Sneeze and Wheeze in a Low Earth Orbit:

Forecasting Pollen from Space

HAQAST

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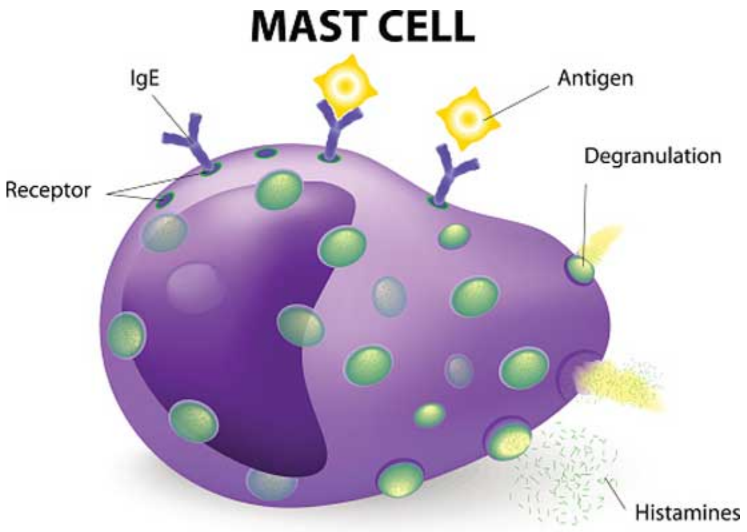
Overview

Allergy Etiology & Epidemiology

Improving Management

Developing Forecasts

ETIOLOGY & EPIDEMIOLOGY



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Disease origins and distribution

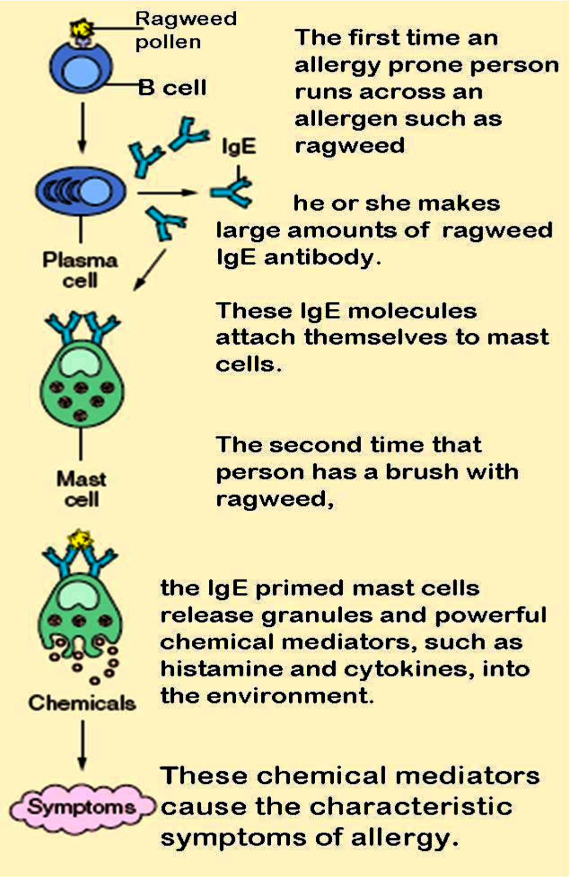
Pollen Allergy Epidemiology

> Substantial disease burden globally
  - Allergic rhinitis (AR) prevalence estimated 10-30%
  - Allergic asthma estimated at 5-10%

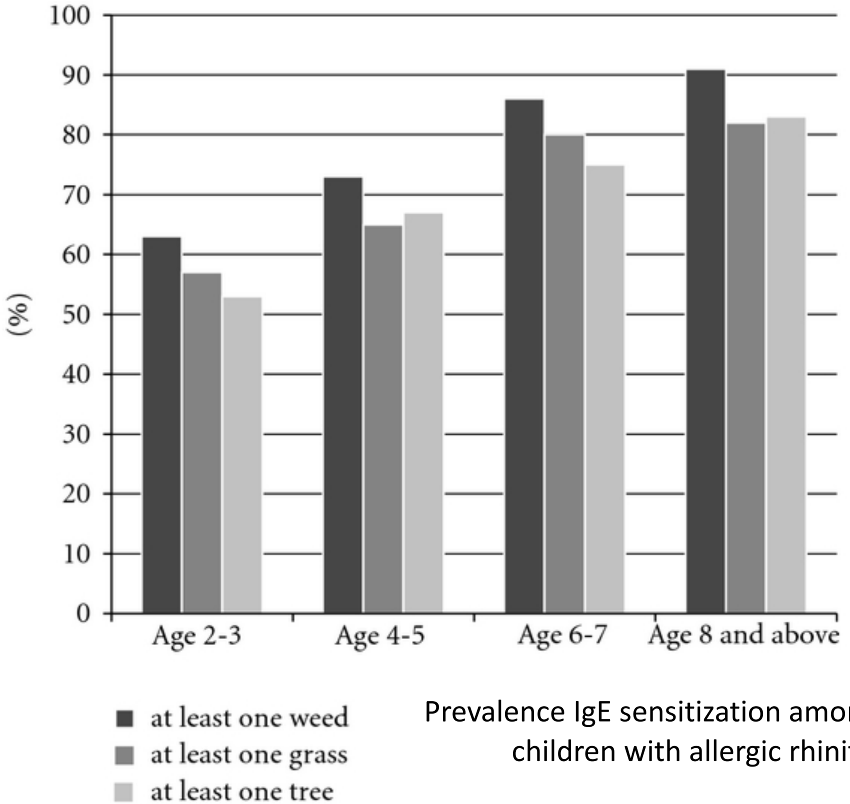
> In US, prevalence estimated at 13% in children and 14% in adults (Meltzer, 2009)
  - AR responsible for 3.5m lost work days and 2m lost schooldays per year (Nathan 2007)
  - Decreased health-related quality of life by 25% (Avarro et al. 2007)
  - Estimated $2-5b costs in US in 2003 (Reed et al. 2004); inflation adjusted $4-7b in $US2018

Allergic Disease

- Allergies immune mediated, driven by immune memory (IgE antibodies)
- Multiple exposures drive allergic disease development and flares
- Generally not life threatening but makes people miserable
- Range of therapies
  - Exposure avoidance
  - Symptom reduction
  - Immune modulation



Sensitization by Age and Exposure



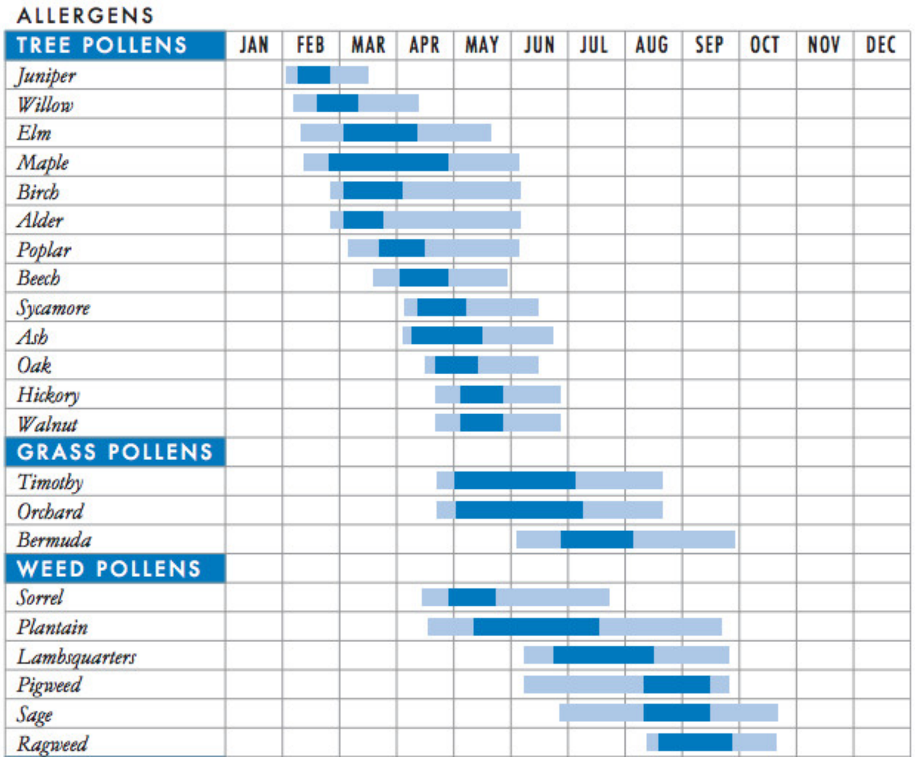
Prevalence IgE sensitization among children with allergic rhinitis

6-7-year-old children	Pollen	Positive percent of 56 children
Most common weeds	Russian thistle	68%
	Pigweed	61%
	Sagebrush	49%
Most common grasses	Saltgrass	58%
	Timothy	48%
	Bermuda	45%
	Johnson	45%
Most common trees	Willow	39%
	Sweet gum	32%
	Mulberry	36%

Prevalent allergens in the Great Basin

Wong et al. 2012

Pollen Types and Seasons



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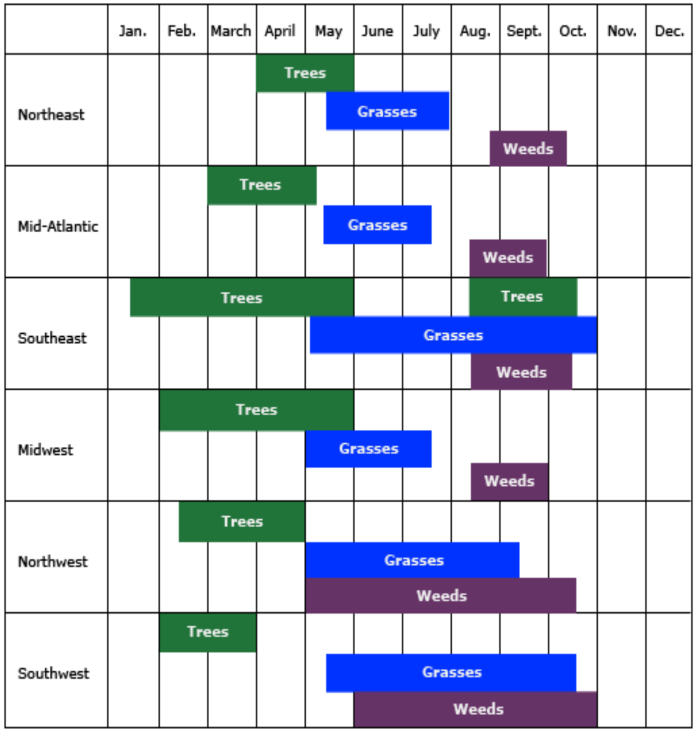
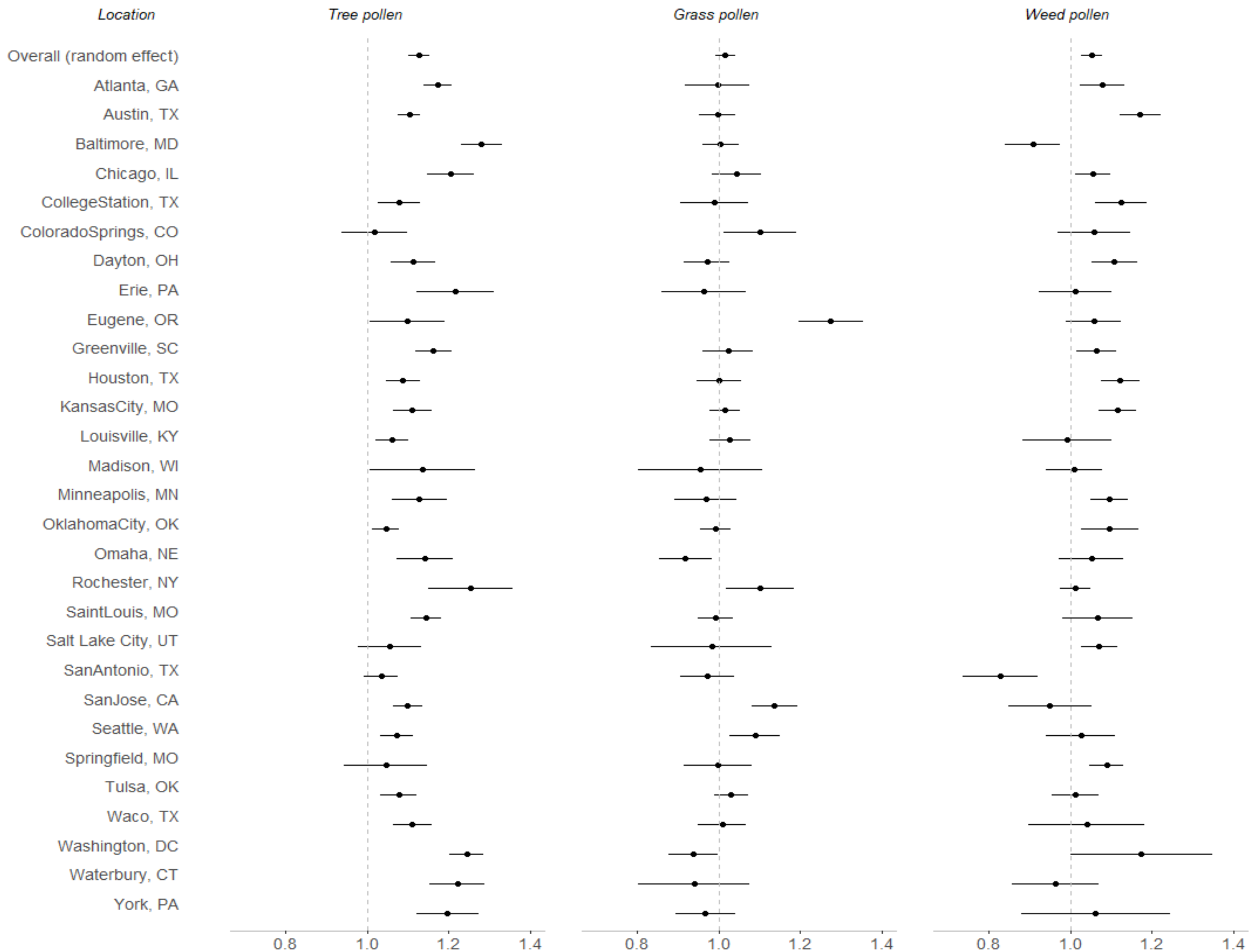


