Global Climate Change, Plant Biology and Public Health.

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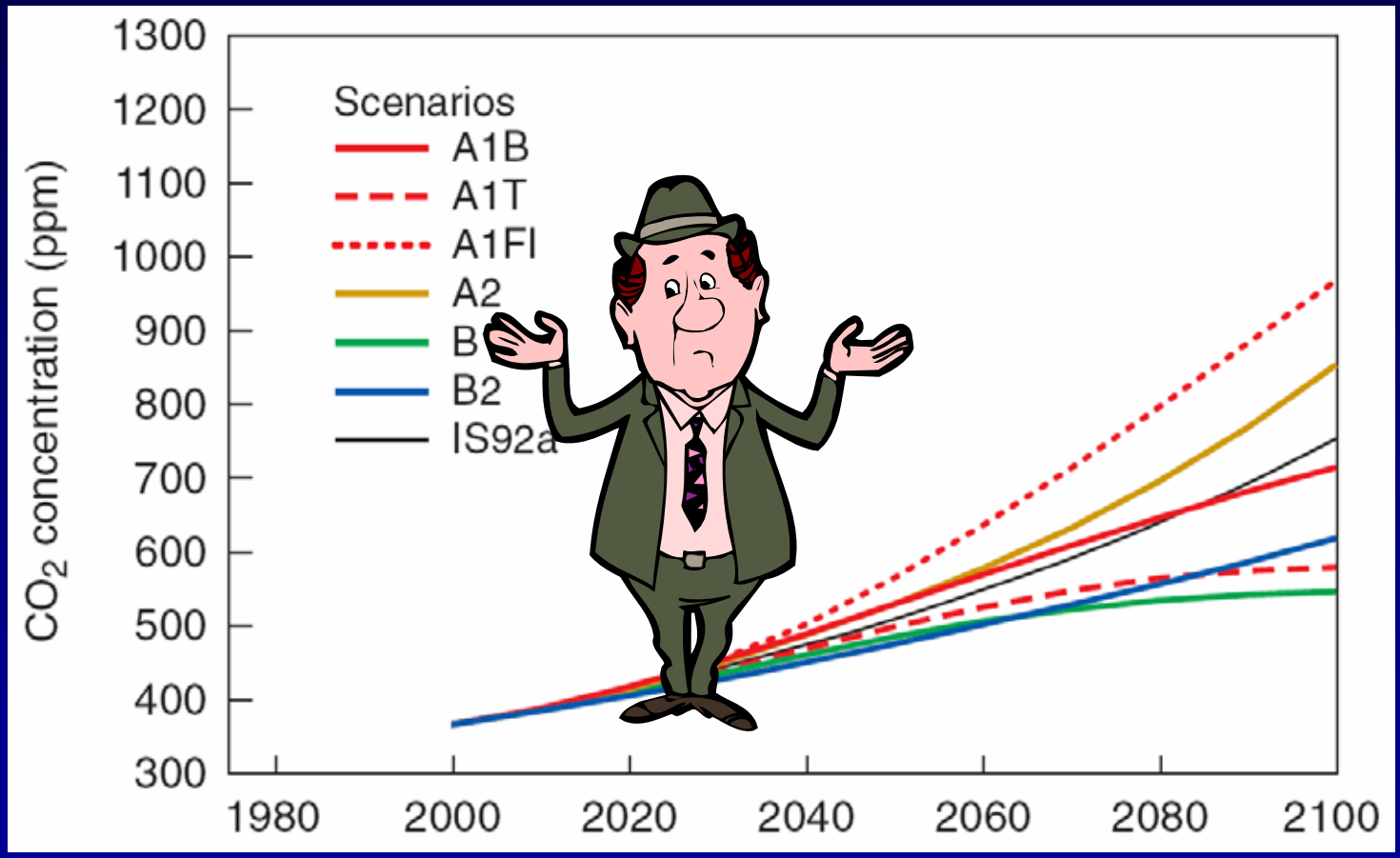
USDA

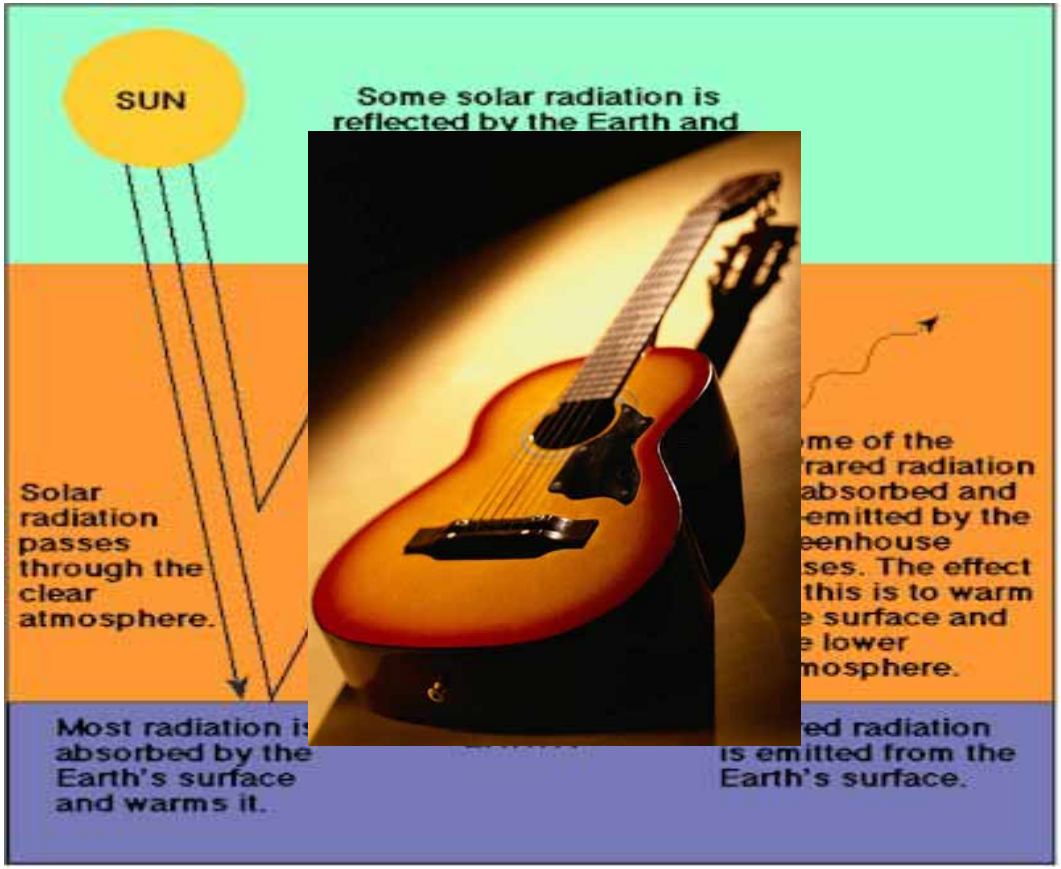
Atmospheric CO_2



Why is carbon dioxide going up? Are humans an influence?
How much will it increase in the atmosphere?
Is carbon dioxide increasing in the atmosphere?
So CO_2 is going up and humans are responsible. So what?

So what if CO_2 goes up? Part I. Indirect impacts.

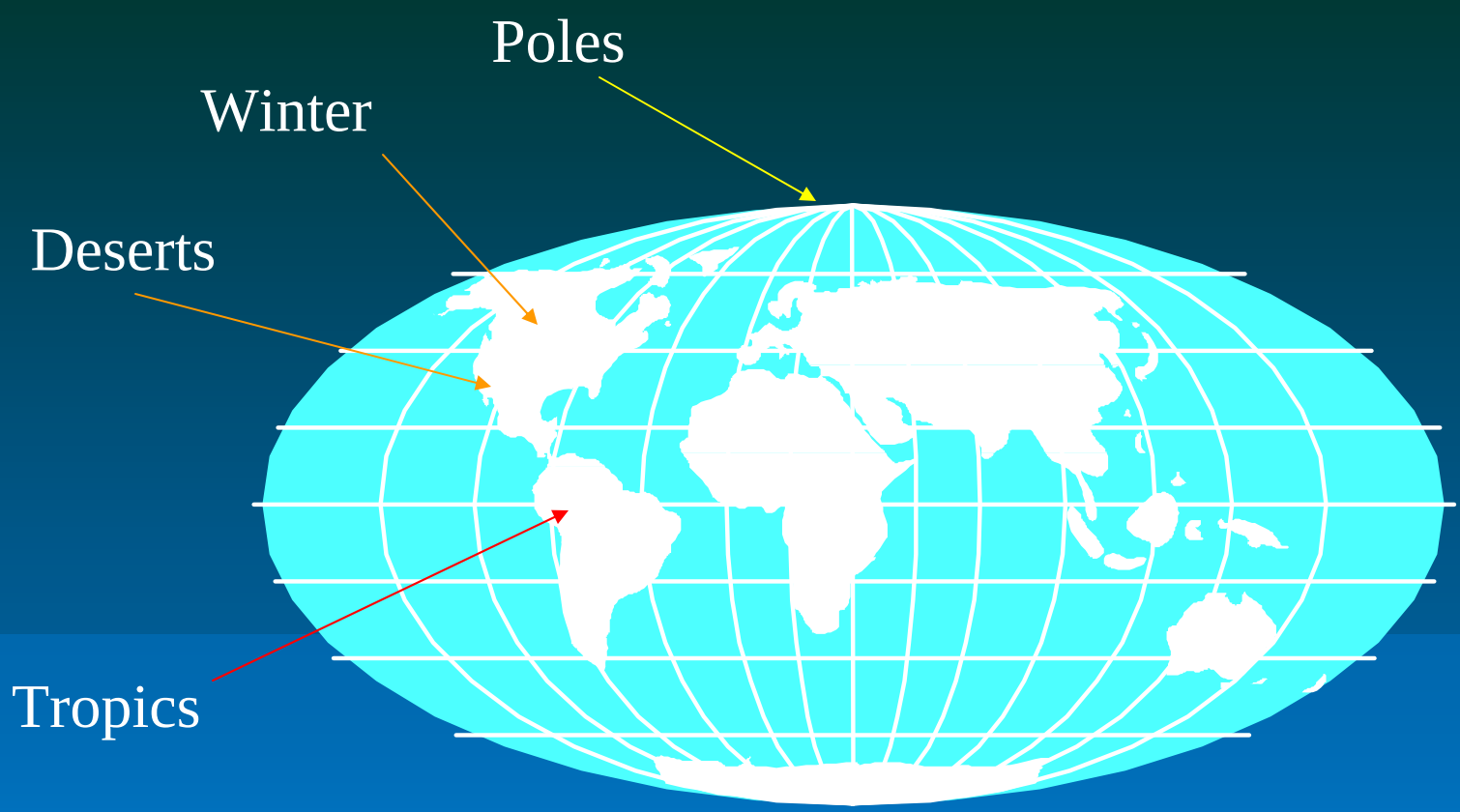
Gas	%
Nitrogen (N_2)	78.1
Oxygen (O_2)	20.1
Argon (Ar)	0.93
Carbon Dioxide (CO_2)	0.038
Water (H_2O)	0.05 to 1



No H_2O and CO_2? Surface temperature would be –18°C. With H_2O and CO_2? Surface temperature is 15°C.

