Lab 1: Energy and Respiration

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DEES & AMNH

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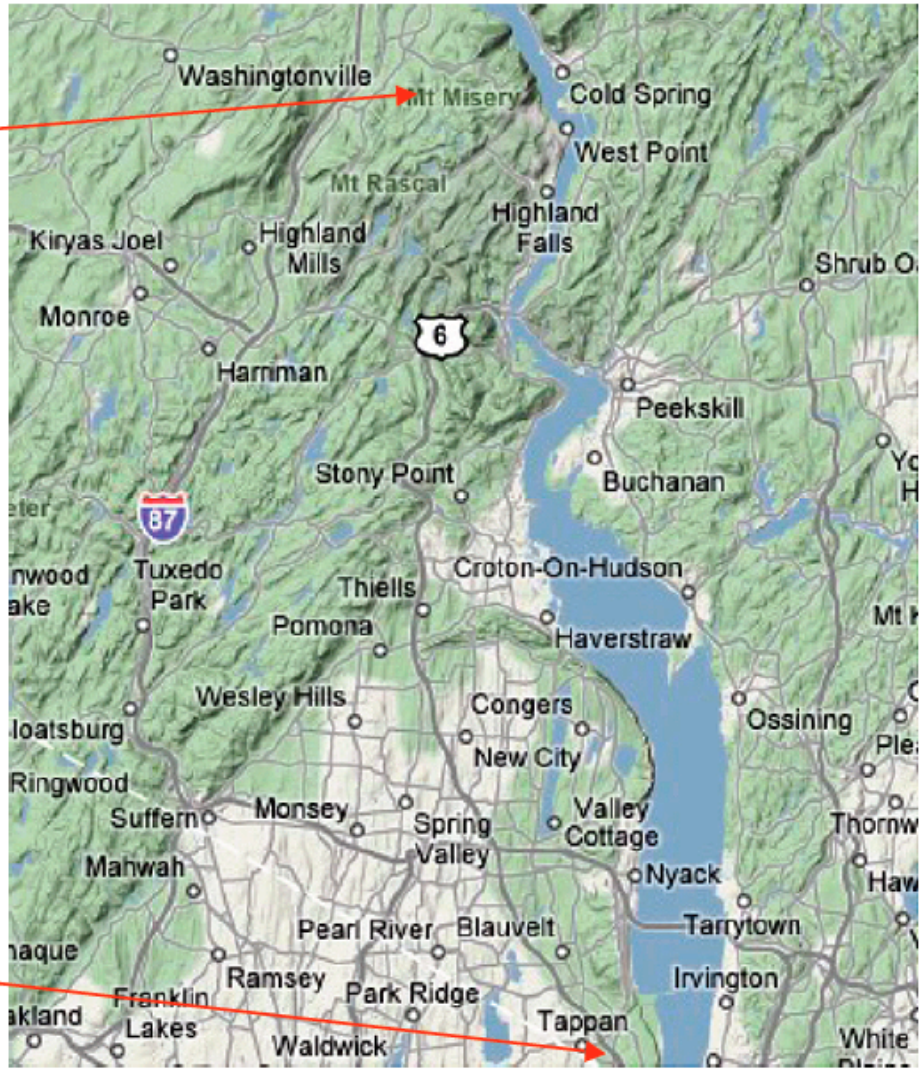
Wednesday 2:30-4:00
554 Schermerhorn

