Global Climate Change, and Airborne Allergens

One Health

5/18/2015

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Disclosures

- Industry Research
  - None
- Industry Speaker
  - None
- Financial
  - No conflicts or disclosures

Globalization, Climate Change and Human Health

Anthony J. McMichael, M.B., B.S., Ph.D.

N Engl J Med 2013, 368;14: 1335-43

Categories of Climate-Change Risks to Health, According to Causal Pathway.

Risk Category Causal Pathway

Primary

Direct biologic consequences of heat waves, extreme weather events, and temperature-enhanced levels of urban air pollutants

Secondary

Risks mediated by changes in biophysically and ecologically based processes and systems, particularly food yields, water flows, infectious-disease vectors, and (for zoonotic diseases) intermediate-host ecology

Tertiary

More diffuse effects (e.g., mental health problems in failing farm communities, displaced groups, disadvantaged Indigenous and minority ethnic groups) Consequences of tension and conflict owing to climate change–related declines in basic resources (water, food, timber, living space)

Changes in Asthma Prevalence

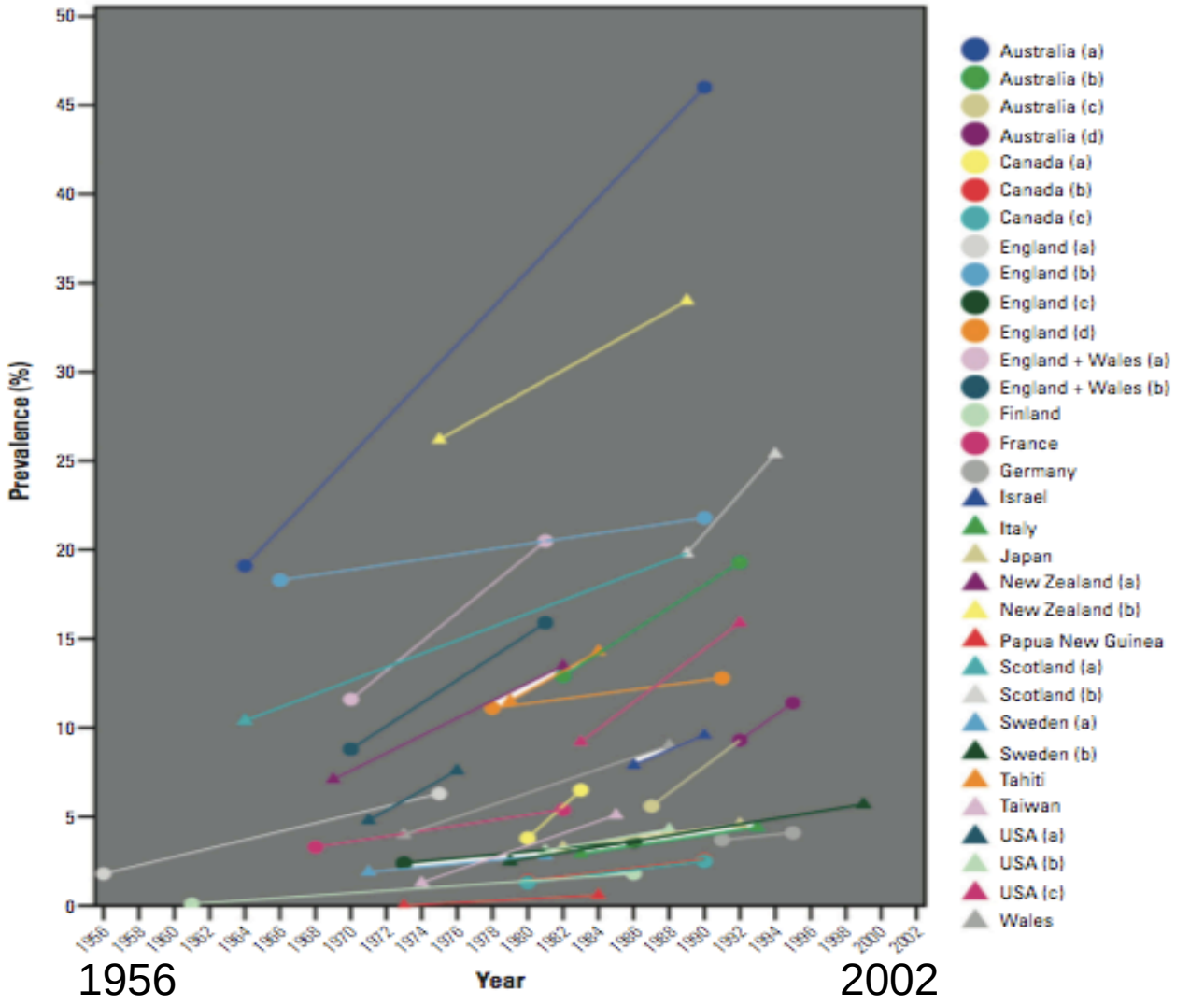
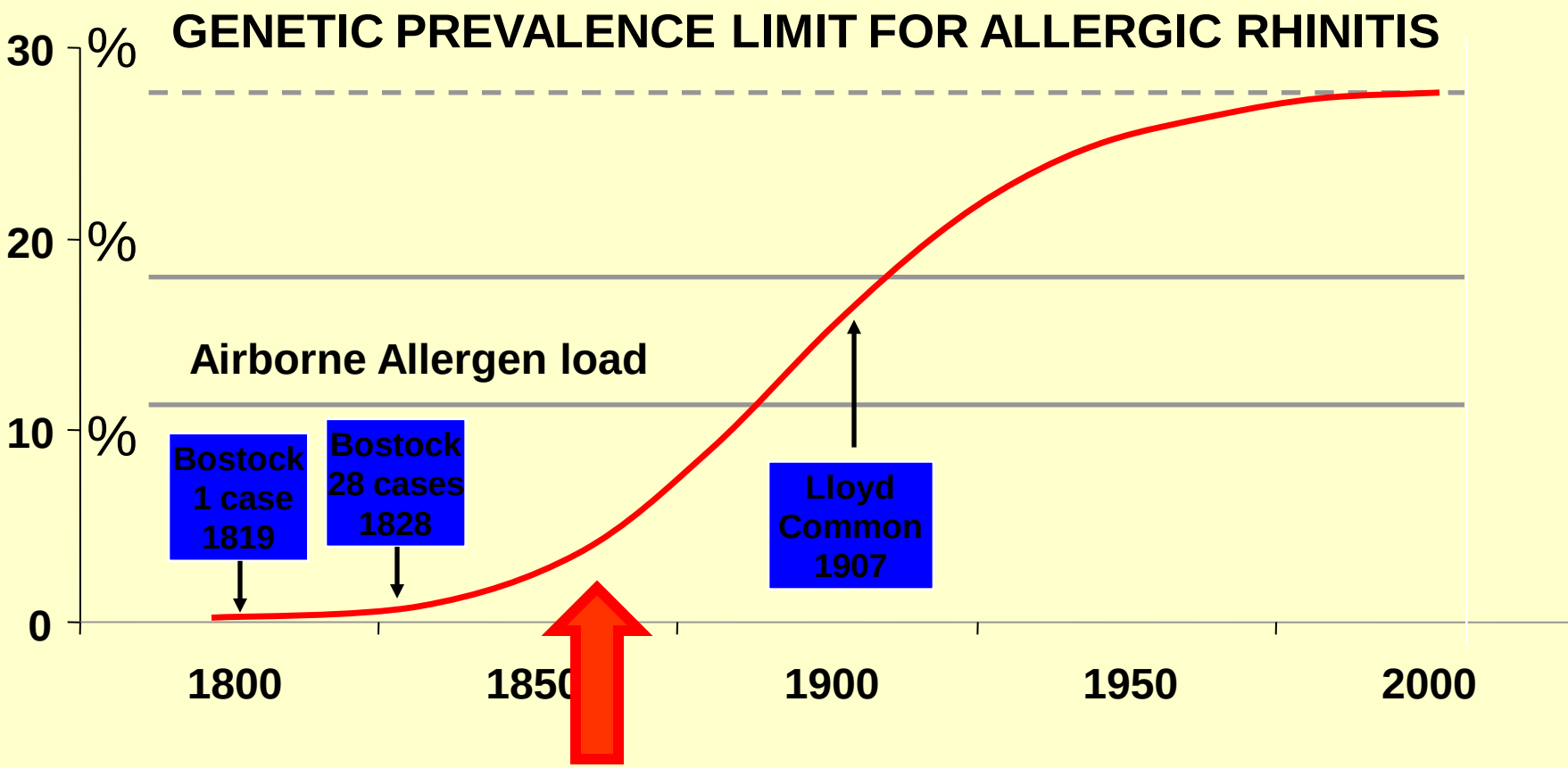


Figure 1. Changes in asthma point prevalence observed since 1956. The locations used different diagnostic criteria, but these were consistent within each study location. Different studies for the same nation are distinguished by a, b, c, and d. Data from Pearce et al. (2000).

