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Outdoor Environmental Impacts of Asthma

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Objectives

1. Understand the process of air sampling and pollen dispersal
2. Discuss climate change driven alterations in aeroallergens
3. Review effects of outdoor allergens on asthma

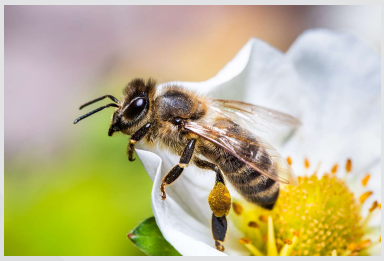
3

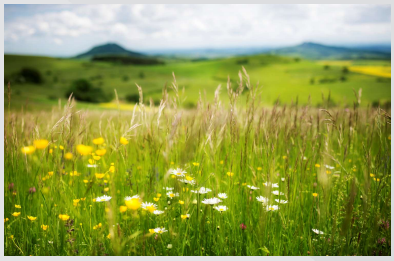
Disclosure Statement

No disclosures

4

Air Sampling & Pollen Dispersal





5

Thommen's Postulates of Allergenicity

I. The pollen must be anemophilous, wind-borne
II. The pollen must be produced in sufficiently large quantities
III. The pollen must be sufficiently buoyant to be carried considerable distances
IV. The plant must be widely and abundantly distributed
V. The pollen must contain an "excitant" of hay fever

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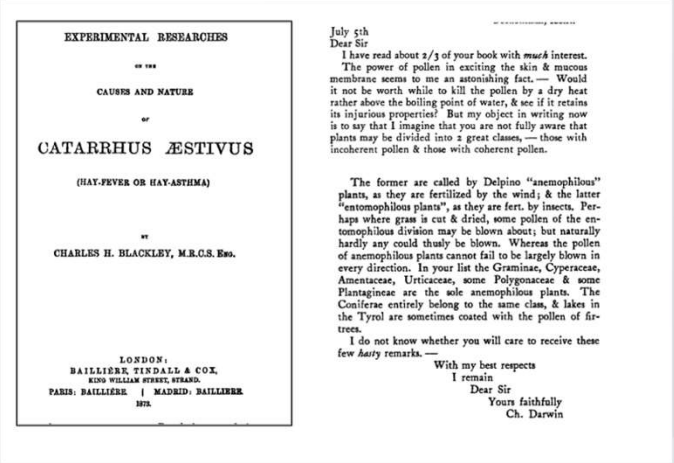
Modes of Pollen Dispersal

- Entomophilous
  - Insect pollinated
- Anemophilous
  - Wind pollinated



EXPERIMENTAL RESEARCHES

ON THE

CAUSES AND NATURE

OF

CATARRHUS ÆSTIVUS

(HAY-FEVER OR HAY-ASTHMA)

BY

CHARLES H. BLACKLEY, M.R.C.S. Eng.

LONDON:
BAILLIÈRE, TINDALL & COX,
KING WILLIAM STREET, STRAND.
PARIS: BAILLIÈRE | MADRID: BAILLIÈRE
1873.

July 5th
Dear Sir
I have read about 2/3 of your book with *much* interest.
The power of pollen in exciting the skin & mucous membrane seems to me an astonishing fact. — Would it not be worth while to kill the pollen by a dry heat rather above the boiling point of water, & see if it retains its injurious properties? But my object in writing now is to say that I imagine that you are not fully aware that plants may be divided into 2 great classes, — those with incoherent pollen & those with coherent pollen.

The former are called by Delpino "anemophilous" plants, as they are fertilized by the wind; & the latter "entomophilous plants", as they are fert. by insects. Perhaps where grass is cut & dried, some pollen of the entomophilous division may be blown about; but naturally hardly any could thusly be blown. Whereas the pollen of anemophilous plants cannot fail to be largely blown in every direction. In your list the Graminae, Cyperaceae, Amentaceae, Urticaceae, some Polygonaceae & some Plantagineae are the sole anemophilous plants. The Coniferae entirely belong to the same class, & lakes in the Tyrol are sometimes coated with the pollen of fir-trees.
I do not know whether you will care to receive these few *hasty* remarks. —
With my best respects
I remain
Dear Sir
Yours faithfully
Ch. Darwin

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Nebraska Outdoor Aeroallergen Panel

