Climate Change and Invasive Weeds: Threats and Consequences.

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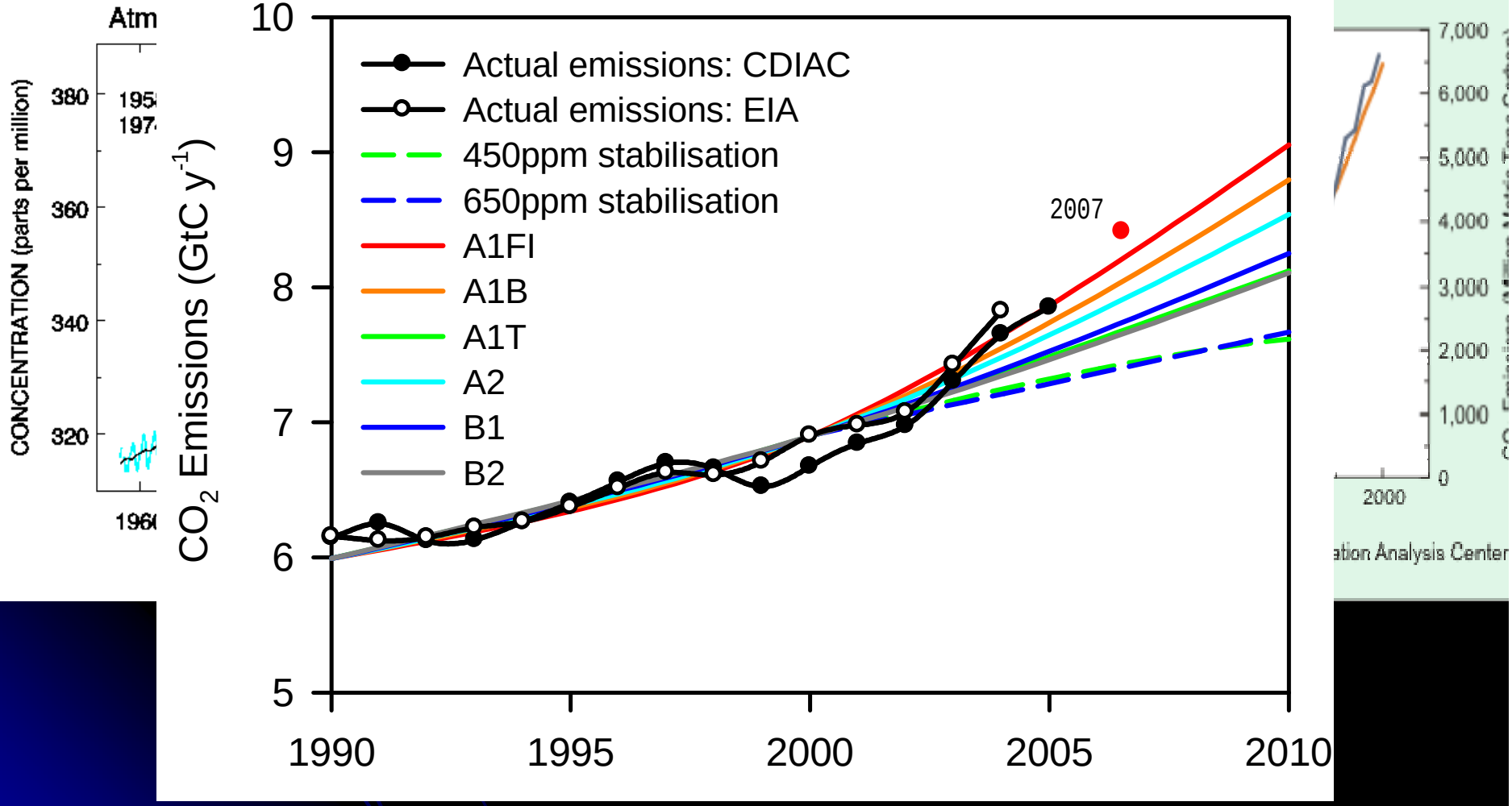
USDA

ARS Agricultural Research Service

Adapting to Climate Change in the Mid-Atlantic, March 24, 2010

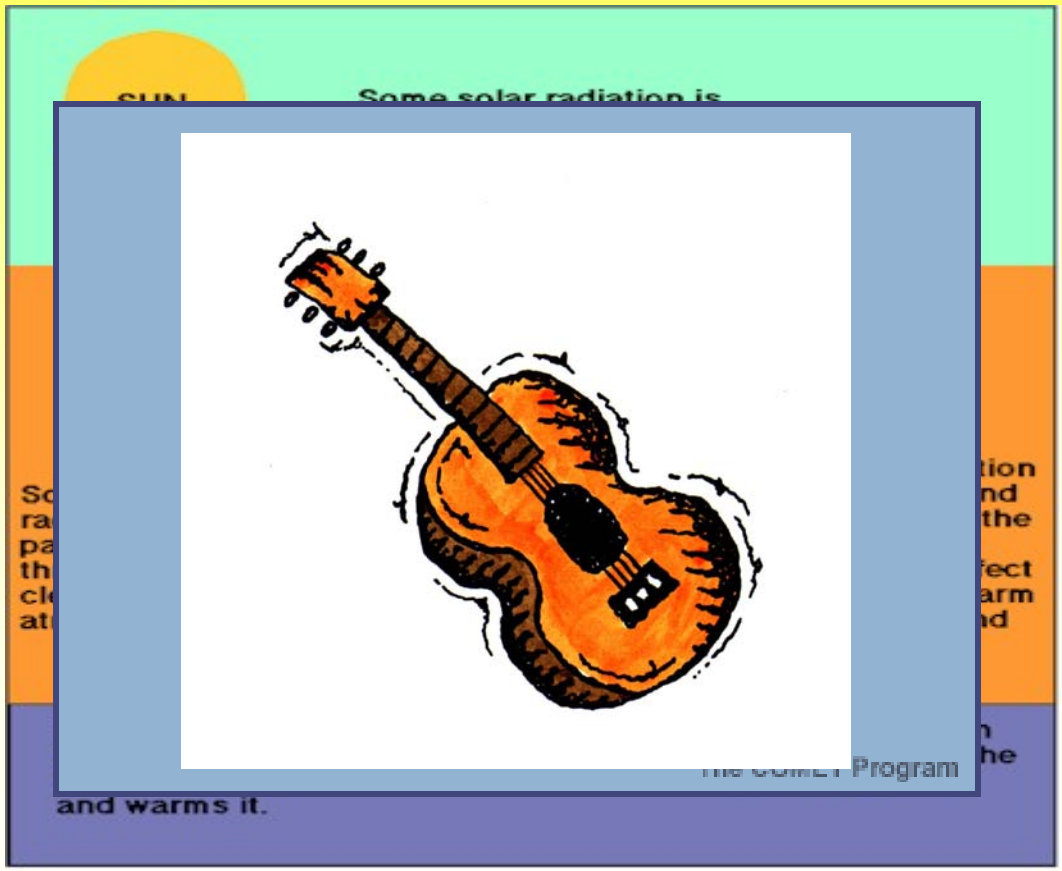
Atmospheric CO_2



So What?

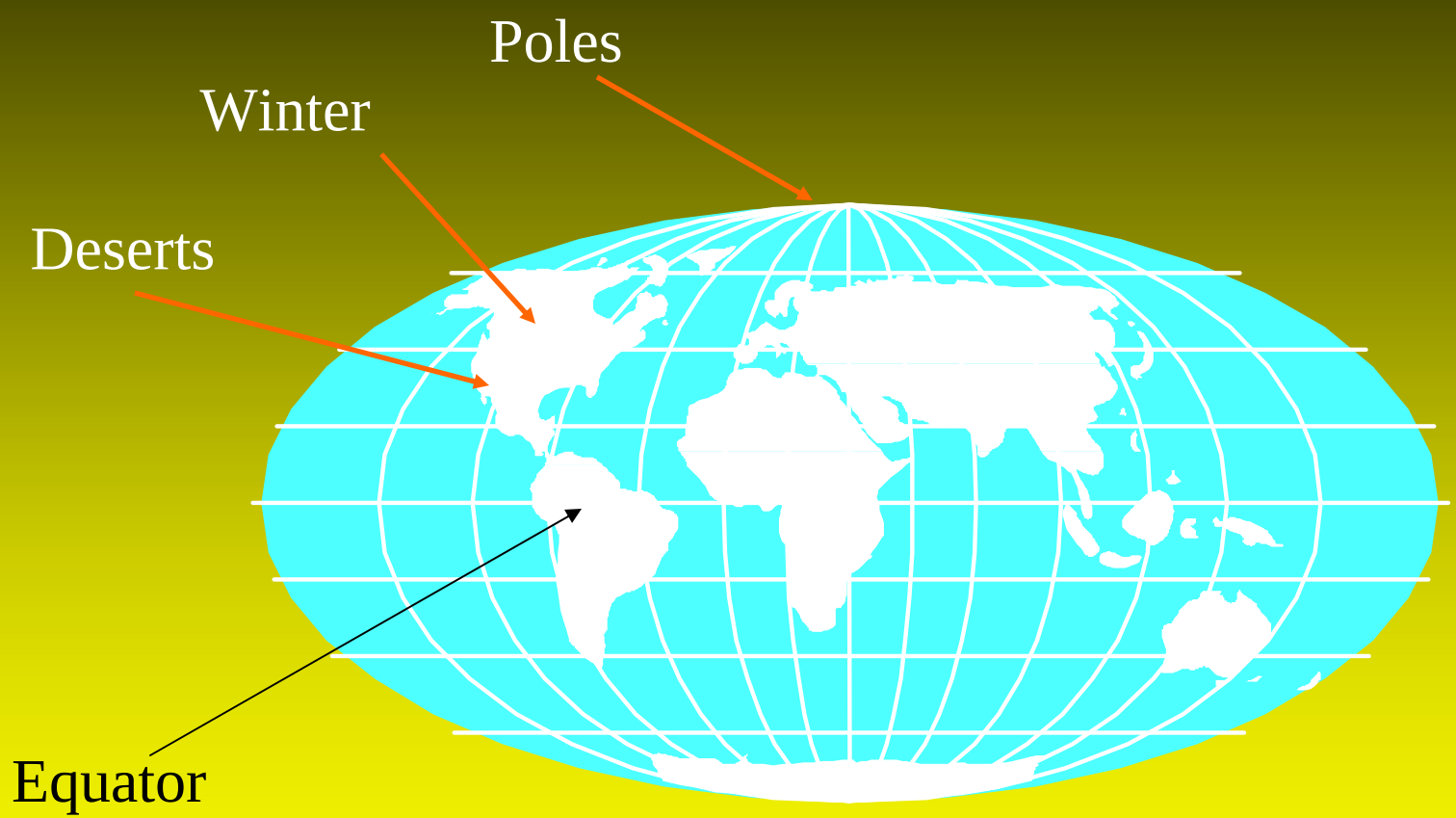
I. An indirect effect of rising carbon dioxide: warmer temperatures.