Adding H_2O or CO_2 reduces the amount of heat leaving the atmosphere.

H_2O vs. CO_2



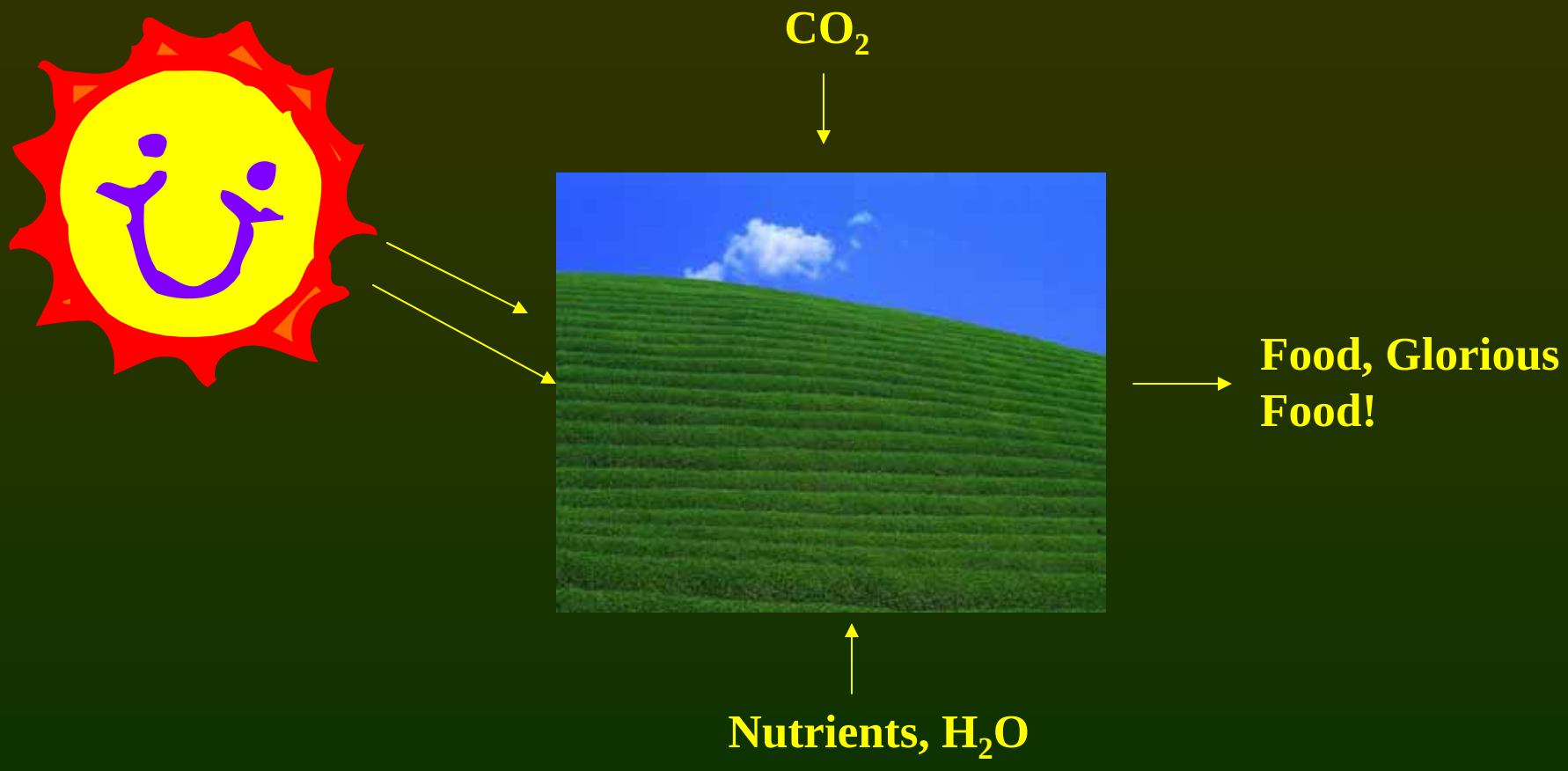
If water vapor is high, it will be the dominant warming gas….little effect of CO_2
If water vapor is low, adding CO_2 will increase the surface temperature.

What are the effects of warming on 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.

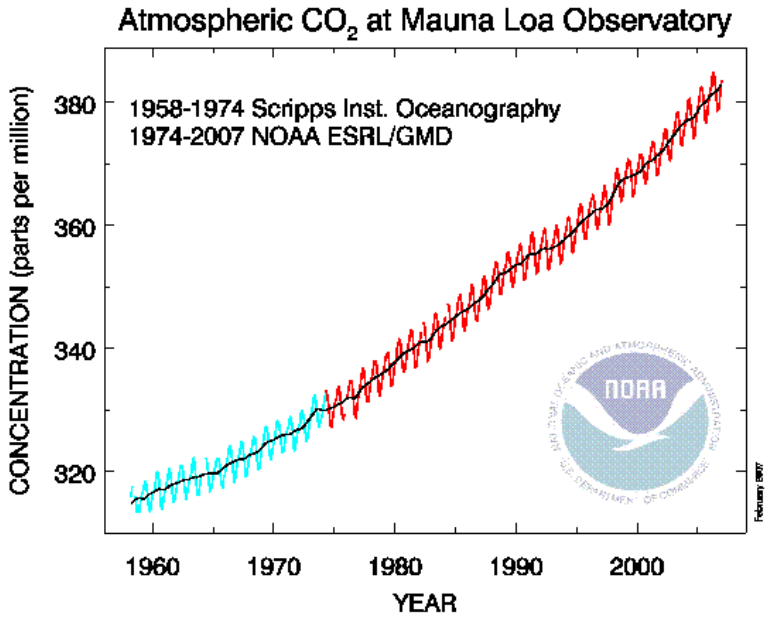


$CO_2 + H_2O + light \rightarrow O_2 + organic\ C + chemical\ energy$

Plants are important

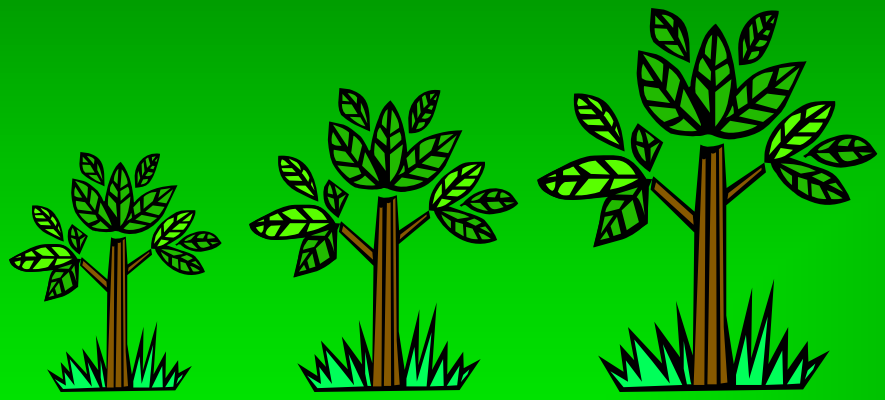
90% of all living biomass is plant material. Plant growth is dependent on four resources:

Sunlight, nutrients, water and carbon dioxide.



Plants evolved at a time when atmospheric CO_2 was much higher than it is today. Consequently, the increase in atmospheric CO_2 represents a very rapid change in a needed resource. Increasing it will result in the overall stimulation of plant growth up to 1000 ppm.