Trees
Ash
Birch
Maple
Cottonwood
Sycamore
Elm
Oak
Walnut
Mulberry
Cedar
Hackberry

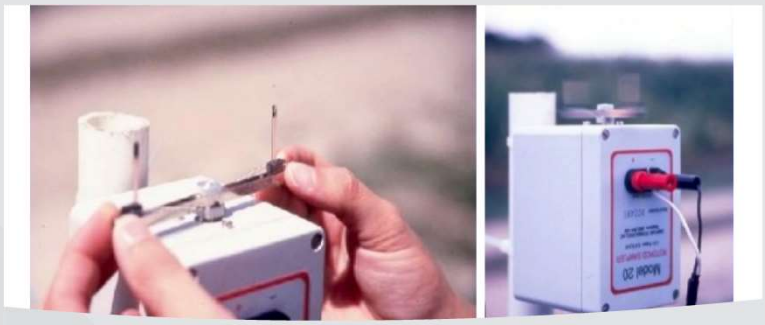
Spores
Alternaria
Helminthosporium
Aspergillus
Penicillium
Cladosporium
Epicoccum

Grass
Bermuda
Johnson
June
Timothy
Orchard

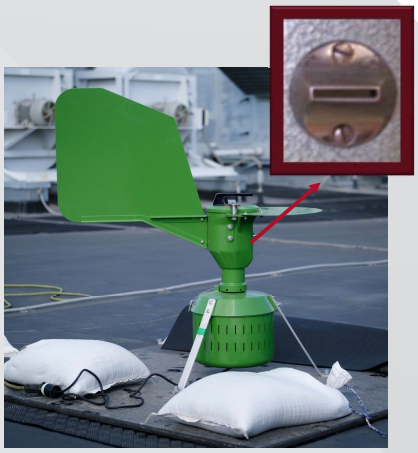
Weeds
Kochia
Russian thistle
Lamb's quarters
Careless/Pigweed
Ragweed
Marshelder
Sagebrush/Mugwort
English plantain
Dock/Sorrel
Nettle

8

Air Sampling Techniques



Rotating Arm Impactors



Hirst-type Spore Traps

9

Air Sampling Techniques

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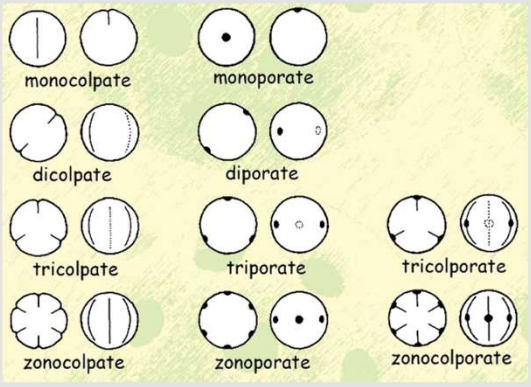
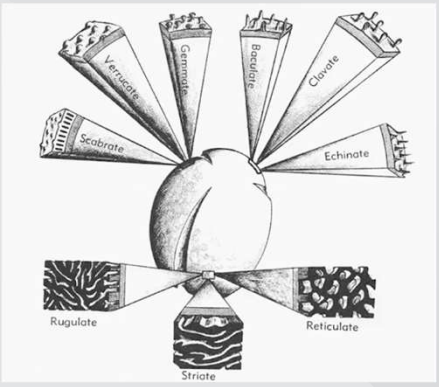
Pollen Surface Characteristics

- ✓ Pore(s)
- ✓ Colpus(colpi)
- ✓ Shape
- ✓ Size
- ✓ Ornamentation



LANG, G., 1994: Quartäre Vegetationsgeschichte Europas. Gustav Fischer Verlag Jena, Stuttgart, New York: 462 S.



Kapp RO. How to Know Pollen and Spores 1969, Wm. C. Brown Compnay Publishers. Dubuque, Iowa.