Gas	%
Nitrogen (N_2)	78.1
Oxygen (O_2)	20.1
Argon (Ar)	0.93
Carbon Dioxide (CO_2)	0.04 up to 0.100
Water (H_2O)	0.05 to 1.00

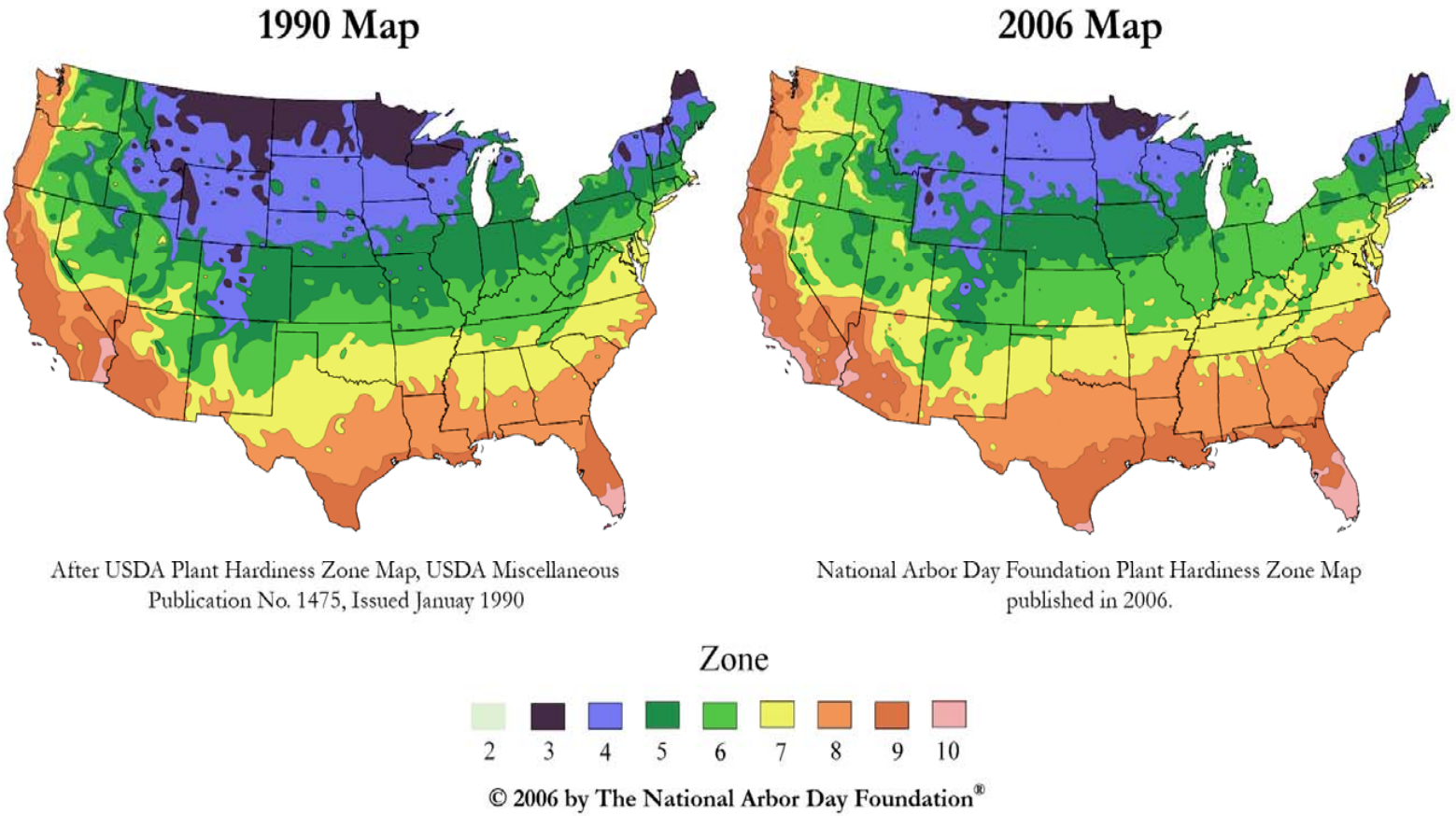


No H_2O and CO_2? Surface temperature would be –18°C. With H_2O and CO_2? Surface temperature is 15°C.

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.



So, indirect effect of temperature on plant distribution.

Warmer winters and northward migration.

