CO₂, Climate Change and the Aerobiology of Allergenic Weeds.

Thanks to:
The doctors and staff of the NAB counting sites for contributing their Ambrosia data for the Midwestern U.S.

Atmospheric CO₂

So what if CO₂ goes up?
I. An indirect effect of rising carbon dioxide: warmer temperatures.

<table>
<thead>
<tr>
<th>Gas</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen (N₂)</td>
<td>78.1</td>
</tr>
<tr>
<td>Oxygen (O₂)</td>
<td>20.1</td>
</tr>
<tr>
<td>Argon (Ar)</td>
<td>0.93</td>
</tr>
<tr>
<td>Carbon Dioxide (CO₂)</td>
<td>0.04 up to 0.100</td>
</tr>
<tr>
<td>Water (H₂O)</td>
<td>0.05 to 1.00</td>
</tr>
</tbody>
</table>

No H₂O and CO₂? Surface temperature would be –18°C. With H₂O and CO₂? Surface temperature is 15°C.

If water vapor is high, it will be the dominant warming gas….little effect of CO₂
If water vapor is low, adding CO₂ will increase the surface temperature.
CO₂, warming and public health.

- Changes in range of insect or rodent borne diseases.
- Changes in water or seafood borne diseases.
- Increasing ground-level ozone, and respiratory ailments.
- Contamination of drinking water due to excessive flooding.
- Heat-related deaths / fewer cold related.
So what if CO\(_2\) goes up?, Part II, direct impacts

Carbon dioxide is the source of carbon for photosynthesis, and consequently for 99% of all life.

\[
\text{CO}_2 + \text{H}_2\text{O} + \text{light} \rightarrow \text{O}_2 + \text{organic C} + \text{chemical energy}
\]

Plants are Important.

Plants are necessary for the flow of energy and carbon through ecosystems. 90% of all living matter consists of plant life.

With the exception of a few subterranean organisms, if plants did not exist, life would not exist.

Plant growth however is dependent on four physical inputs.

*SUPPOSE*.................
But isn't more plant growth desirable?

“We are living in an increasingly lush environment of plants and animals as a result of the carbon dioxide increase. This is a wonderful and unexpected gift from the industrial revolution.”

WSJ

Two assumptions:

1. That all plants will respond equally and competition will be unaffected.

2. All plants are equally desirable. (i.e. “green is good”).

“People who imagined that life on earth consisted of animals moving against a green background, seriously misunderstood what they were seeing. That green background was busily alive. Plants grew, moved, twisted and turned, fighting for [resources]; and they interacted continuously with animals—discouraging some with bark and thorns, poisoning others, and feeding still others with pollen and seeds. It was a complex, dynamic process…one which most people didn’t understand. “

Michael Crichton, Page 86, “Jurassic Park”
If CO₂ stimulates plant growth, can we use it to boost crop yields? Is there variation within a crop to CO₂?

![Graph showing CO₂ in rice and soybean crops](image)


**CO₂ is a VERY smart molecule.**

Green is not always good.
Climate change, plants and public health

**Direct Effects**
Allergies / Aerobiology
Contact dermatitis
Toxicology

**Indirect Effects**
Nutrition/Food Supply
Medicine / Narcotics
Spread of disease vectors
Increased pesticide use.

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Overview of Biological Processes.
Plants and allergies

Principle Fall Allergen

~35 million sufferers

Common ragweed.

Determining Ragweed Pollen Production

Sampling pollen from ragweed catkins.
Response of common ragweed to CO₂

- **Pollen Production**
  - 280 ppm: 4.8 g
  - 370 ppm: 10.9 g*
  - 600 ppm: 20.5 g*

- **Antigen Amb a1 ELISA / mg protein**
  - 280 ppm: 4490
  - 370 ppm: 5290
  - 600 ppm: 8180*

Chamber Study, USDA
*Functional Plant Biology 27:893-898
*Functional Plant Biology 32:667-670

Ragweed in real life

All this is “blue-sky” hypothetical anyway. It won’t happen in real-life, and even if it does, temperature and carbon dioxide effects are a long ways away.

Mauna Loa, “Official” CO₂ data.
Is the rise in CO$_2$ the same everywhere?

- Change in average day-time CO$_2$ concentration (ppm) from downtown Baltimore to an organic (rural) farm.

300  400  500
Farm  Park  City
386.2  402.2  455.5

Is the increase in temperature the same?

- Change in average daily temperature (°C) from downtown Baltimore to an organic (rural) farm (2002).

15  17  19  21  23
Farm  Park  City
18.6  19.1  20.7
Urbanization and climate change.