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Cupressaceae Pollen

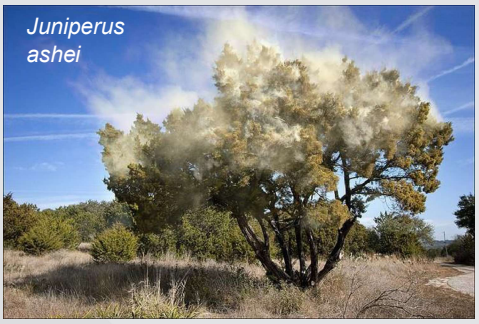

Image: PMID 34582944

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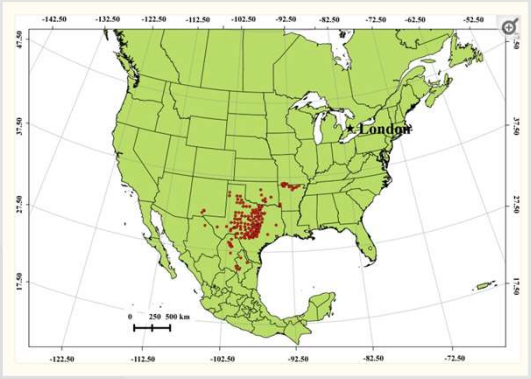
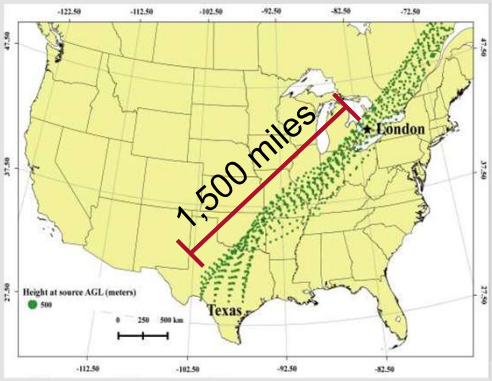
Long–Distance Anemophilous Transport



Juniperus ashei **(mountain cedar) distribution map in United States**



HYSPLIT modeling air parcel trajectories

PMID 28273170

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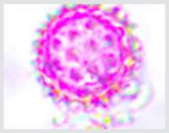
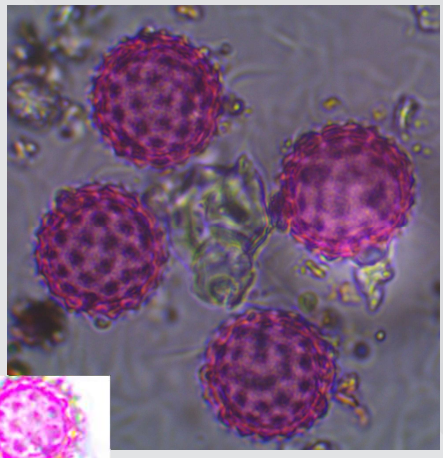
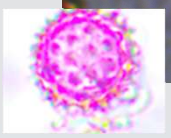
Ragweed Pollen







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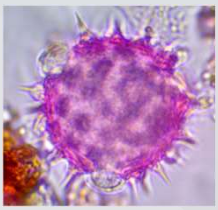
Goldenrod Pollen



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How Climate Change Drives Alterations in Aerobiology



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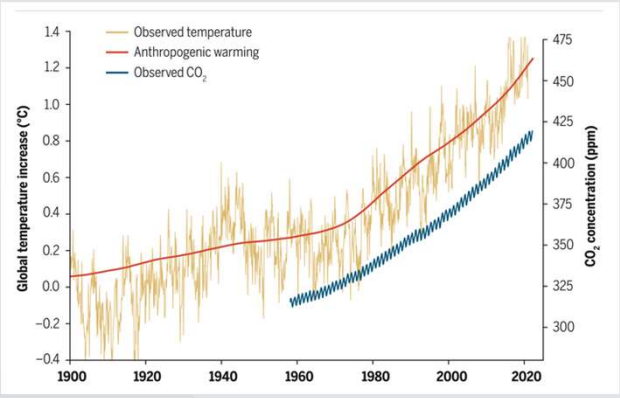
Anthropogenic Climate Change and Aerobiology



Matthews HD, et al. Science 2022; 376: 1404-1409

Since the Industrial Revolution:

- Atmospheric CO_2
  - Increase 280 ppm → 415 ppm (Δ48%)
- Global avg surface temp
  - Increase ~ 2°F
  - 2023 warmest year since global records began in 1850
  - The 10 warmest years in the 174-year record have all occurred in the last decade (2014-2023)