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

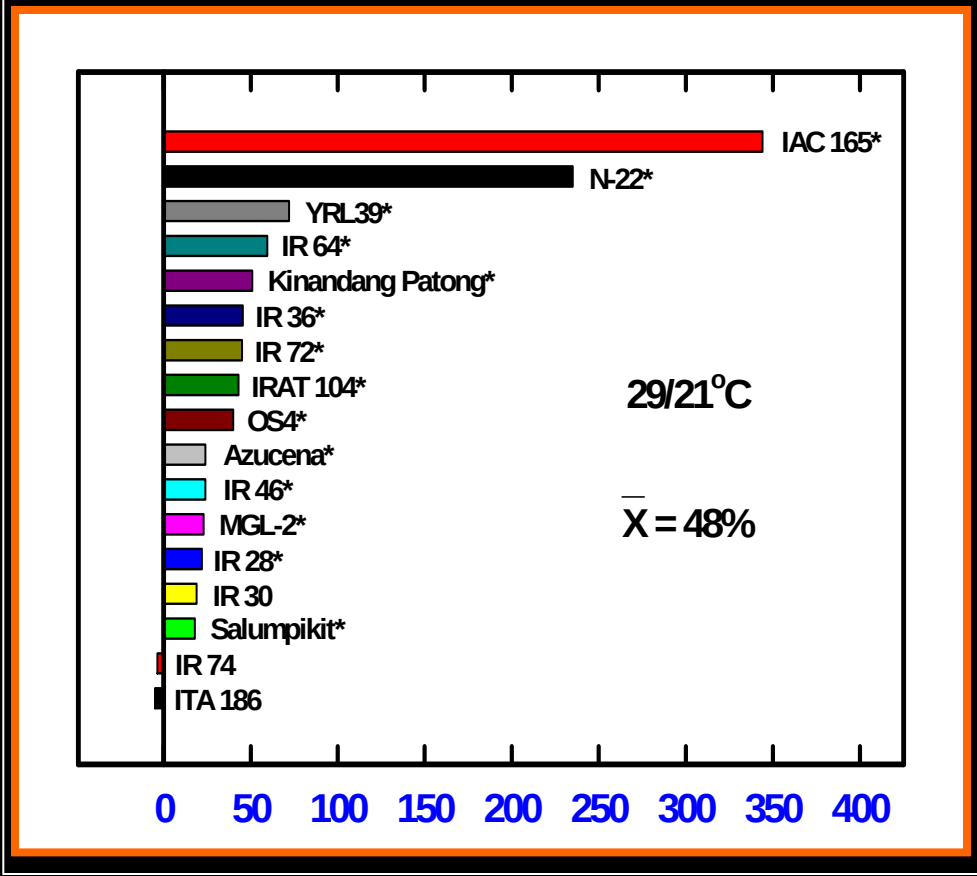
Two assumptions:

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

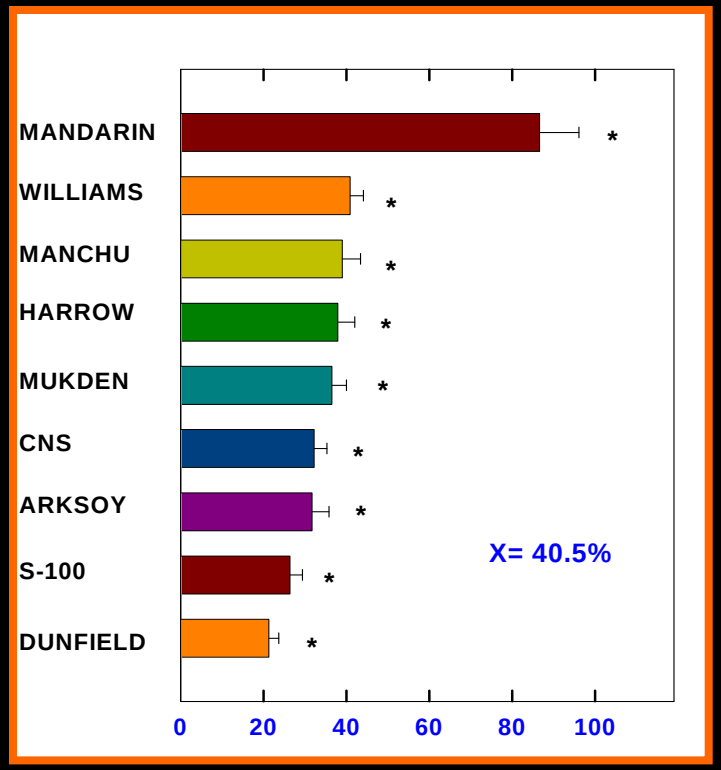
2. All plants are equally desirable. (i.e. “green is good”).

If CO_2 stimulates plant growth, can we use it to boost crop yields? Is there variation within a crop to CO_2?

Rice



Soybean



Ziska et al. 1996, J Exp Bot. 47:1353.

Ziska et al. 2001, Crop Science 41:385.

But not all plants are beneficial.

How can plants affect public health?
Some direct effects:

- **Allergies / Asthma:**
- **Contact dermatitis:**
- **Poison/Toxicology:**

1. CO_2, plants and allergies

Principle Fall Allergen

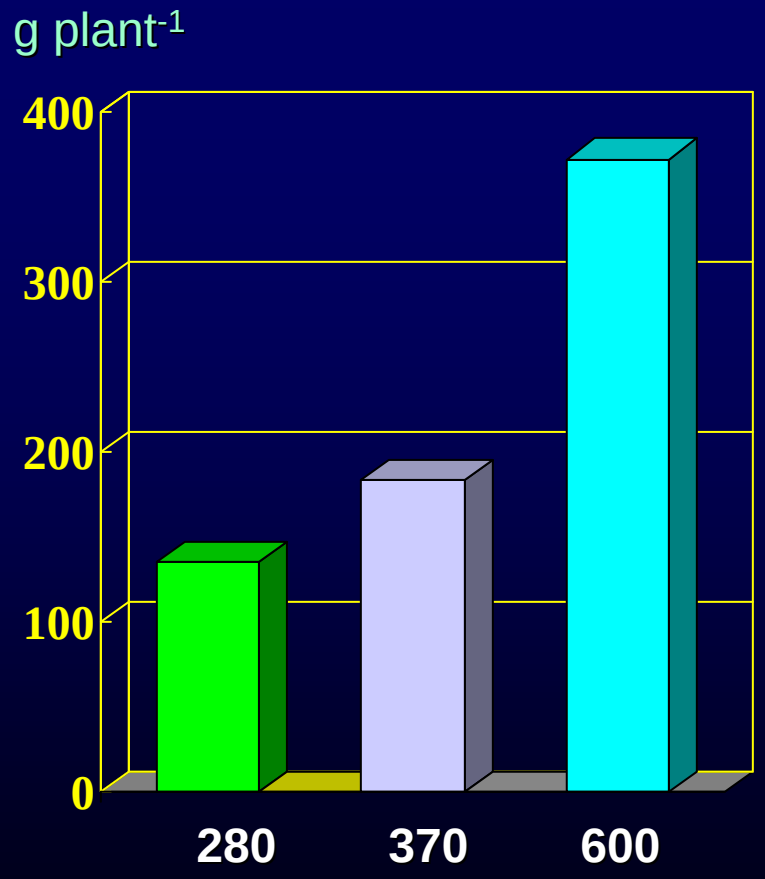
~35 million sufferers

Common ragweed.

Determining Ragweed Pollen Production

Sampling pollen from ragweed catkins.

Response of common ragweed to CO_2



- **Pollen Production**

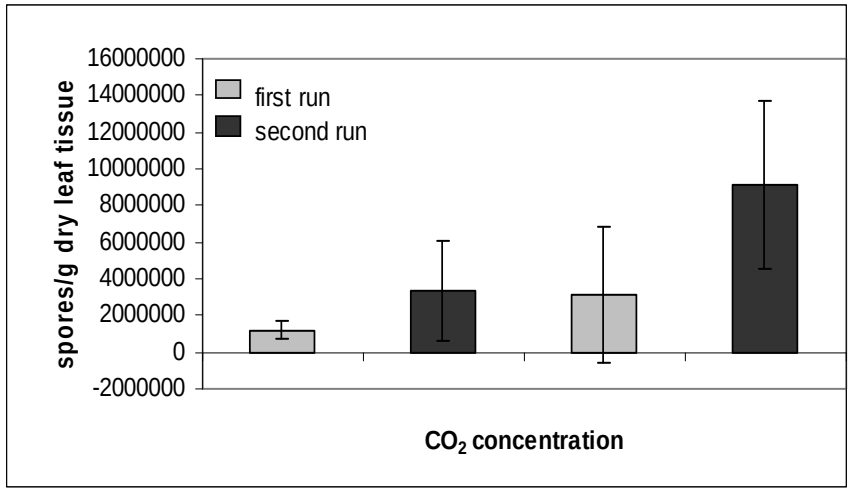
280 ppm	**4.8 g**
370 ppm	**10.9 g***
600 ppm	**20.5 g***

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

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.



For timothy grass grown from 300-600 ppm CO_2, rising carbon dioxide levels results in reduced leaf N levels. Initial data suggest that this could, in turn, increase the rate of sporulation.

