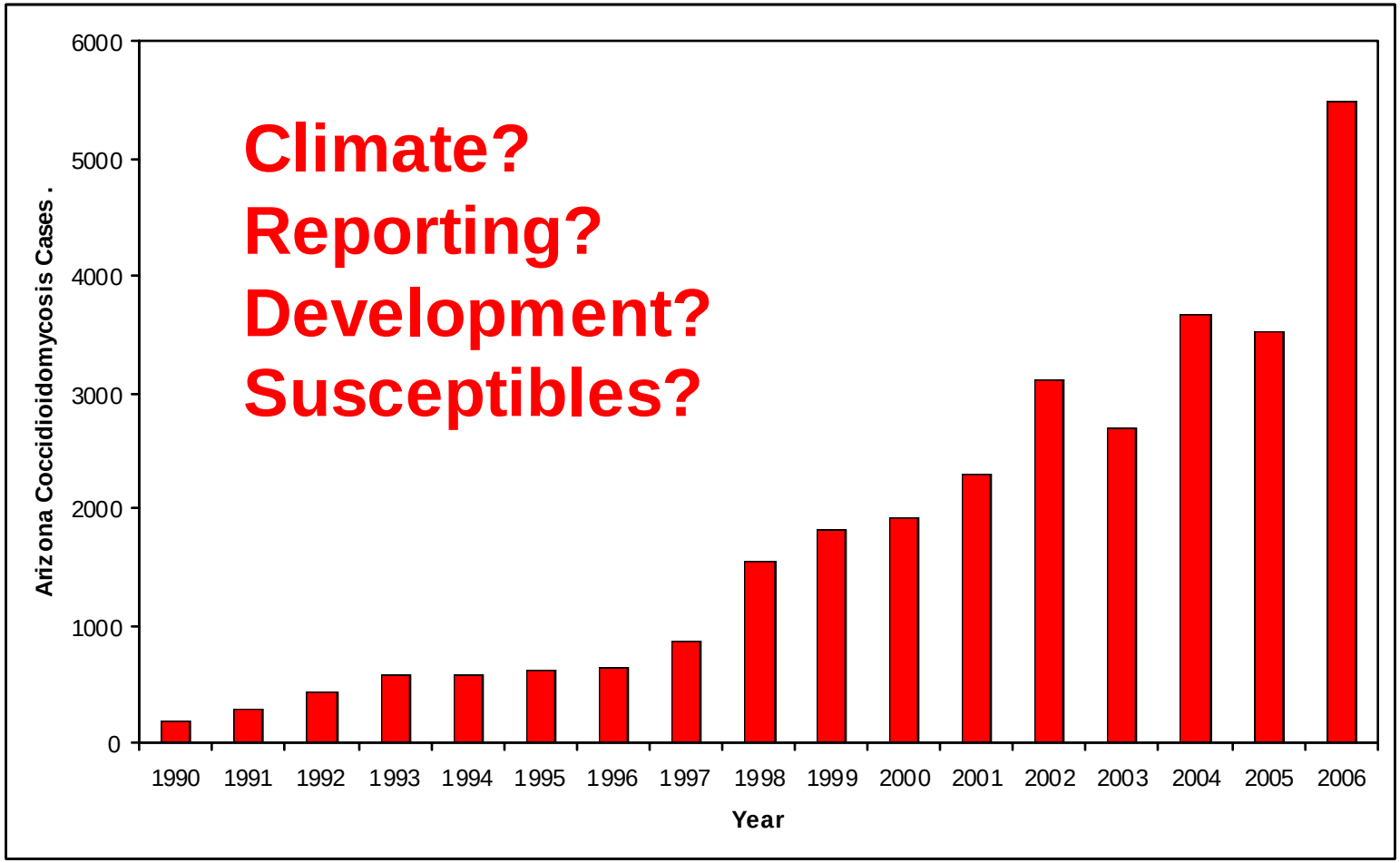


Spherule and endospores in lung tissue

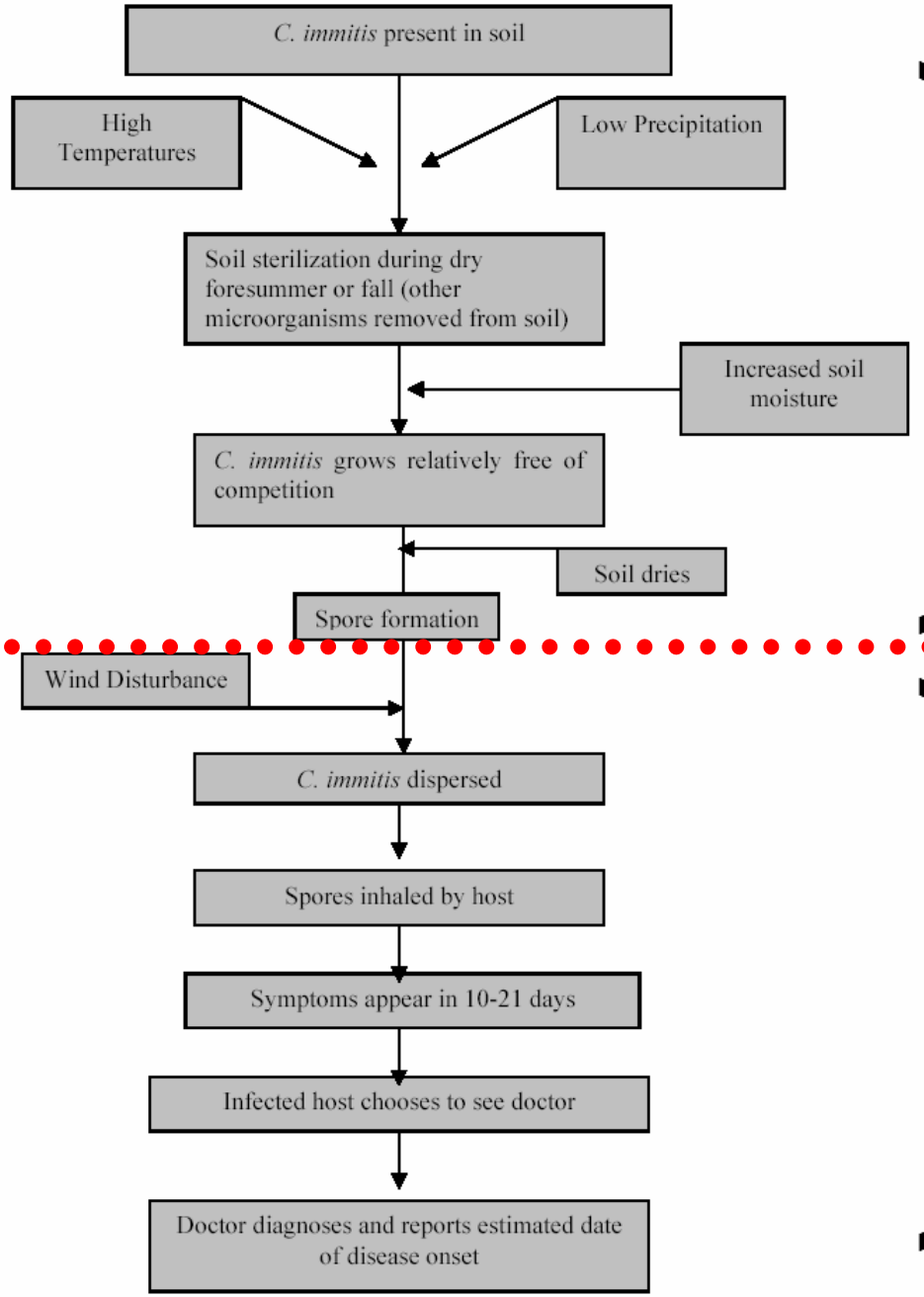
Previous Cocci-Climate Research

- Initial cocci-climate links established in 1950s and 1960s
  - Many anecdotal relationships between climate and incidence identified, but only a few quantitative studies
    - e.g., Hugenholtz 1957, bivariate correlation of incidence to climate in Maricopa County; also Maddy 1965
- Early 1990s outbreak in California
  - Possible link to drought (Jinadu 1995)
- Most recently, work by my group and by CDC/ADHS
  - Kolivras et al. 2001, *Aerobiologia*, lit. review
  - Kolivras & Comrie 2003, *Int. J. Biometeorol.*, multivariate models
  - Comrie 2005, *Env. Health Persp.*, seasonal precip/dust models
  - Park et al. 2005, *J. Infect. Dis.*, multivariate model (a.k.a. Komatsu et al. 2003, *MMWR)*
  - Comrie & Glueck 2007, *Annals NYAS*, model sensitivity
  - UA work in progress/gray lit: Tabor, O'Rourke, Fisher/Bultman et al.

An Emerging Valley Fever Epidemic in Arizona



Source: AZ Dept of Health Services



Environmental Controls

"Grow & Blow" hypothesis

- GROW in the Soil: grow the fungus and subsequently form spores
  MOIST → DRY

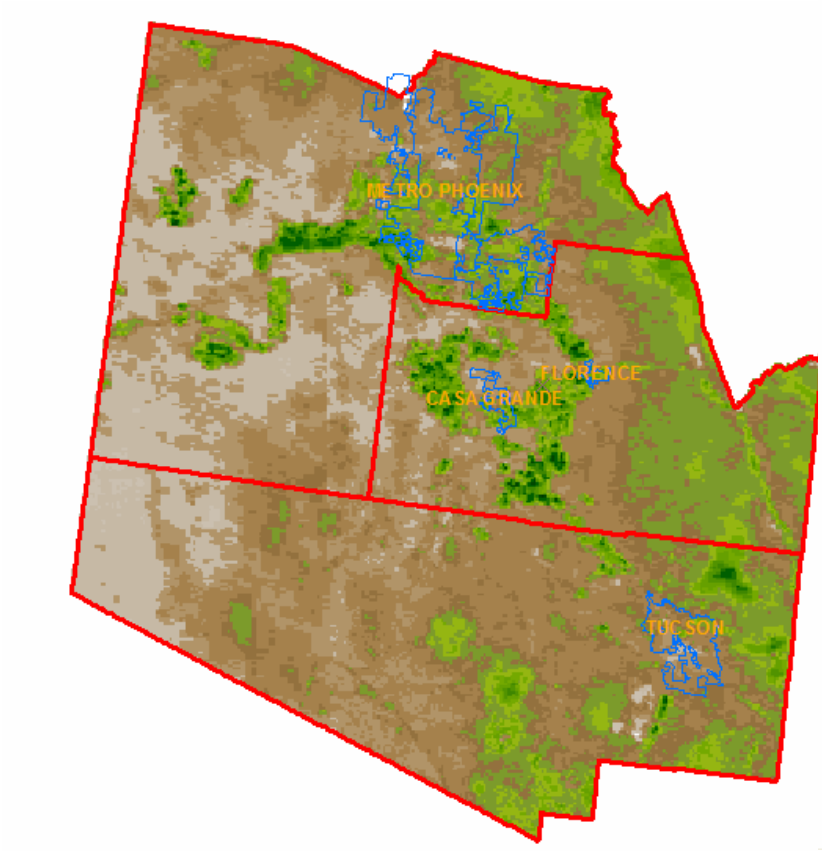
- BLOW in the Air: disperse spores by disturbance and/or wind
  DRY & WINDY/DUSTY