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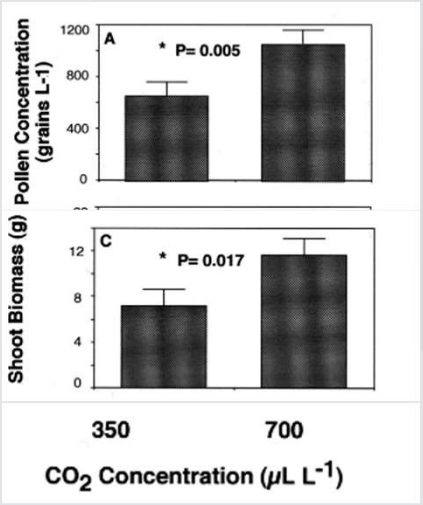
↑CO_2 = ↑ Pollen Production

- Growing in CO_2 rich environments markedly (61%) increased ragweed pollen production (p= 0.005)



Wayne P, et al. Annals AAI. 2002; 88(3): 279-282

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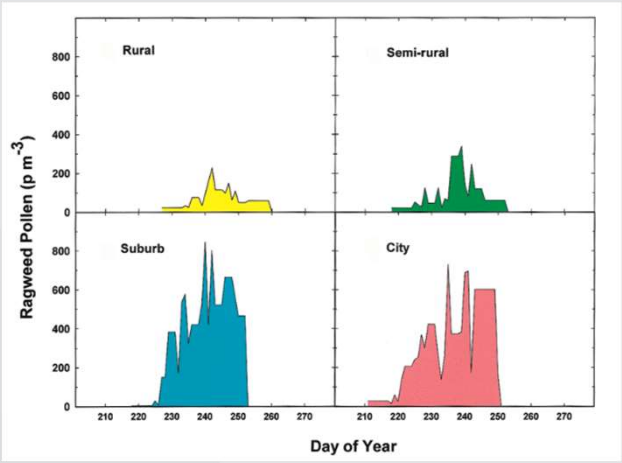
Climate Driven Increased Pollen Production



- Study of urban ragweed as a surrogate for climate change
- Ragweed planted in different areas with consistent: seeds, soil composition, water supply
- Rotorod samplers at each site
- Avg daily CO_2 30% higher in urban areas
- Avg daily temp up to 1.9℃ higher at urban site
- Ragweed flowered earlier, grew faster and produced significantly more pollen in urban areas

Liska LH, et al. JACI. 2003; 111(2): 290-295

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Climate Change Indicators: Length of Growing Season (1895-2020)

- Avg length of growing season increased > 2 weeks
- Large steady increase over past 30 years
- Length of growing season has increased in nearly all states (↑AZ, CA)
- In recent years the final spring frost has occurred earlier than any point since 1895

https://www.epa.gov/climate-indicators/climate-change-indicators-growing-degree-days

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Change in Length of Pollen Season

- 11 National Allergy Bureau (NAB) with ragweed data for 15+ years
- Latitudes range from Georgetown, TX to Saskatoon, Canada
- Significant increase in pollen season length
- Findings largely attributed to lengthening of frost-free days

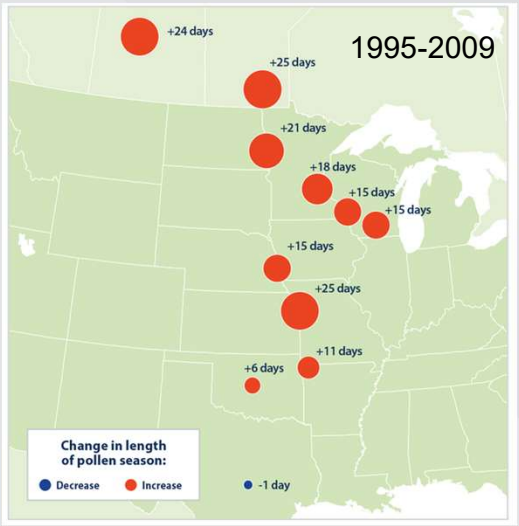

Image: EPA.gov

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

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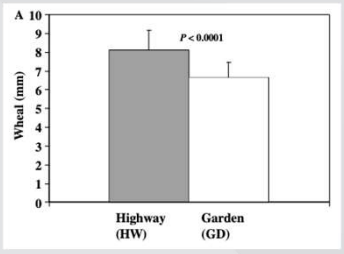
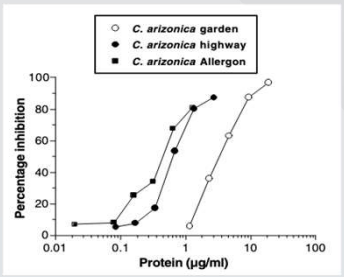
Pollution Driven Allergenicity Alteration *(Cupressus arizonica)*