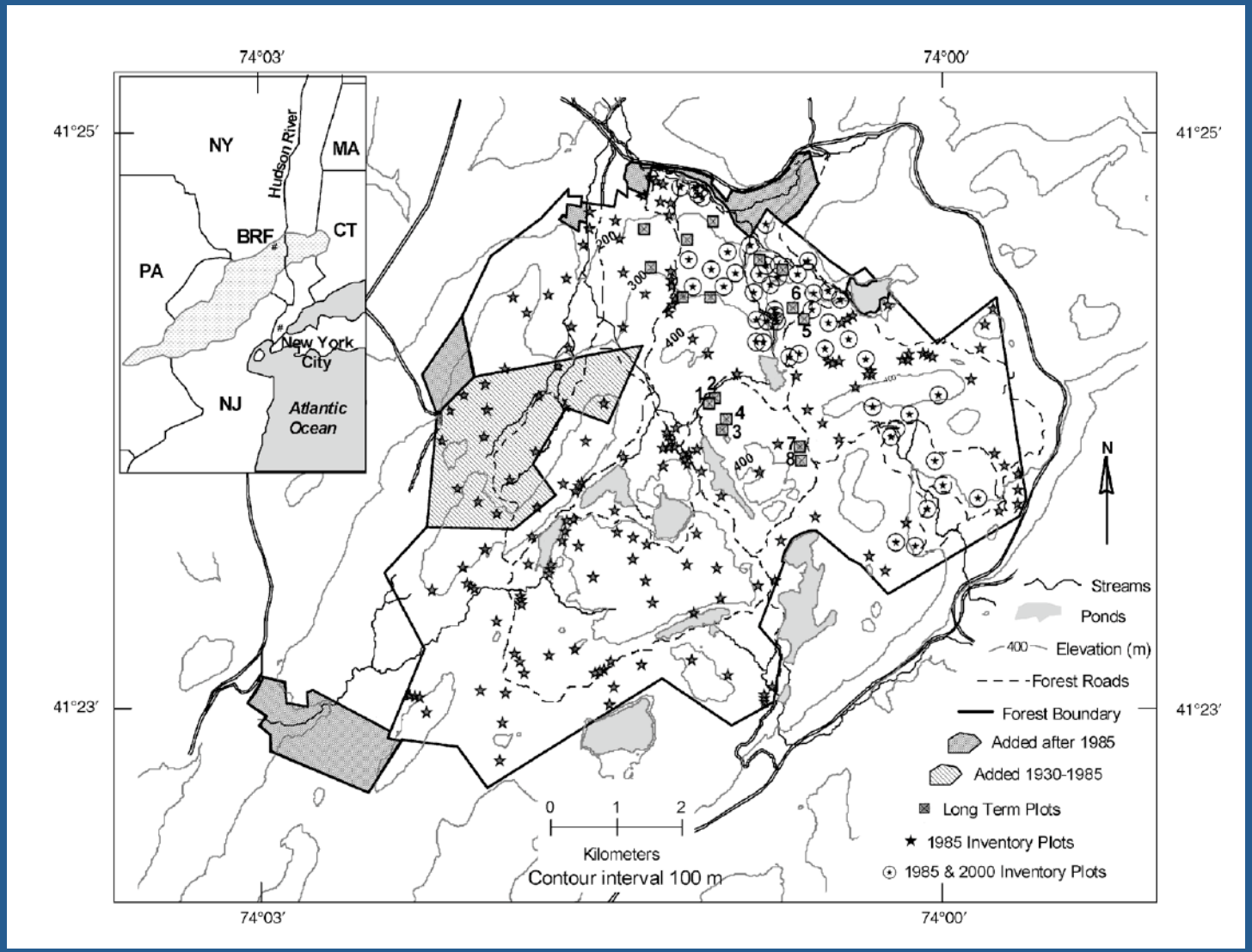
- 9 labs (Wednesday 4-7 pm, 555 Schemerhorn)
- 3 Field trips (Fridays)
- Reports are due one week after the lab (by midnight the next Wednesday), and you'll get feedbacks one week after
- ALL lab reports are uploaded through CourseWorks
- Late reports will be deduced 10% automatically