Beggs PJ et al. Environ Health Perspect 2005 (Australia)

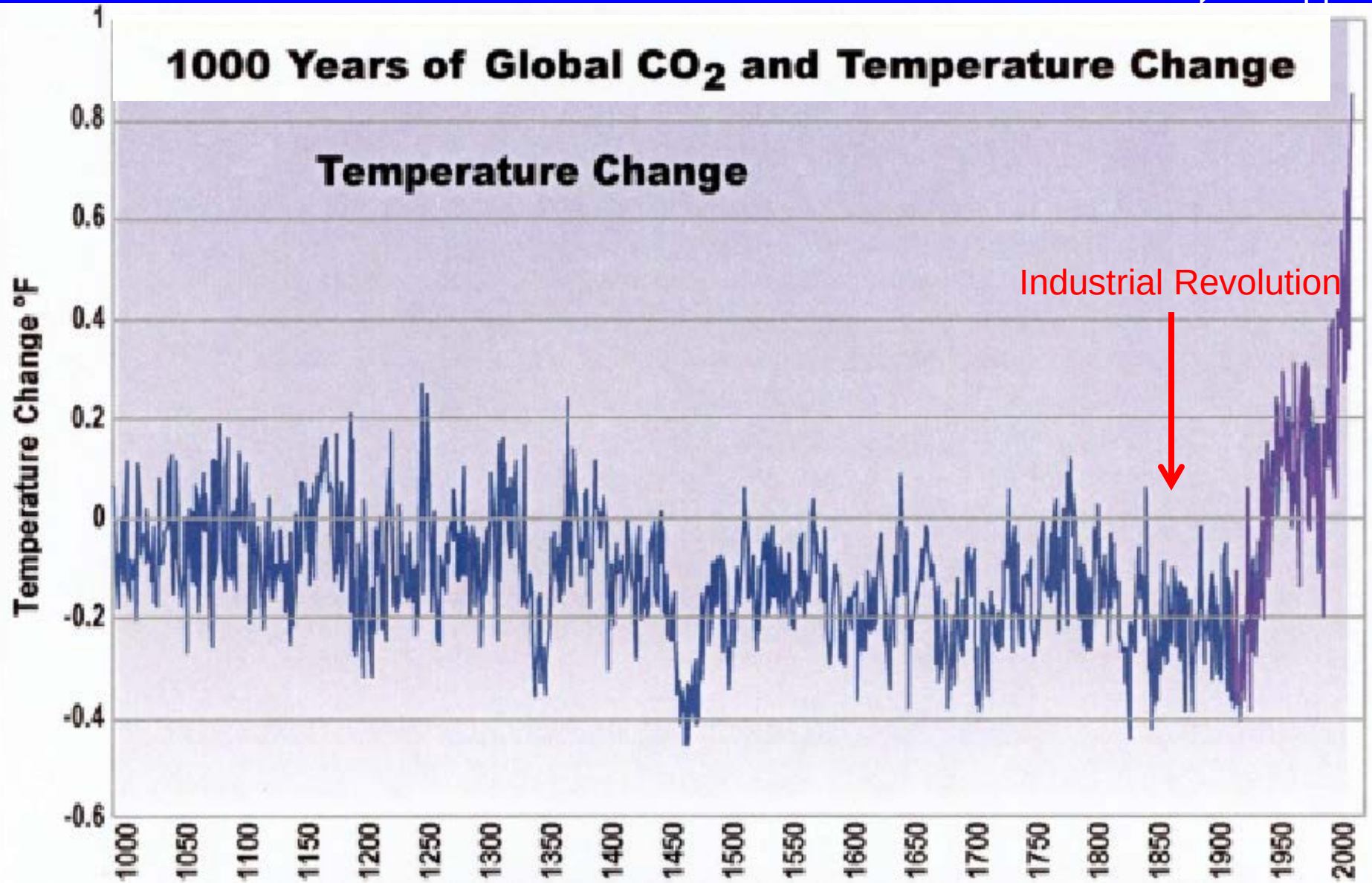
PREVALENCE OF ALLERGIC RHINITIS SINCE THE INDUSTRIAL REVOLUTION



Suspected factors contributing to the rising prevalence of allergic & pulmonary disease

- Industrialization
- Changes in antigen exposure
- Changes in childhood infections
- Changes in home construction
- Changes in activity: location and intensity
- Changes in dietary habits
- Smoking by infant's care givers
- Hygiene Hypothesis
- Biodiversity loss / Microbiota

June 2014 → 400 ppm



Intergovernmental Panel on Climate Change

HEALTH EFFECTS OF CLIMATE CHANGE

Temperature Rise [1]
Sea level Rise [2]
Hydrologic Extremes

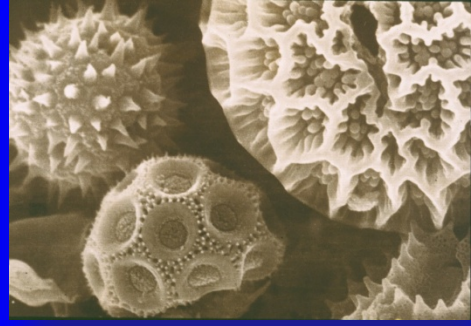
[1] **3°C** by 2100
[2] **40 cm** by 2100

IPCC estimates

Adapted from Patz,1998

Urban Heat Effect	Heat Stress Cardiorespiratory failure
Air Pollution & Aeroallergens	Respiratory diseases, COPD, Asthma & Allergy
Insect related Diseases	Malaria Dengue Encephalitis Hantavirus Rift Valley Fever Stings / Anaphylaxis
Water-borne Diseases	Cholera Vibrio parahaemolyticus Cryptosporidiosis Campylobacter Leptospirosis
Water resources & food supply	Malnutrition Diarrhea Toxic Red Tides Failed ice cellars Contaminated water
Mental Health & Environmental Refugees	Forced Relocation Overcrowding Infectious diseases Human Conflicts Cultural Impact

Climate Change is Correlated with Allergens



- Increased and faster plant growth
- Increase in plant height & biomass
- Increase in pollen production
- Increase in allergenic proteins in pollen
- Earlier and longer pollen seasons
- Higher latitudes more affected

Barnes CS, et al. J Allergy Clin Immunol:In Practice 2013;1:137-41
D'Amato GD, et al. WAO Journal 2011; 4:121-125
Ziska L, et al. Proc Natl Acad Sci 2011;108(10):4248-51
Shea K, et al. J Allergy Clin Immunol 2008;122:443-53
Wayne P et al. Ann Allergy Asthma Immunol 2002;88:279-282

Changes in Weed Pollination

Ziska L, Caulfield. Amer J of Plant Physiology,2000;27:893-8 (US)

- Tested whether the increase in atmospheric CO_2 concentrations since the Industrial Revolution may alter growth and pollen production of ragweed

- <u>Controlled chambers:</u>
  - Pre-industrial levels of CO_2 (280 mcl/L)
  - Current levels of CO_2 (370 mcl/L) ⇒ **+ 132 %**
  - Projected 2100 of CO_2 (600 mcl/L) ⇒ **+ 90 %**