Research Approach

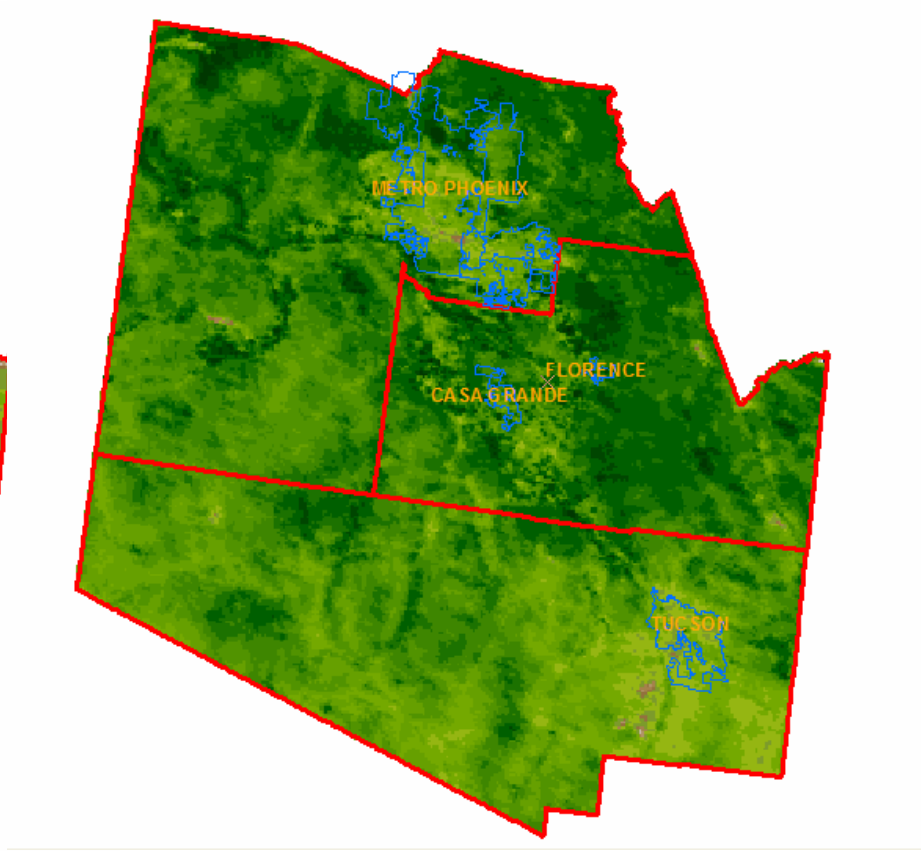
- Improve understanding of relationships between climate variability and valley fever *incidence* in humans
  - No useful long-term data on actual spores in soil or air
  - Ongoing vaccine and mycology research
    - *Coccidioides* is a select agent (BSL3 required)
- Develop predictive models based on climate and geospatial analyses
  - Anticipate use of climate forecasts, satellite monitoring
- Interdisciplinary research and stakeholder group
  - Climatologists, geographers, MDs, epidemiologists, mycologists, microbial geneticists, soil scientists
  - Collaboration with Arizona Department of Health Services
- Develop a decision-support system with public health stakeholders
  - Enables preparedness, sensitive-group warnings, enhanced surveillance and targeted intervention

Soil Moisture Changes via Satellite

Potentially better than rain gauges? NDVI and soil moisture indices may show "integrated" signal