Nowak-Wegrzyn A. Up To Date, 2017

Pollen and Health - Methods

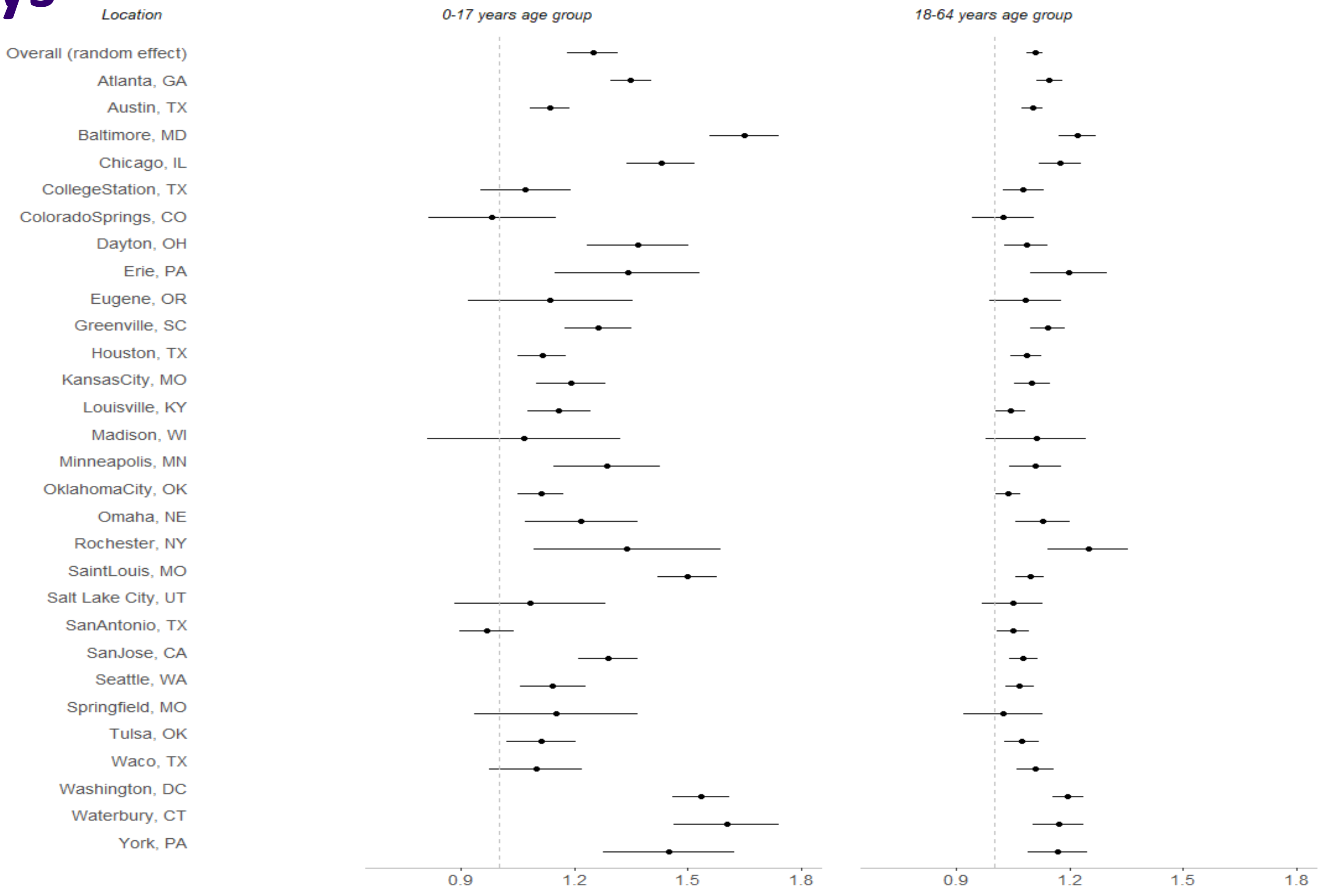
- Retrospective analysis of associations between tree, weed, and grass pollen and several morbidity measures in the continental US, controlling for particulate air pollution, ozone, and influenza-like illness
- Set season start at cumulative count of 50 grains/m^3 unless mean seasonal total count ≤2,000 grains, then 2.5%
- Metropolitan Statistical Area (MSA) linked with NAB stations, county $PM_{2.5}$ and O_3, weekly CDC ILI prevalence
- GEEs used to estimate daily counts

RR Prescription Med Refill High Pollen Days



Saha et al. in preparation

RR Prescription Med Refill High Tree Pollen Days



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Saha et al. in preparation

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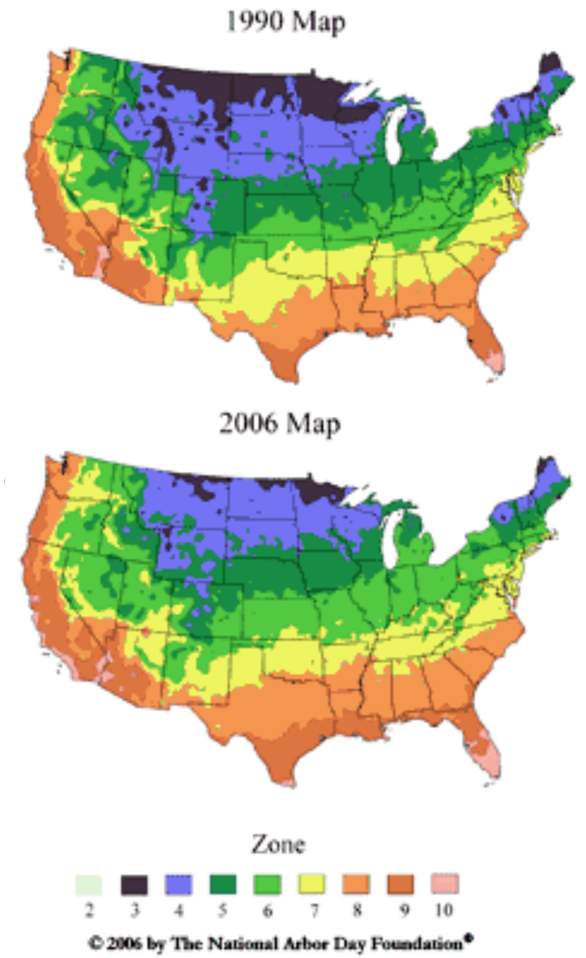
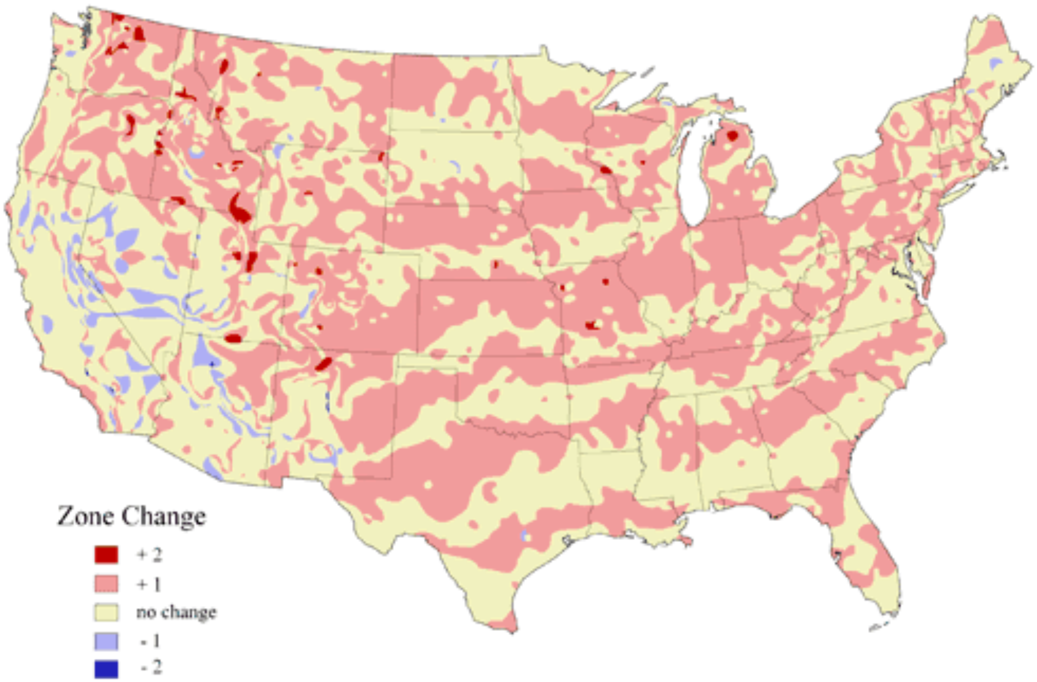
An Increasingly Common Picture

Warming and Plant Hardiness





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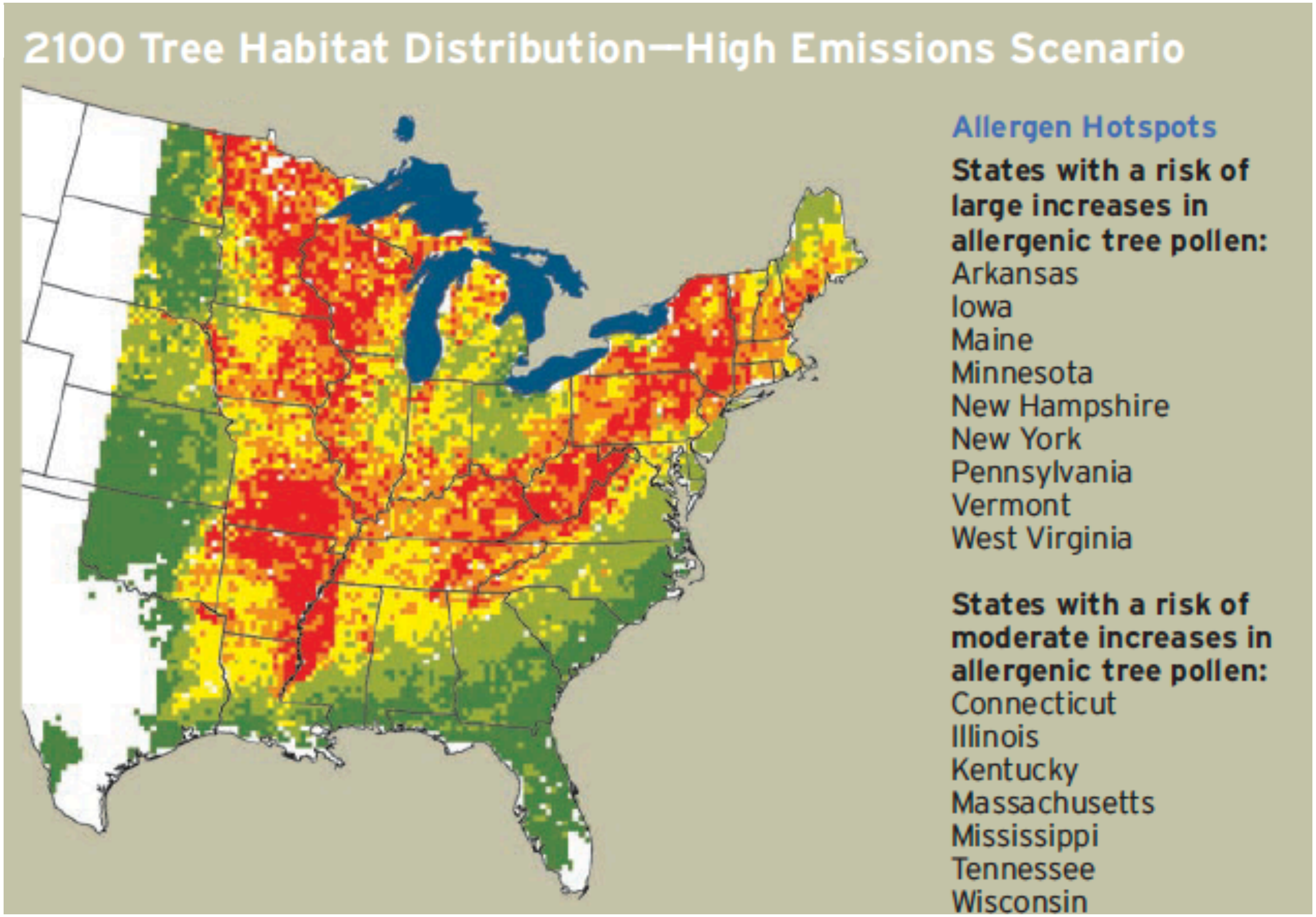
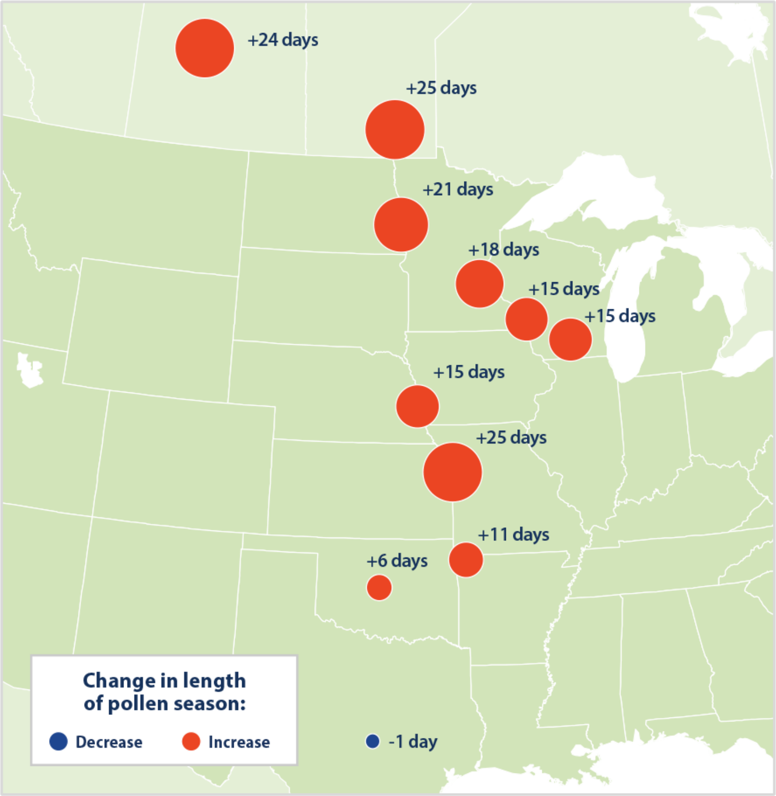
Warming and Allergic Plant Suitability