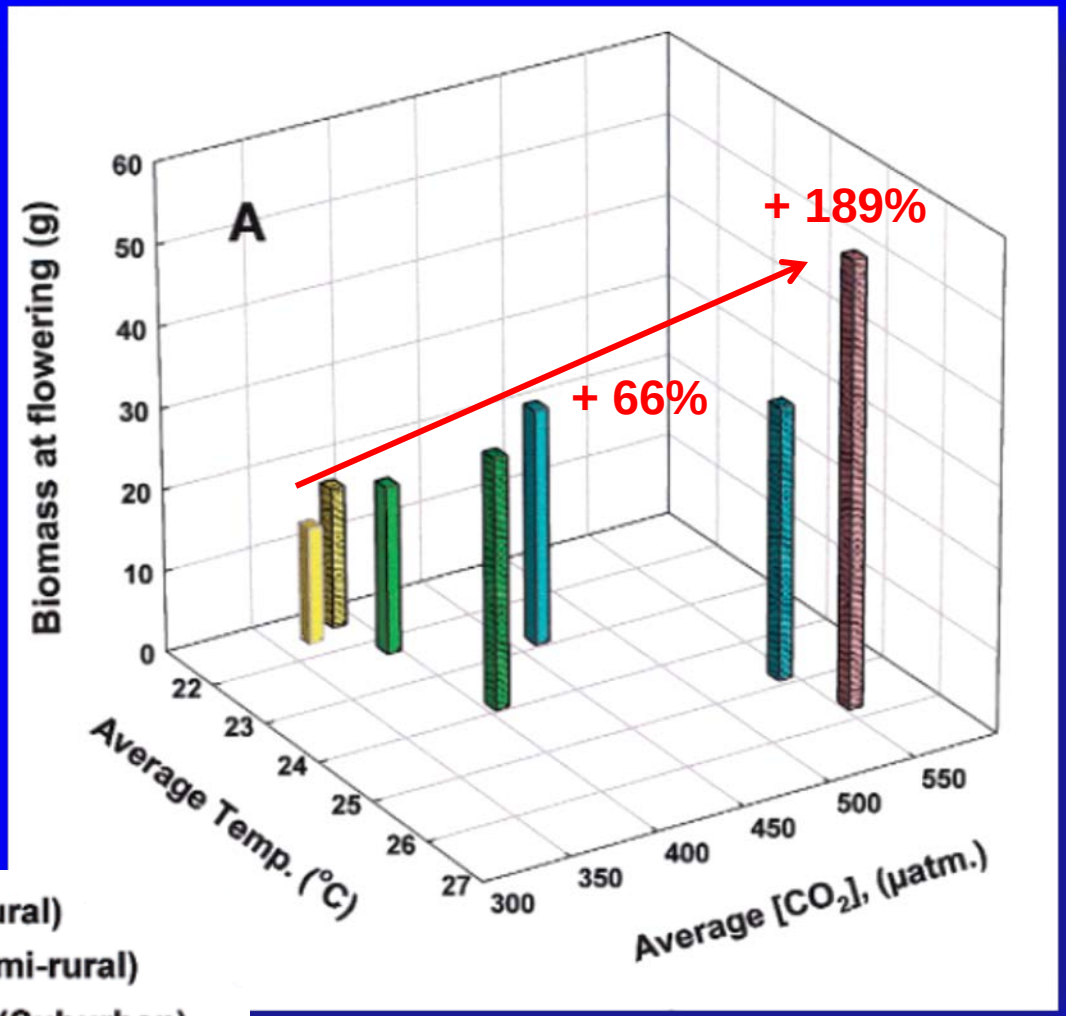
- <u>Results</u>
  - +132% increase in pollen production from preindustrial to current
  - +90% increase in pollen production from current to 2100

Changes in Weed Pollination

Ziska L, et al. J Allergy Clin Immunol, 2003. 111(2):290-5

- URBAN versus SUBURBAN versus RURAL (Baltimore, USA)
- Existing temperature and CO_2 concentration
  - 2000
    - CO_2 30% higher in urban
    - Temperature 1.8 °C higher in urban
  - 2001
    - CO_2 31% higher in urban
    - Temperature 2 °C higher in urban
- Ragweed grew faster, flowered earlier and produced significantly greater biomass & pollen in the urban areas (189%) versus rural
  - Associated with increased temperature & CO2

Rural vs. Urban Ragweed



Urban ragweed emerged 3-4 days earlier vs. rural

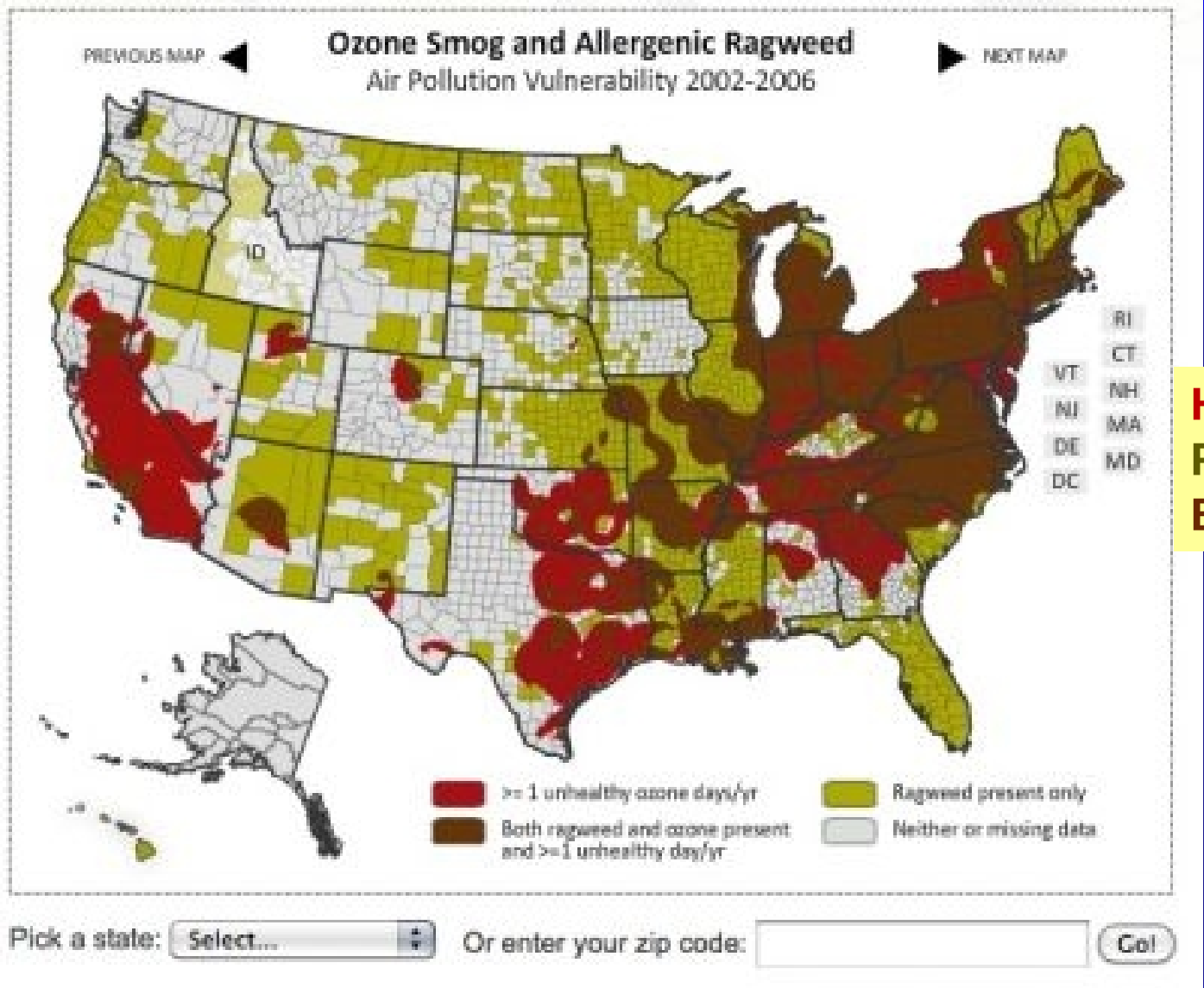
Suburban ragweed 61-66% greater biomass vs. rural

Urban 189% greater vs. rural

Ziska, JACI 2003 (US)