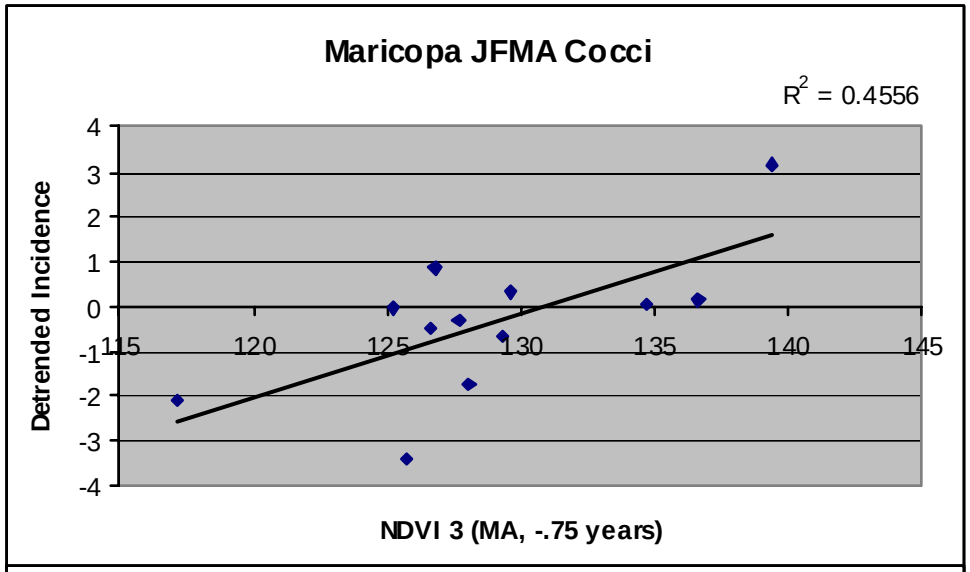


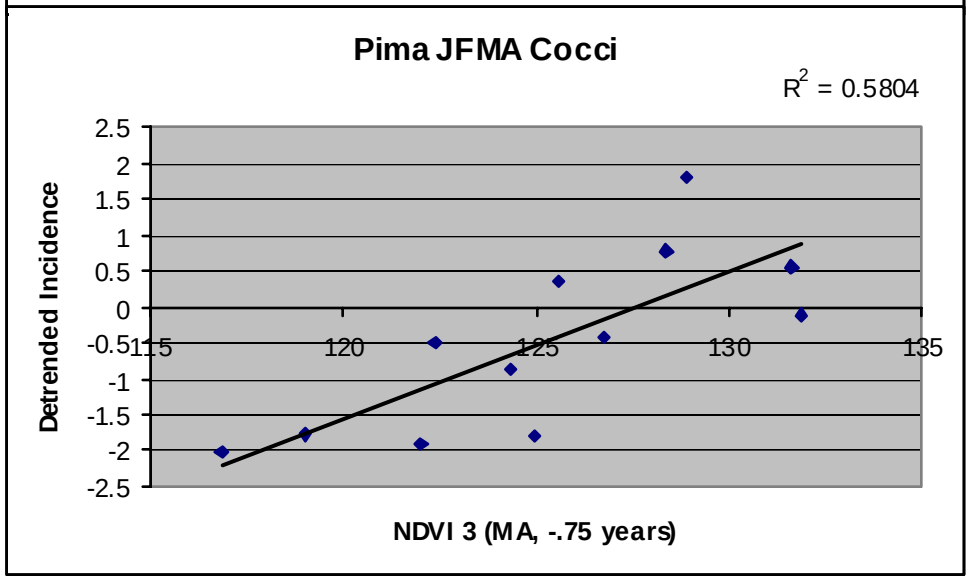
Dry: July 2002



Moist: March 2005

Satellite Soil Moisture vs. Cocci Incidence

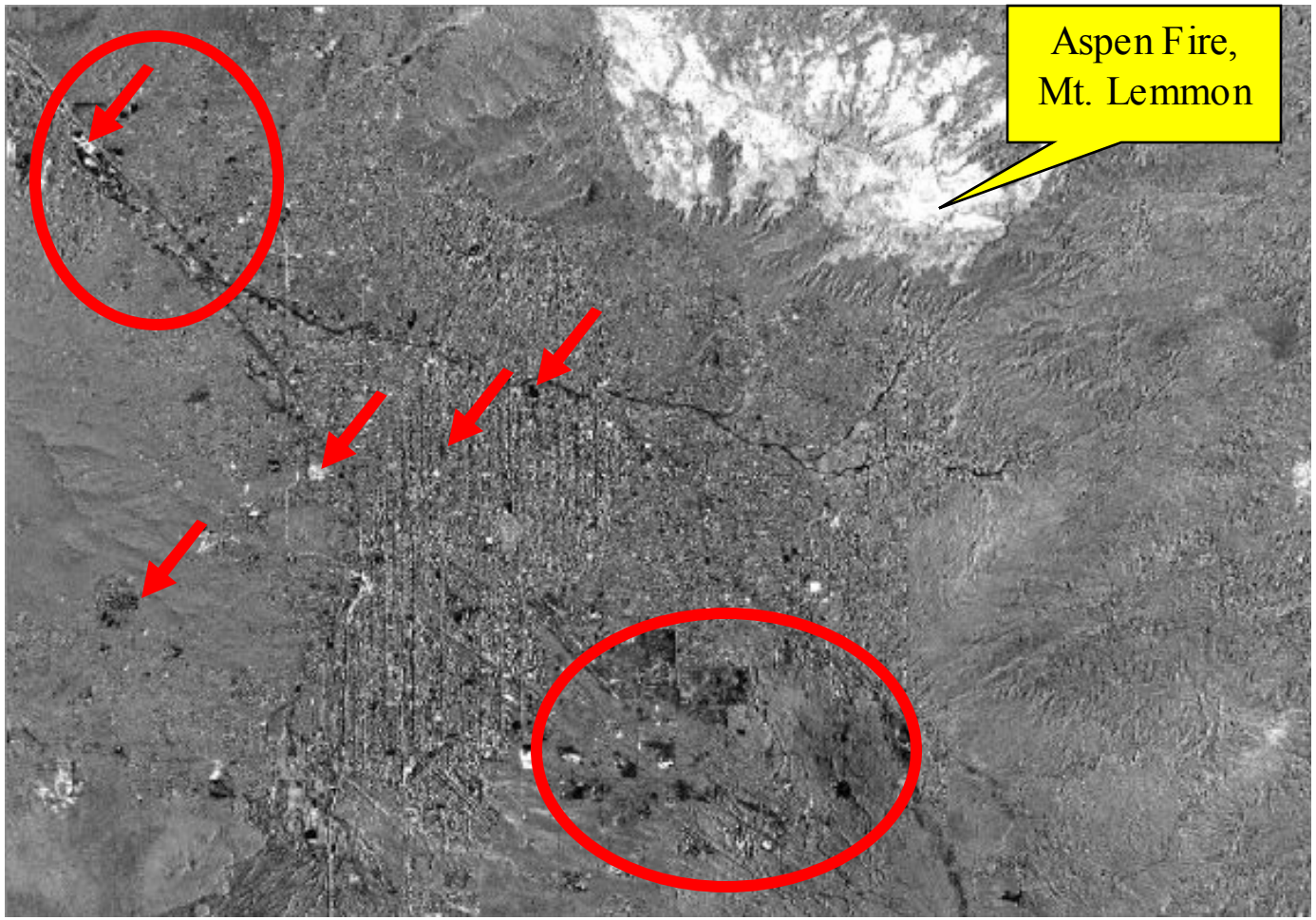