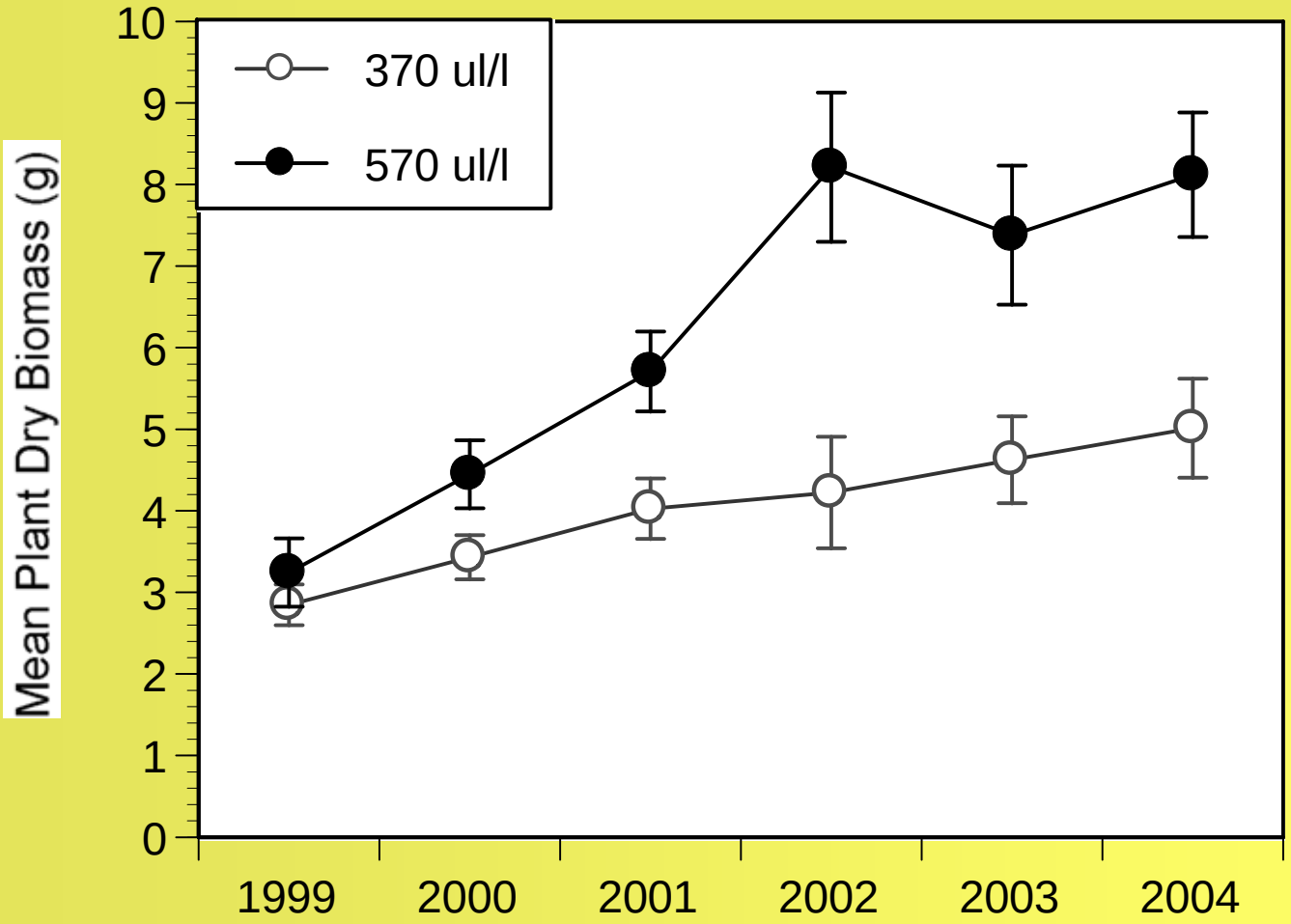
2. CO_2, plants and contact dermatitis

Can rising CO_2 alter the growth or toxicity of poison ivy?

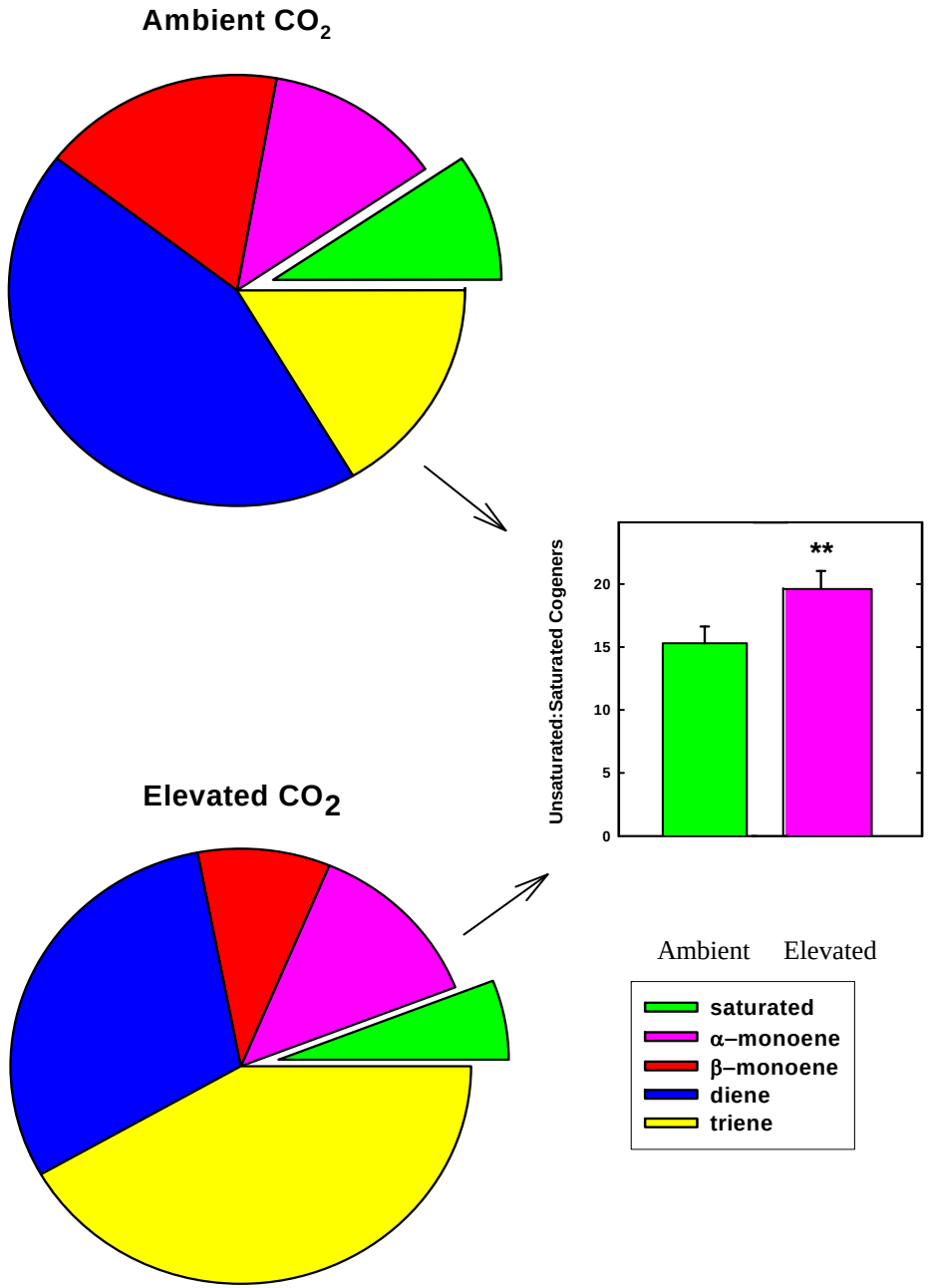
The Duke University FACE Site: State of the Art.

Poison ivy at Duke Face ring.

Poison ivy plants grow faster at elevated CO_2



Poison ivy allergenicity



Duke University, USDA study, *PNAS* 103:9086-9089

3. CO_2, plants and poison

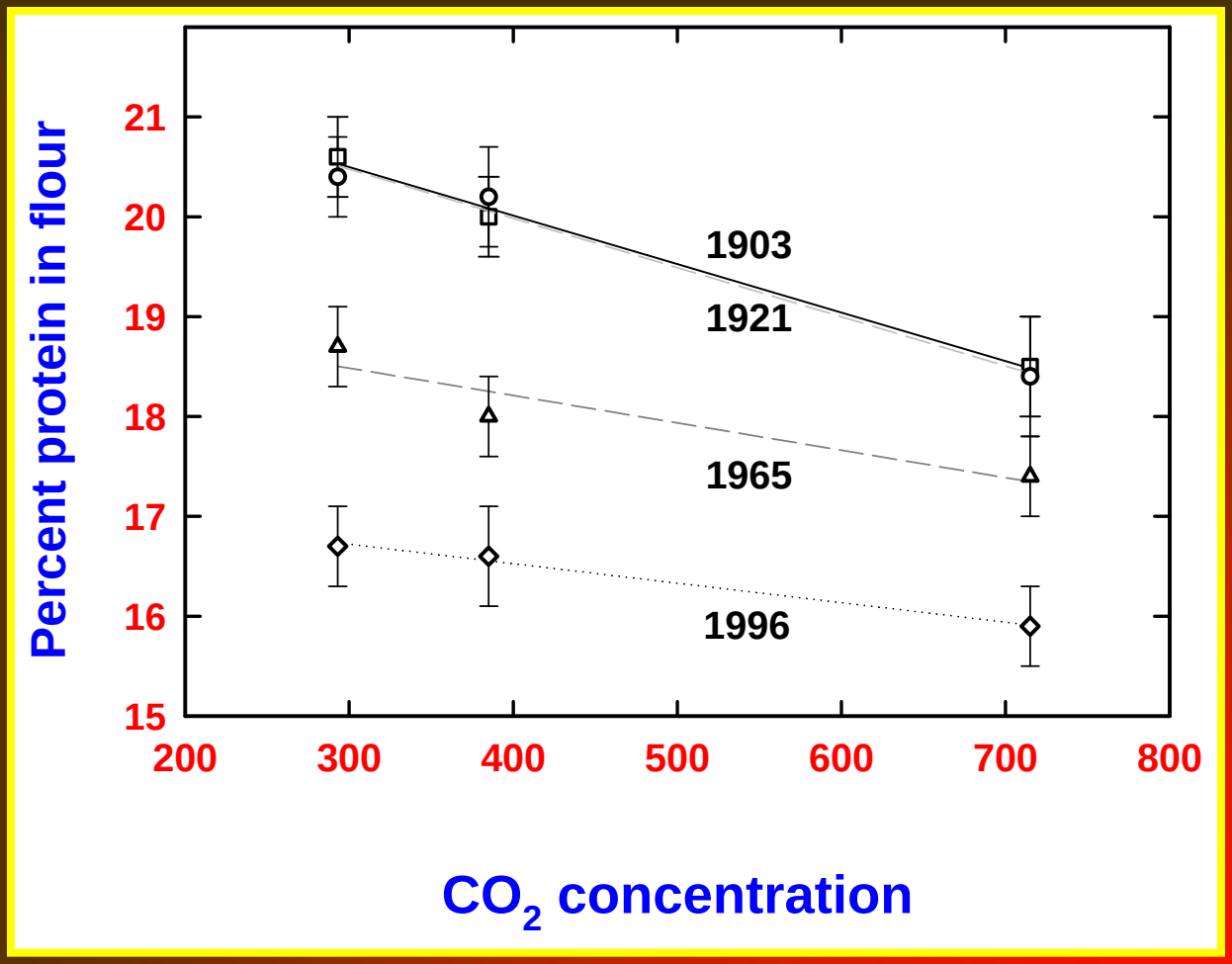
Castor bean (Ricinus communis), produces ricin, one of the deadliest poisons known to man. Increasing CO_2 by 300 ppm results in a 34% increase in photosynthesis (Grimer and Komor 1999).