High pollution area pollen

Low pollution area pollen

Skin prick testing to each extract
n = 75
C. arizonica sensitized allergy patients





Cortegano I, et al. Allergy. 2004; 59: 485-490

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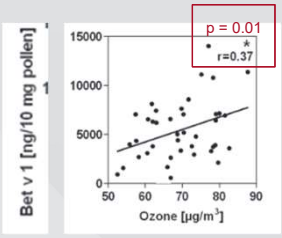
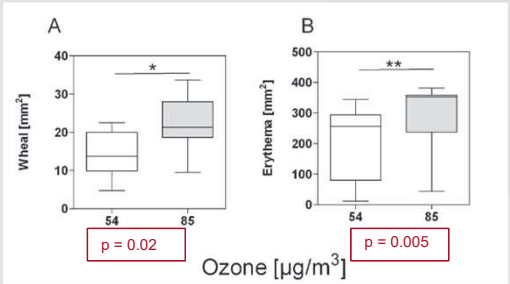
Ozone Driven Allergenicity Alteration (Birch pollen)

- Catkins collected from 40 birch trees in the greater Munich area (rural-urban)
- Ozone level measured at site of each tree sampled
- Birch allergic patients SPT to birch pollen extract from lowest ozone tree and mean ozone tree pollen





Beck I, et al. PLoS One. 2013; 8(11)

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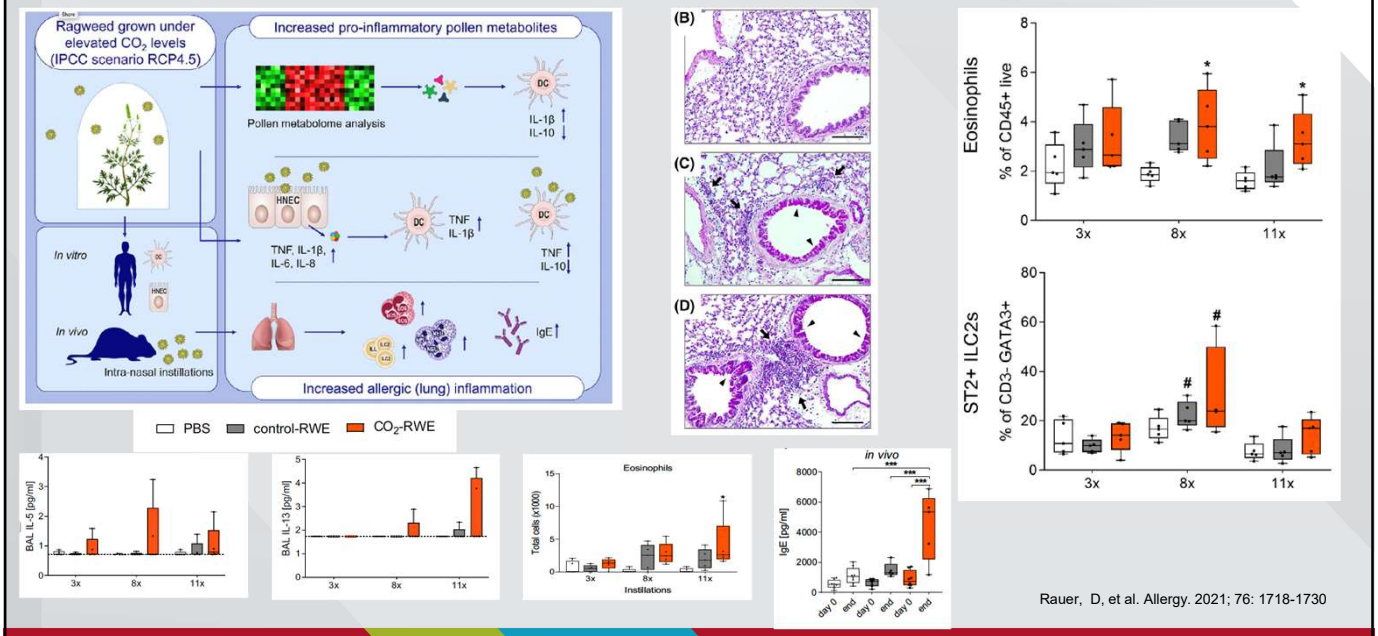
CO_2 Driven Pollen Allergenicity Alternation