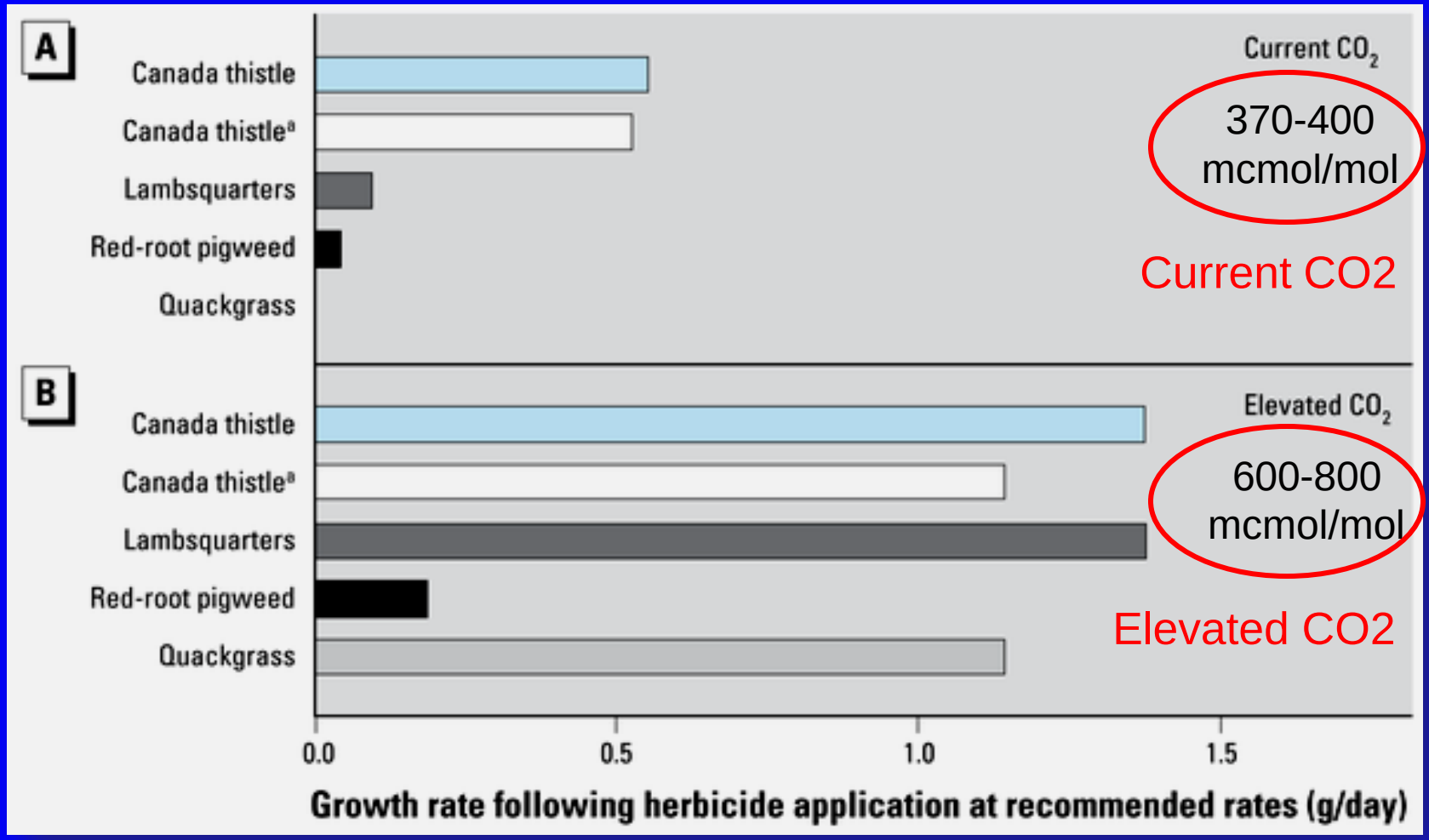
The National Resources Defense Council

Pollution & Allergenic Ragweed August 3, 2011



High Ozone
Ragweed
Both

Change in Growth Rate for Weedy Species in Increased CO2 Environment Despite Herbicides



Ziska LH, Epstein PR, Schlesinger WH 2009. Rising CO_2, Climate Change, and Public Health: Exploring the Links to Plant Biology. Environ Health Perspect 117:155-158.

Increasing Amb a 1 content in Ragweed pollen as a function of rising CO2 concentration

Singer BD et al, Func Plant Biology 2005;32:667-70 (US)

Table 2. Protein and Amb a 1 in extracts of ragweed pollen obtained from plants grown under controlled conditions of [CO_2]

The [CO_2] used correspond approximately to the pre-industrial concentration, the current concentration and that projected for 2050. Samples of pollen pooled from plants grown under the different [CO_2] were extracted as described in the methods. ELISA was performed in triplicate with each sample; results are mean ± standard deviation

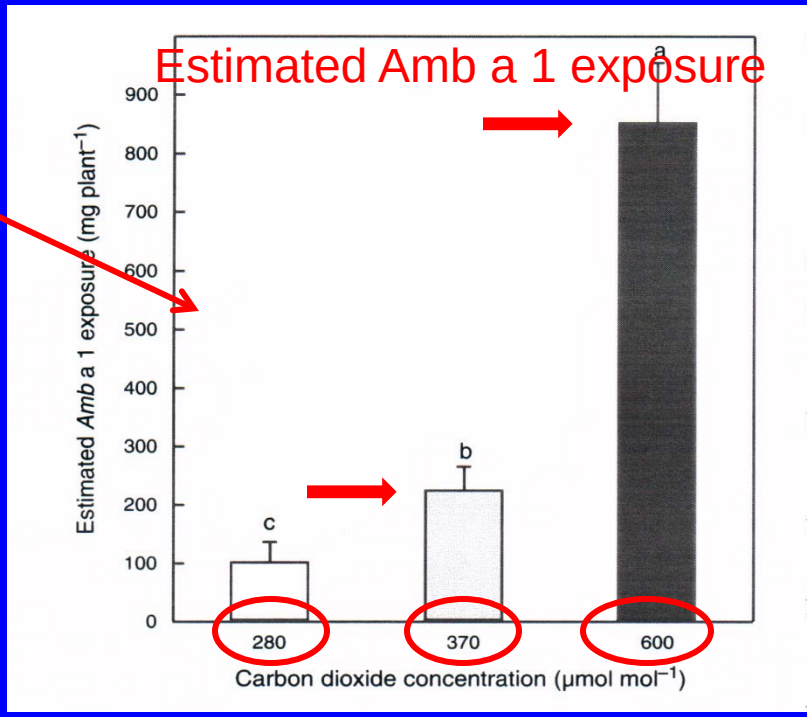
CO2 | Protein | Amb a 1 | Amb a 1/pollen

[CO_2] (μmol mol^{-1})	Protein concentration (μg mg^{-1} pollen)	Amb a 1 concentration (ELISA mg^{-1} protein)	Amb a 1 concentration (ELISA mg^{-1} pollen)
280	21 ± 2	4490 ± 960[A]	93 ± 20[A]
370	20 ± 2	5290 ± 560[B]	103 ± 11[B]
600	22 ± 2	8180 ± 900	178 ± 20

[A] $P<0.005$ when compared with projected 21st century [CO_2], t-test using unequal variances.
[B] $P<0.01$ when compared with projected 21st century [CO_2], t-test using unequal variances.

Studies conducted in controlled environmental chambers

→Increased Amb a 1 concentrations as a function of CO2.



Change in relative exposure to Amb a 1 (mg plant-1) as a function of total pollen production

Recent warming by latitude associated with increased length of ragweed pollen season in central North America

Ziska L, et al. Proc Natl Acad Sci 2011, 108(10):4248-51

Northern latitude		Length	First Frost	Frost Free
Saskatoon Canada	52.07	+27	+18	-21
Winnipeg Canada	50.07	+25	+17	-23
Fargo ND	46.8	+16	+15	-20
Minneapolis MN	45.0	+16	+13	-22
LaCross WI	43.8	+13	+9	-18
Madison WI	43.0	+12	+8	-18
Papillon NE	41.15	+11	+8	-13
Rogers AR	36.33	-3	+3	-8
Oklahoma City OK	35.47	+1	+6	-11
Georgetown TX	30.63	-4	-1	+7

Changes in Tree Pollination

- International research to identify pollen trends
  - Poland (Puc, Wolski. Ann Agric Environ Med, 2002)
    - increase in birch pollen concentration correlated with air temperature
  - Denmark (Rasmussen A. Aerobiologia, 2002)
    - earlier start, earlier peak and increased level of birch pollen correlated with increased winter and spring temperature
  - Spain (Vazquez L. et al. Int J Biometeorol, 2003)
    - projectors of pollen concentration included temperature and sunlight hours
- Summary
  - Pre-season temperature and precipitation are important projectors of tree pollen production and start date