Winte

3 - 4

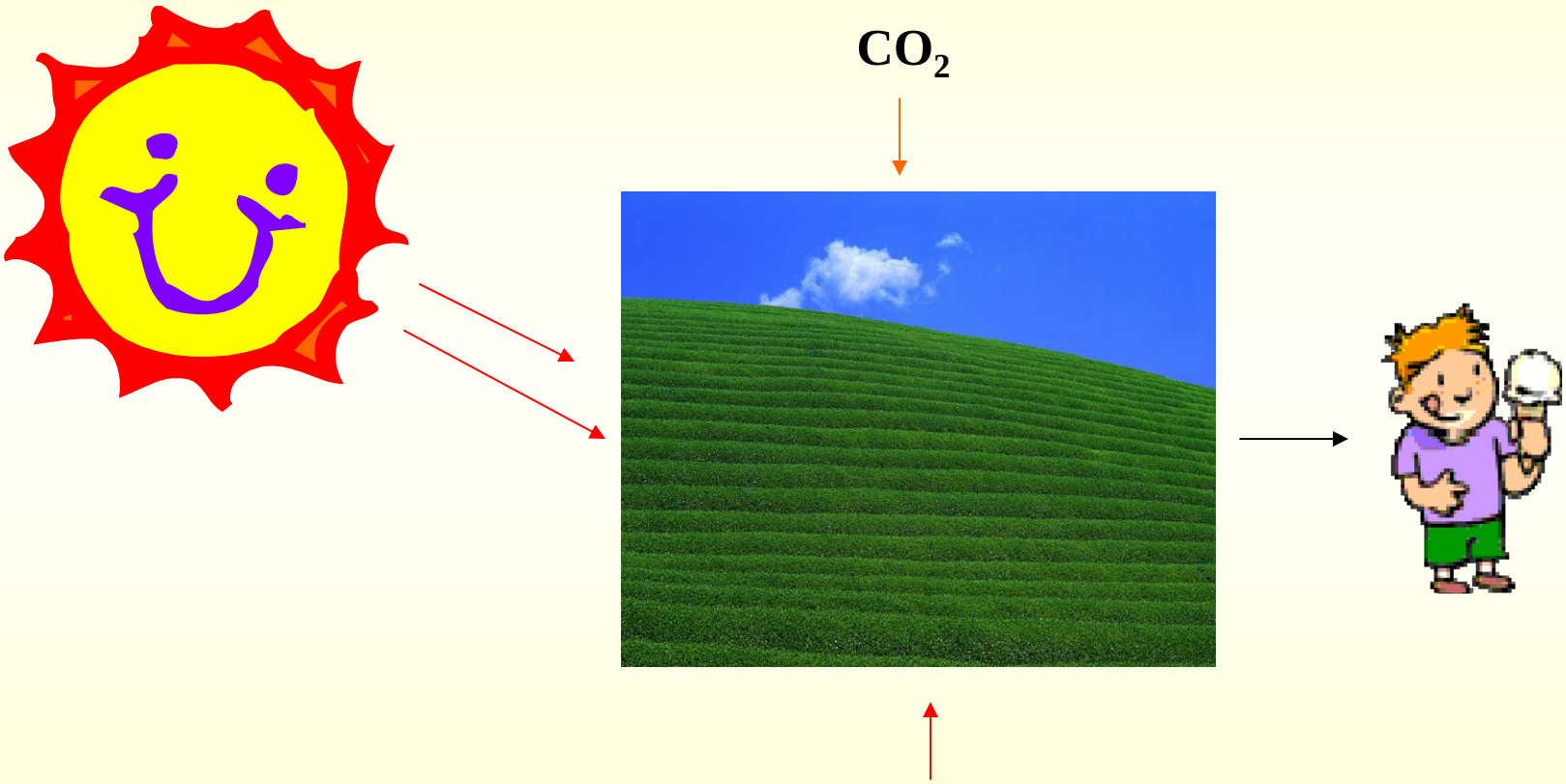
4 - 5

5 - 6

6 - 7

7 - 8

II. A direct effect of rising CO_2: Stimulation of plant growth.



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

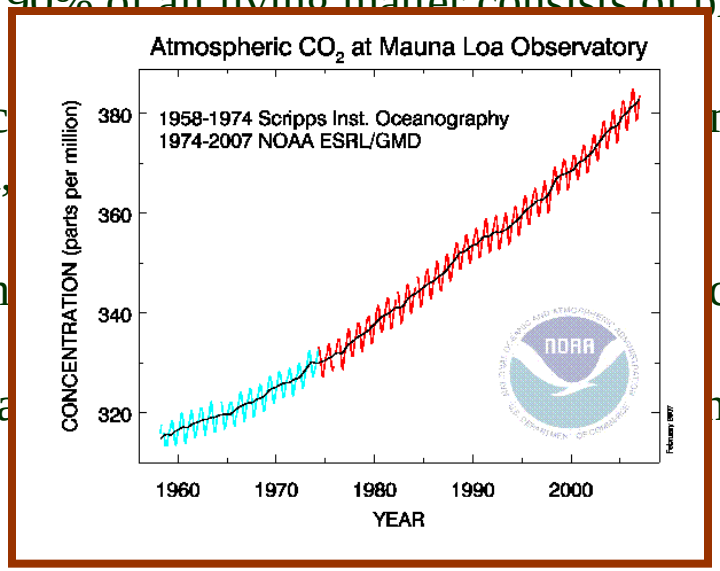
Plants are Important.

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

With the exc ms, if plants did not exist,

Plant growth cal inputs.

Any perturba ng systems.

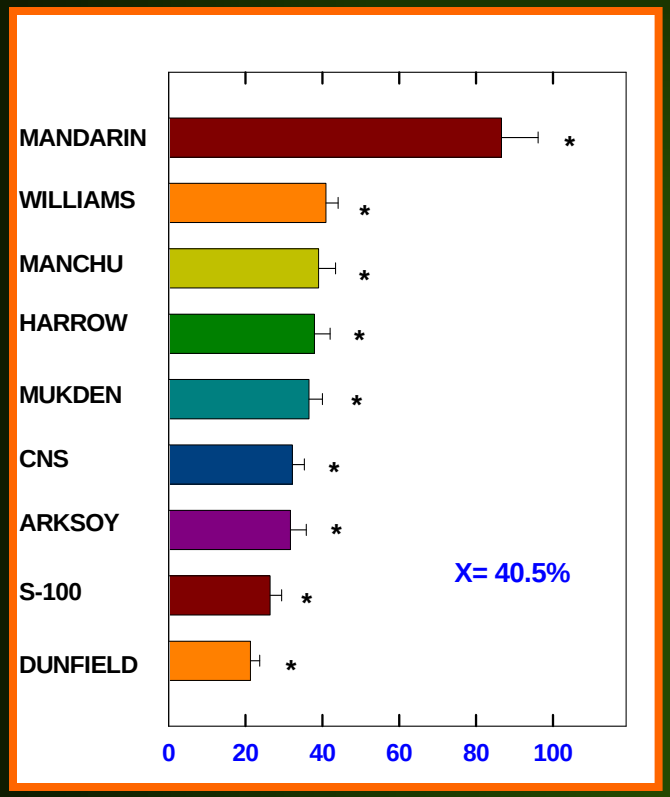


"People who imagined that life on earth consisted of animals moving against a green background, seriously misunderstood what they were seeing. That green background was busily alive. Plants grew, moved, twisted and turned, fighting for [resources]; and they interacted continuously with animals—discouraging 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"

But isn't more plant growth, "good"?

Genetic variability in soybean with increasing CO_2



Evaluation of yield response of 9 soybean cultivars to 710 ppm CO_2.

Greenhouse study, USDA
Crop Science 41:385-391

CO_2 is a VERY smart molecule.

Green is not always good.

CO_2, climate change and plant biology

Food Security

Crop/weed competition

***Invasive plant species**

Weeds and public health.

Invasive weeds

A weedy species, usually non-native for a given region, whose introduction results in wide-spread environmental or species degradation.

- **Financial Cost: In the billions.**
- **Environmental Cost: loss of genetic diversity**

8 million acres of Kudzu

5 million acres of Canada thistle

How will temperature and/or CO_2 alter the potential success of invasive weeds?

1. Canada thistle, nitrogen and CO_2
2. Minimal temperatures and Kudzu migration
3. In real time.

CO_2 and Canada thistle

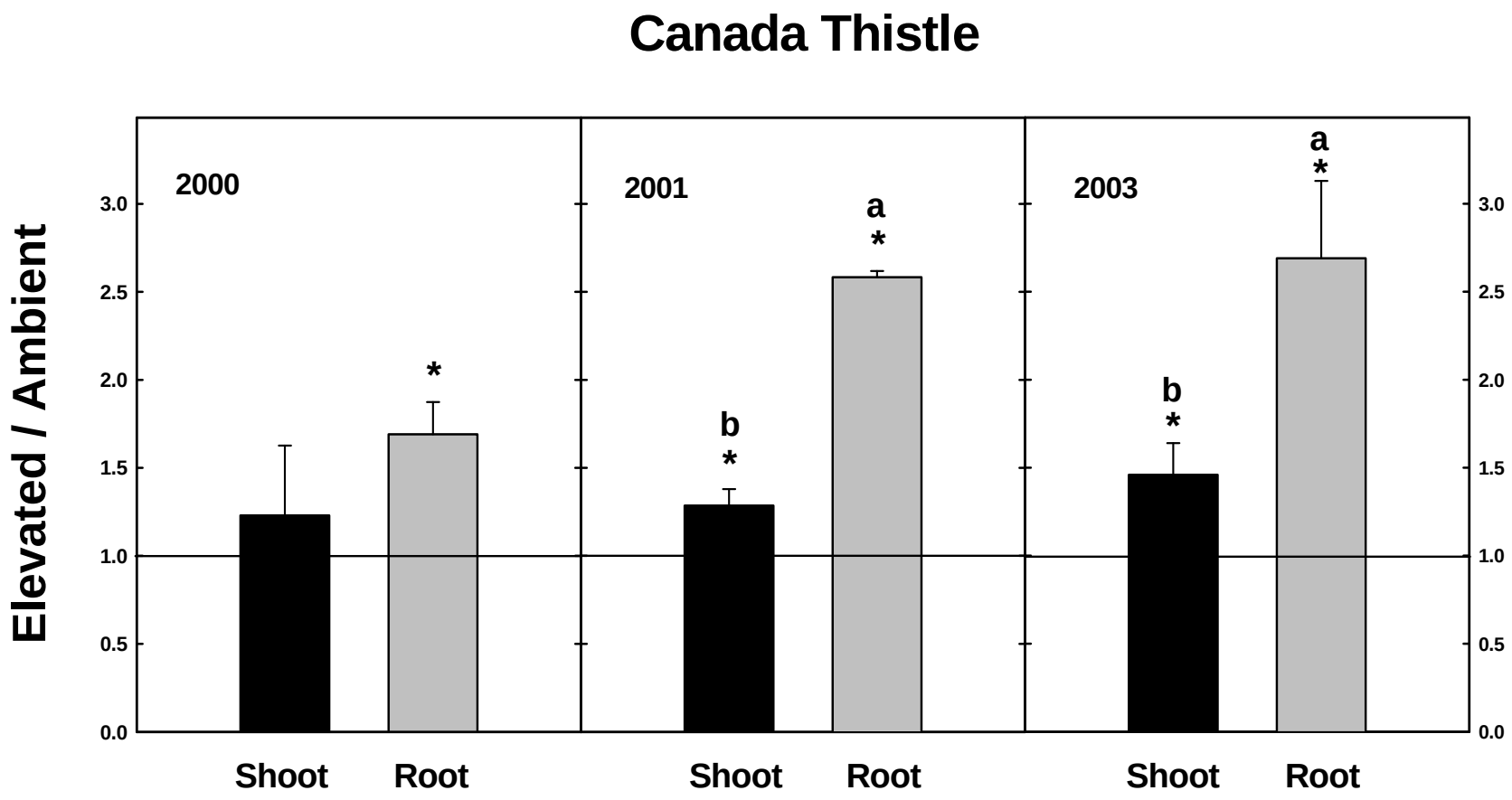
Some Noxious Weeds: The best of the worst.