<table>
<thead>
<tr>
<th>Daytime Carbon Dioxide (ppm)</th>
<th>Rural</th>
<th>Suburban</th>
<th>Urban</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>2002</td>
<td>2003</td>
<td>2004</td>
</tr>
<tr>
<td></td>
<td>381</td>
<td>373</td>
<td>380</td>
</tr>
<tr>
<td></td>
<td>394</td>
<td>370</td>
<td>400</td>
</tr>
<tr>
<td></td>
<td>458</td>
<td>520</td>
<td>456</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Daytime Air Temperature (°C)</th>
<th>Rural</th>
<th>Suburban</th>
<th>Urban</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>2002</td>
<td>2003</td>
<td>2004</td>
</tr>
<tr>
<td></td>
<td>25.1</td>
<td>22.5</td>
<td>24.4</td>
</tr>
<tr>
<td></td>
<td>25.8</td>
<td>23.9</td>
<td>25.3</td>
</tr>
<tr>
<td></td>
<td>26.6</td>
<td>24.7</td>
<td>26.3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Night-time Temperature (°C)</th>
<th>Rural</th>
<th>Suburban</th>
<th>Urban</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>2002</td>
<td>2003</td>
<td>2004</td>
</tr>
<tr>
<td></td>
<td>19.6</td>
<td>18.0</td>
<td>19.0</td>
</tr>
<tr>
<td></td>
<td>19.3</td>
<td>18.6</td>
<td>19.2</td>
</tr>
<tr>
<td></td>
<td>22.3</td>
<td>21.3</td>
<td>22.5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Change in season length (days)</th>
<th>Rural-Rural</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>36</td>
<td>41</td>
<td>52</td>
<td>39</td>
<td></td>
</tr>
</tbody>
</table>

Are these differences consistent?

**CO₂ differences August, 2004**

What about other meteorological variables?

**8-h daytime ozone. 2004 season**

Overall: Urban-induced increases in carbon dioxide, air temperature and growing season are consistent with most IPCC near-term scenarios. With the exception of N deposition, other variables did not differ consistently, but N low relative to soil N. George et al. Oecologia, 159:637-647.

Can we study the effects of climate change **NOW**?

Placing four 2x2 m² plots
Near downtown Baltimore.
Use same soil and seed bank in suburban and rural locations.
Urban locale had longer growing season (milder winter), warmer temperatures, and more carbon dioxide.


CO₂/H₂O hypothesis suggests warmer Winters.

Observed changes in growing zones.
Scaling Up: Warming should increase with increasing latitude. Is a climate signal apparent with respect to length of ragweed pollen season?

Climate signal: From June 21st to first frost.

Latitude and pollen

![Graph showing the relationship between latitude and pollen season slope with a linear trend line and an $r^2$ value of 0.82.]
Latitude and frost

Allergenic pollen producers, Western Weeds:
Season: May through October
- Ragweed (A. atemissiifolia)
- Giant Ragweed (A. trifida)
- Russian thistle (Salsola kali)
- Marsh elder (Iva species)
- Yellow Dock (Rumex crispus)
- Pigweed (Amaranthus retroflexus)
- English plantain (Plantago lanceolata)
- Fireweed (Kochia scoparia)
- Cocklebur (Xanthium strumarium, X. spinosa)
- Lambsquarter (Chenopodia album)
- Marsh elder (Iva species)
- Cocklebur (Xanthium strumarium, X. spinosa)
- Yellow Dock (Rumex crispus)
- Lambsquarter (Chenopodia album)
- Marsh elder (Iva species)
- Cocklebur (Xanthium strumarium, X. spinosa)
- Yellow Dock (Rumex crispus)
- Lambsquarter (Chenopodia album)

Allergenic pollen producers, Northeast Weeds:
Season: May through September
- Ragweed (A. atemissiifolia)
- Giant Ragweed (A. trifida)
- Russian thistle (Salsola kali)
- Marsh elder (Iva species)
- Pigweed (A. retroflexus)
- Mugwort (Artemisia vulgaris)
- English plantain (Plantago lanceolata)
- Russian thistle (Salsola kali)
- Cocklebur (Xanthium strumarium, X. spinosa)
- Lambsquarter (Chenopodia album)
Fungal decomposition of plants.

*Alternaria alternata* has been associated with a number of respiratory problems such as rhinitis, asthma, allergic dermatitis and allergic sinusitis. The spores are the cause of the allergic reactions. Rising CO$_2$ increases C:N ratios, with subsequent effects on spore production.

Research and Education.

**Investment in Agricultural Research, United States.**

**Highlights:**

1999, 10 scientists, own lab

2008, National Program on climate change eliminated.

2009, 3 scientists, no lab, no national program. 52, 60, 61.

For every dollar spent on agricultural research, NIH spends approximately 100 dollars