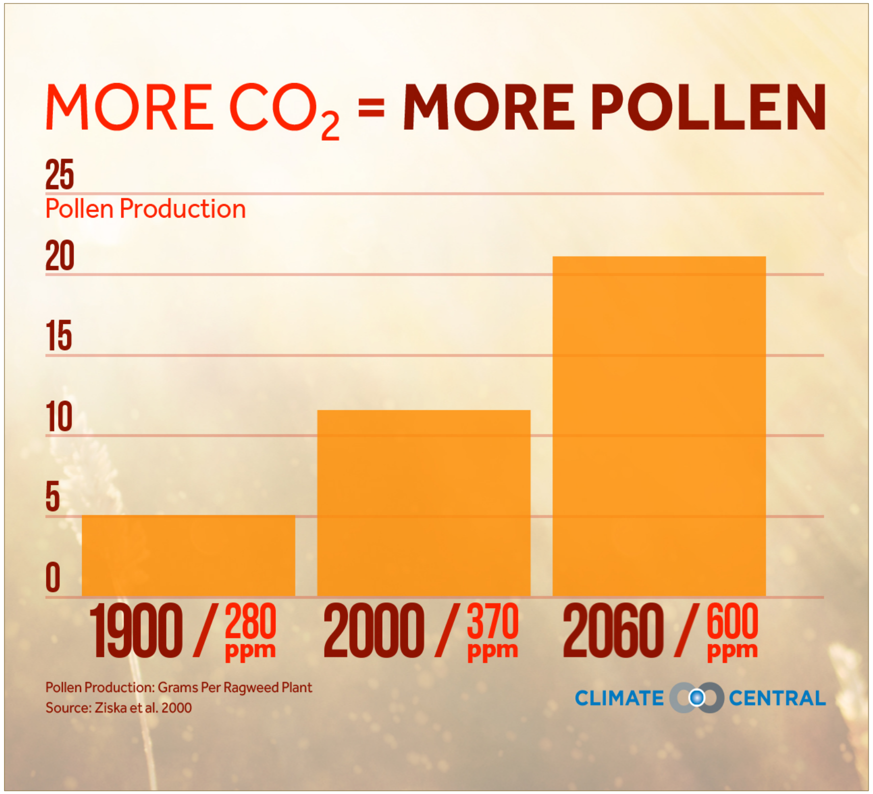


Asthma and Allergy Foundation 2010

CO_2 and Warming Double Whammy

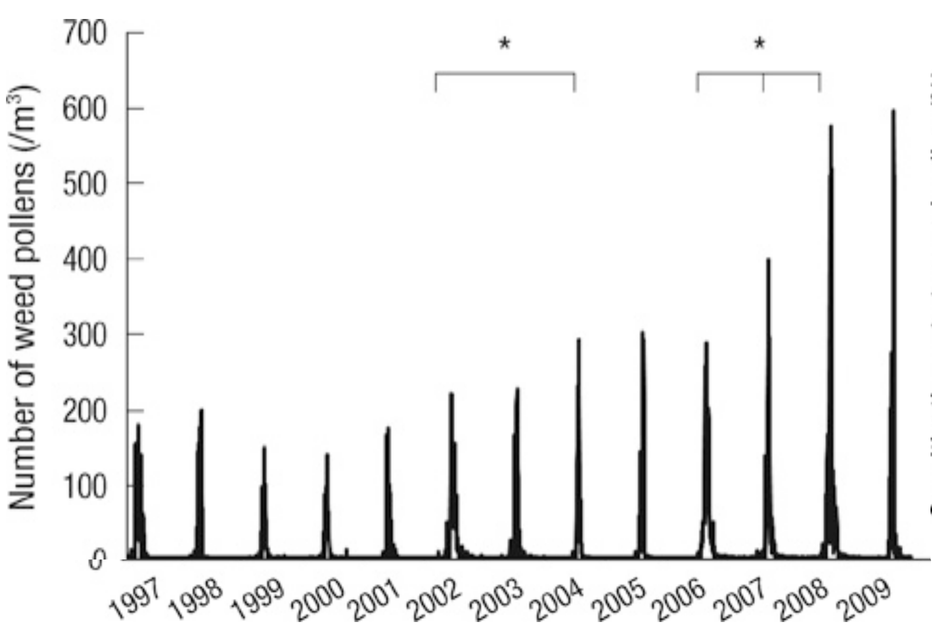


US EPA

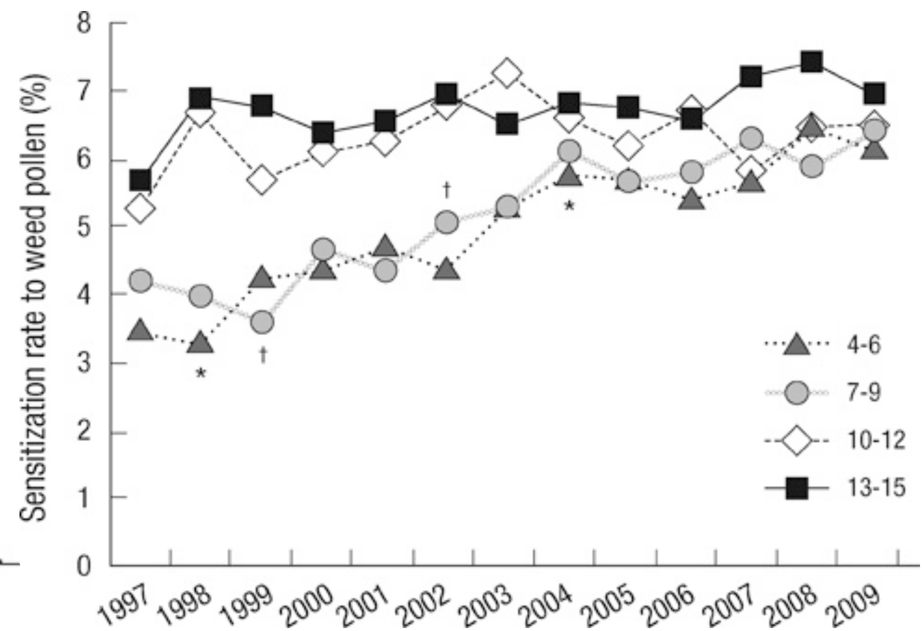


Climate Central

Sensitization and Pollen Levels



Annual weed pollen counts from 1997 to 2009 in Seoul. Weed pollen included ragweed, Japanese hop and mugwort.



Annual sensitization rates to weed pollen allergens according to age. Weed pollen included ragweed, Japanese hop and mugwort.

Kim et al. 2011

Take-Home Findings

> Widespread, significant disease burden
> Increasing with socioeconomic development
> Pollen exposure is a strong driver of incidence
> Increases in temperature and CO_2 will very likely increase allergic disease burden

