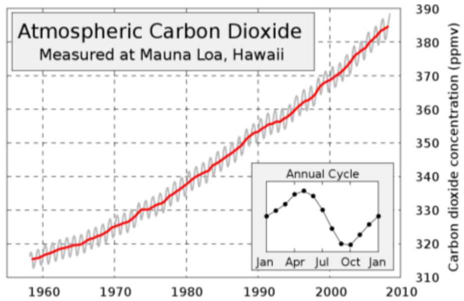
## Weeds and climate change

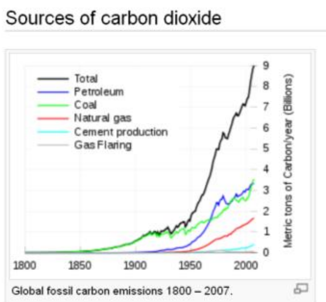
Today's topic: Climate change

- $CO_2$ and global warming
- Weed growth and competition
- Weed distribution

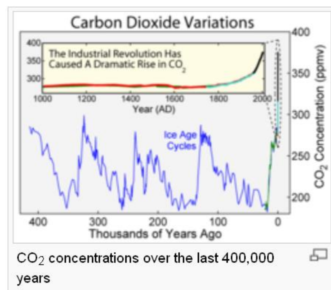
## Atmospheric $CO_2$ concentrations



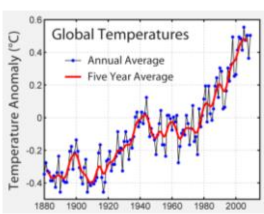

## Atmospheric $CO_2$ concentrations

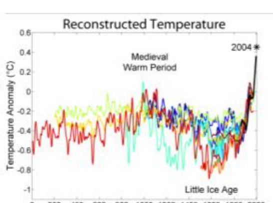



## Atmospheric $CO_2$ concentrations



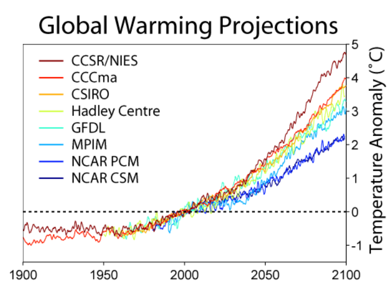

## Global temperatures



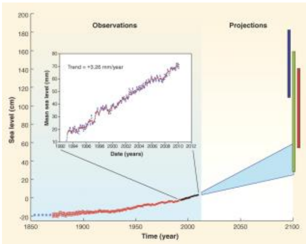




## Global temperatures

Expect increase of 2.4 to 6.4 C by 2100

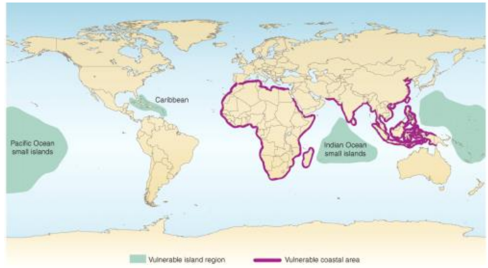


## Global warming and sea level rise




Nicholls and Cazenave. 2010. Science 328:1517-1520

## Regions at risk of flooding due to global warming



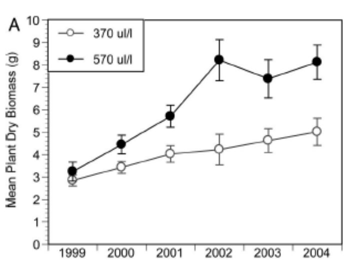

Nicholls and Cazenave. 2010. Science 328:1517-1520

## What does this mean for weeds?

- Dynamics of competition
- Geographical distribution

## $CO_2$ is good for plants!

## Poison ivy growth and $CO_2$




Poison ivy vines growing up a tree. Notice the variation in size and shape of the leaves. Picture taken mid-April in USDA zone 7a-7b.