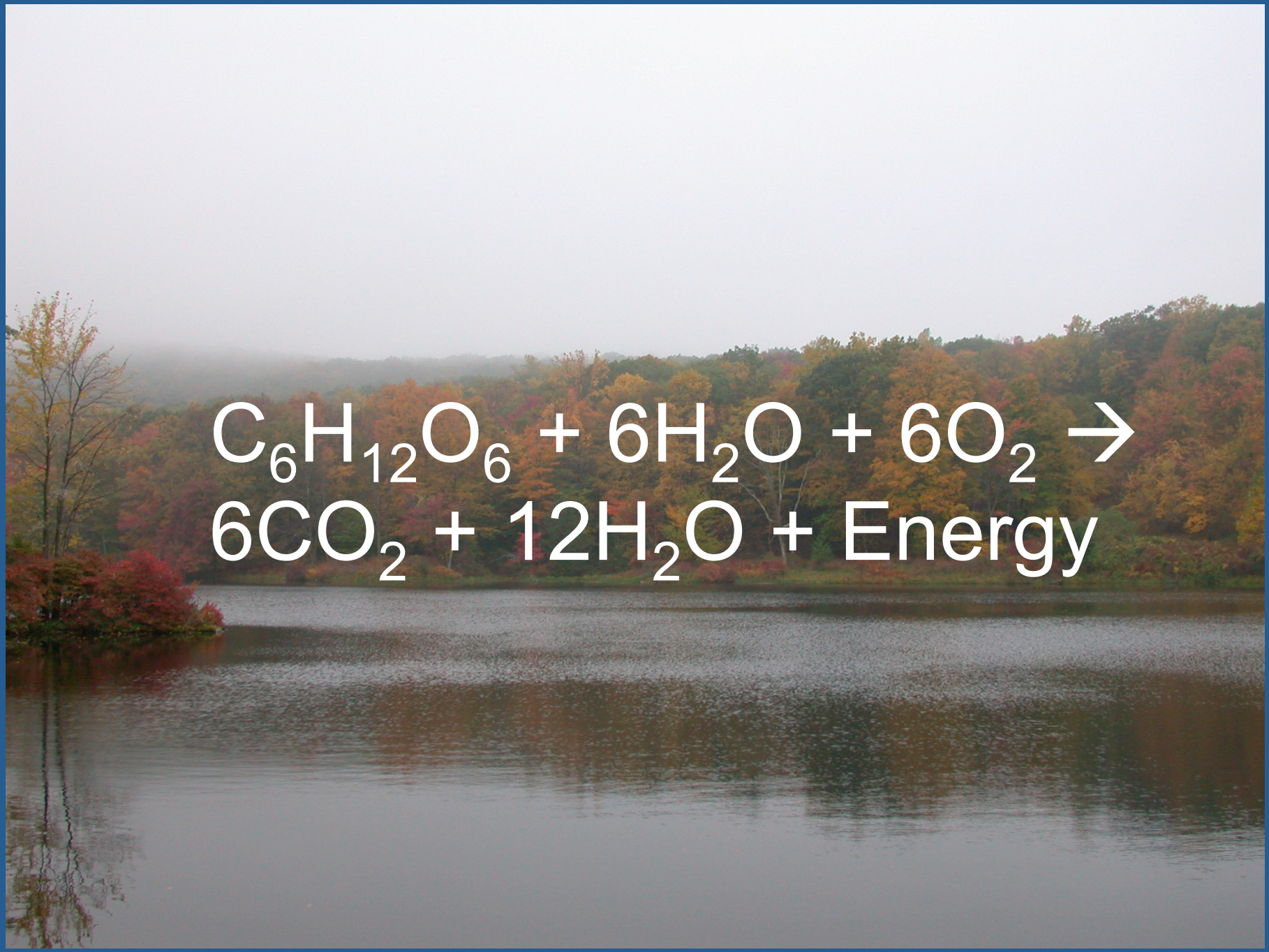
www.blackrockforest.org



LAMONT DOHERTY EARTH OBSERVATORY
THE EARTH INSTITUTE AT COLUMBIA UNIVERSITY