Rauer, D, et al. Allergy. 2021; 76: 1718-1730

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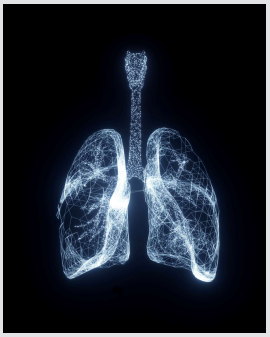
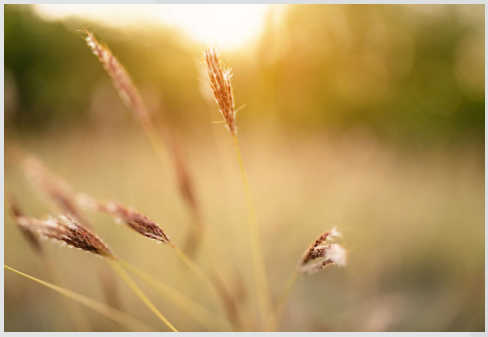
Effects of Outdoor Allergens on Asthma





Rorie A. Immun Clin N America. 2022; 42(4): 771-786

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John Bostock's First Description of Hay Fever (1819)

John Bostock c. 1836

"a sensation of heat and fullness in the eyes, first along the edges of the lids, and especially in the inner angles, but after some time over the whole of the eyeball; a slight degree of redness in the eyes and a discharge of tears; worsening of this state until there was intense itching and smarting, inflammation, and discharge of a very copious thick mucous fluid. To these symptoms were added sneezing, tightness of the chest and difficulty in breathing"

Ramachandran M, Aronson JK. John Bostock's first description of hay fever. *J R Soc Med*. 2011;104(6):237-240. doi:10.1258/jrsm.2010.10k056

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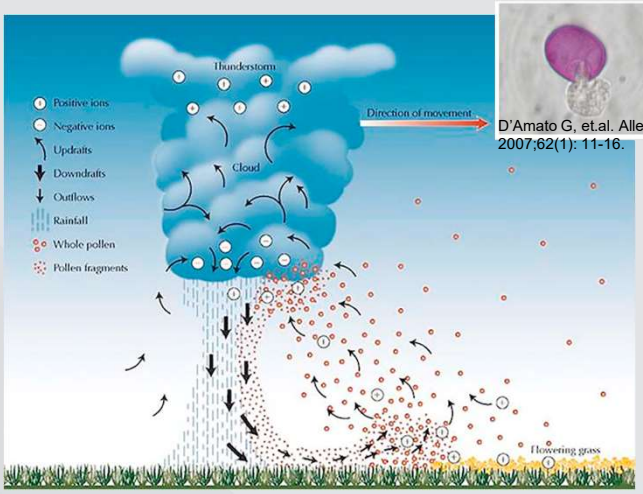
Thunderstorm Asthma



Taylor PE, Jonsson H. *Curr Allergy Asthma Rep*. 2004;4:409–413

D'Amato G, et.al. Allergy. 2007;62(1): 11-16.

Date	Location	Suspected Allergen
July 1983	Birmingham, United Kingdom	Fungal spores
June 1984	Nottingham, United Kingdom	Fungal spores
November 1984	Melbourne, Australia	Not specified
November 1987	Melbourne, Australia	Grass pollen
July 1989	Leicester, United Kingdom	Fungal spores
November 1989	Melbourne, Australia	Grass pollen
November 1990	Tamworth, Australia	Grass pollen
June 1994	London, United Kingdom	Grass pollen
October 1997	Wagga, Australia	Grass pollen
October 1998	Newcastle, Australia	Grass pollen
July 2000	Calgary, Canada	Fungal spores
July 2002	Cambridge, United Kingdom	Fungal spores
November 2002	Al-Khobar, Saudi Arabia	Not specified
November 2003	Melbourne, Australia	Grass pollen
June 2004	Naples, Italy	*Parietaria* pollen
June 2005	South-East England, United Kingdom	Not specified
May 2010	Puglia, Italy	Olive tree pollen
November 2010	Melbourne, Australia	Grass pollen
November 2011	Melbourne, Australia	Grass pollen
July 2013	London, United Kingdom	Not specified
November 2013	Ahvaz, Iran	Grass pollen
October 2014	Canberra, Australia	Grass pollen
October 2015	Israel	Not specified
October 2015	Ahvaz, Iran	Not specified
November 2016	Melbourne, Australia	Gras pollen
December 2016	Kuwait, Middle East	Not specified
December 2017	Hamilton, New Zealand	Not specified
September 2018	Yulin, China	Mugwort pollen