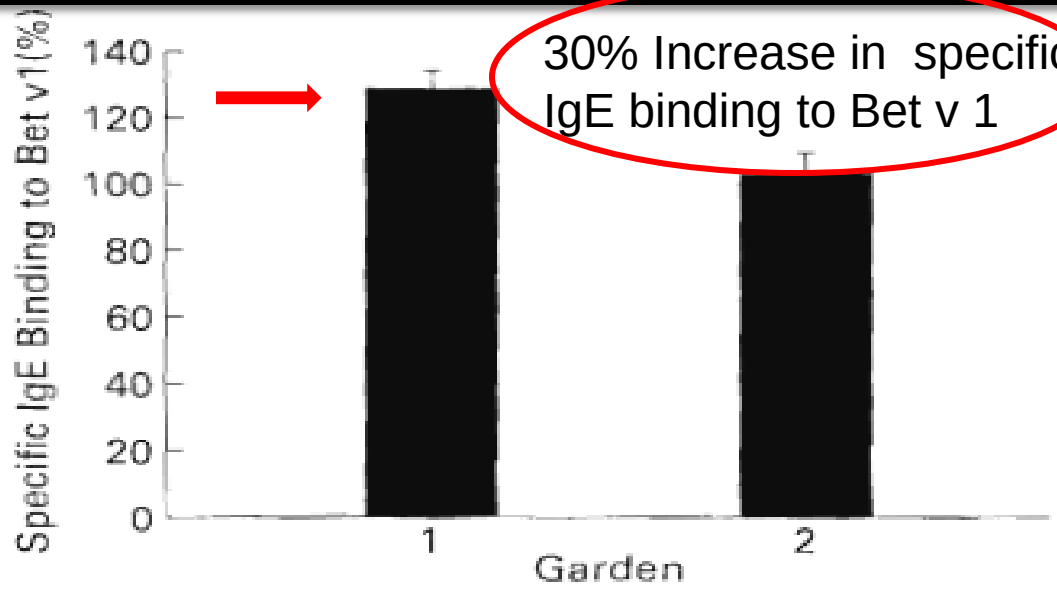
Changes in Birch Allergenicity (*Finland*)

Ahlholm JU, et al.Clin Exp Allergy, 1998, 28:1384-1388

Genetic and environmental factors affecting the allergenicity of birch (*Betula pubescens* ssp. *czerepanovii* [Orl.] Hämet-Ahti) pollen

J. U. AHLHOLM, M. L. HELANDER and J. SAVOLAINEN*

*Unit of Aerobiology and Mycological Ecology, Department of Biology and *Medicity Research Laboratory, Department of Pulmonary Diseases and Clinical Allergology, University of Turku, Turku, Finland*



30% Increase in specific IgE binding to Bet v 1

P<0.05

Fig. 2. The means and the standard errors of the band intensities of Bet v 1 in pollen samples collected from the tree line gardens. Values are proportional to standard bands and expressed as percentages. The bars were significantly different (Tukey's test, $P < 0.05$).

The Possible Role of Climate Changes In Variations of Pollen Seasons and Allergic Sensitizations over 27 years

Ariano R, Canonica GW, Passalaqua G; *Genoa Italy*

- Study Period 1981-2007
- Methods
  - Pollen collected with a Hirst type trap
  - Pollens monitored
    - birch, cypress, olive, grass, weed (*parietaria*)
  - Patients evaluated
    - Prick Skin Test for both indoor and outdoor allergens
  - Climate Variables monitored
    - Irradiation, Temperature, # days >30 °C, Humidity & Rainfall

Ariano R, et al. Annals Allergy Asthma Immunol 2010;104:215-222 (Italy)

The Possible Role of Climate Changes in Variations of Pollen Seasons and Allergic Sensitizations over 27 years

Ariano R, Canonica GW, Passalaqua G; *Genoa Italy*

- Results:
  - Pollen trends
    - Increased pollen cycle duration (earlier)
      - Trees & Weeds
    - Increased pollen load
      - Trees, Grasses & Weeds
  - Patient trends (# of patients with positive skin test)
    - Increased pollen sensitivity throughout study period
    - No change in DM sensitivity during same period
  - Correlation between Climate & Pollen/Patient trends
    - Increased irradiation > increased temp & # days >30°C
    - No correlation with humidity & rainfall

Ariano R, et al. Annals Allergy Asthma Immunol 2010;104:215-222 (Italy)

Findings

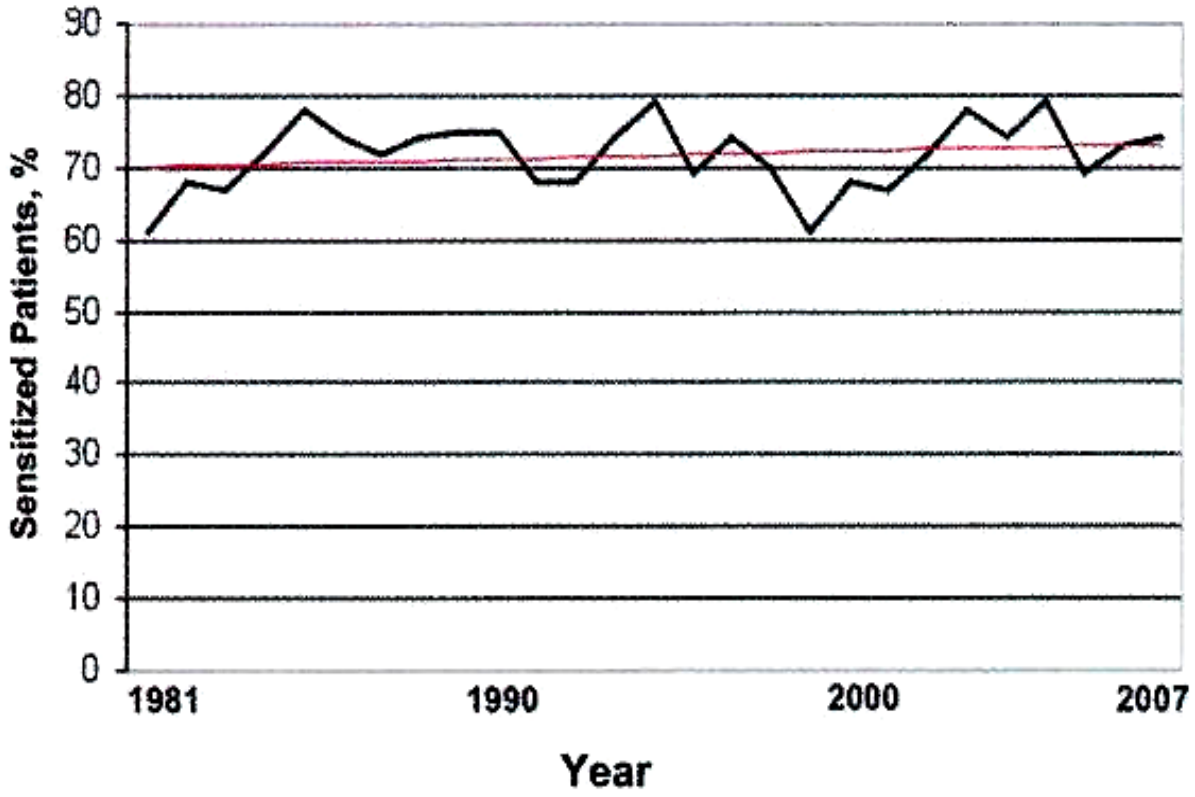


Figure 7. Percentage of patients sensitized to house dust mite during the study period. The linear trend line is shown in red.

The Possible Role of Climate Changes in Variations of Pollen Seasons and Allergic Sensitizations over 27 years

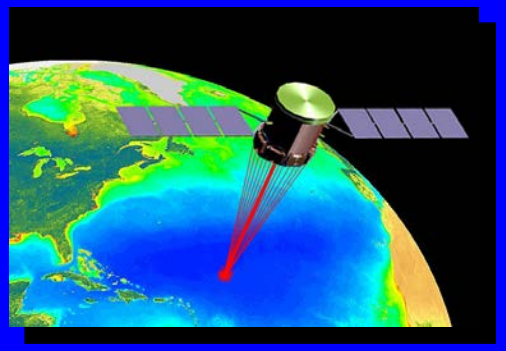
Ariano R, Canonica GW, Passalaqua G; *Genoa Italy*

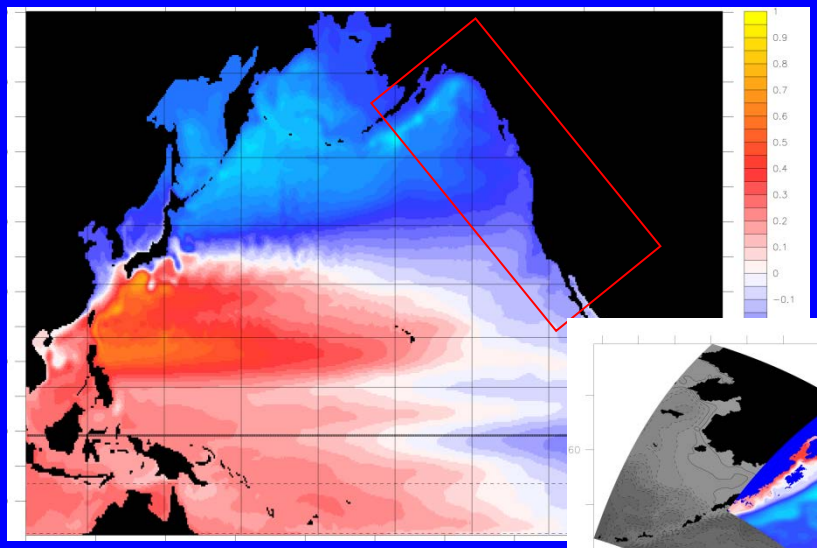
Conclusion:

- The progressive climate changes, with increased temperatures, may modify the global pollen load and may influence the rate of allergic sensitization over long periods.