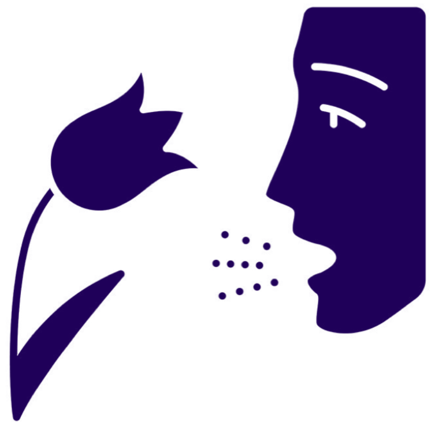
MANAGEMENT

Image available here

What to do, and not do, for pollen allergies

Allergic Disease Management

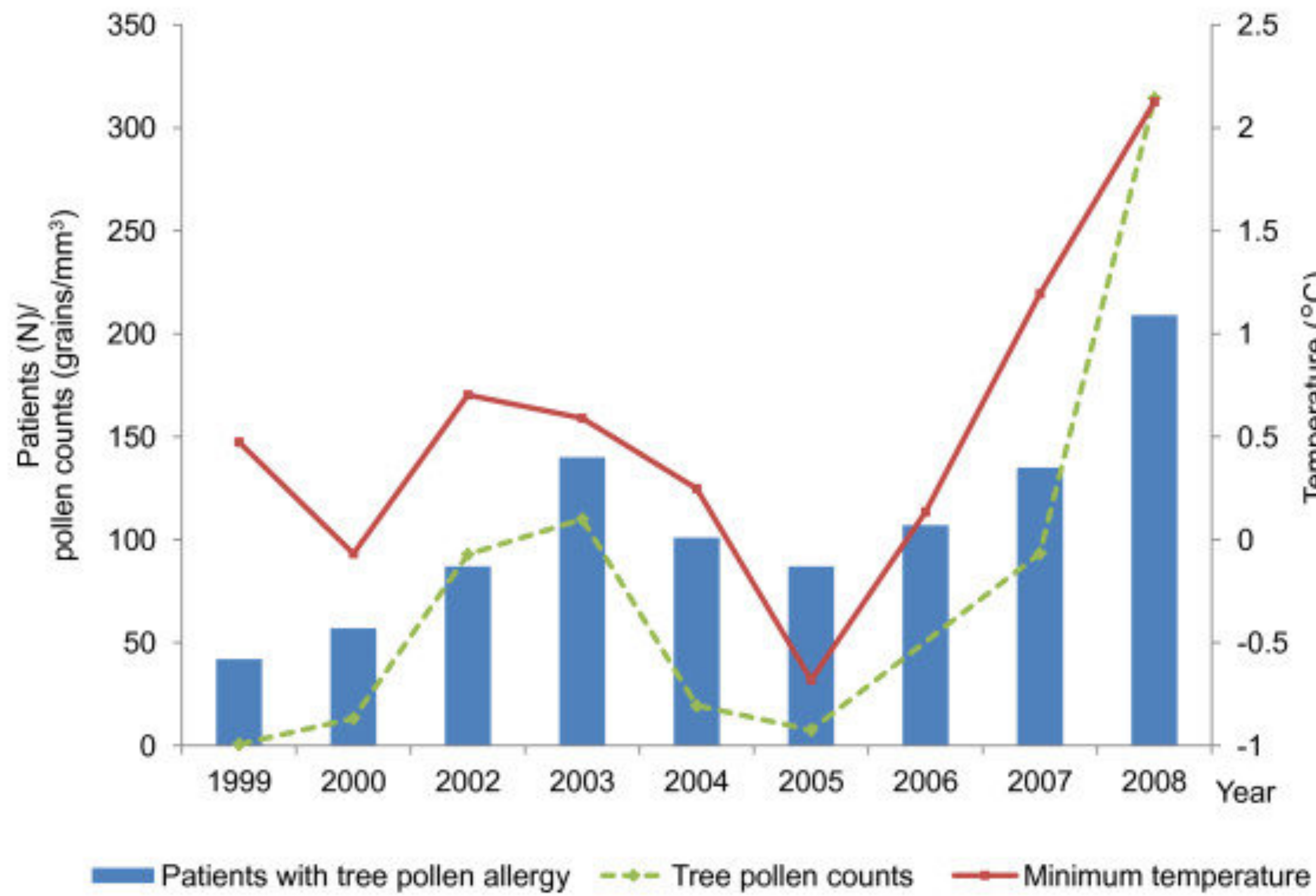
Medication



Exposure Reduction

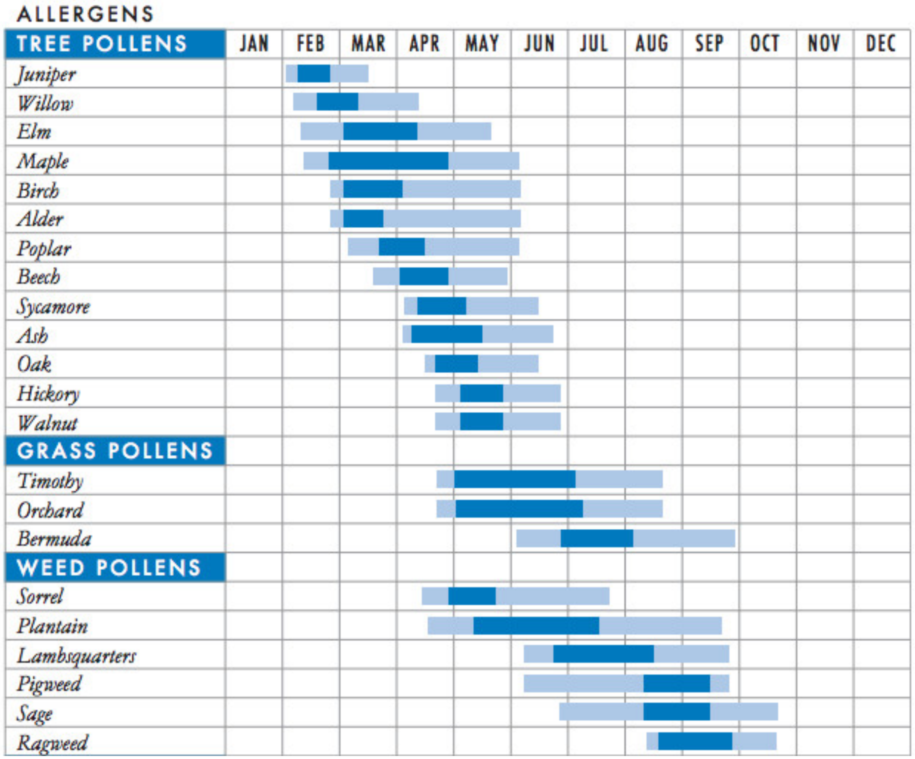
Immune Therapy

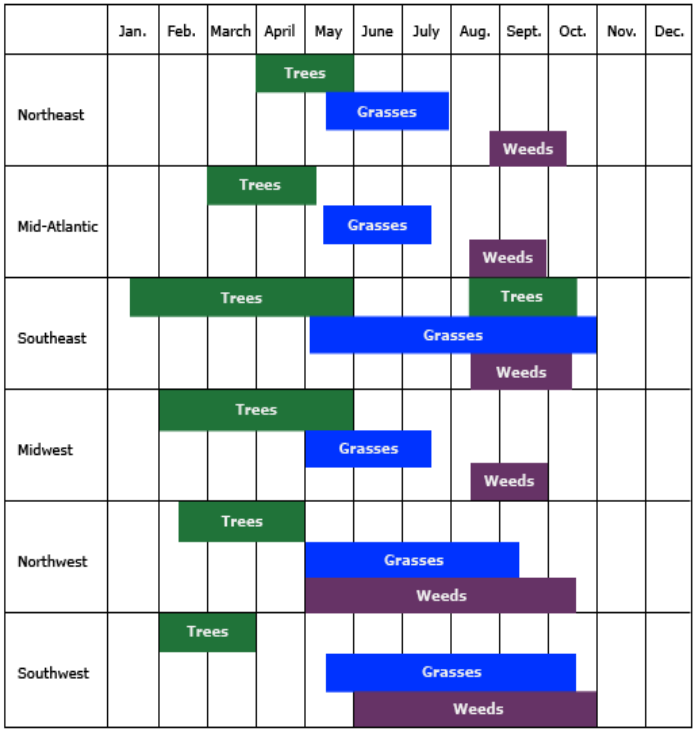
Symptoms and Pollen Counts



Kim et al. 2011

Pollen Types and Seasons





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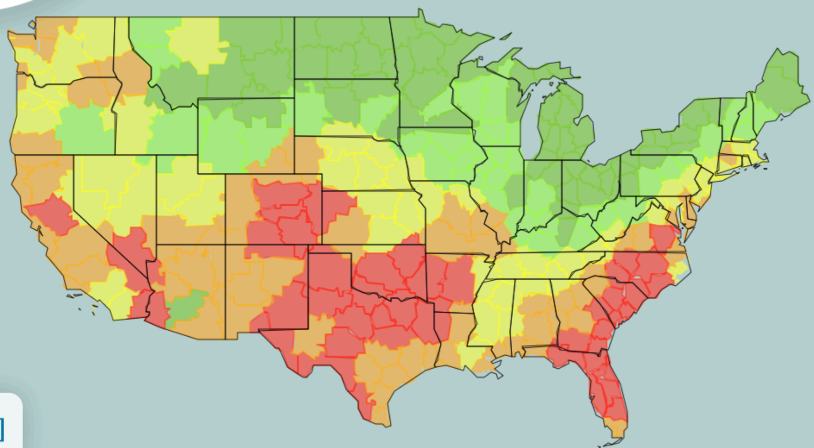
Nowak-Wegrzyn A. Up To Date, 2017

Pollen.com

Enter city or ZIP to get your allergy forecast

HOME | FORECAST | ALLERGY | RESEARCH | TOOLS



legend [+]

National Allergy Map

20% *of the country in medium status*

Click map to zoom in and explore regions, states and cities

ALLERGY

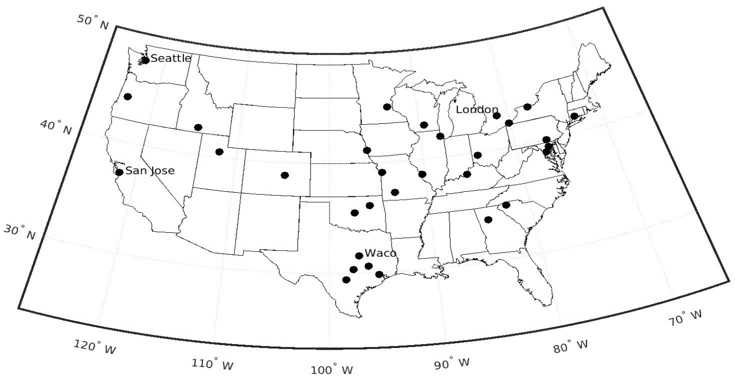
FORECAST

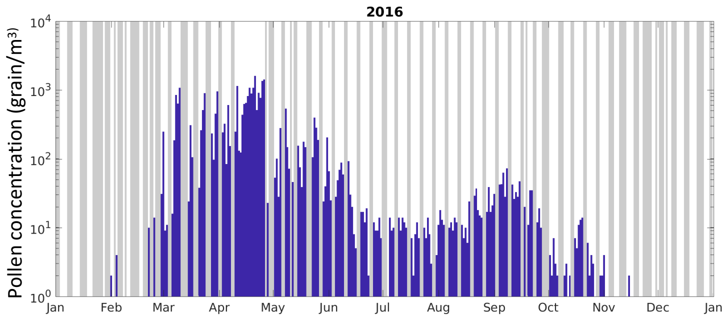
RESEARCH

TOOLS

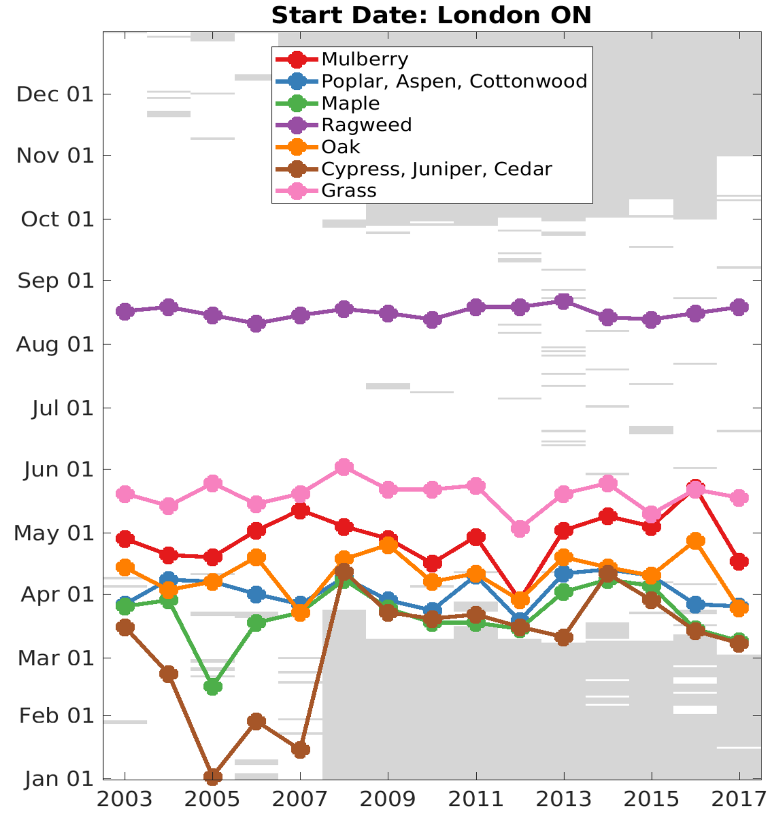
Allergy Outlook

NAB Data





US Army Centralized Allergen Extract Lab, Silver Spring, MD



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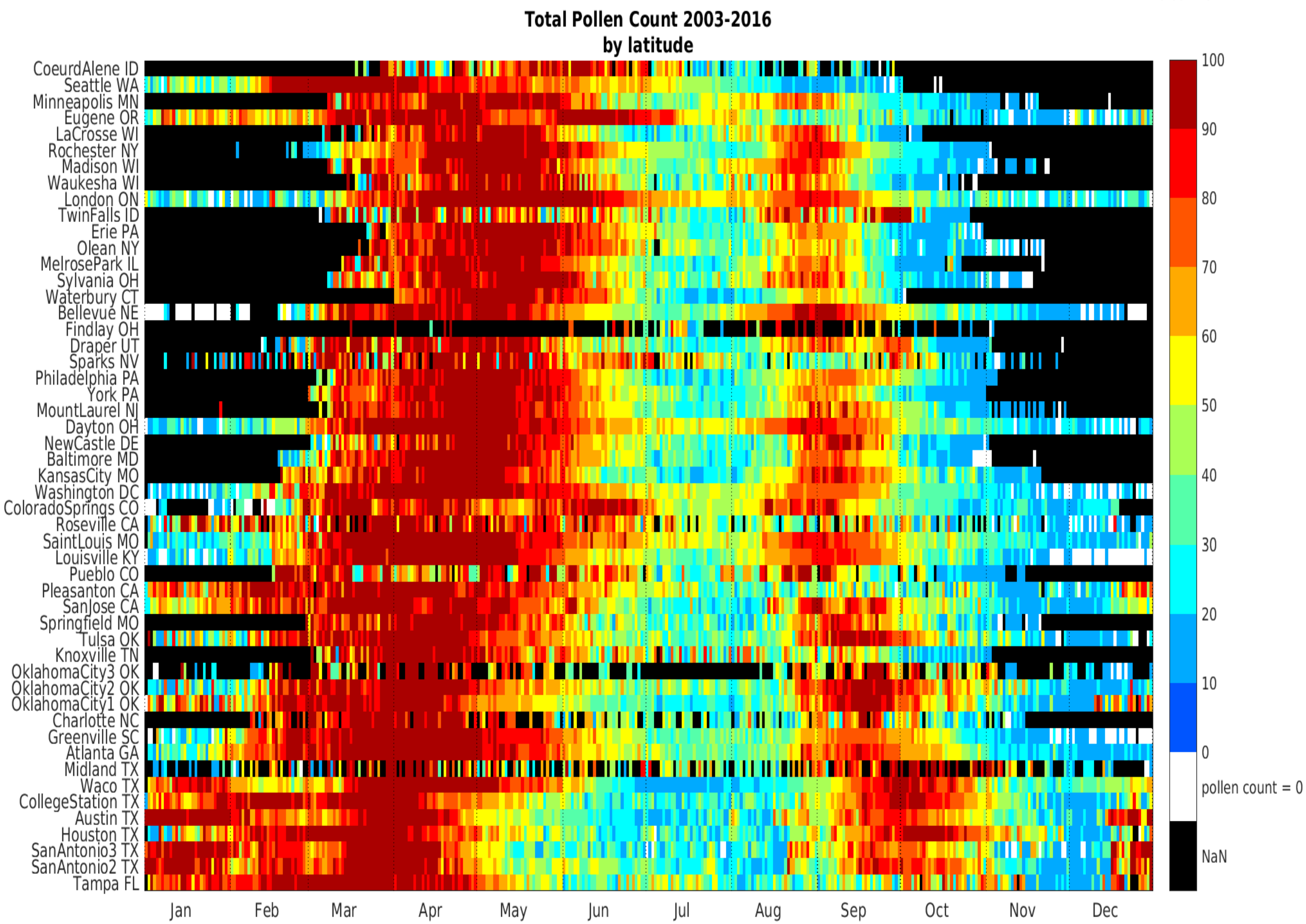
Pollen Calendar NAB Data



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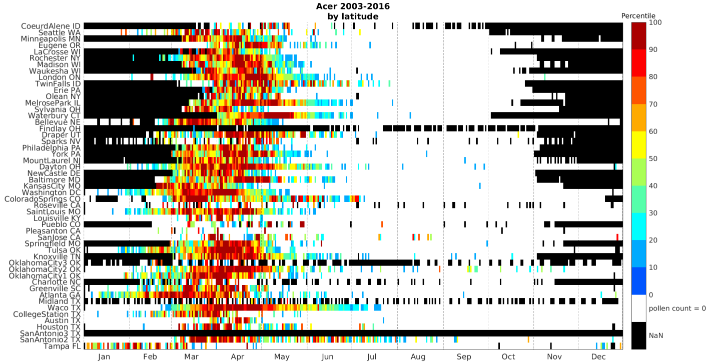
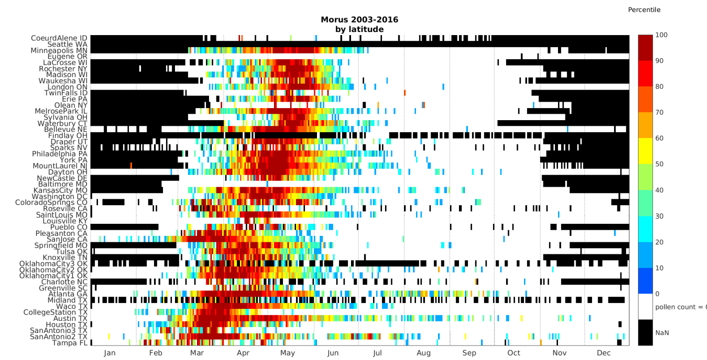
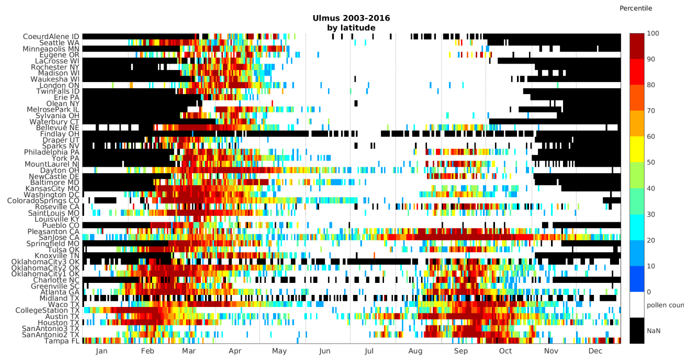
Allergenic Trees