Skinner et al. Weed Science, 48:640

1.	Cirsium arvense, Canada thistle	33 lists
2.	Carduus nutans, musk thistle	24 lists
3.	Lythrum spp., loosestrife	24 lists
4.	Convolvulus arvensis, field bindweed	23 lists
5.	Euphorbia esula, leafy spurge	22 lists
6.	Acroptilon repens, Russian knapweed	20 lists
7.	Sorghum spp., sorghum	20 lists
8.	Cardaria spp., whitetop	17 lists
9.	Centaurea maculosa, spotted knapweed	17 lists
10.	Sonchus arvensis, perennial sowthistle	17 lists
11.	Centaurea diffusa, diffuse knapweed	16 lists
12.	Elytrigia repens, quackgrass	16 lists
13.	Cuscuta spp., dodder	12 lists
14.	Linaria dalmatica, Dalmation toadflax	12 lists
15.	Centaurea solstitialis, yellow starthistle	11 lists

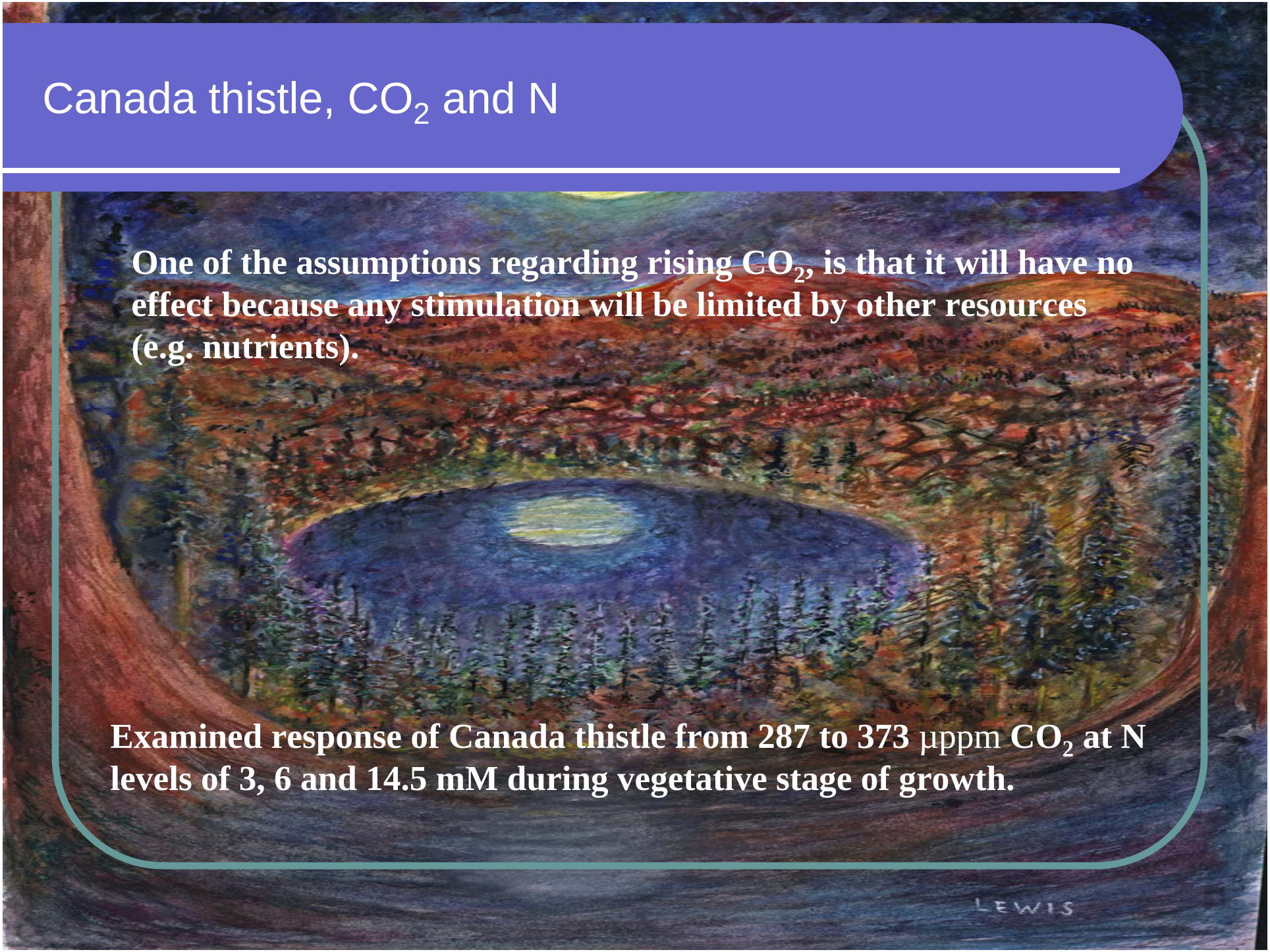
Canada thistle

Canada thistle: Best of the worst.



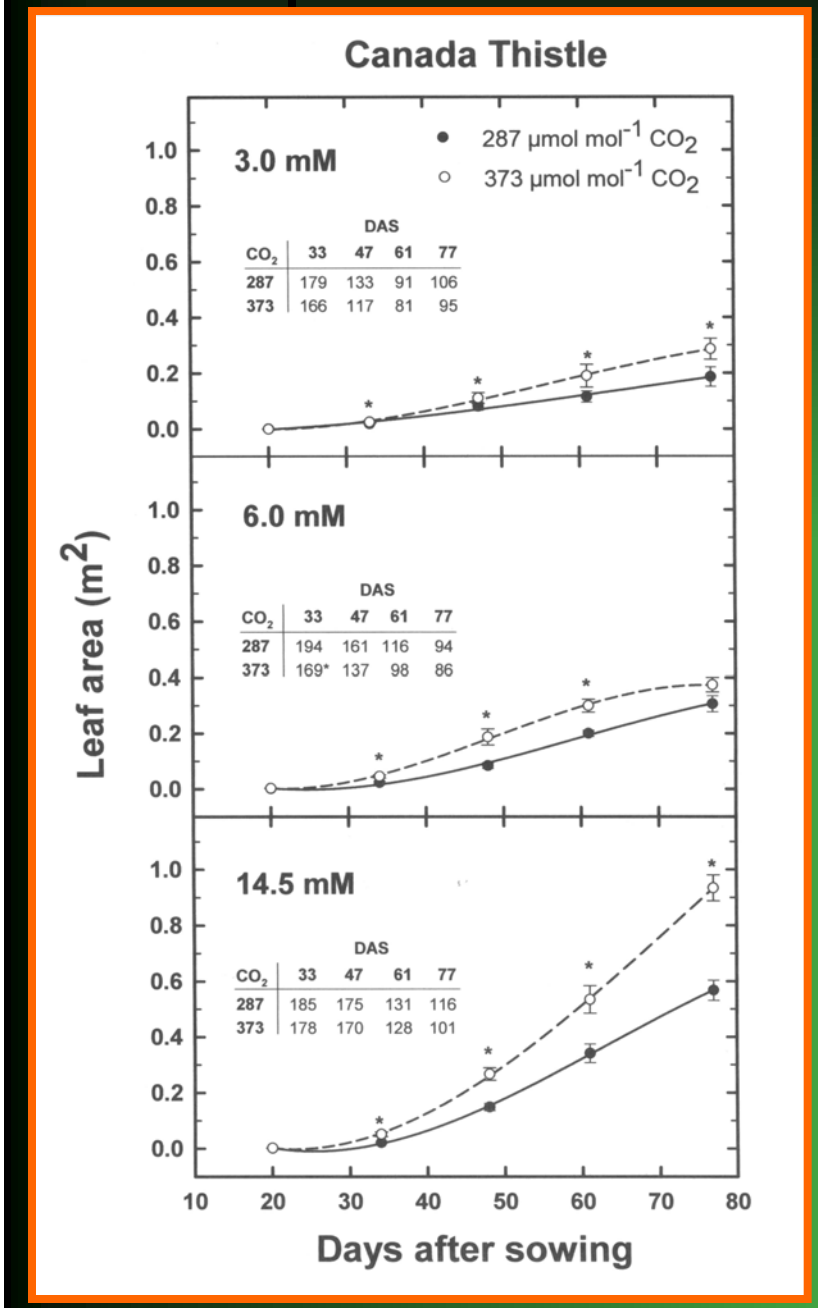
3 years of field trials at +250 ppm above ambient.

Canada thistle, CO_2 and N



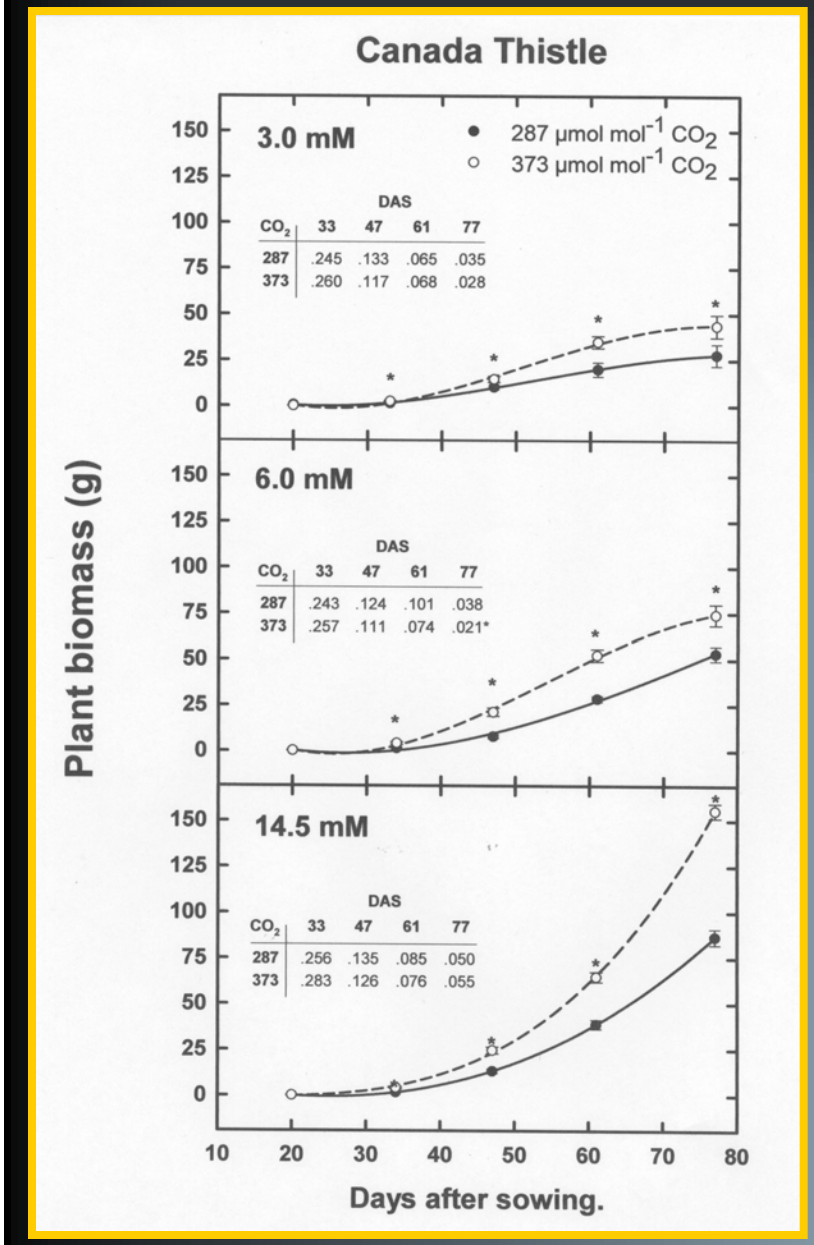
One of the assumptions regarding rising CO_2, is that it will have no effect because any stimulation will be limited by other resources (e.g. nutrients).