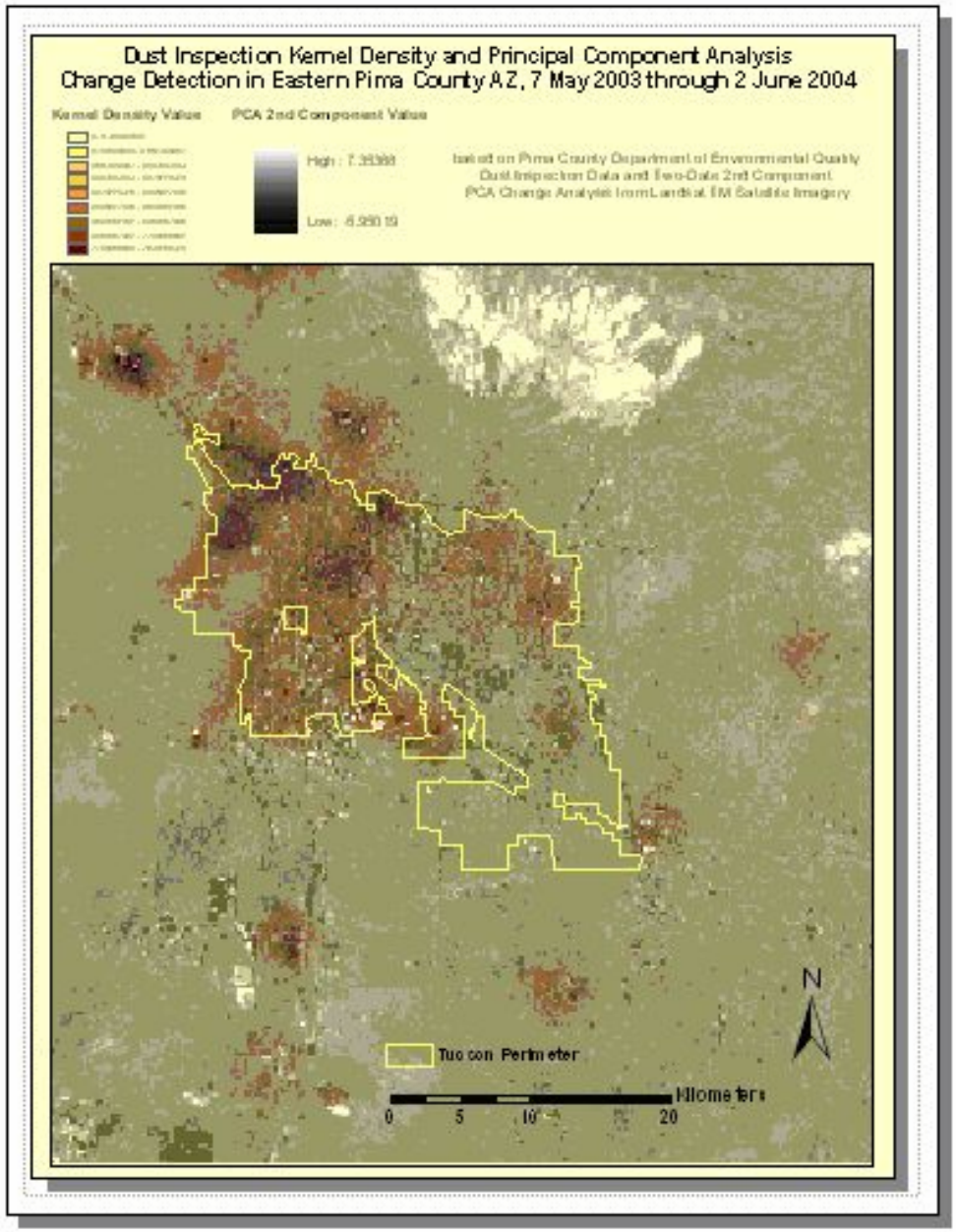
- Preliminary results show selected strong bivariate relationships for some seasons
- Links to prior year conditions, others up to 4 years earlier