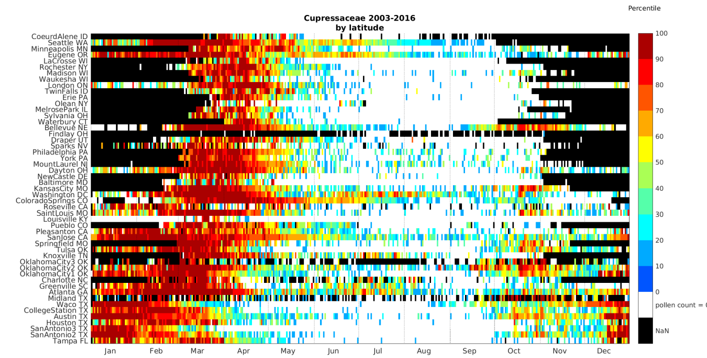
Acer (Maple)



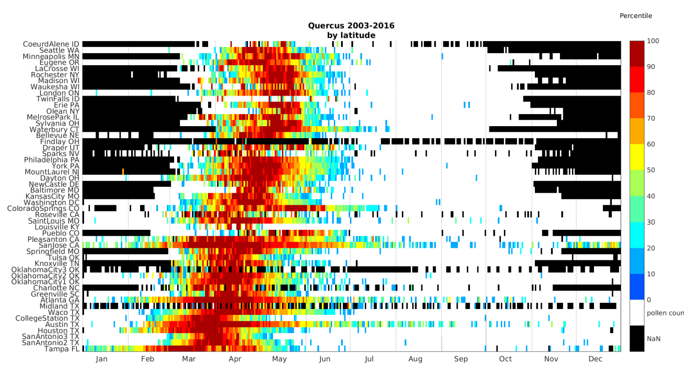
Morus (Mulberry)



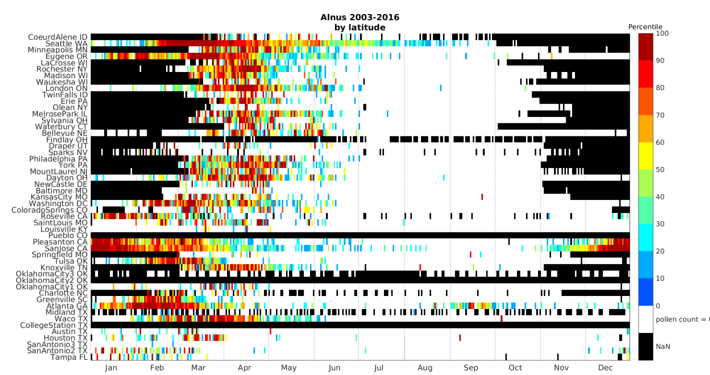
Ulmus (Elm)



Cupressus (Cypress)



Quercus (Oak)



Alnus (Alder)

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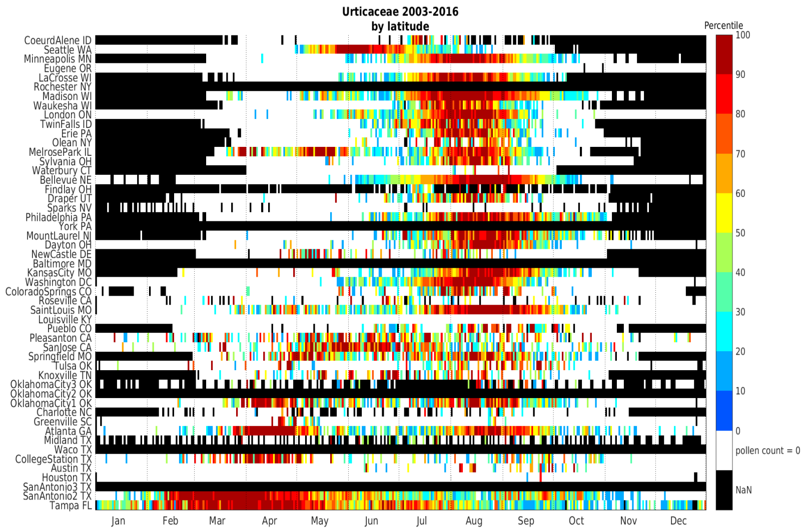
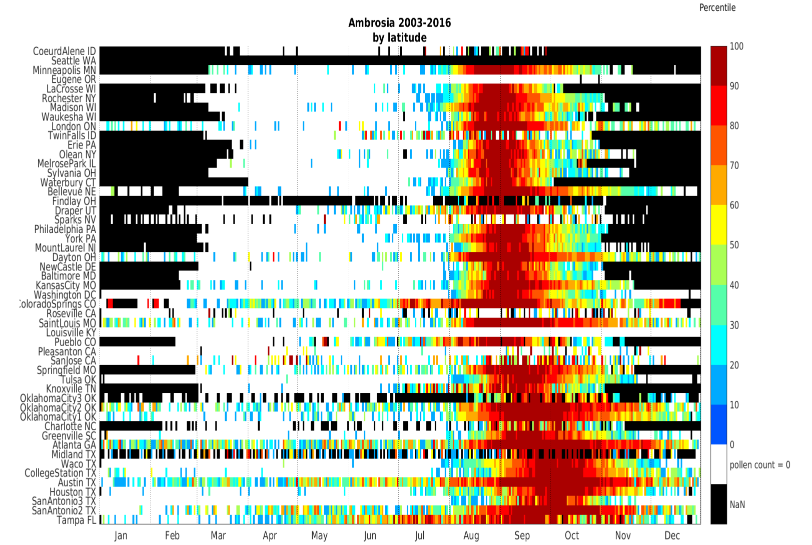
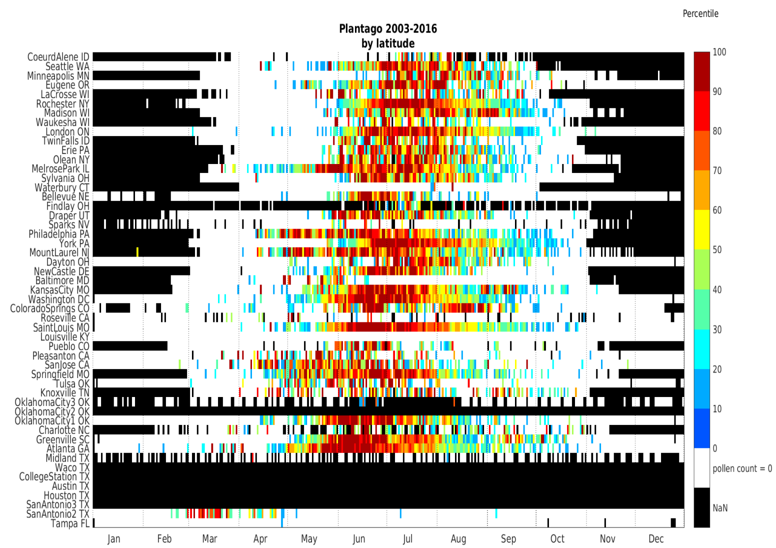
Allergenic Weeds



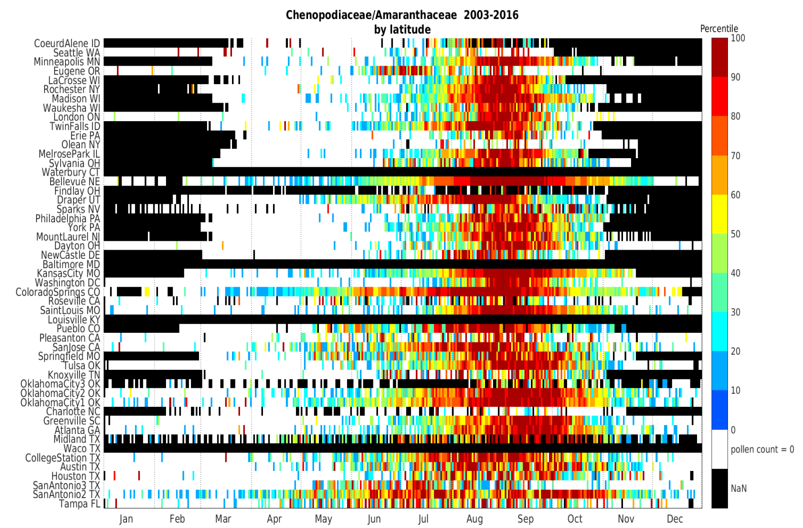
Urticacae



Ambrosia



Plantago



Chenopodiaceae/Amaranthacae

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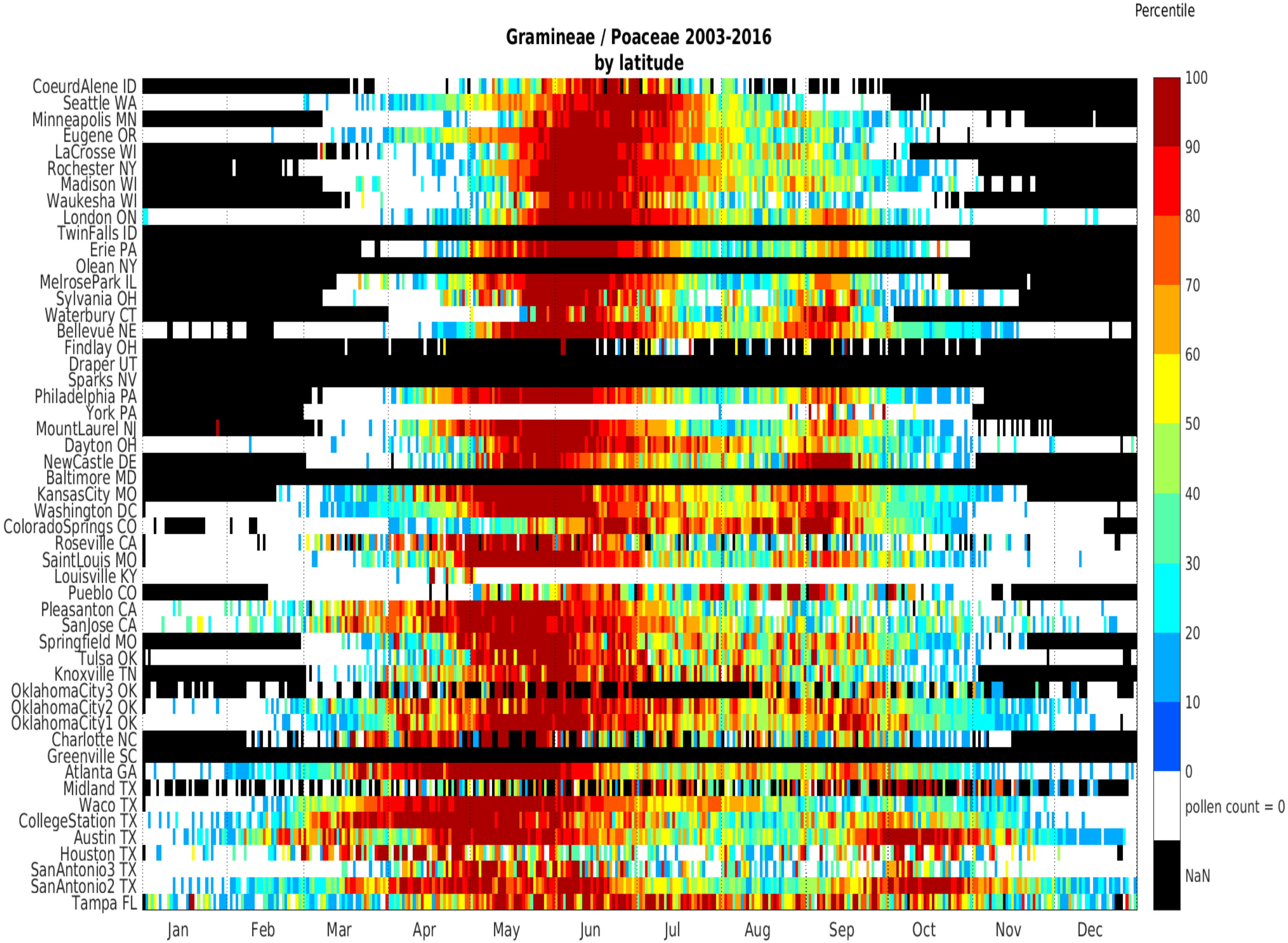
Allergenic Grass