- 3,365 people presented to ER (↑672%)
- 476 asthma-related hospital admissions (↑ 992%)
- 35 people were admitted to an ICU (↑ 600%)
- 10 asthma deaths

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Thunderstorm Asthma in the US?

Analysis of 63,789 asthma-related ED visits in Louisiana 2010-2012

- ✓ Specifically, higher precipitation (RR= 1.145 per 1 g/m^2/s) and lower mean temp (RR = 1.011 per 1℃ change)

Park JH, et al. Env Health Pers. 2022; 130(8)

Review of 215,832 asthma-related ED visits in Atlanta Georgia 1993-2004

- ✓ Increased ER visits on thunderstorm days ($p<0.001$)
- ✓ Asthma visits ↑3% over the day following thunderstorm

Grundstein A, et al. Thorax. 2008; 63(7)659-660

Review of 142,330 asthma-related ED visits in MSP, MN 2007-2018

- ✓ Thunderstorm + high pollen (>75%) (RR 1.047)
- ✓ Thunderstorm + normal pollen no Δ
- ✓ No thunderstorm + high pollen no Δ

Smith L, et al. Env. Health. 2022; 33(5)624-632

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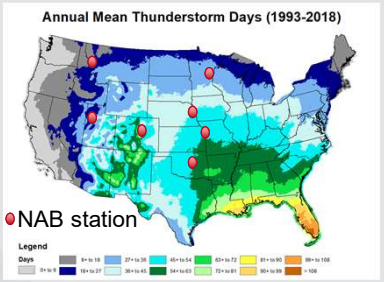
Are We Missing Something?

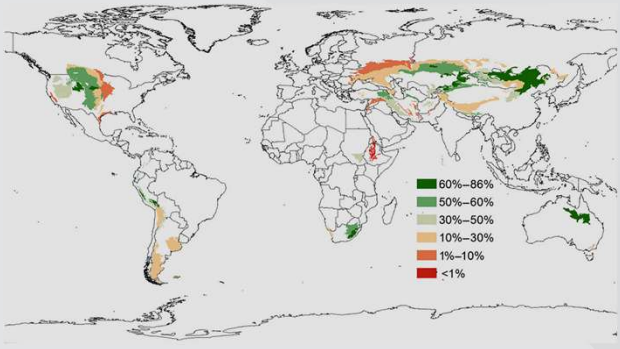
- Nebraska sandhills 1 of 7 remaining large grasslands worldwide

- Nebraska 36-54 thunderstorms days per year



weather.gov/jetstream/tstorms

Intactness of Global Grasslands



Dirac Twidwell and Rheinhardt Scholtz / Conservation Science and Practice

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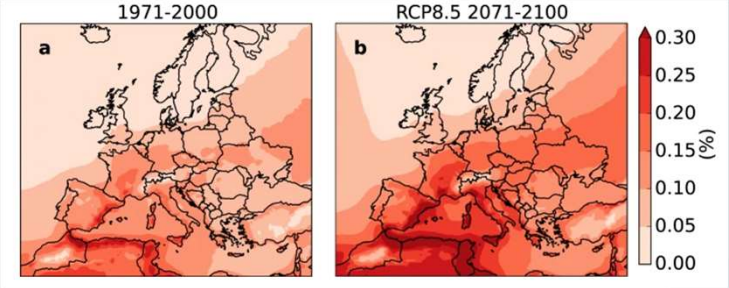
Increase in Severe Thunderstorms