How can plants affect public health?

Some indirect effects:

- Nutritional changes.
- Medicines / Narcotics.
- Disease vector biology.
- Pesticide use.

CO_2 and human nutrition.



% Flour protein from wheat lines released during the 20th century.

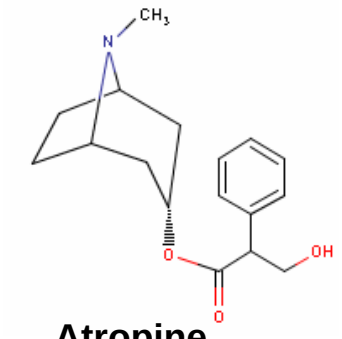
Recent cooperative work with NIH indicates an increase in omega-3-fatty acids in mung bean with rising CO_2.

2a. CO_2, plants and medicine

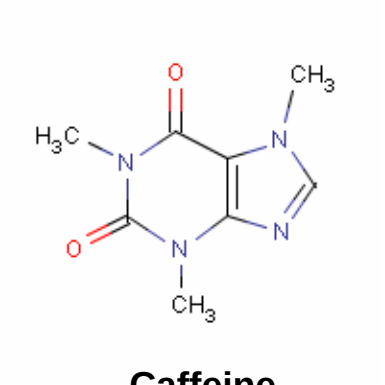
Drug	Action/Clinical Use	Species
Acetyldigoxin	Cardiotonic	Digitalis lanata
Allyl isothiocyanate	Rubefacient	Brassica nigra
Atropine	Antichotinergic	Atropa belladonna
Berberine	Bacillary dysentery	Berberis vulgaris
Codeine	Analgesic, antitussive	Papaver somniferum
Danthron	Laxative	Cassia spp.
L-Dopa	Anti-Parkinson	Mucuna spp.
Digitoxin	Cardiotonic	Digitalis purpurea
Ephedrine	Antihistamine	Ephedra sinica
Galanthamine	Cholinesterase inhibitor	Lycoris squamigera
Kawain	Tranquilizer	Piper methysticum
Lapachol	Anti-cancer, anti-tumor	Tabebuia spp.
Ouabain	Cardiotonic	Strophanthus gratus
Quinine	Anti-malarial	Cinchona ledgeriana
Salicin	Analgesic	Salix alba
Taxol	Anti-tumor	Podophyllum peltatum
Vasicine	Cerebral stimulant	Vinca minor
Vincristine	Anti-leukemic agent	Catharanthus roseus

Approximately 15% of all current pharmaceuticals in developed countries are derived solely from plants (85% in undeveloped countries).

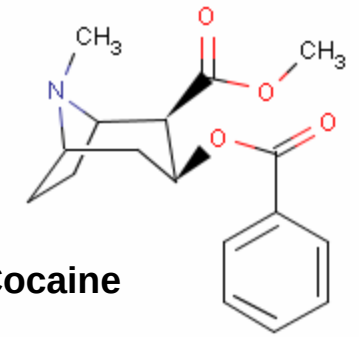
Alkaloids derived from plants



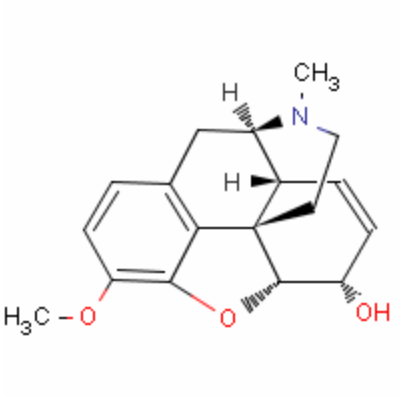
Atropine



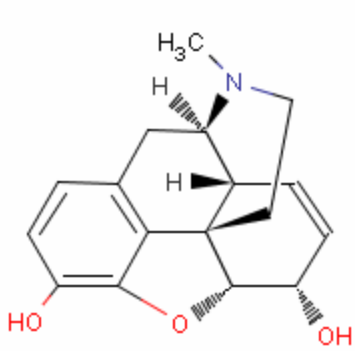
Caffeine



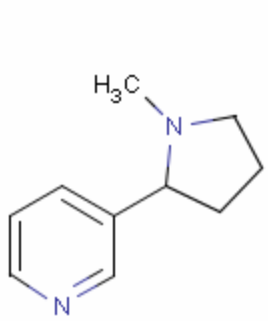
Cocaine



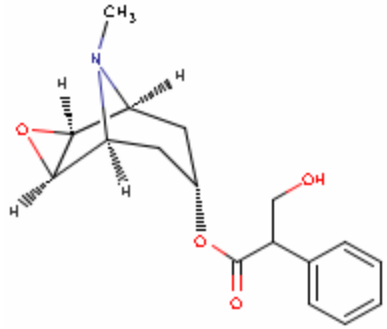
Codeine



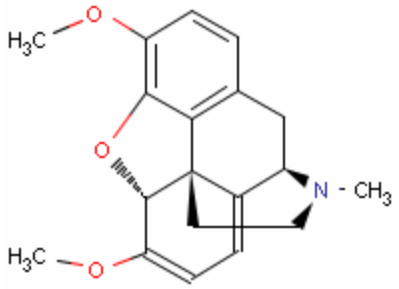
Morphine



Nicotine



Scopolamine



Thebaine

Atropine and scopolamine

Variable	Averages					P-values		
	294	378	690	22.1	27.1	CO_2 Effect	T. Effect	CO_2xT
Jimson weed.								
Atropine (mg g^{-1})	1.4	1.3	1.4	1.1	1.7	—	***	(*)
Atropine (mg)	11.9	14.7	18.9	11.5	18.4	*	**	(*)
Scopolamine (mg g^{-1})	1.9	2.2	2.4	2.2	2.1	***	—	—
Scopolamine (mg)	12.9	20.9	25.4	18.8	20.8	**	—	—

(*), P<0.10; * , P<0.05; ** , P<0.01; *** , P<0.001

2b. CO_2, plants and narcotics.

Effects unknown

Growth increases.

Anecdotal evidence

Papaver setigerum DC. (Wild poppy)

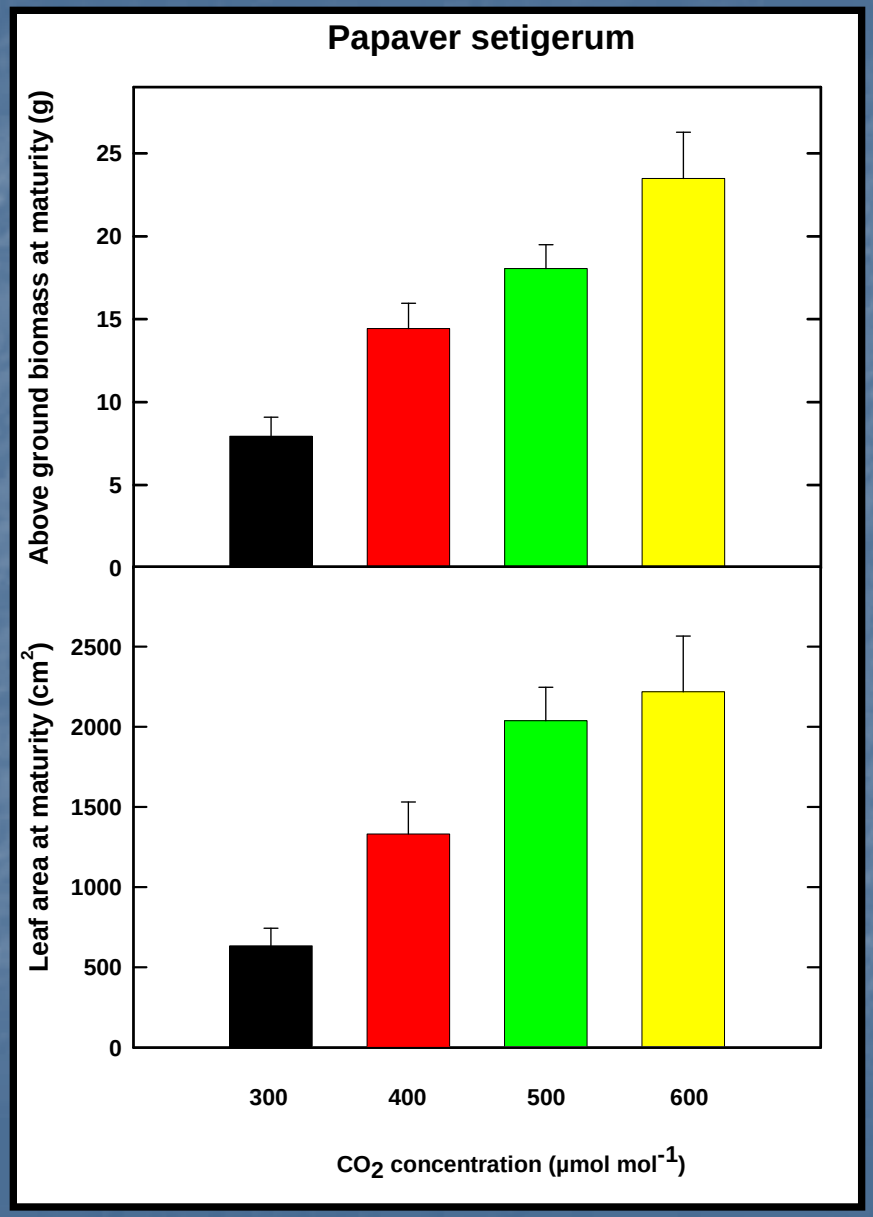
Quantify growth and alkaloid production to carbon dioxide