Mohan et al. 2006. PNAS. 103:9086-9089

## Poison ivy growth data

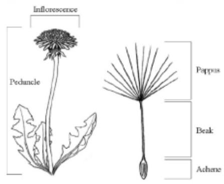
Table 1. Averages and P values of the ANOVA for $CO_2$ concentration for vegetative and qualitative characteristics of poison ivy after 250 d.[a,b]

| | Averages (μmol mol$^{-1}$) | | | | |
|---|---|---|---|---|---|
| Variable | 300 | 400 | 500 | 600 | P value[c] $CO_2$ effect |
| Leaf area (cm$^2$) | 2,169 c | 4,779 b | 5,663 ab | 6,568 a | *** |
| Leaf wt (g) | 13.2 d | 31.8 c | 37.8 b | 43.3 a | ** |
| Stem wt (g) | 27.8 d | 52.1 c | 63.8 b | 87.1 a | ** |
| Rhizome length (cm) | 343 d | 547 c | 664 b | 851 a | ** |
| Rhizome (No). | 1.11 c | 1.75 b | 2.19 ab | 2.25 a | ** |
| Urushiol (mg g$^{-1}$ FW) | 0.23 | 0.26 | 0.28 | 0.36 | 0.18 (NS) |
| Urushiol (mg) | 15.0 d | 40.9 c | 53.3 b | 78.1 a | ** |

[a] Unless otherwise specified, data are per plant, e.g., urushiol (mg) is the average production of urushiol in milligrams per plant.
[b] Abbreviations: No., number; FW, fresh weight; NS, not significant.
[c] Different letters indicate significant differences as a function of [$CO_2$] treatments using a Fisher's Protected LSD.
* $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$.

Ziska et al. 2007. Weed Sci. 55:288-292

## Dandelion and $CO_2$




$CO_2$ levels:
Ambient (370 µmol/mol)
Elevated (730 µmol/mol)

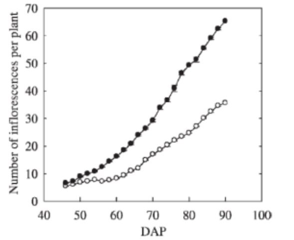
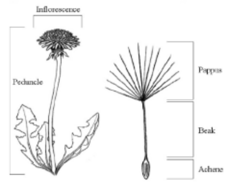



Figure 3. Cumulative number of inflorescences produced per plant in dandelion plants grown under ambient (unfilled symbols) or elevated (filled symbols) $CO_2$. $P < 0.01$ after 50 d after planting (DAP). Vertical bars indicate 1 standard error of the mean (SEM). SEM not shown if smaller than the symbol. $n = 21$ before 50 DAP, and $n = 11$ after 50 DAP.

McPeek and Wang. 2007. Weed Sci. 55:334-340

## Dandelion and $CO_2$

(more data)




$CO_2$ levels:
Ambient (370 µmol/mol)
Elevated (730 µmol/mol)

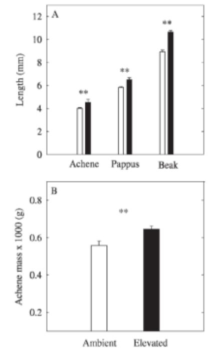



Figure 6. Effect of elevated $CO_2$ on seed dispersal properties, which included (A) lengths of achene, pappus hair, and beak, and (B) on achene mass. Plants grown under ambient and elevated $CO_2$ are represented by unfilled and filled bars, respectively. Vertical bars indicate 1 standard error of the mean (SEM). ** $P < 0.01$; $n = 11$.

McPeek and Wang. 2007. Weed Sci. 55:334-340

## Rising $CO_2$ effect on competition

**Table 1.** Competition studies of crop and weed species as a function of $CO_2$.

| Weed | Crop | Favored? | Environment | Reference |
|---|---|---|---|---|
| 1. Different Photosynthetic Pathway | | | | |
| *Sorghum halepense* ($C_4$) | Meadow fescue | Crop | Glasshouse | Carter and Peterson (1983) |
| *Sorghum halepense* ($C_4$) | Soybean | Crop | Chamber | Patterson et al. (1984) |
| *Echinochloa glabrescens* ($C_4$) | Rice | Crop | Glasshouse | Alberto et al. (1996) |
| *Paspalum dilatatum* ($C_4$) | Grasses | Crop | Chamber | Newton et al. (1996) |
| Grasses ($C_4$) | Lucerne | Crop | Field | Bunce (1993) |
| *Amaranthus retroflexus* ($C_4$) | Soybean | Crop | Field | Ziska (2000) |
| *Xanthium strumarium* ($C_3$) | Sorghum | Weed | Glasshouse | Ziska (2001c) |
| 2. Same Photosynthetic Pathway | | | | |
| *Chenopodium album* ($C_3$) | Soybean | Weed | Field | Ziska (2000) |
| *Taraxacum officinale* ($C_3$) | Lucerne | Weed | Field | Bunce (1995) |
| *Plantago lanceolata* ($C_3$) | Grasses | Weed | Chamber | Newton et al. (1996) |
| *Taraxacum* and *Plantago* ($C_3$) | Grasses | Weed | Field | Potvin and Vasseur (1997) |