Examined response of Canada thistle from 287 to 373 µppm CO_2 at N levels of 3, 6 and 14.5 mM during vegetative stage of growth.



Canada thistle, CO_2 x N

No change in relative stimulation of leaf area.



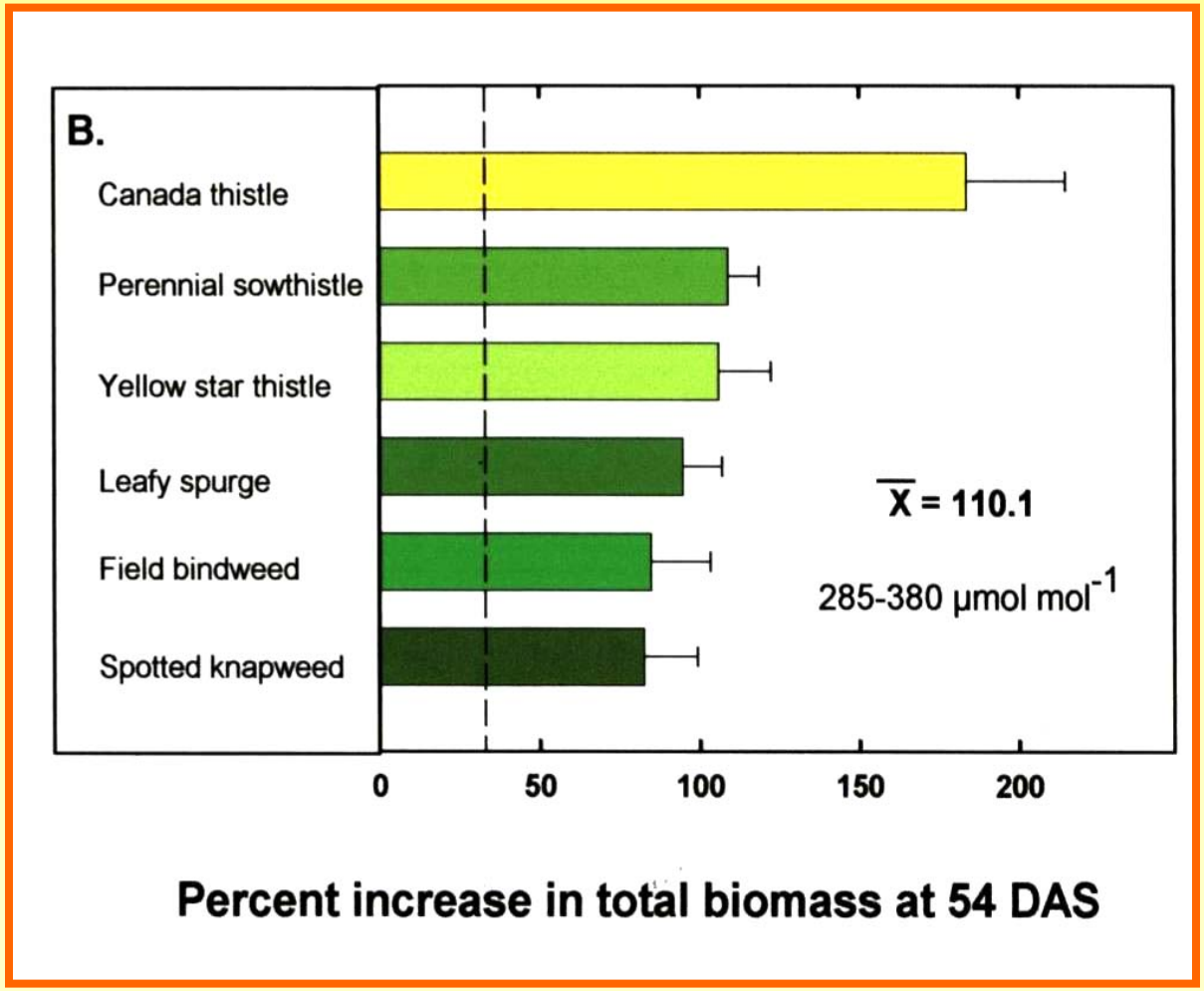
Canada thistle, CO_2 x N

No change in relative stimulation of plant biomass.

Overall for Canada thistle.

- Strong response to rising carbon dioxide with differential response of root>>shoot.
- The response to recent changes in carbon dioxide appears independent of N concentration.

Present vs. Past



So far only examined individual plant response.

Does CO_2 preferentially select for invasive species within communities?

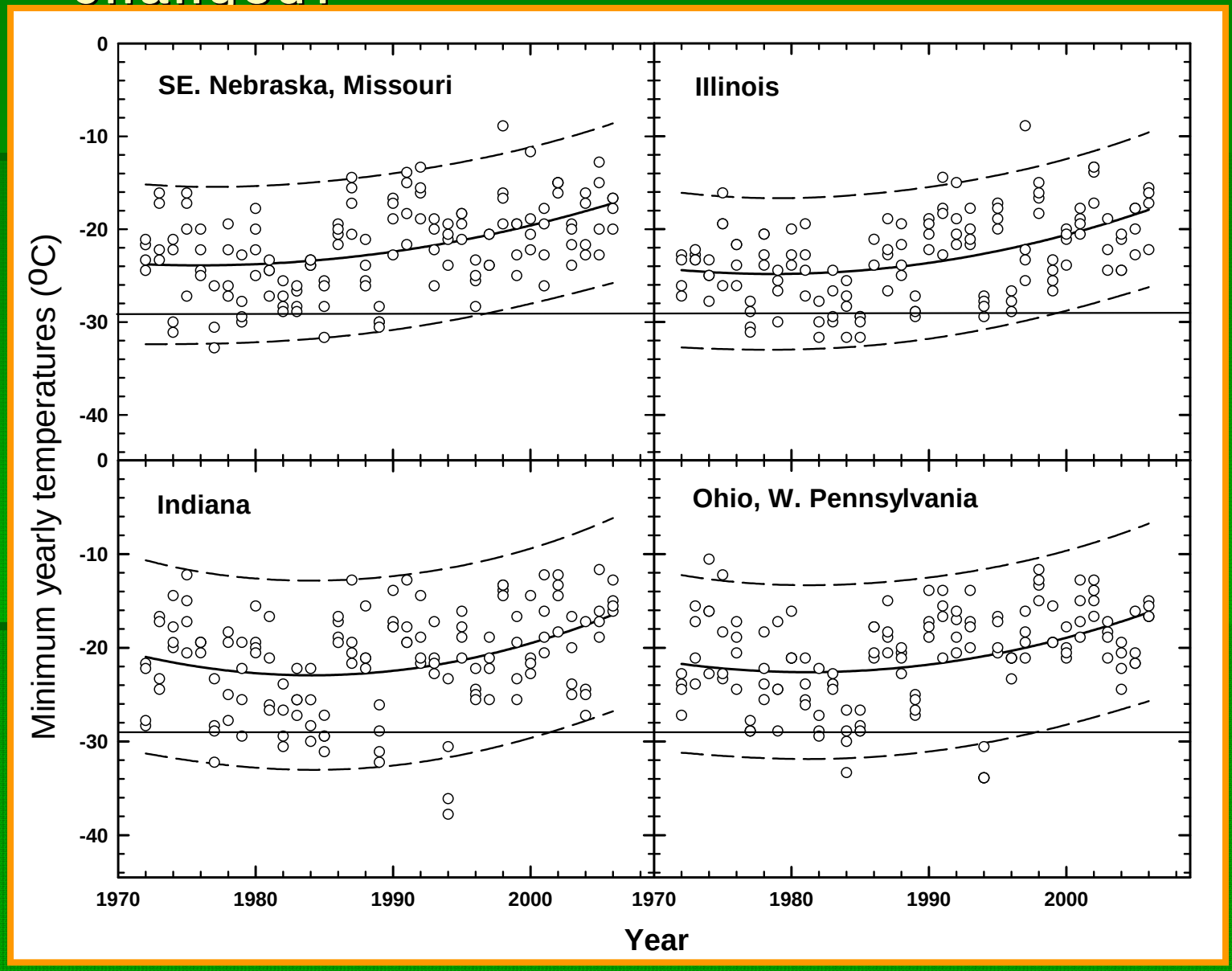
Species	Community	Favored?	Reference
Yellow star thistle	California grassland	No.	Dukes, 2002
Honey mesquite	Texas prairie	Yes.	Polley et al. 1994
Japanese honeysuckle	Forest under-story	Yes.	Belote et al. 2003
Cherry laurel	Forest under-story	Yes.	Hattenschwiler & Korner 2003
Red Brome	Desert	Yes.	Smith et al. 2000

Out of over 600+ Invasives in N. America alone.