300 ppm **~1950**

400 ppm **Current**

500 ppm **~2050**

600 ppm **~2090**

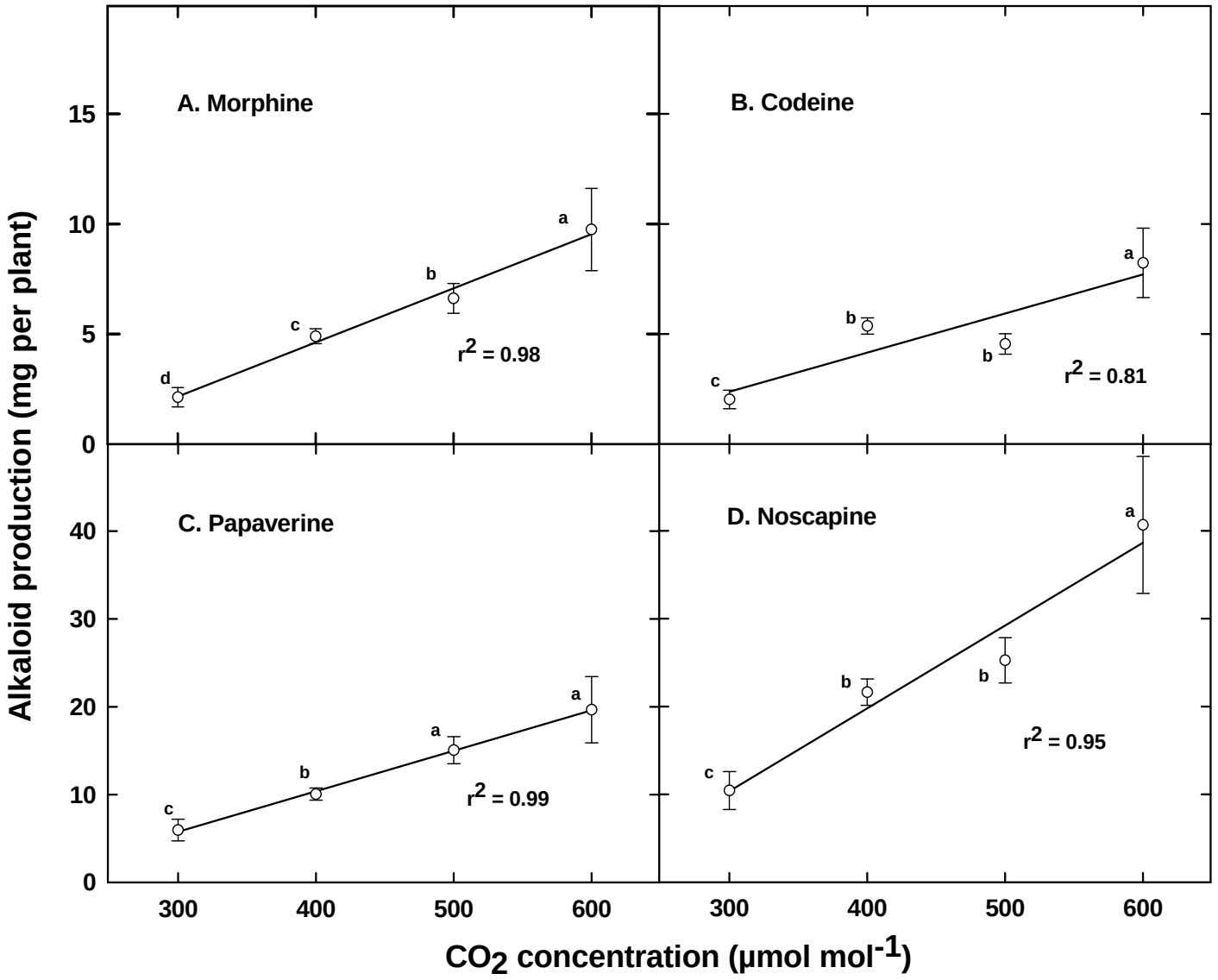


P. setigerum is sensitive to even small (100 ppm) increases in carbon dioxide.

Greatest relative stimulation has occurred with recent (last few decades) CO_2 increase.

	Averages				P-value
Variable	300	400	500	600	CO_2 Effect
Capsule No.	14.6	29.4	32.9	52.1	***
Capsule Wt. (g)	1.44	2.47	3.55	4.30	***
Latex (mg)	97	198	259	363	***
Morphine (%)	2.20	2.34	2.56	2.67	0.06

Concentration of other alkaloids did not increase with increasing CO_2.

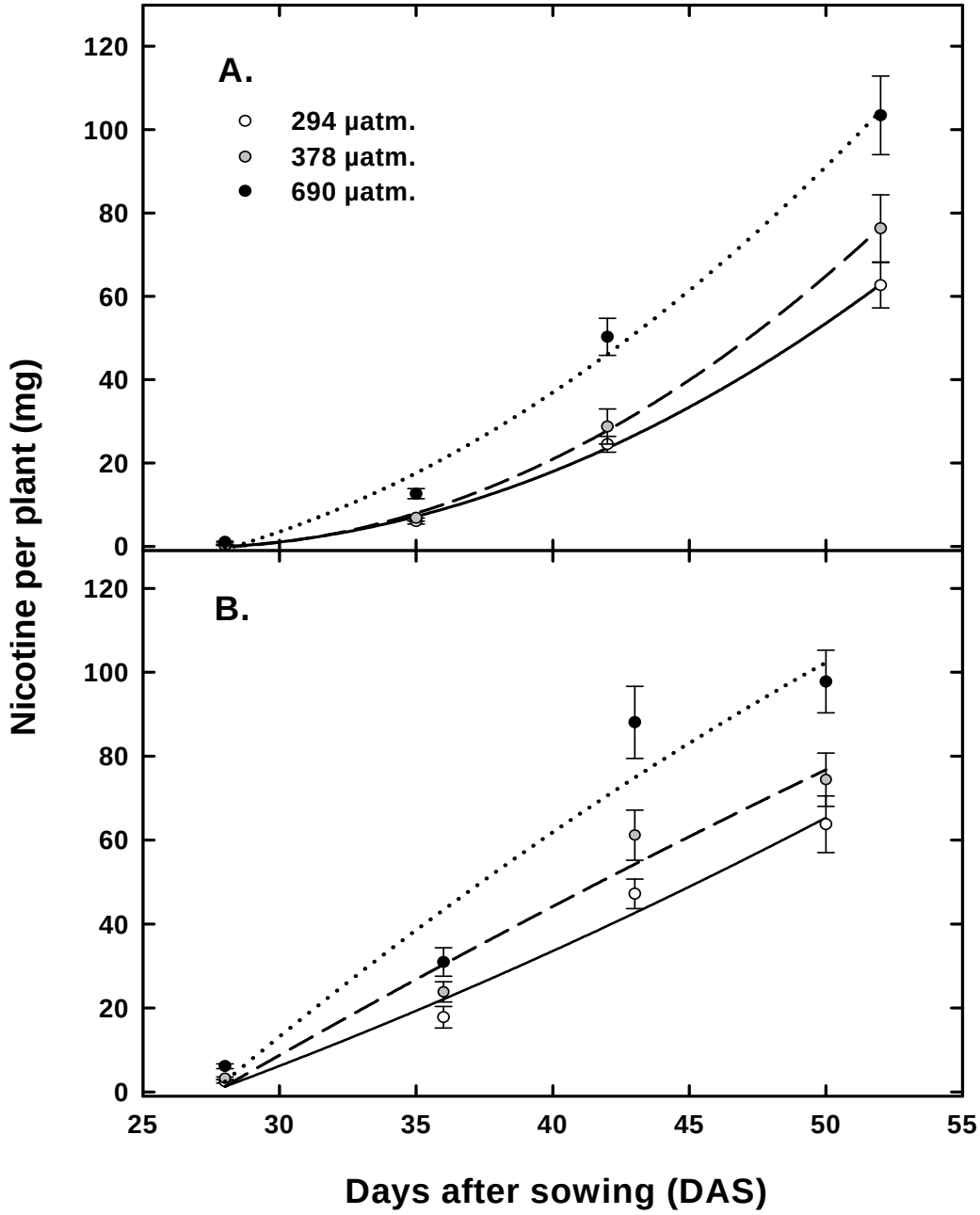


3-4 x increase in alkaloid production in wild poppy with recent and projected CO_2 increases.

Nicotine production

Nicotine Concentration

294 ppm	4.7 µg g^{-1}
378 ppm	4.4 µg g^{-1}
690 ppm	3.6 µg g^{-1}



3. CO_2, plants and disease vectors

plants are not vectors per se, but:

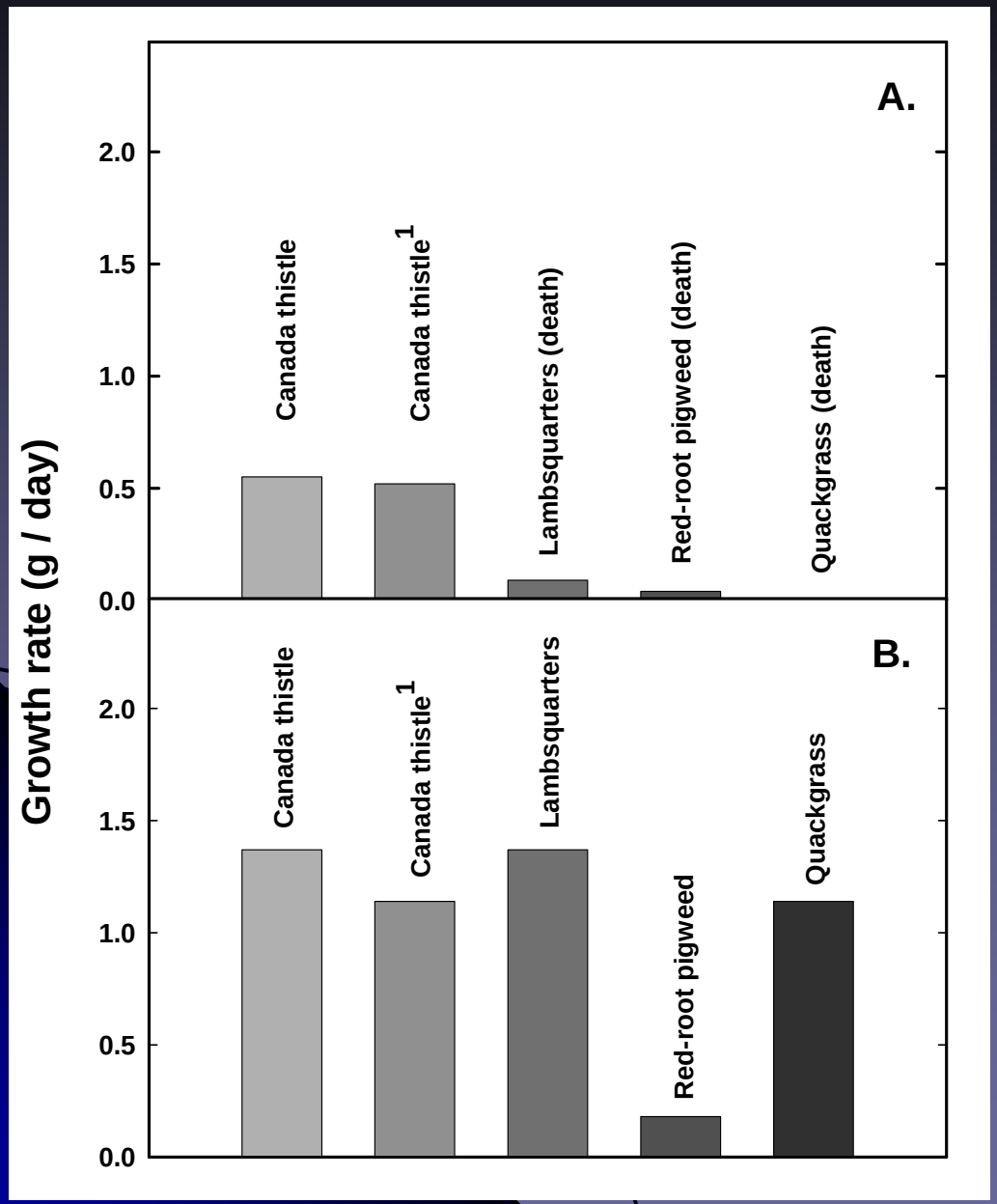
CO_2 / temperature

4. CO_2, plants and pesticides.

Why can't we just control these weeds?

As carbon dioxide increases, glyphosate efficacy is reduced

A synopsis of CO_2 impacts on herbicide efficacy



Efficacy is reduced in a number of studies. The basis for the reduction is not entirely known.

Climate change, plants and public health

Direct Effects

Allergies

Contact dermatitis

Toxicology

Indirect Effects

Nutrition

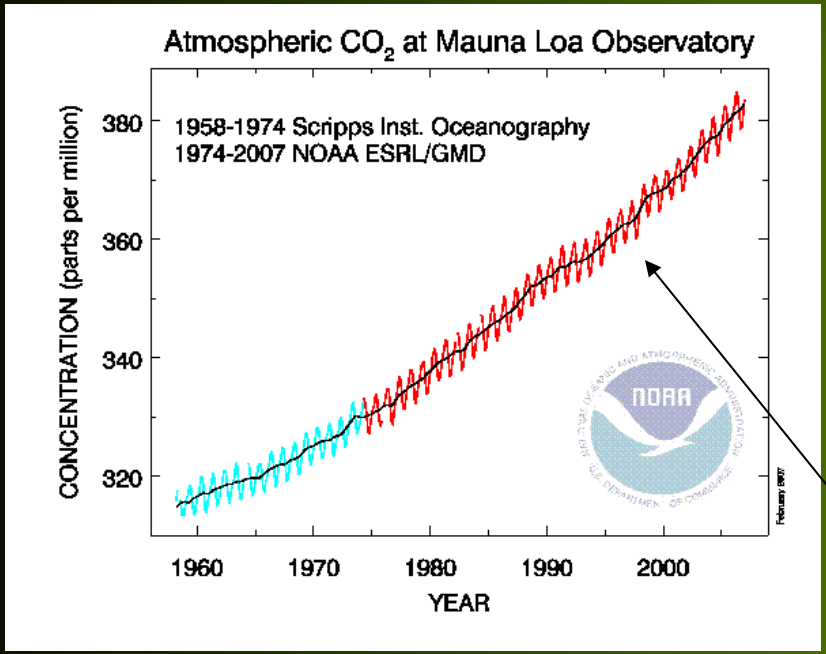
Medicine

Spread of disease vectors

Increased pesticide use.

Prove me wrong…

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.

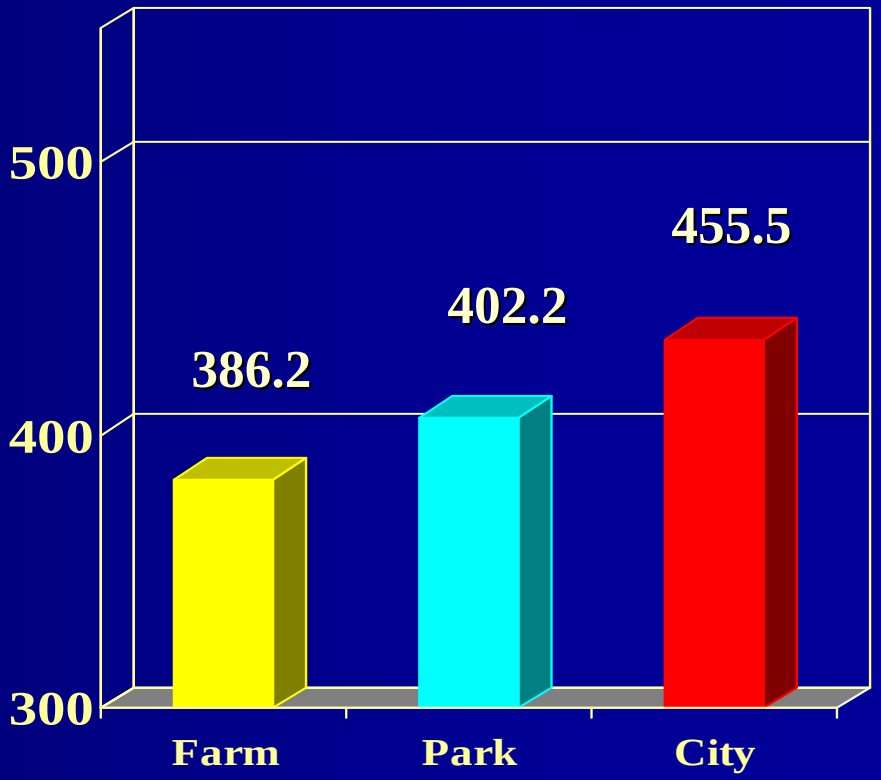


Mauna Loa, “Official” CO_2 data.

10,000 feet on a mountaintop in Hawaii.

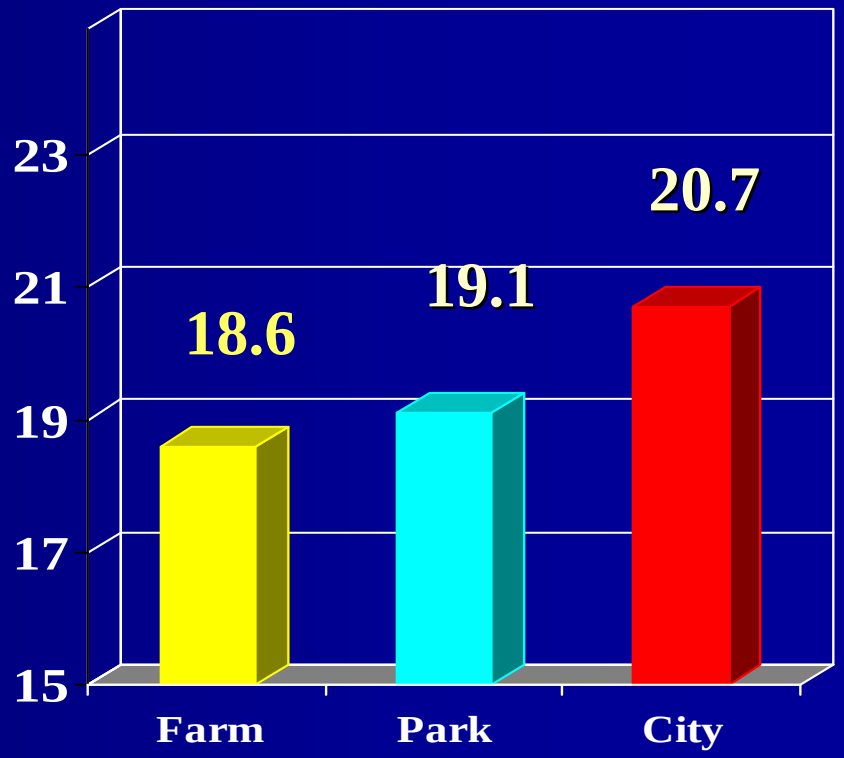
Is the rise in CO_2 the same everywhere?

- Change in average day-time CO_2 concentration (ppm) from downtown Baltimore to an organic (rural) farm.



Is the increase in temperature the same?

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



And if it isn't…Can we study the effects of climate change NOW?

Placing four 2x2 m^2 plots
Near downtown Baltimore.
Use same soil and seed bank
in suburban and rural locations.

"Necessity may be the mother of invention, poverty is the father…."

First year response, rural farm, 2002

First year re-growth of fallow soil, +90% lambsquarters, 6-8 feet in height.