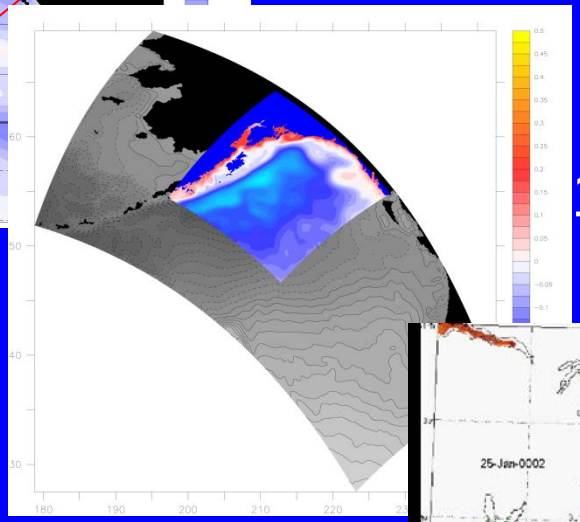
Ariano R, et al. Annals Allergy Asthma Immunol 2010;104:215-222 (Italy)

SNAP
Scenario Network Alaska Program

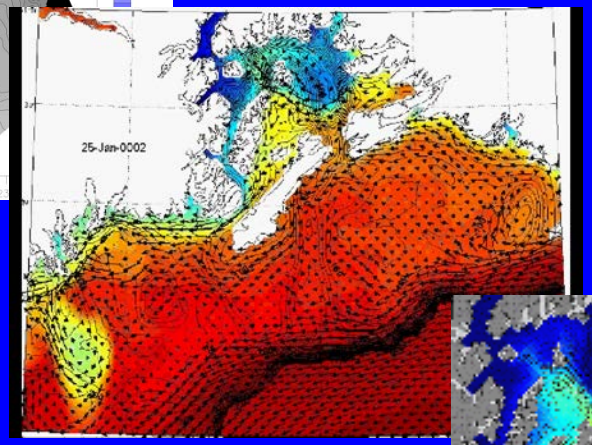




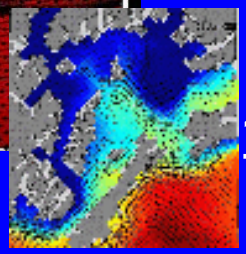
50 km grid



12 km grid



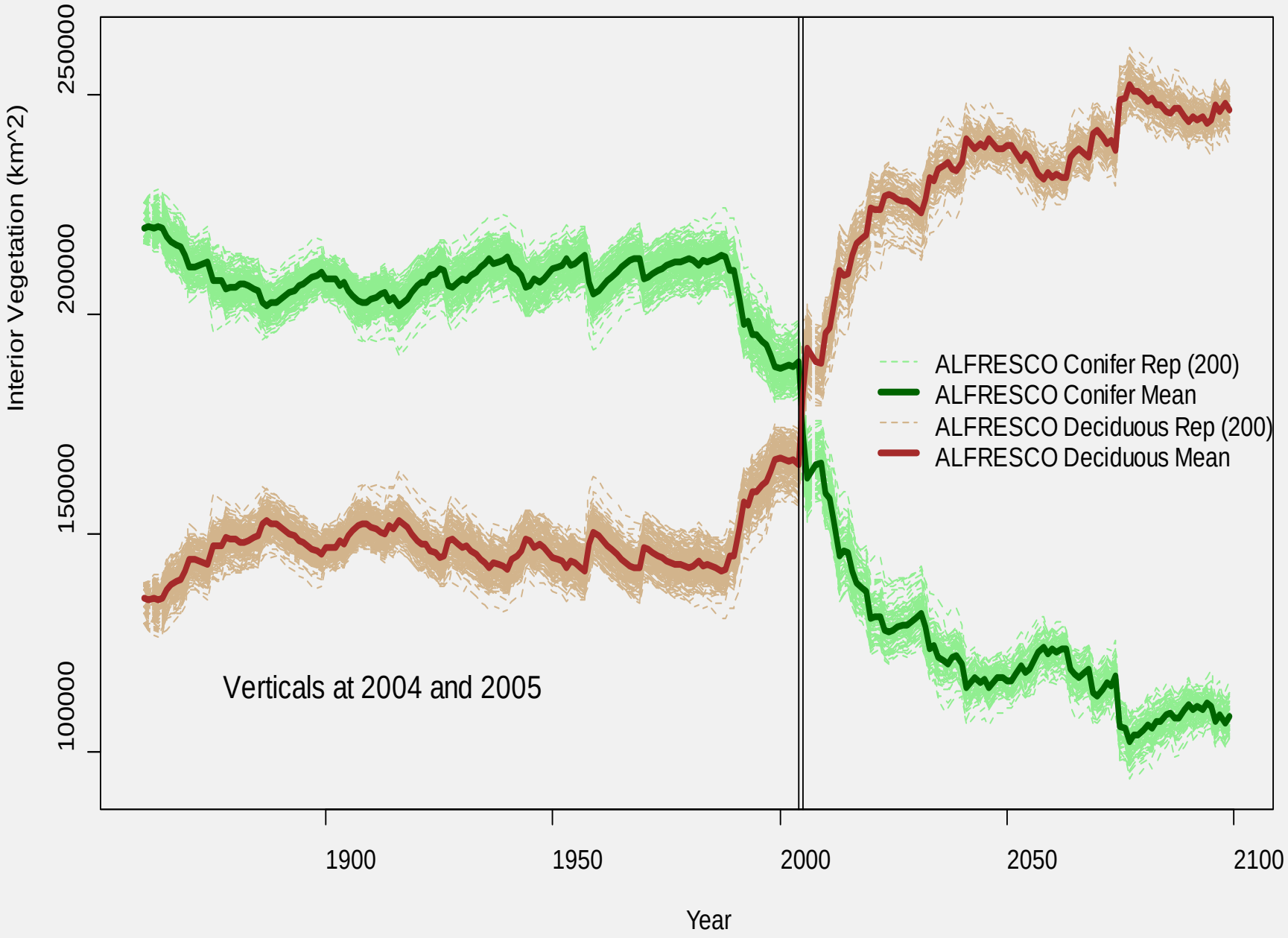
3 km grid



1 km grid

Vladimir Romanovsky, PhD
Scott Rupp,PhD
University of Alaska, Fairbanks

Simulated Vegetation Distribution



Trees invading warming Arctic will cause warming over the entire region

Swann AL, et al. Proc Nat Acad Sci 2010; 107(4):1295-1300 (US)

Denali National Park is one area that will become more heavily forested as the result of global warming. A new study indicates that as (broadleaf) trees move northward with increasing temperatures, they will enhance warming over the entire Arctic north above 60 degrees north latitude, accelerating the melting of sea ice

University of California, Berkeley

Mummified Trees Could Take Climate Scientists Back to the Future

Joel Barker,
Byrd Polar Research Center
Ohio State University
National Science Foundation

The landscape of Quttinirpaaq National Park is dominated by glaciers and sparse high-arctic tundra vegetation.

The mummified trees have very narrow growth rings, indicating a very harsh environment during their lifetime.