Gramineae/Poaceae

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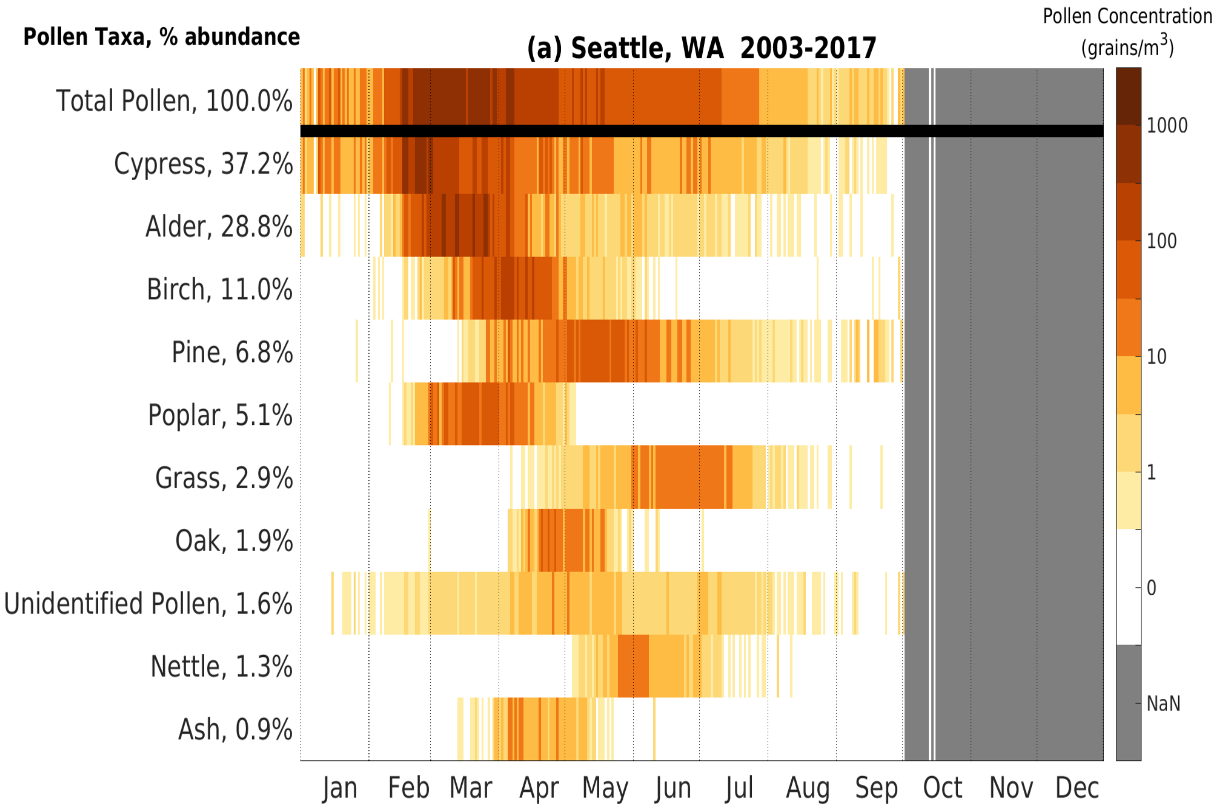
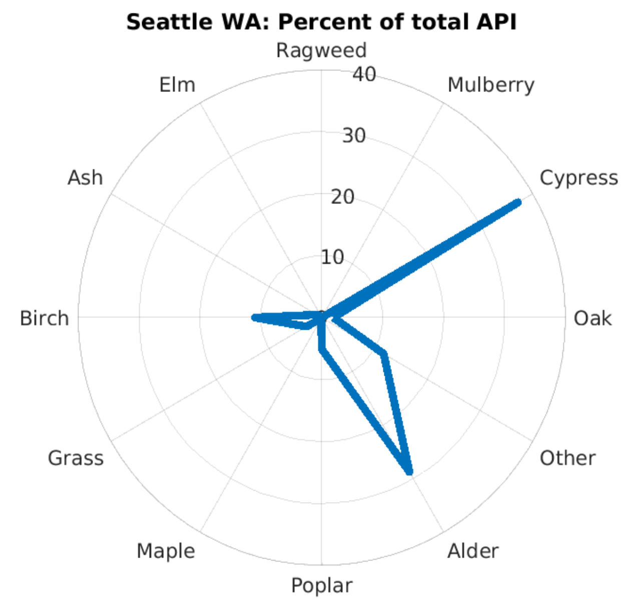
Site-specific Exposures - Seattle





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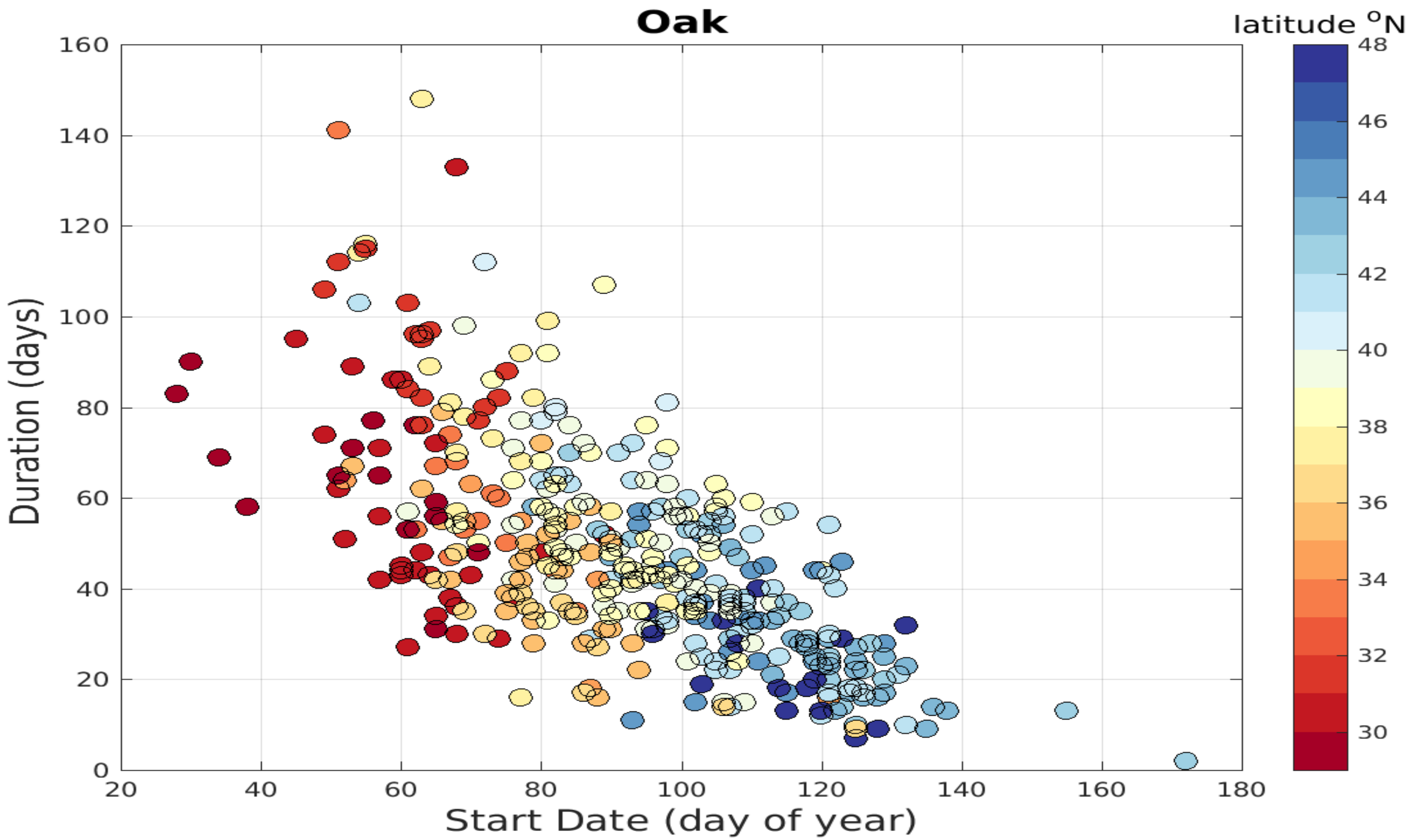
Start Date, Season Duration, Latitude



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- # FORECASTING

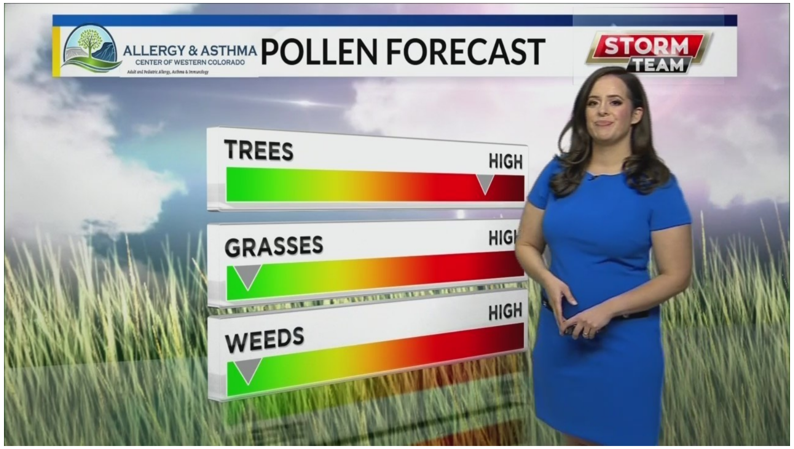


Image available [here]

Building better forecasts

Forecast Model Goals

- Develop model(s) that:
  - Work for all three major types (trees, weeds, grasses) and for specific taxa
  - Work across wide range of geographies
  - Capture start date a week in advance
  - Capture high counts several days in advance
  - Capture season end for ragweed
- Accurately support the decisions patients, clinicians, and others need to make

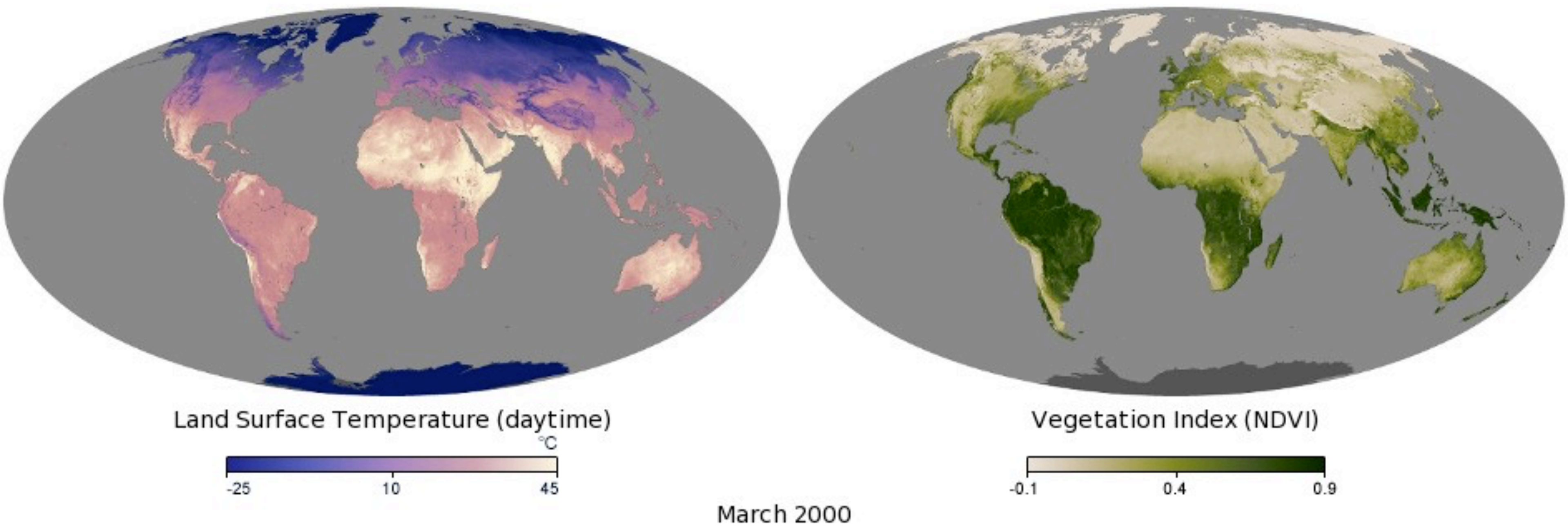
Factors Associated with Pollen in the Air

- **Temperature**
- **Humidity**
- **Solar radiation**
- **Wind speed**

Seattle, 19 March 2019
75F, very dry, high winds
Courtesy of Jeff Baars, UW Atmospheric Science

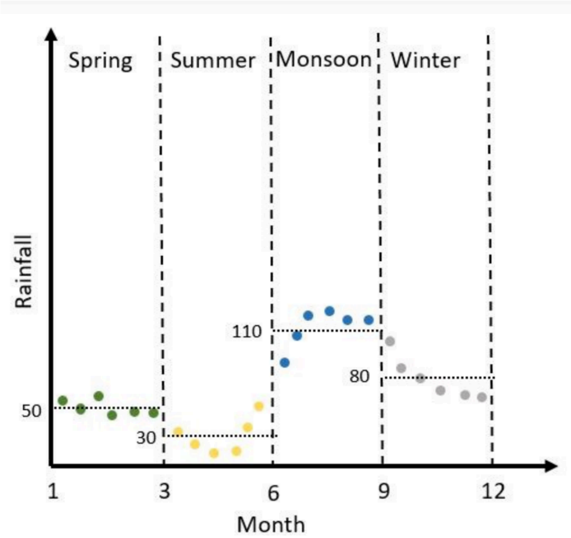
Factors Associated with Pollen Overall

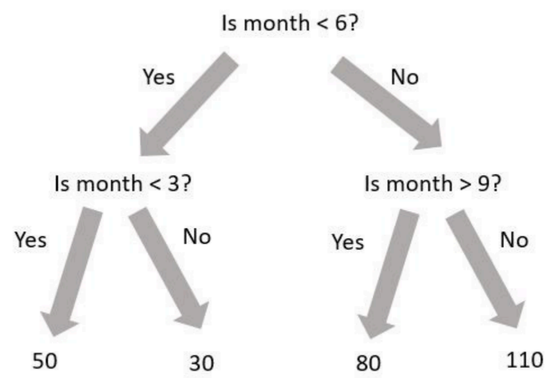
1. Meteorology 2. Vegetation 3. Geography 4. Pollen



Model Development

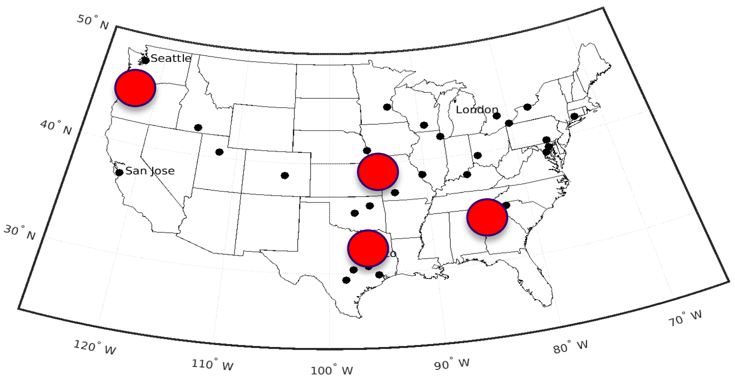
- Machine learning random forest decision tree model
- Ensemble of decision trees to build predictive model
- Computationally efficient, captures nonlinear relationships
- Example: Predicting rainfall for a specific season