(About as big as it gets)

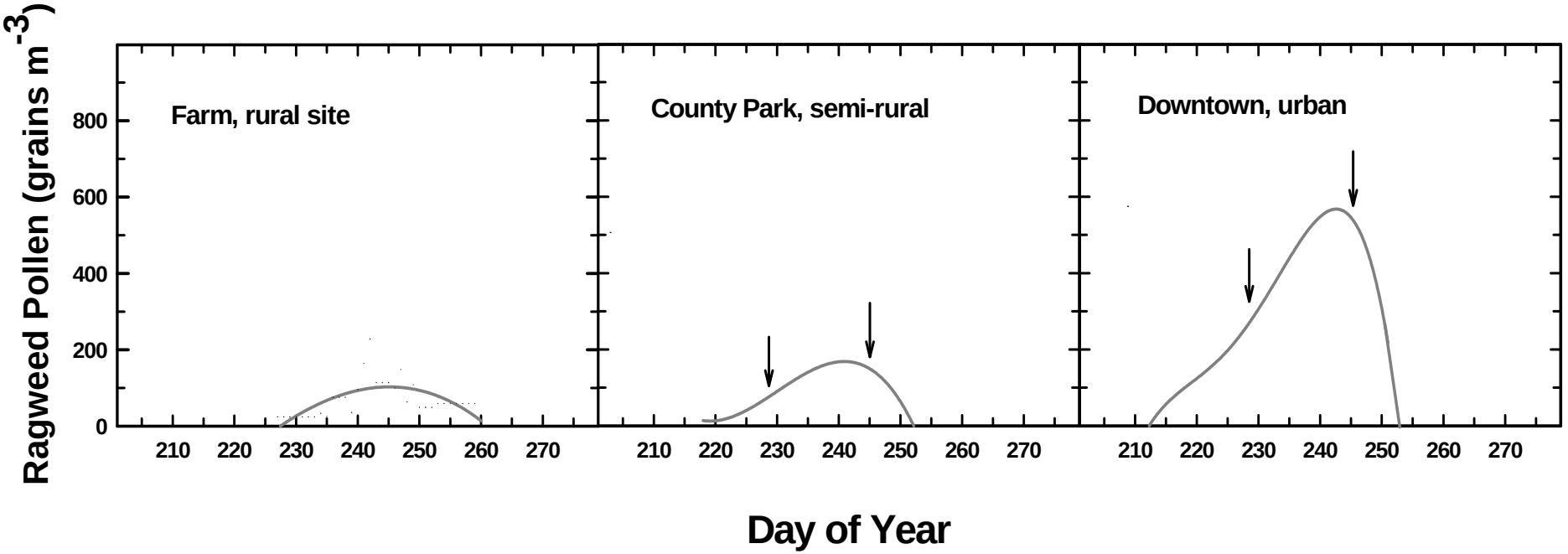
First year response, urban Baltimore, 2002

First year re-growth, 80% lambsquarters, 10-12 feet in height. More annual weeds present.

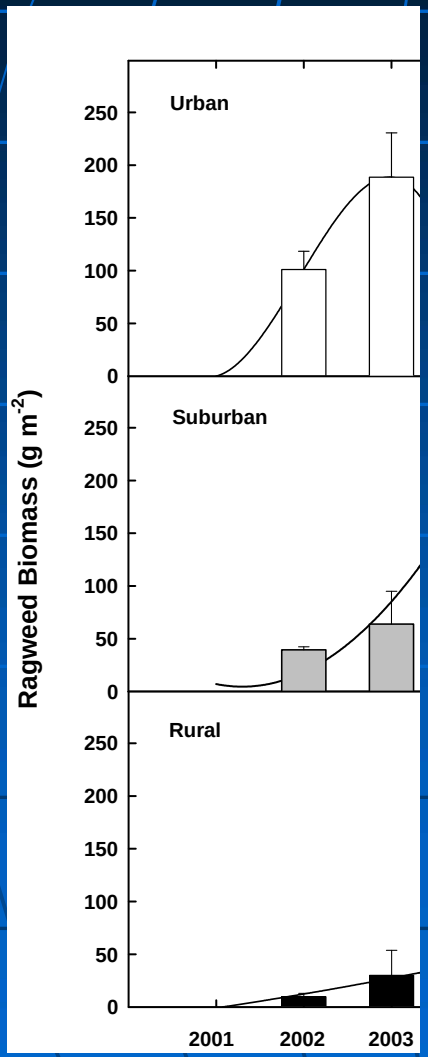
No other meteorological factors (wind speed, ozone, etc.) varied along the transect.

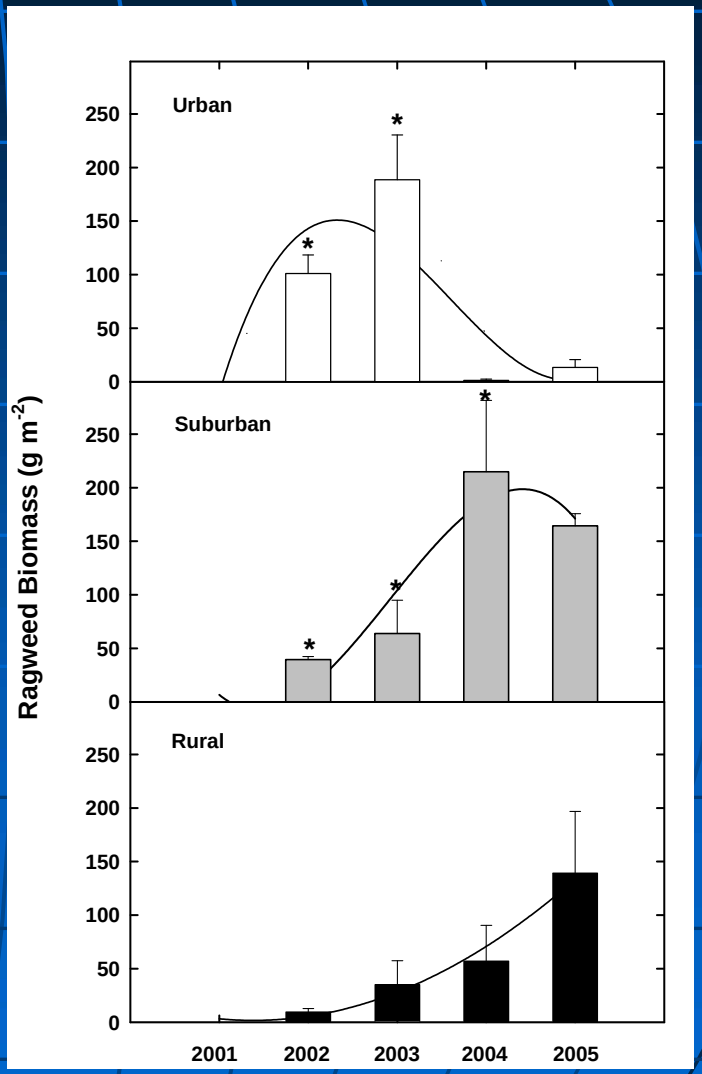
Ziska et al. Oecologia, 139:454-458, 2004

Got ragweed?


Ragweed Pollen (grains m-3)
Farm, rural site
County Park, semi-rural
Downtown, urban
0
200
400
600
800
210
220
230
240
250
260
270
Day of Year

Ragweed persistence 2001-2005





And after 5 years…….

Rural Urban

Ragweed populations have diminished in urban locations, but trees (another important source of pollen) have compensated!

Litter deposition and seed germination.

Rural location

Greater litter deposition from the urban site (high carbon dioxide, temperature) prevents germination of small seeded annuals (e.g. ragweed), while promoting larger seeded (usually perennial) species.

Urban location

Weeds and Public Health: Real Time:

But I still see ragweed in the city. What's up with that?

Some tentative conclusions: allergies

Ragweed, in the chamber, in monocultures, in competition, shows a strong initial response to CO_2 and/or temperature. This suggests that ragweed has--and may continue-- to show a strong temporal response to rising CO_2 and/or temperature associated with climate change.

With respect to urbanization, while initial growth and pollen production is high following a disturbance, population persistence may be shortened due to CO_2/temperature induced changes in litter deposition and the rate of succession. Yet higher rates of soil disturbance may allow for continuous ragweed populations. What is the rate of soil disturbance? What other species will show an increase in pollen? What about plant decomposition and sporulation?

Some tentative conclusions: poison ivy and contact dermatitis

Poison ivy in the forest shows a disproportionate increase in growth rate with future levels of carbon dioxide.

These increases in growth rate are concurrent with qualitative changes in urishiol that are likely to increase the incidence of contact dermatitis.

Would poison ivy growing in an urban environment already show a similar response? What other species might be affected? Can urushiol be used in oncology?

Some tentative conclusions: toxicology

Difficult to make any. Very little data. Likely that CO_2 will affect the concentration of poisonous compounds.

Some tentative conclusions: human nutrition.

In general, the ratio of carbon:nitrogen increases as carbon dioxide increases, with a subsequent decrease in protein concentration.

Likely to be a multitude of effects, some positive, some negative.

Which qualitative factors related to nutrition are likely to change? What patterns can we discern? Only a handful of studies.

Some tentative conclusions: Plants and Medicines

Plants are a major source of medicines—new and old.

Rising carbon dioxide and/or temperature will alter the concentration and production of these medicines.

Similar changes can be expected for narcotic plants.

How will this change drug efficacy? How will this alter our ability to control or regulate narcotics?

Some tentative conclusions: CO_2, plants and disease vectors.

Food supply for rodents or mosquitoes will determine where they can remain viable. Direct effects of CO_2 on the quantity and quality of these plants, as well as climatic effects on their distribution will influence disease vectors in, as yet, unpredictable fashion.

Some tentative conclusions: Pesticide use

Herbicides are the most frequently used chemicals in the United States. Alteration of their efficacy by carbon dioxide or temperature will only be overcome by increasing concentration or application. This may have significant effects on residual chemicals in the environment.

What other pesticides are likely to change? Will climate uncertainty necessitate more frequent spraying?

Recognition

Assessment

Research

Adaptation

Science

POLITICS

Walt Kelly (1913-1971)
(To his children)

There is no need to sally forth, for it remains true that those things which make us human are, curiously enough, always close at hand.

Resolve then, that on this very ground, with small flags waving and tinny blast on tiny trumpets, we shall meet the enemy,

and not only may he be ours…….

…he may be us.