Canadian Arctic

Changes in Mold Sporulation

- Although not well studied, several papers suggest a correlation between rising CO2 & Temperature and increasing mold spore counts and mycelia growth

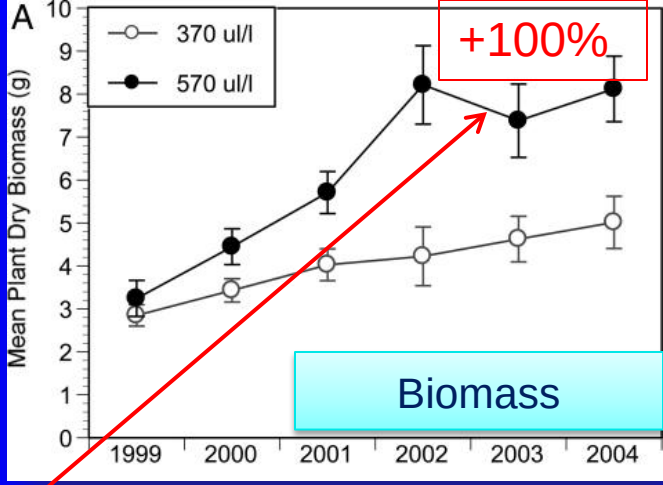
- Retrospective study of mold spore concentrations over 27 years in the UK Hollins PD, et al. Int J Biometerol.2004;48(3):137-43
  - Increased number of days *Cladosporium* spores exceeded allergenic concentration correlated with rising regional temperature

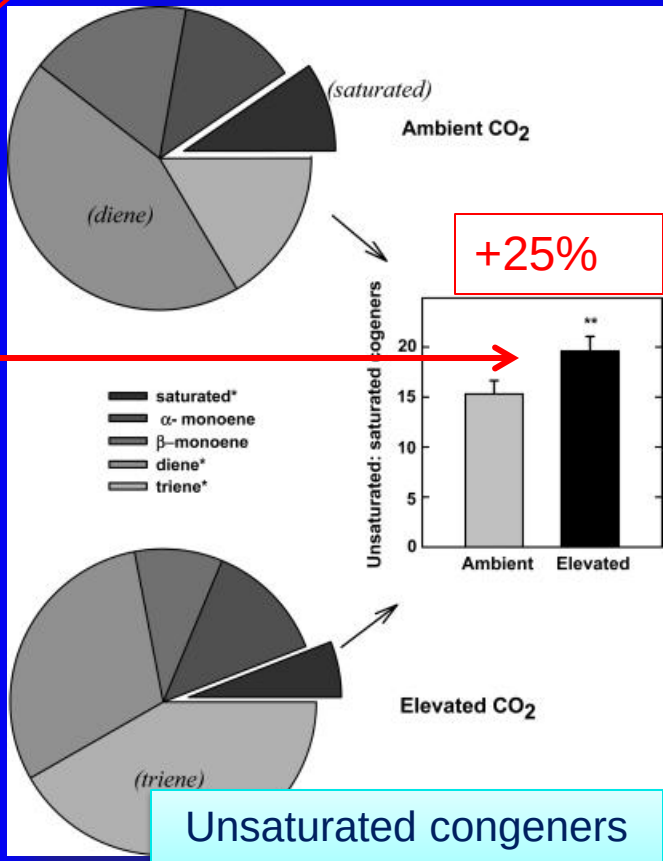
- Correlation between rising CO2 and increasing mycelia colonies has been established Lake JA, et al. J Experimental Botany.2009;60(11):3123-3131
  - Increase of CO2 from 400ppm to 800ppm increased established mycelia colonies 40%

Biomass and Toxicity of Poison Ivy to Elevated CO2

Mohan JE, Ziska LH, et al PNAS,2006;103(24):9086-89

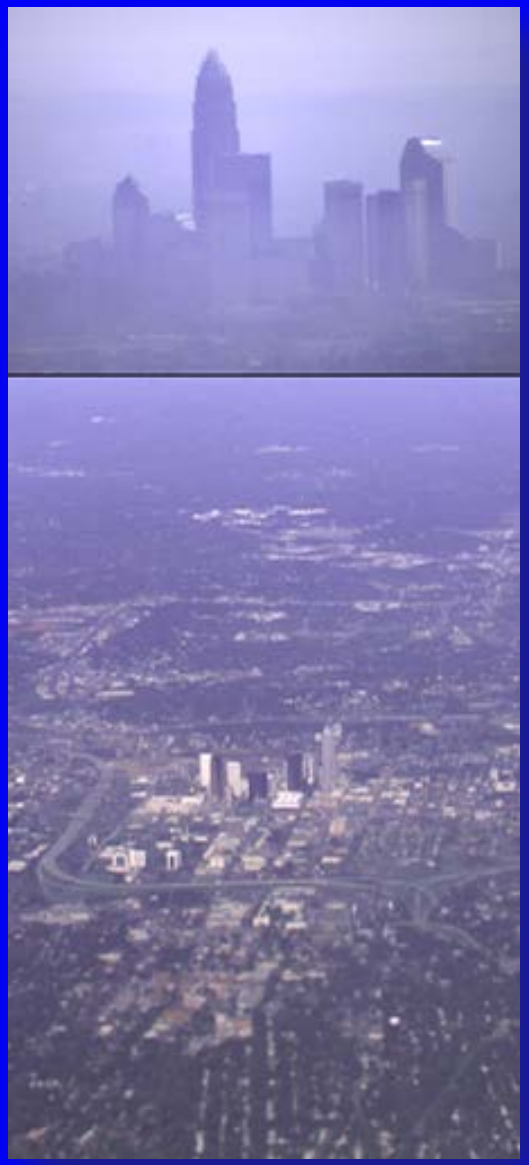
- 6 year study at Duke University
- Increasing CO2 (570 versus 370 mcl/L)
  - Increased photosynthesis by 77%
  - Annual biomass doubled
    - Increases annual growth by 150% compared to the 75% annual growth of the plants exposed to ambient CO2
  - The more allergenic “unsaturated urushiol” increased
  - The more unsaturated the urushiol the more poisonous the plant
- Increasing vine abundance may inhibit forest regeneration



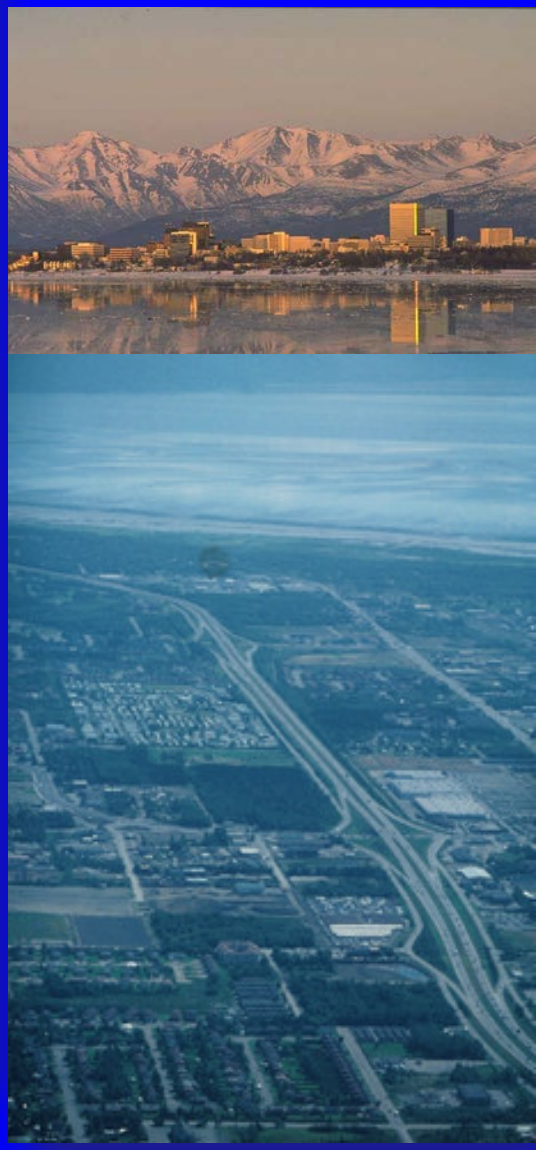


Hotspots: Cities

- Air pollution / CO2
- Heat waves
- Increased pollen
- Exacerbations of chronic disease
- Extreme precipitation events and storms