- NOAA estimates 16 million thunderstorms each year which will increase
- Projected favorable conditions for increase in severe storms
  - USA, Europe, Australia

Percentage of lighting with hail > 5 cm



Raddler AT, et. al. *Nature*. 2019

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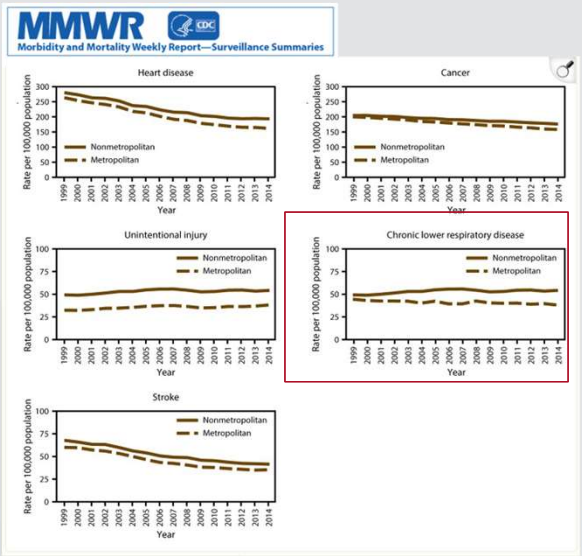
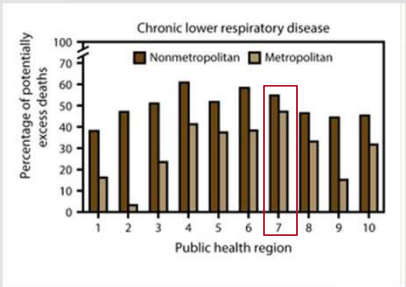
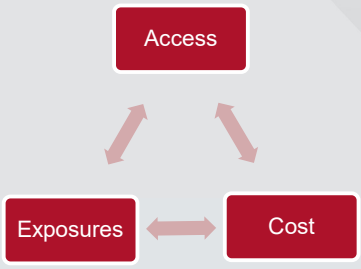
Top 5 Causes of Death in Rural America







PMID: 28081057

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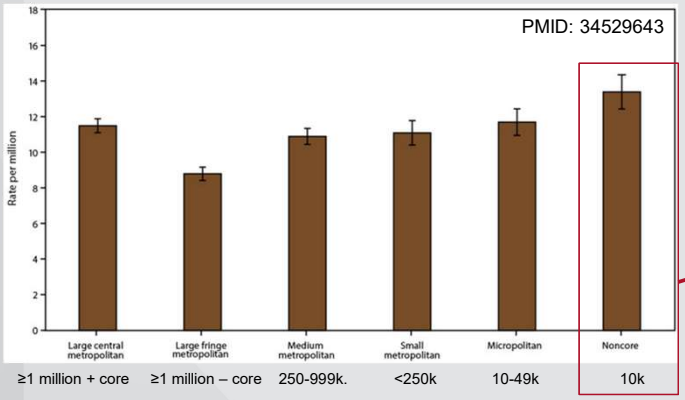
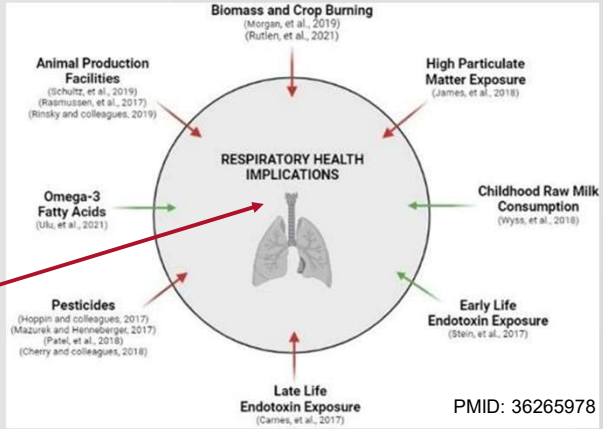
Rural Asthma

Asthma Deaths by Geographic Area





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Conclusion

- Aerobiology is a cornerstone of allergic airway disease
- Environmental influences and climate change have direct impacts on our health
- Chronic lower respiratory disease is a common cause of rural morbidity and mortality

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BUFFETT CANCER CENTER
DURHAM RESEARCH CENTER
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