Kudzu migration and temperature:

Ah, you may have watched the blacksnake run
To the shaded hole from the blistering sun,
And you may have seen the swallow's flight
And the shooting star in the deep, dark night;
But until you have watched the kudzu grow
You never have seen the fastest show.

Has the minimum temperature threshold changed?



Kudzu and migration

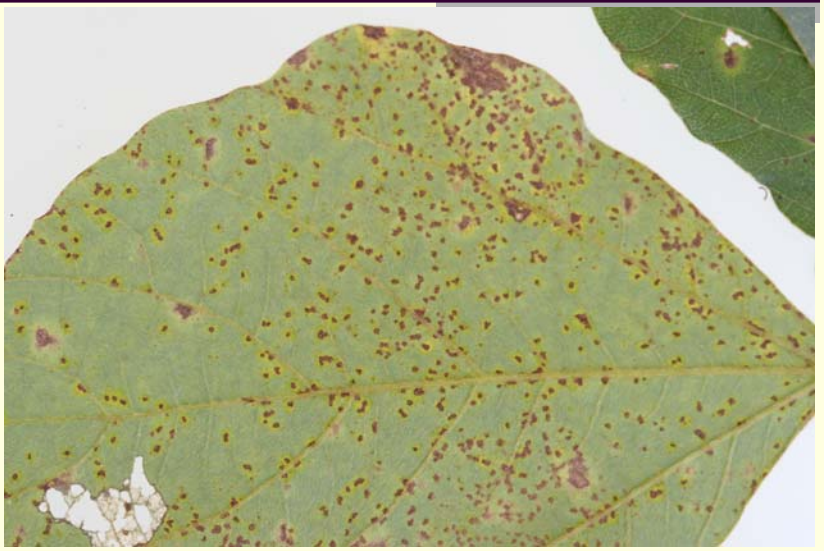
Some implications.

1. Data suggest that the link between global warming and the spread of an invasive species may be real, not hypothetical. What about spring temperatures?

2. Why else should you care if kudzu moves northward?

Asian soybean rust….

Soybean



Kudzu

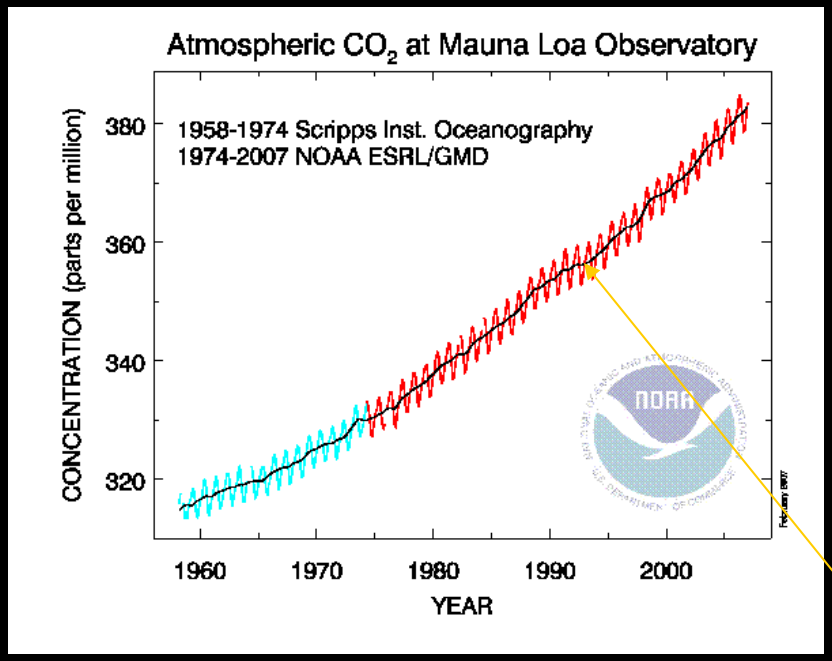
Kudzu can serve as an alternative host for the pathogen. If warmer winters allow kudzu to move northward, what will the impact be on the spread of the disease?

Summary: Invasive weeds and CO_2 / temperature

- Initial evidence indicates that increasing minimum winter temperatures associated with climatic change may be a factor in the northward spread of kudzu.
- Canada thistle, the “worst” invasive, shows a strong response to CO_2, but greater below ground, relative to above ground growth. Response to CO_2 is nitrogen independent.
- Suggestion that CO_2 may select for invasives within assemblages of plants.

In real time?

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.

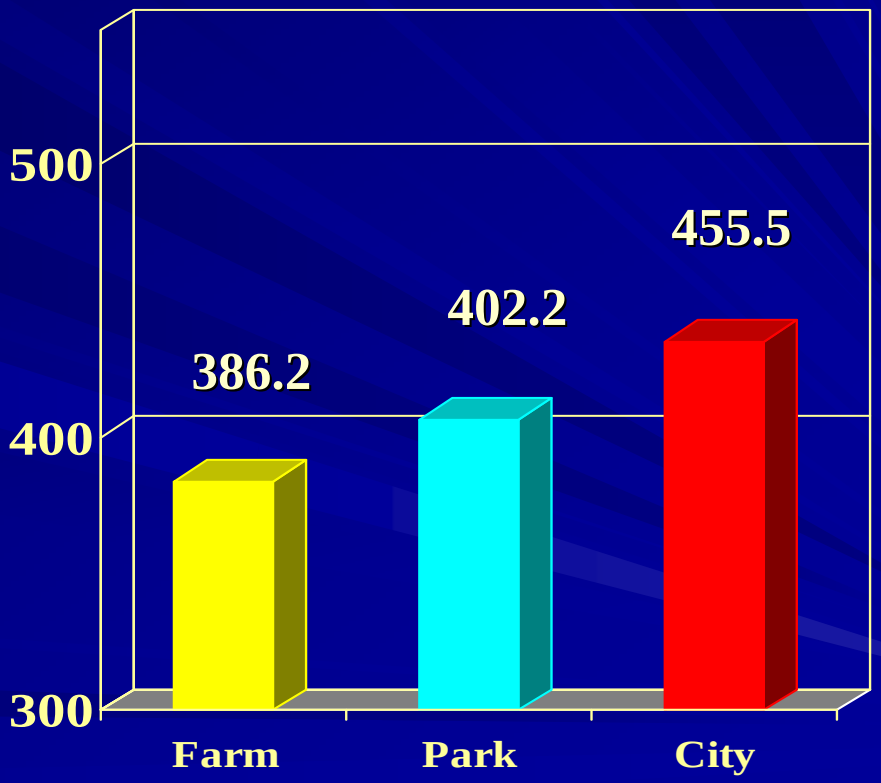


Mauna Loa, “Official” CO_2 data.

10,000 feet on a mountaintop in Hawaii.

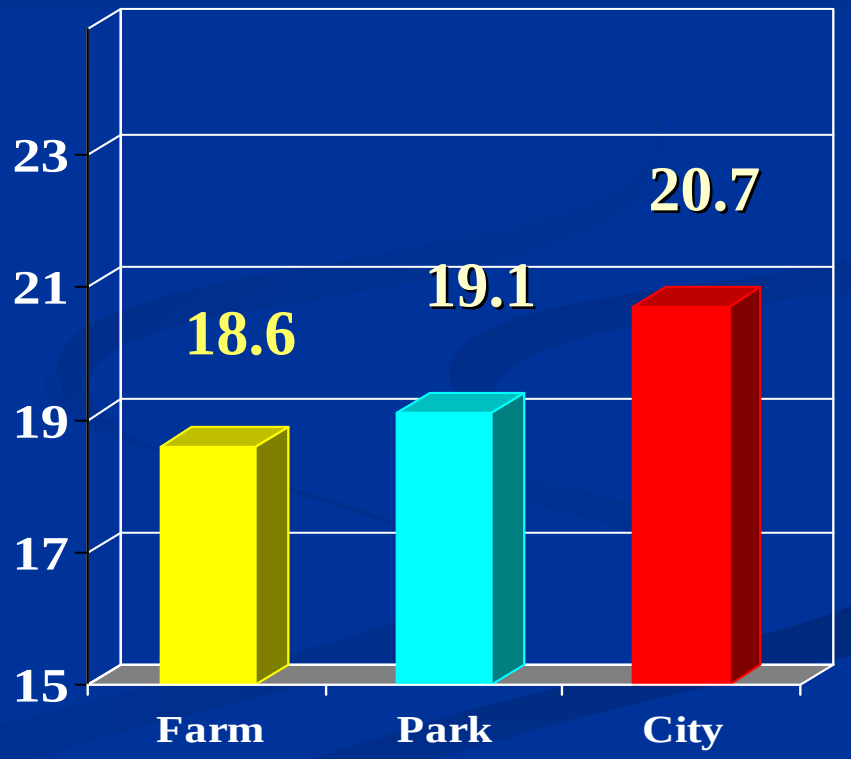
Is the rise in CO_2 the same everywhere?

- 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…."

Technical skills….

Back-filling to maintain uniform bulk density

Took mixed fallow topsoil (top 20 cm. 99% of seed bank), and placed it at each site.