Land Cover Change Detection

Identify surface disturbance in space/time (e.g., construction)



- Tucson
- May 7, 2003 to June 2, 2004 Change
- Landsat TM imagery
- White & Black show most changed locations

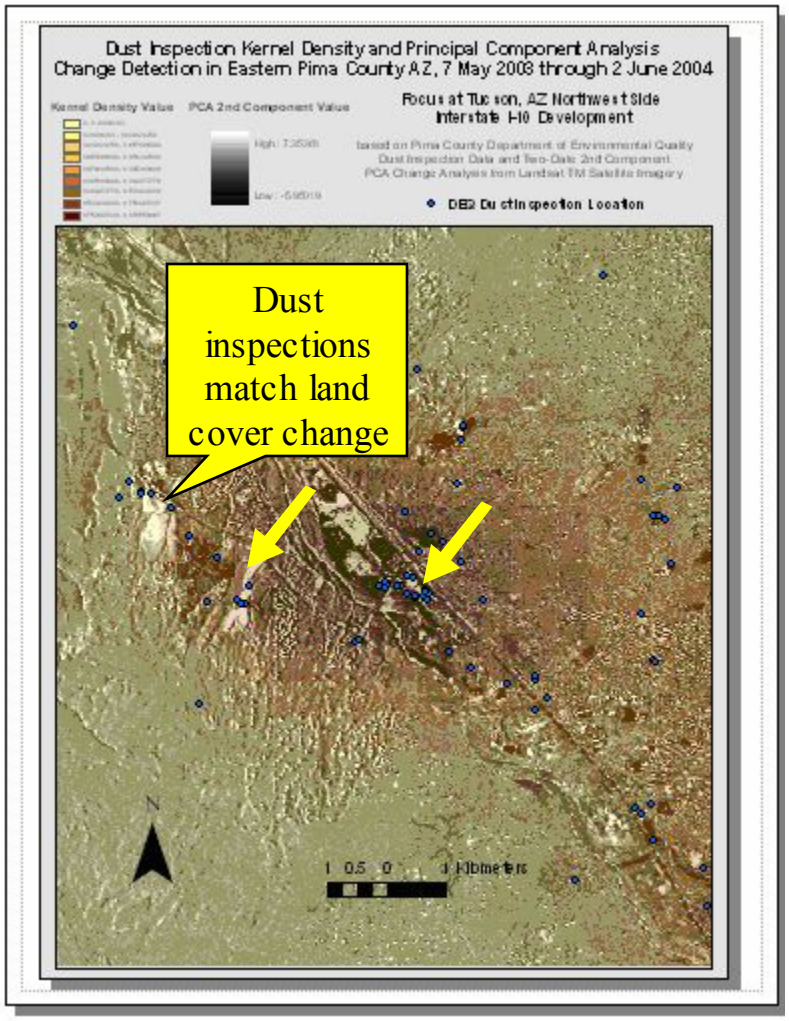


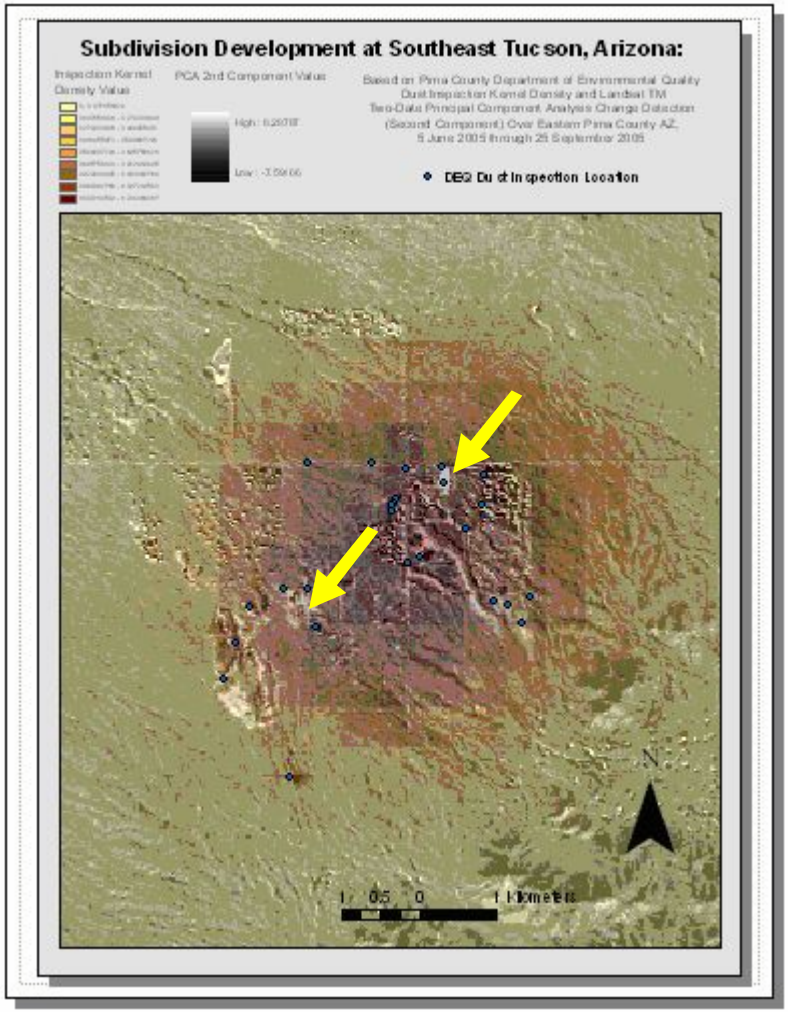
Dust Permits & Land Cover Change

- Tucson, 2003-2004
- Associate "change pixels" with dust inspections
- Inspection permit locations from Pima County DEQ
- Combined change/dust inspection image
  - Brown = dusty