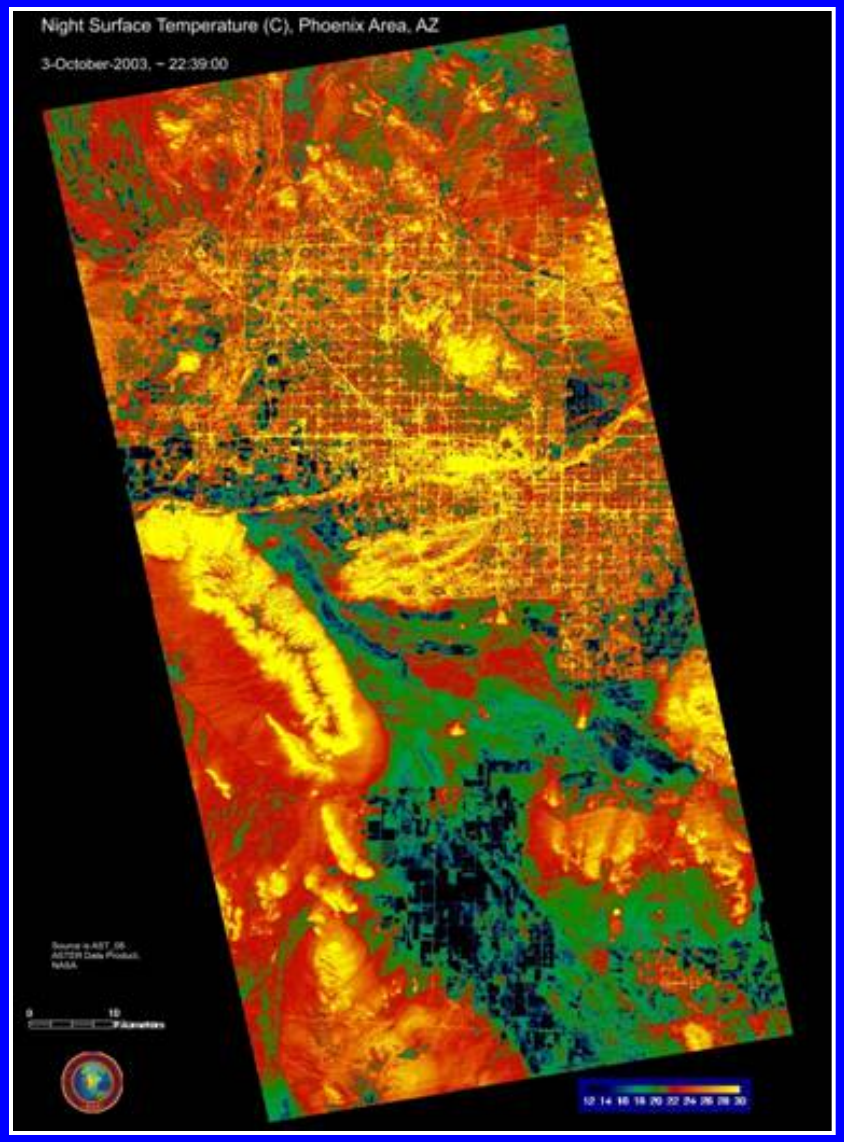


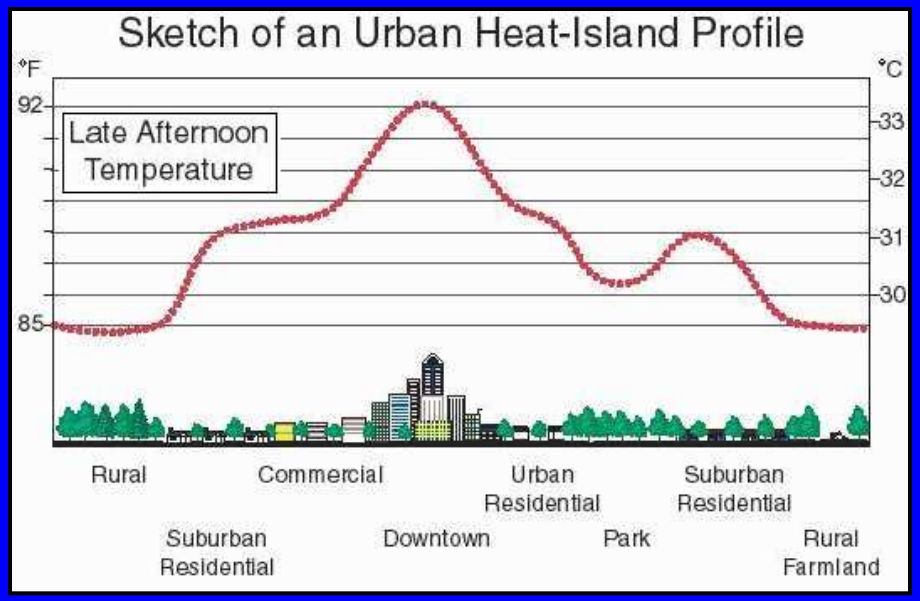
Atlanta



Anchorage

Urban Heat-Island Effect





Thermal Satellite Image of Phoenix, AZ Night Surface Temperature

CDC Environmental Health

Common Air Pollutants

Ozone (ground ozone)

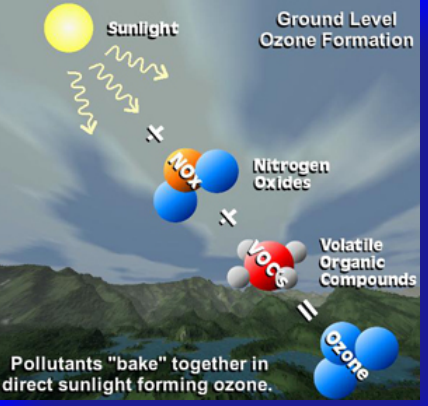
Nitrogen Dioxide

Sulfur Dioxide

Carbon Monoxide

Lead

Particulate Matter ($PM_{2.5}$)



Ozone (O_3^-)

Stratopheric Ozone

- Naturally occurring in the stratosphere (6-30 miles)
- Protective “ozone layer”
- Blocks most UV-B rays

Ground Ozone

- Near ground level
- Cars, factories, power plants, gasoline vapors & chemical solvents
- VOC + NOx + Heat + Sunlight = OZONE
- Increased risk of respiratory disease
- Interferes with the ability of plants to produce and store food, increasing susceptibility to disease, insects, other pollutants, and harsh weather

www.epa.gov

Air Pollution in Alaska

Distribution or Survival of Insects

- Arthropods are extremely temperature sensitive

- Climate changes have impacted life cycles and expanded inhabitable territory
  - Hymenoptera are surviving winter and expanding northward, resulting in increased sting events, anaphylaxis and fatalities (Alaska)
  - Mosquitoes and plant communities are migrating to higher ground as temperatures warm, permafrost thaws and glaciers retreat (Worldwide)
  - Beetle plagued forests in Alaska have impacted over 4,000,000 acres, (US)
  - Lepidoptera are expanding their northern boundaries in the northern hemisphere, (UK)
  - Ticks (*Ixodes ricinus*) have extended northwards in Sweden associated with fewer winter days below 10 degrees and more summer days above 50 degrees, (Sweden)

Impacts of Climate Change on Plant Food Allergens

Beggs PJ, Wylczk NE. Air Qual Atmos Health 2008; 1:119-23 (Australia)

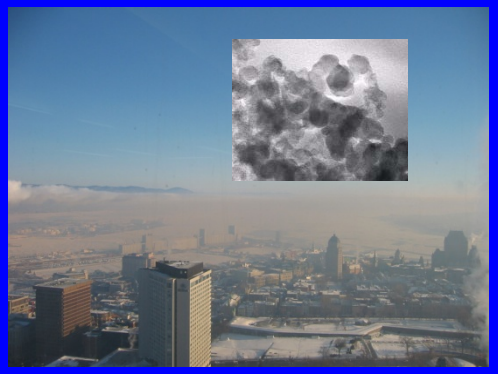
- To date, no studies of the impacts on plant food allergens
- Allergenic plant foods are responsive to increases in CO2 and temperature
  - Could climate variables impact influence allergenic characteristics?
  - Could this explain the reported increase in prevalence of food allergy over the past decades?
- This question is ripe for research

Why Us?

CO_2, Climate Change and Health in our Backyards

Bet v 1

Fire & Smoke Pollution



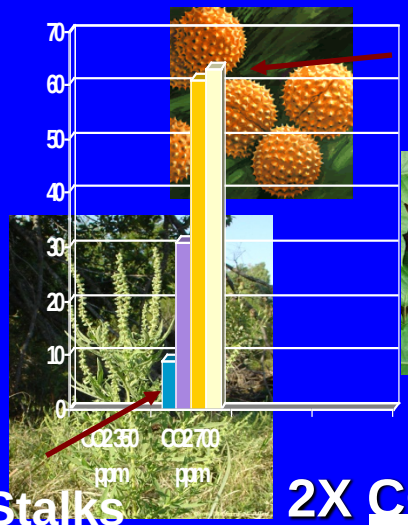
Tree pollen

Mold

Heatwaves & smog

Particulates & pollen

Pollen



Poison Ivy

Mosquitoes

Stalks

2X CO_2

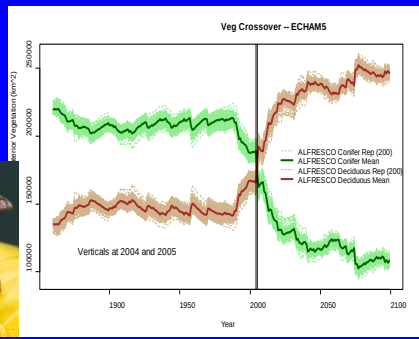
Changing Insect Patterns

Ragweed

ELISA-quantified

Ticks

Hymenoptera



“You can observe a lot just by watching”

Lawrence Peter “Yogi” Berra


Thank You


Questions ?
jdemain@allergyalaska.com