Watered at each site to match ET

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.

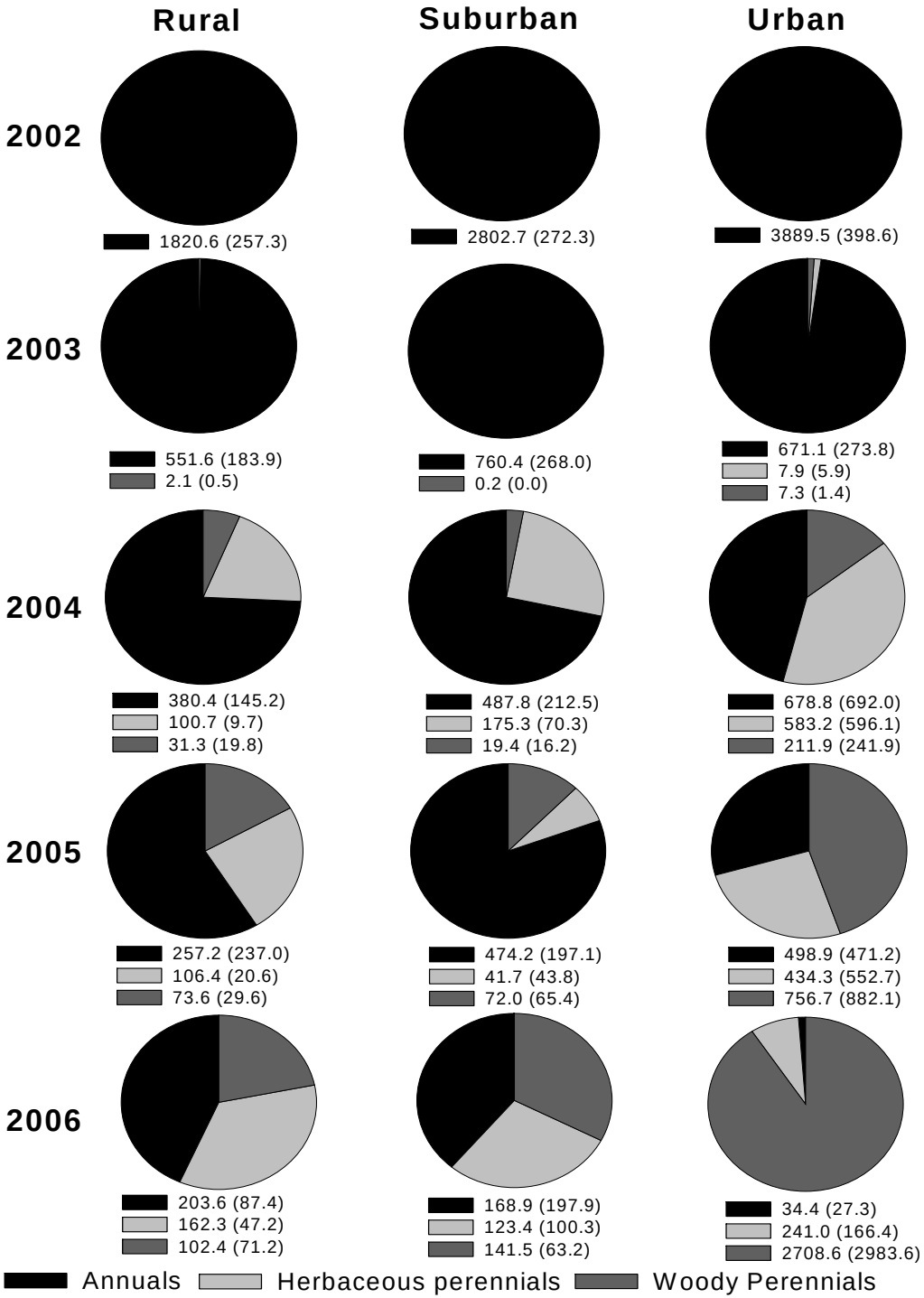
No other meteorological factors (wind speed, ozone, etc.) varied along the transect.

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

George et al. Atmos. Env. 41:7654-7665, 2007

And after 5 years……

Why is succession faster in urban areas?



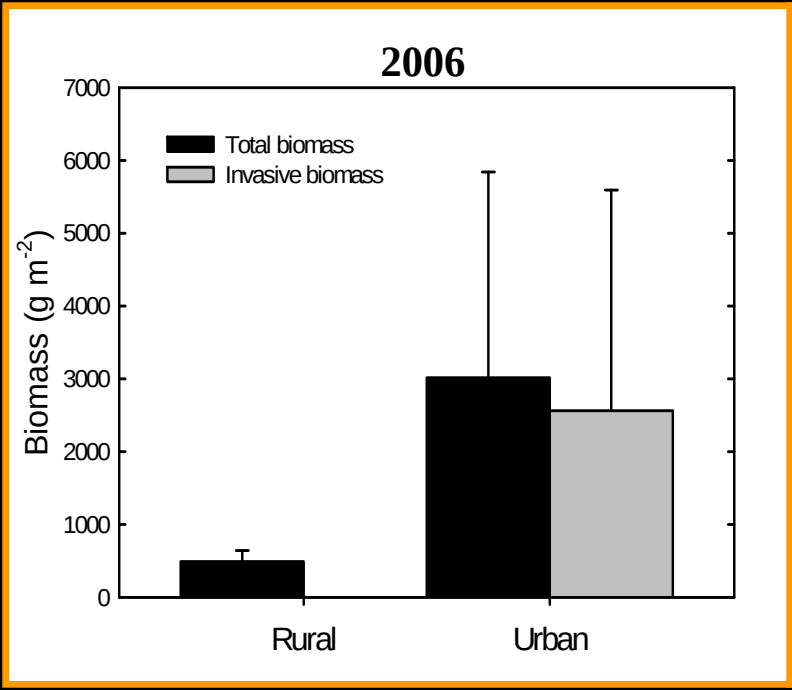
Litter deposition and seed germination.

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 Climate Change: Real Time: After 5 years



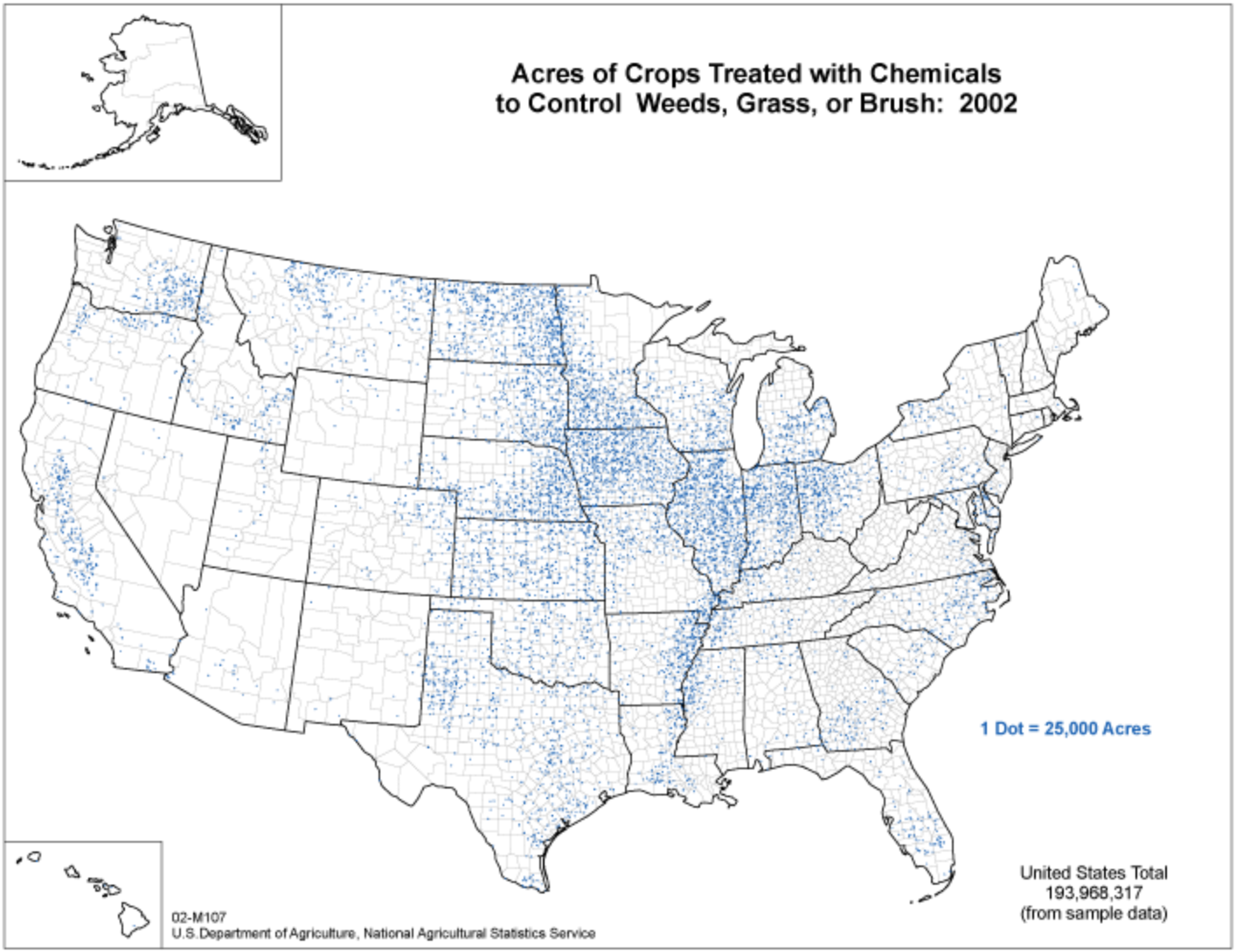
High percentage of invasive perennials in city.