In general, elevated $CO_2$ levels favor photosynthetic efficiency of C-3 plants in competition. However, plants respond differently, so accurate predictions are difficult.

From: Ziska, L. 2004. Pp. 159-176 in: Weed Biology and Mangement. Inderjit, ed., Kluwer

## Plants differ in their use of $CO_2$

**C-3 vs. C-4 plants**

C-4 $CO_2$ fixation limits *photorespiration* and is an advantage under conditions of high light, high heat, and limited moisture.

However, C-3 $CO_2$ fixation requires less metabolic energy, so C-3 plants are more efficient in moderate conditions.

## Climate affects species distribution

If climate change predictions come true, cropping systems are likely to change in geographic distribution.

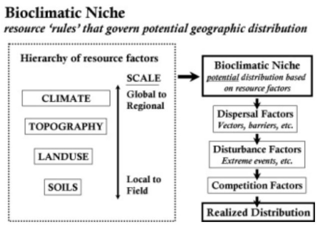
- Change in endemic species
- Increased risk of invasion

## Climate affects species distribution

Purple nutsedge (*Cyperus rotundus*) is readily killed by freezing (-2 C)
Yellow nutsedge (*Cyperus esculentus*) tolerates freezing


# Climate affects species distribution

Climate is the primary determinant of vegetation distribution




McDonald et al., 2009. Ag. Ecosys. and Environ. 130:131-140

# Climate affects species distribution

Features that may favor invasive plants in global climate change:


High seed production (cheatgrass) | Rapid growth (Japanese knotweed) | Generalist pollinators (musk thistle)

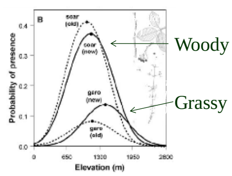
Bradley et al., 2010. Trends Ecol & Evol. 25:1310-318

# Climate affects species distribution

| Element of global change | Prevalence of plant invaders[a] |
|---|---|
| Increased atmospheric $CO_2$ | + |
| Rising temperature | ± |
| Changing precipitation regime | ± |
| Changing land use or land cover | + |
| Increased N deposition | + |
| Increased global commerce | + |

# Effect of global warming on plant distribution

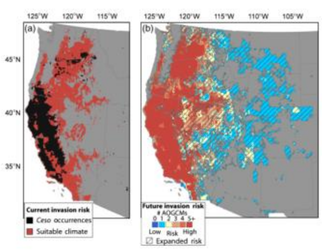
- Plant distributions in mountains of western Europe studied between 1905 and 2005
- 118 of 171 species studied moved higher up mountains
- Average shift of 29 m/decade




Lenoir et al., 2008. Science 320:1768-1771

# Climate and plant invasion

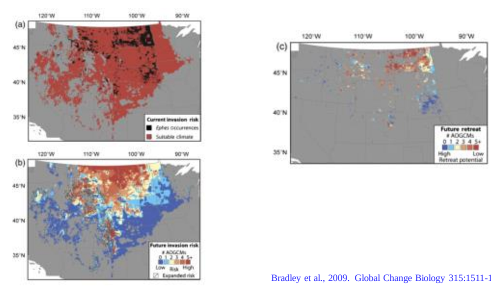
Yellow starthistle (*Centaurea solstitialis*).
- Increased risk




Bradley et al., 2009. Global Change Biology 315:1511-1521

# Climate and plant invasion

Leafy spurge (*Euphorbia esula*).
- Decreased risk




Bradley et al., 2009. Global Change Biology 315:1511-1521

## Summary

- Be aware of trends occurring in atmospheric $CO_2$ and global temperature.
- Understand how plants respond to $CO_2$ and temperature changes.
- Be able to describe how weed competition and distribution may be affected by climate change.
- Be able to discuss the impact of climate change on weed management.