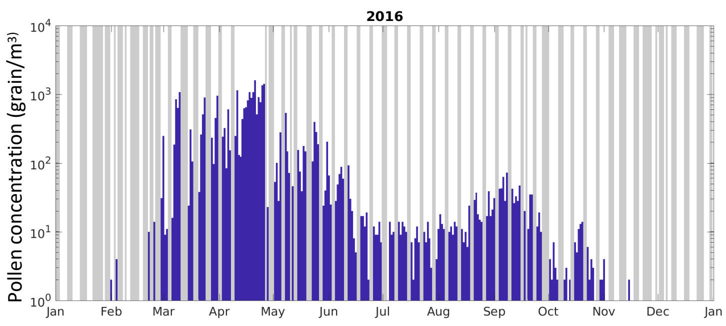




Figures from medium.com

NAB Data





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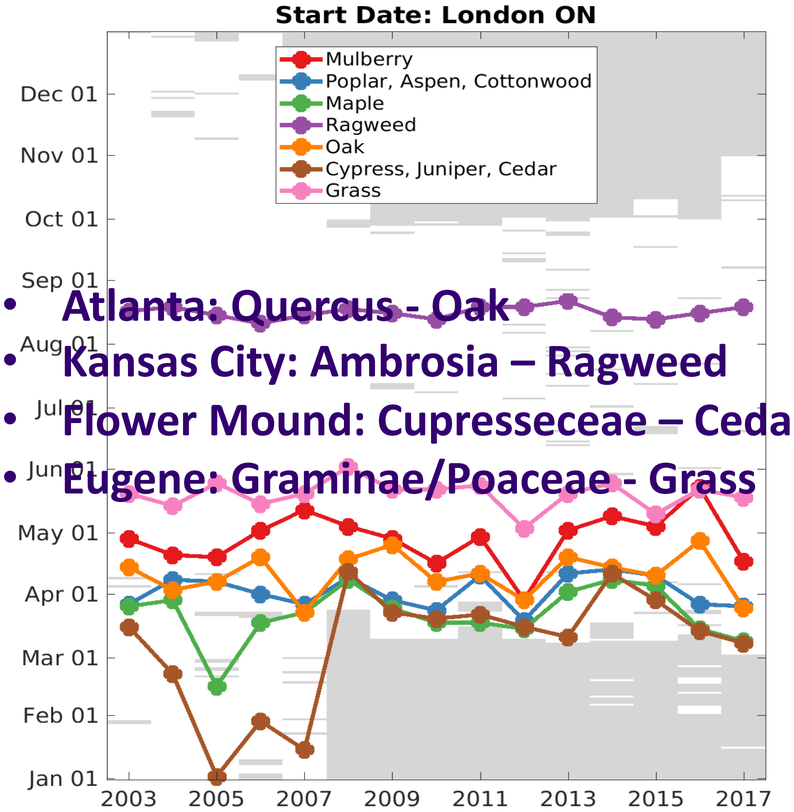

- Atlanta: Quercus - Oak
- Kansas City: Ambrosia – Ragweed
- Flower Mound: Cupresseceae – Cedar
- Eugene: Graminae/Poaceae - Grass

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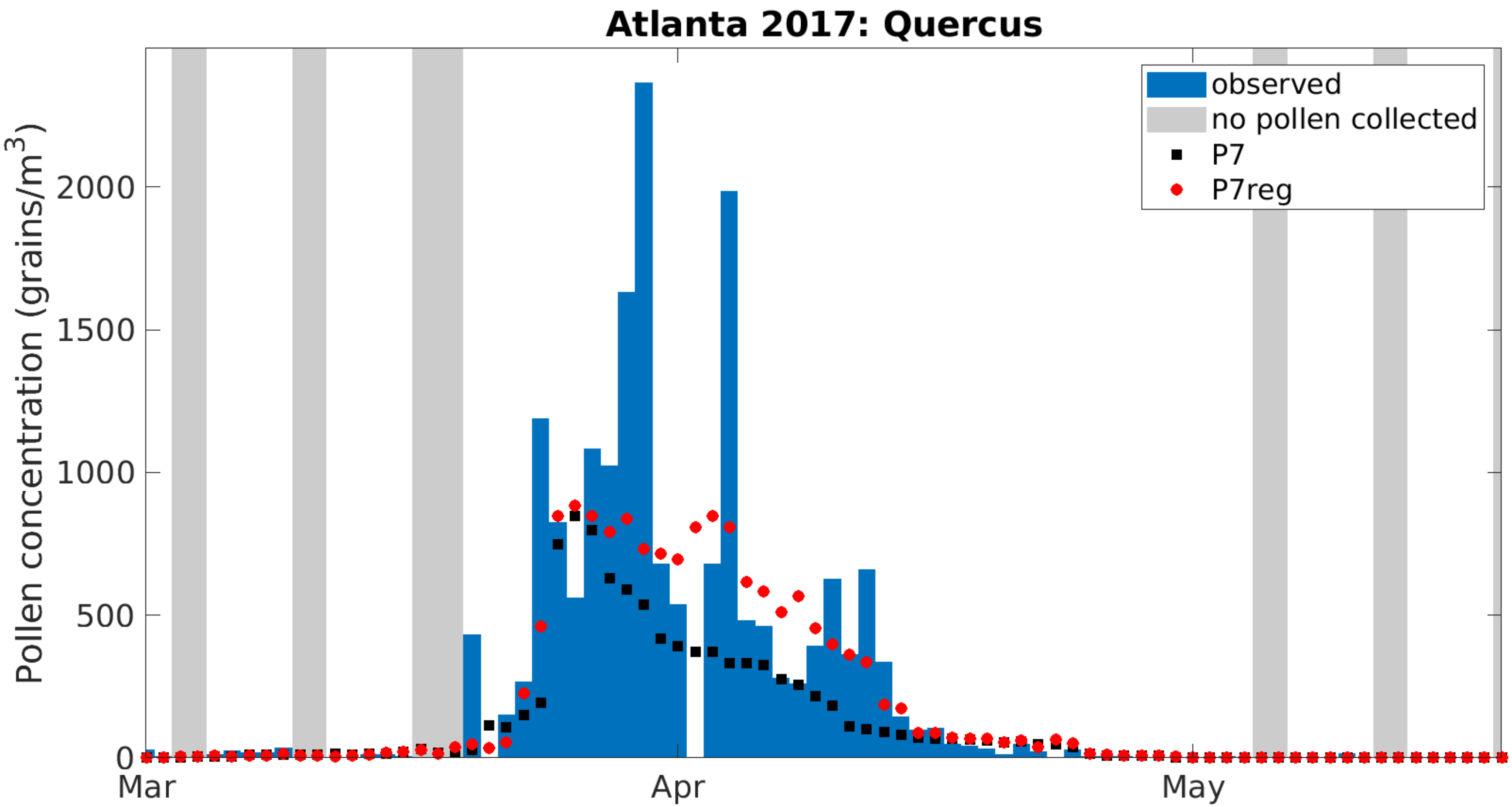
Atlanta – Quercus - Oak



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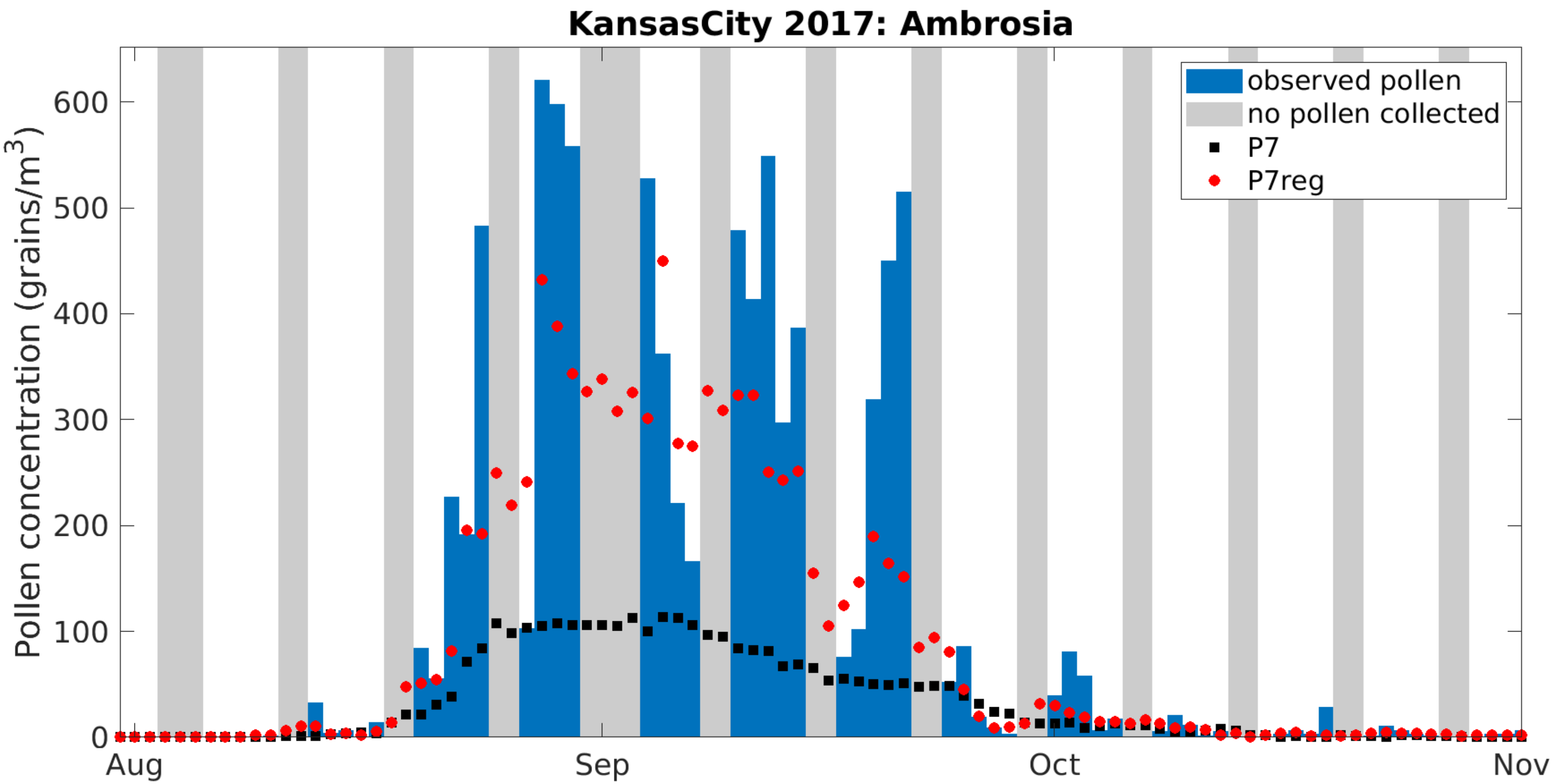
Kansas City – Ambrosia - Ragweed



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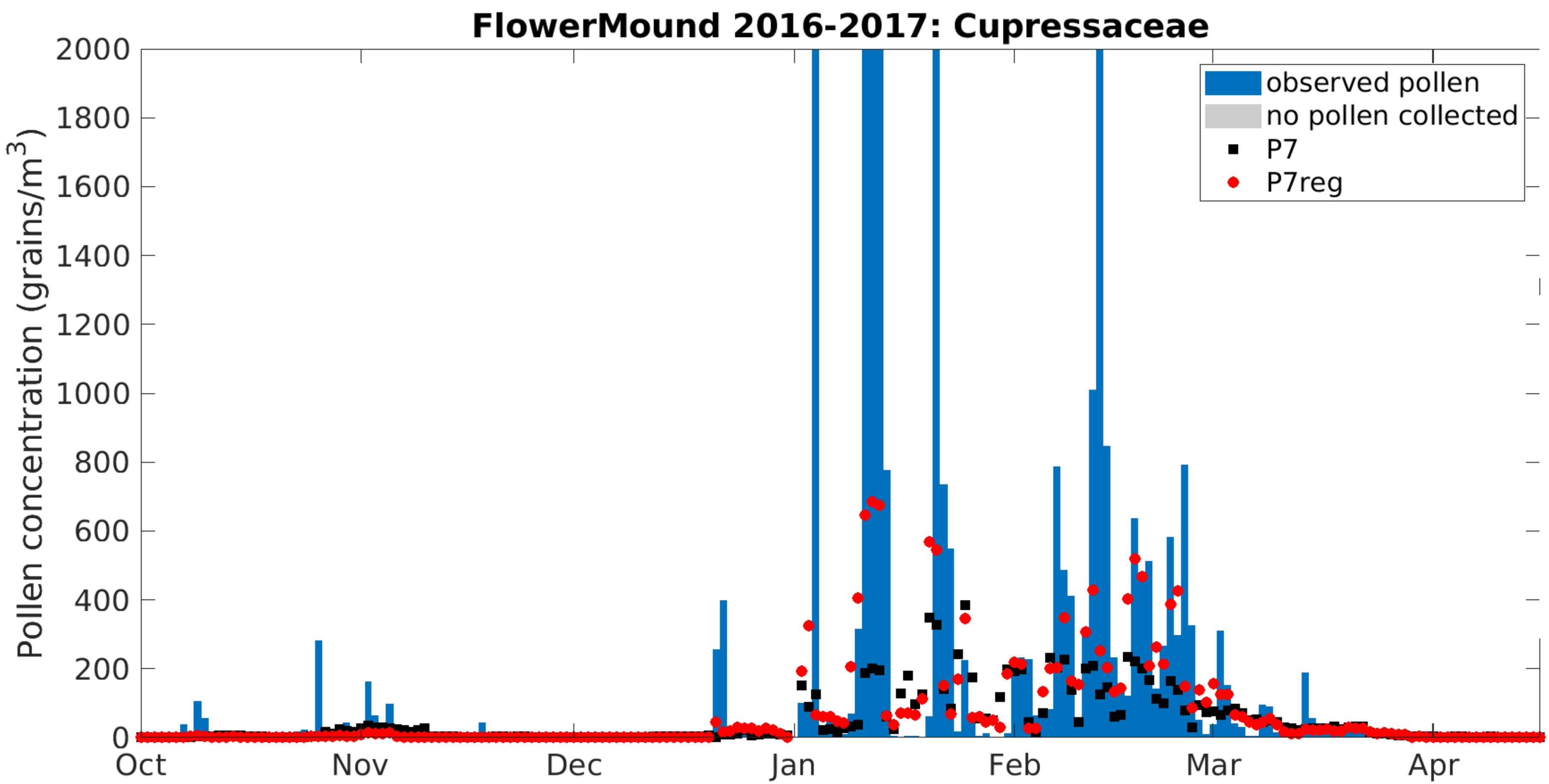
Flower Mound – Cupressaceae - Cedar