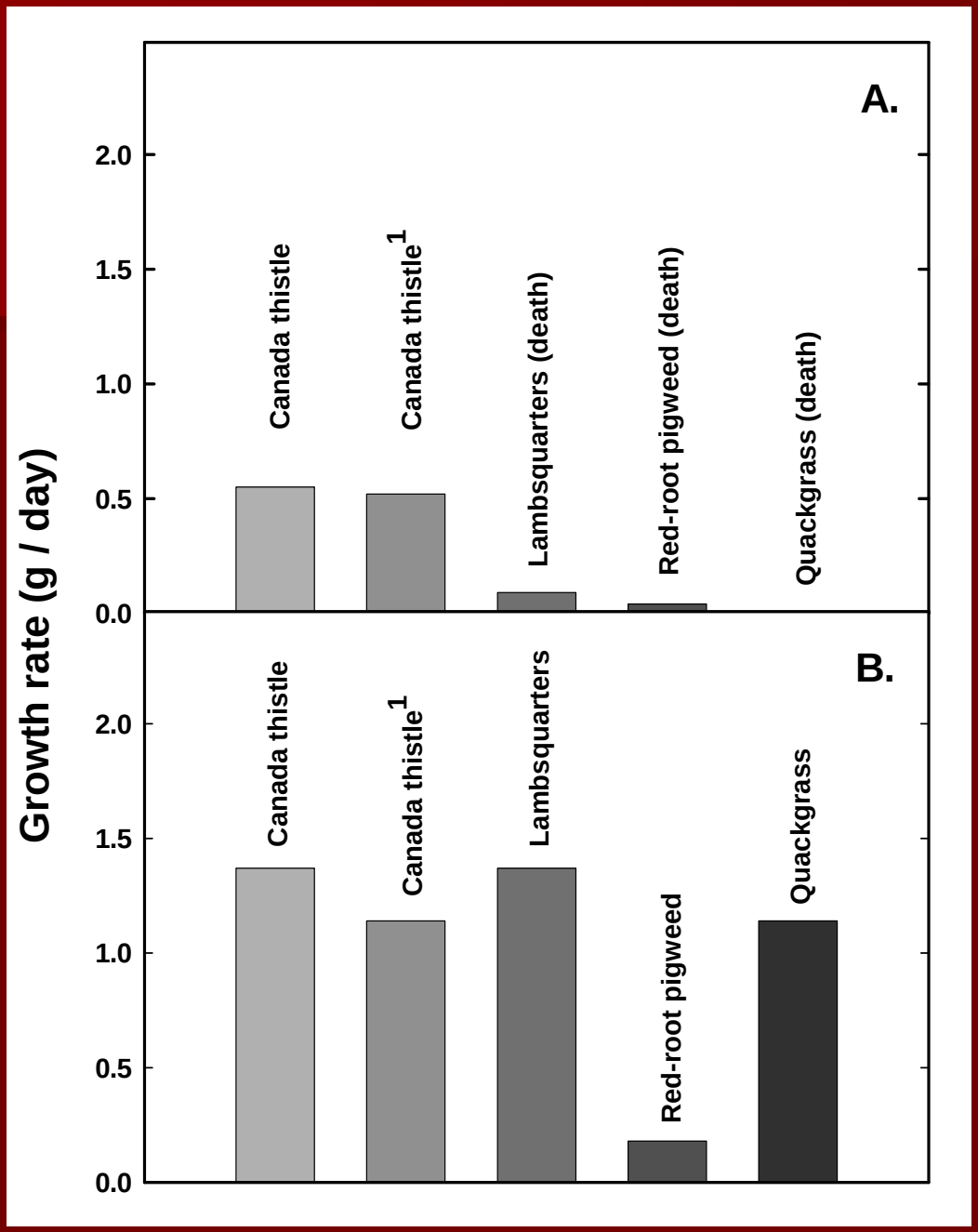
Summary: Real Time

Urban areas mimic future climate change: Longer growing seasons, more carbon dioxide, warmer temperatures. Do these conditions contribute to the spread of invasive plants?

Is Baltimore an anomaly? Check out the backyards of abandoned homes.

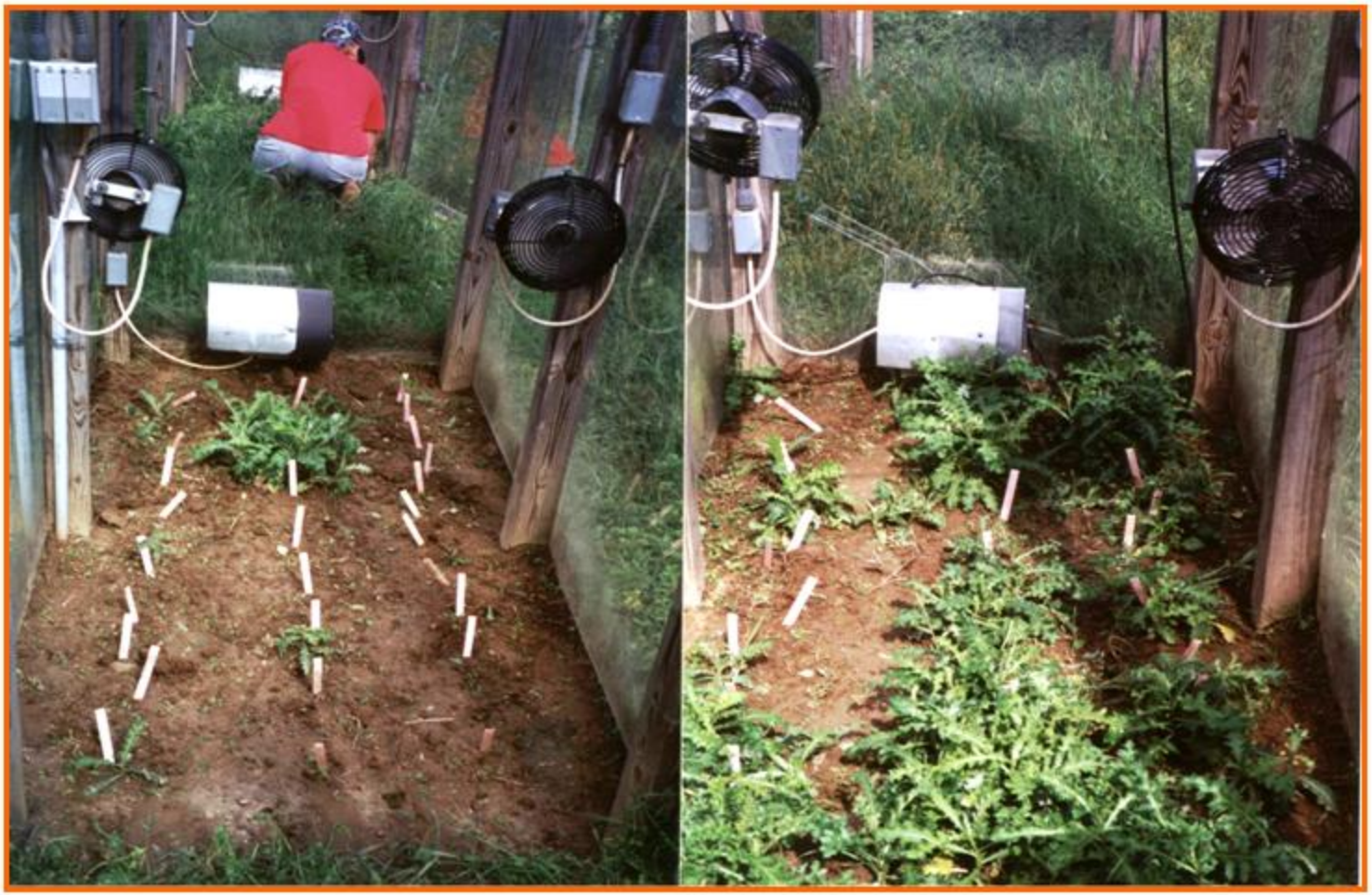
Climate change/CO_2, implications for weed management.





Change in herbicide efficacy as a function of increased carbon dioxide.

Ambient CO_2 Future CO_2 (+300 ppm)



Increasing CO_2 reduces herbicide efficacy.

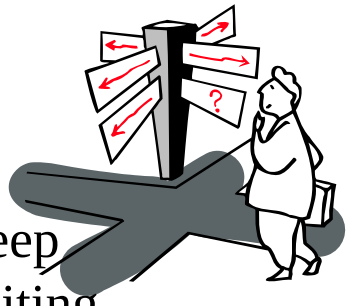
e.g. Ziska et al. *Weed Science* 2004

Summary: Weed Management

Chemical control of weeds is very much dependent on climate. Climate is likely to change in ways that will be difficult to predict but changes in weed distribution are almost certain.

Biological? Cultural? Physical? Unknown.

Where do we go from here?



Invasive plants are invasive, in part, because they lack predators to keep populations in check. Climate therefore, will be a major factor in limiting population establishment and spread of invasive species. Differential response to CO_2 may also favor invasive species.

As climate and carbon dioxide change, invasive weed populations will change.

Which ones are more likely to increase their range? Why?

How will climate and CO_2 alter competition between native and invasive plants?

How can we manage invasive species in the future?

WHAT ELSE? WHAT DO **YOU** THINK?

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