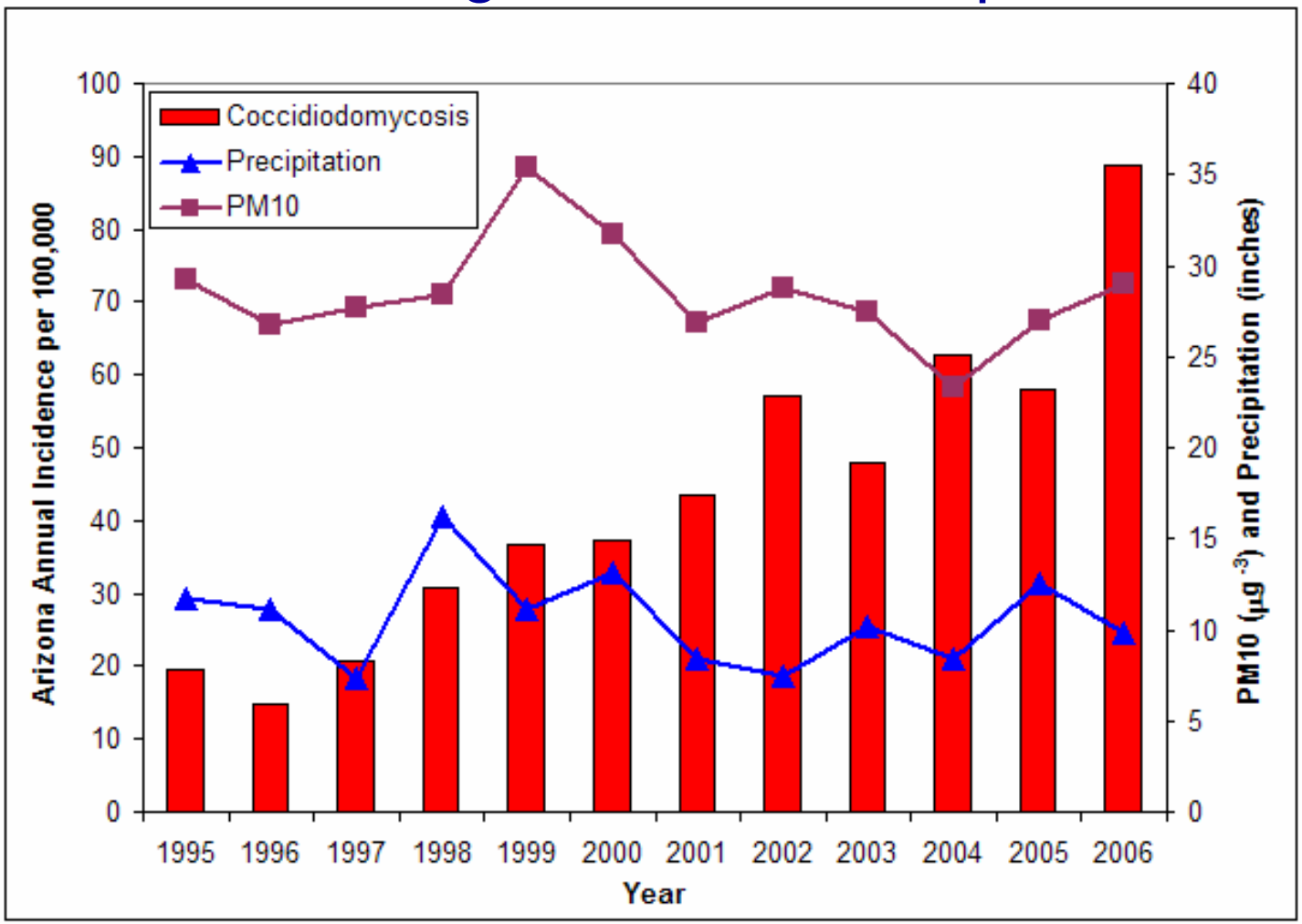
NW Tucson

SE Tucson

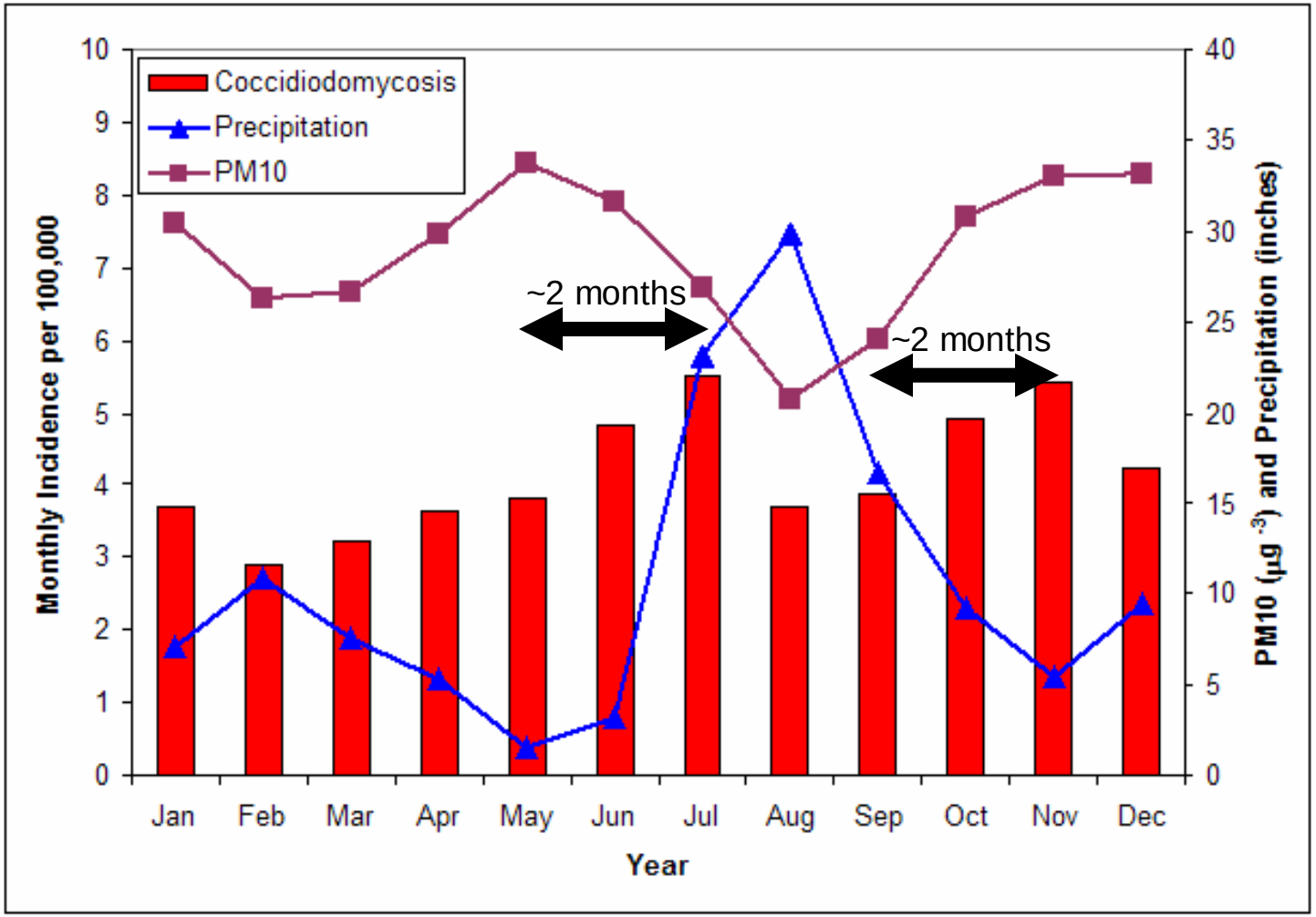




Cocci Continues Upward Trend, But No Matching Trends in Precip and Dust

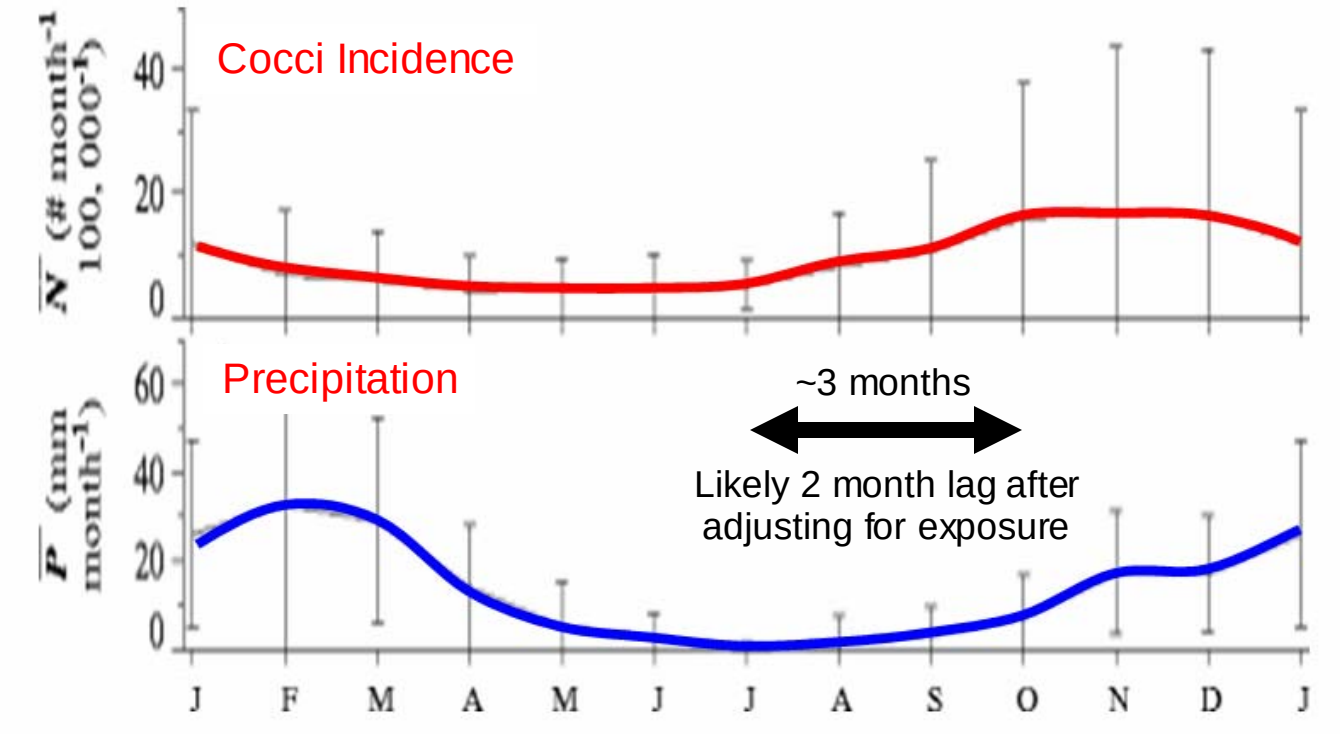


Strong Seasonal Patterns in Precip and Dust Co-Vary with Cocci



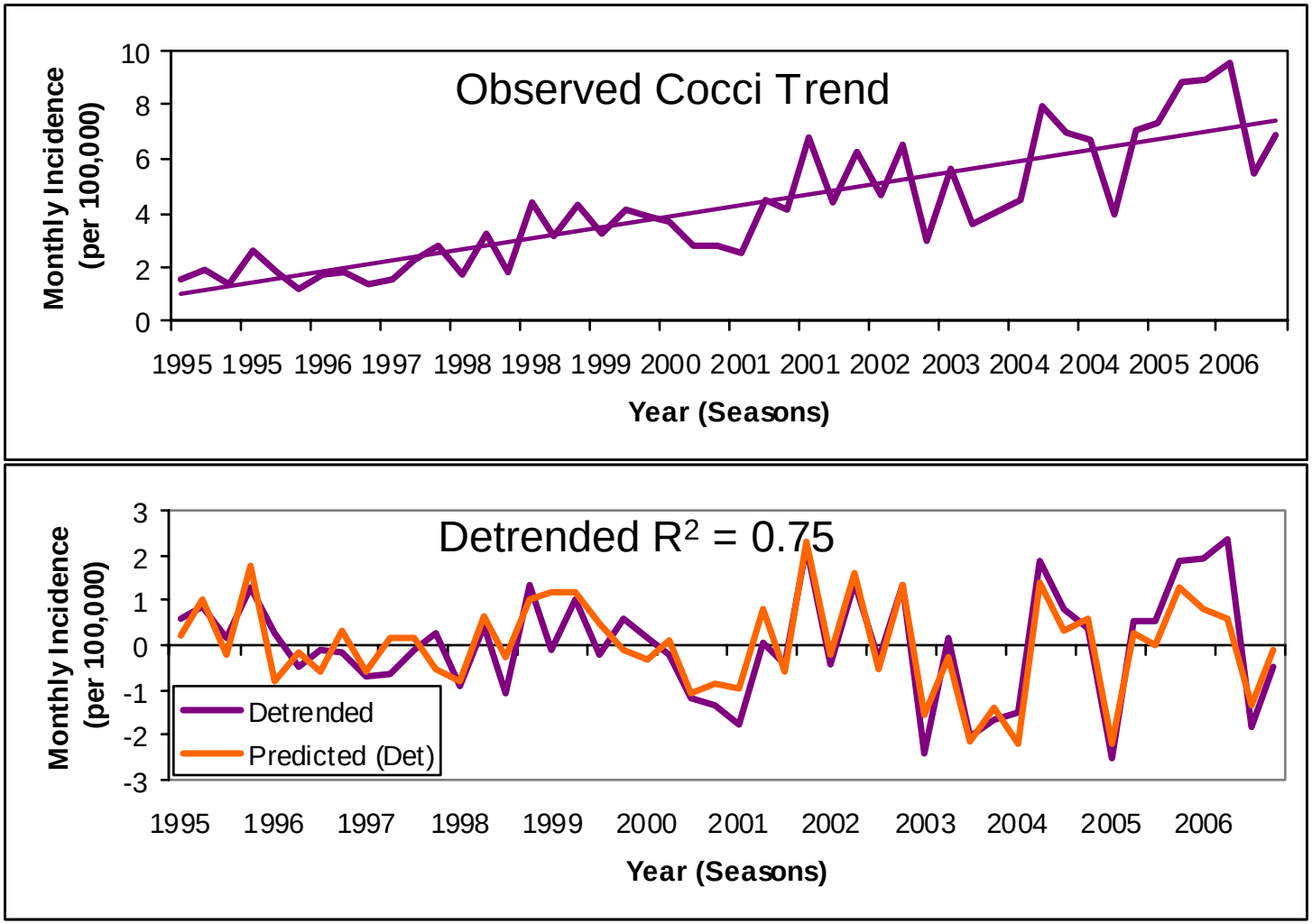
Incidence data are case-adjusted to Estimated Exposure Date per Comrie (2005)

California Cocci Incidence Rises after Dry Season, But Poor Links to Annual Variability

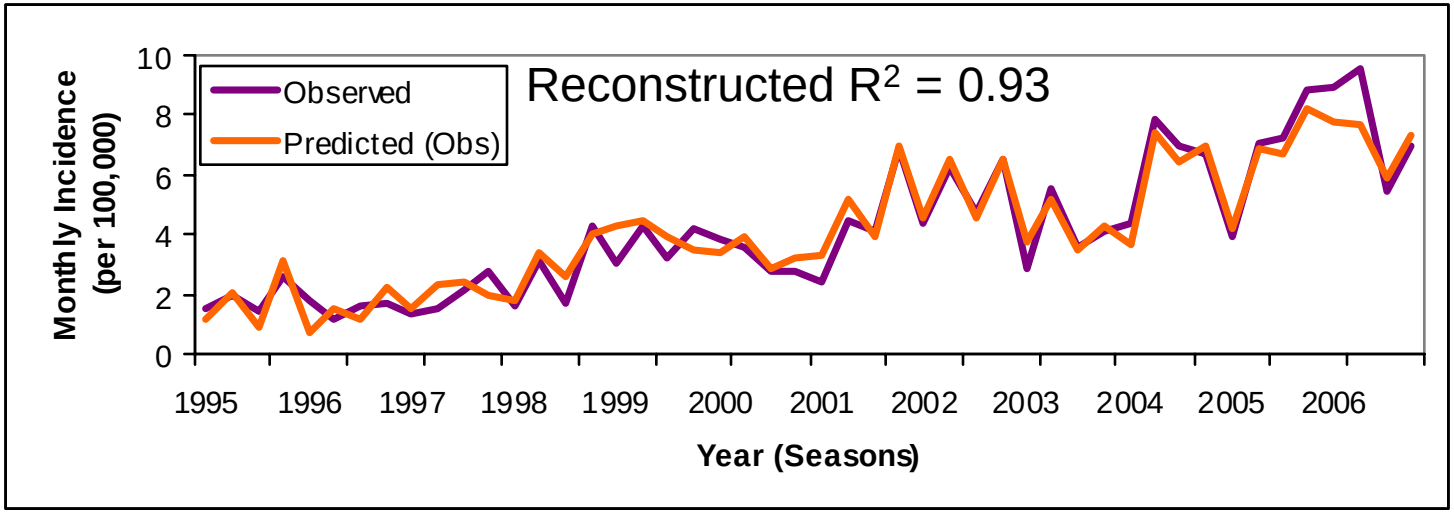


Zender CS, Talamantes J (2006) Int J Biometeorol 50:174–182

Pima County Valley Fever
Seasonal Detrended Model



Pima County Valley Fever
Seasonal Model + Trend