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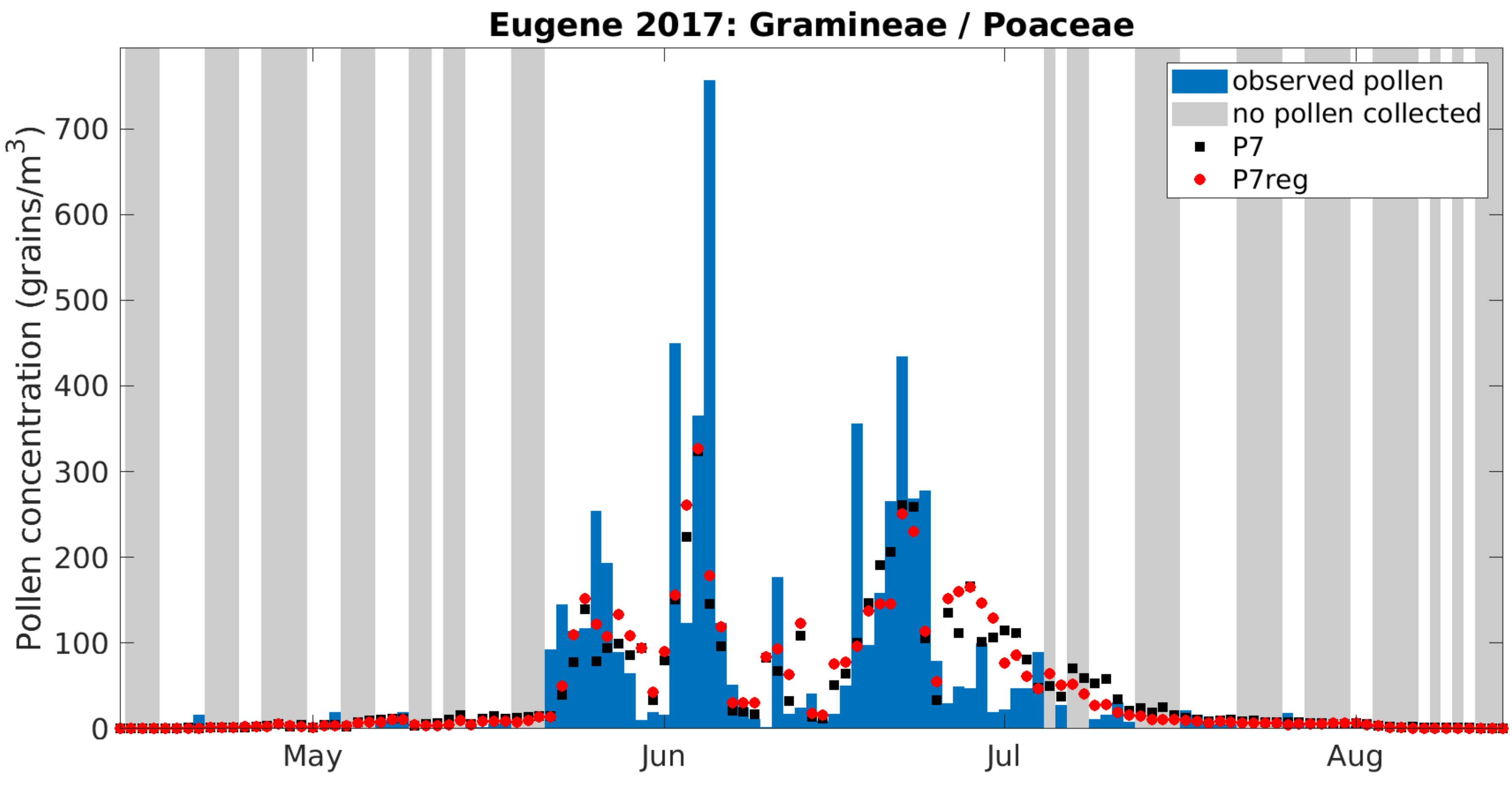
Eugene – Gramineae / Poaceae - Grass



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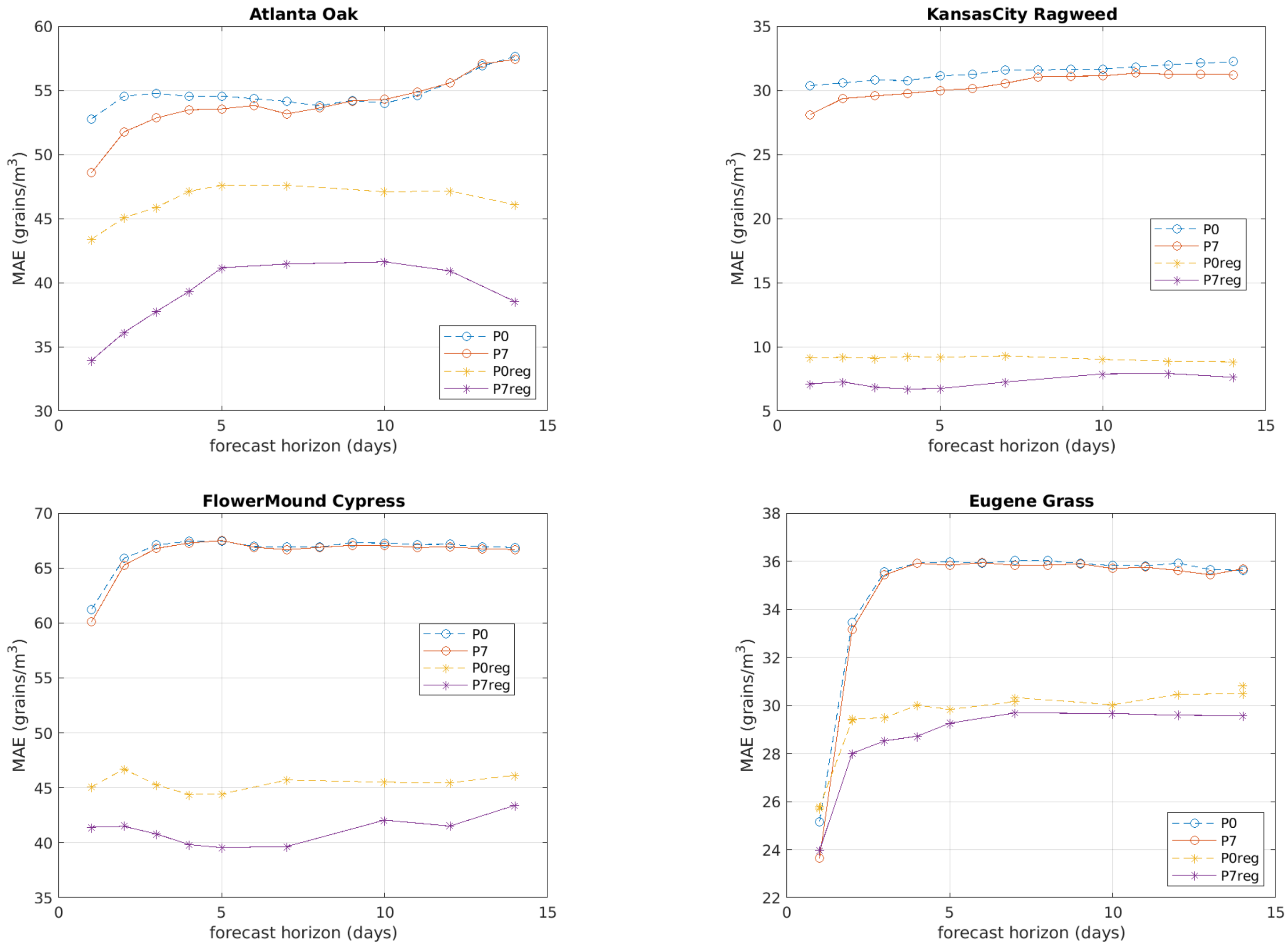
Role of Regional Data



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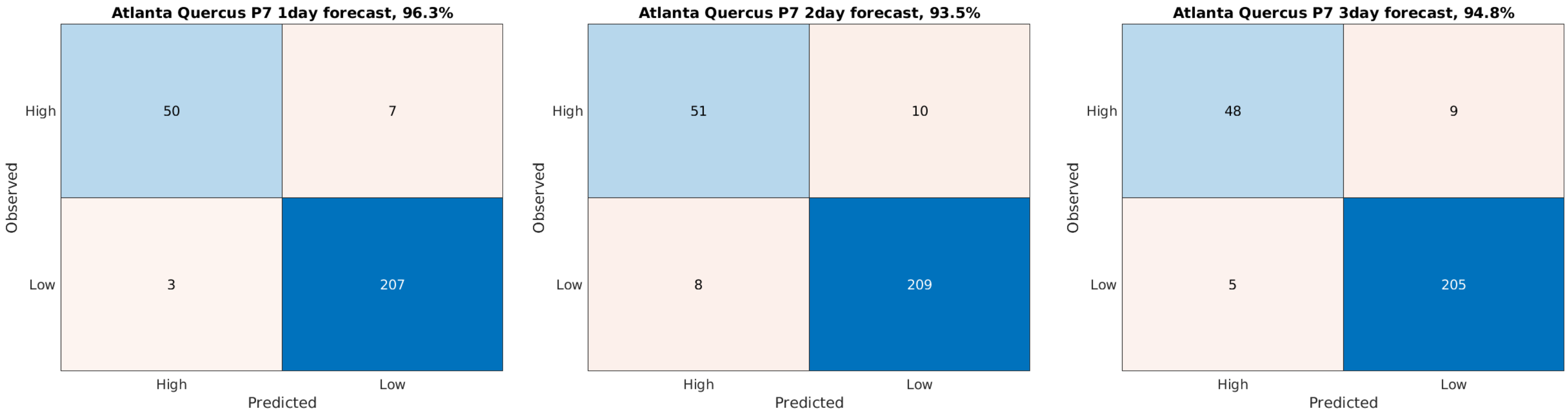
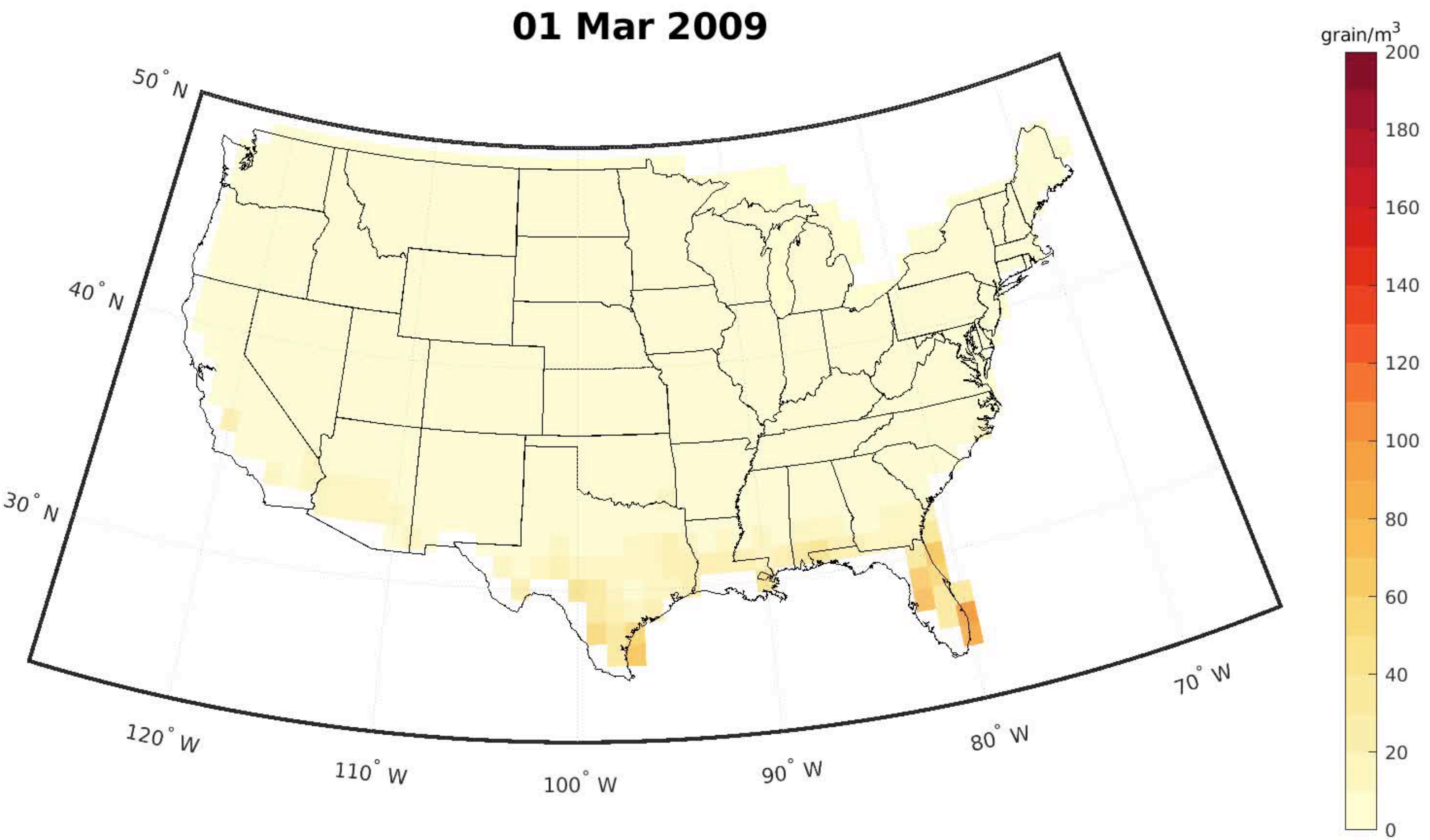
Accuracy – Atlanta – 1, 2, and 3 days



Mean average error Atlanta pollen season start date 14 day forecast: 4.7 days

Daily Oak Pollen Concentration



Next Steps

- Refine models for each taxon
- Develop regional models
  - Produce hindcast gridded estimates
  - Produce climate change projections
- Link with health damage functions
- Incorporate weather forecast data
- Bring forecast products online

Thank You!

HAQAST

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