Key Antecedent Precipitation Periods for the Detrended Model

← Year-4 → ← Year-3 → ← Year-2 → ← Year-1 → Cocci Season

JFMA-4	MJJ-4	AS-4	OND-4	JFMA-3	MJJ-3	AS-3	OND-3	JFMA-2	MJJ-2	AS-2	OND-2	JFMA-1	MJJ-1	AS-1	OND-1	JFMA-0	MJJ-0	AS-0	OND-0	
	-											+				<---				JFMA
			+			+											<---			MJJ
		-													-	-		<---		AS
							-							-	+				<---	OND

- Within prior year, dry monsoon/winter or wet fall lead to higher cocci incidence for AS & OND cocci
- Other links sporadic, may be sensitive to small N
- Results are PRELIMINARY – need cross-validation

Interim Conclusions & Future Work

- Satellite data may be useful in the next generation of seasonal models
  - May provide more spatial detail, improved predictors
- Climate effect on detrended cocci incidence promising; still supports "Grow & Blow" hypothesis
  - Climate models cannot account for the broad cocci trend
  - Precipitation a useful predictor, but roles of specific seasons not as clear
  - Dust does not emerge as a predictor in these Pima Co. results
  - All conclusions are preliminary
- Coming soon…
  - Finalize satellite measures over time/space, combine with climate models
  - Climate model runs to include Maricopa, Pinal and Pima counties
  - Potential climate change impacts based on climate model results
  - Work with ADHS, incl. public health decision-making implications

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