Map of Black Rock Forest

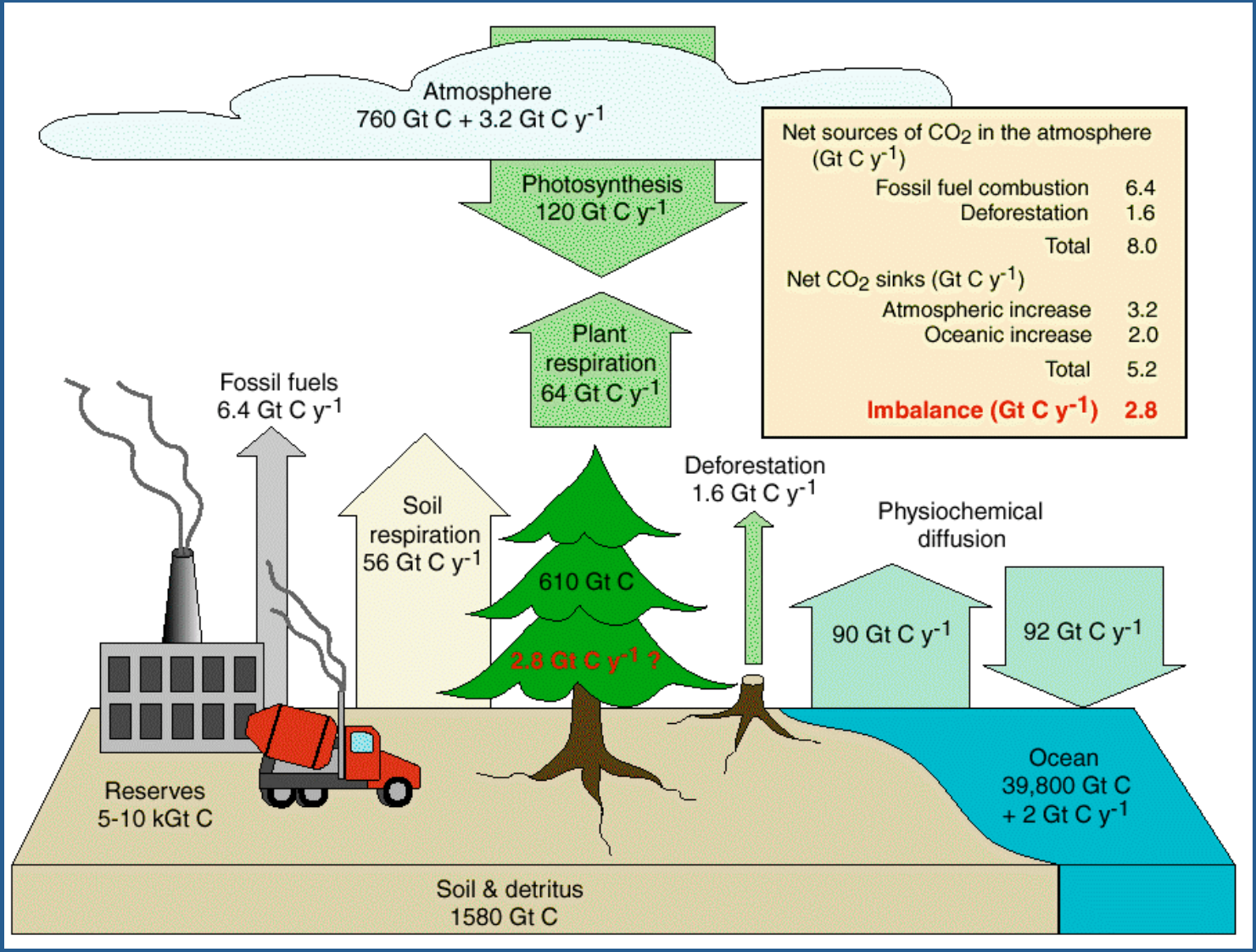



$C_6H_{12}O_6 + 6H_2O + 6O_2 \rightarrow$
$6CO_2 + 12H_2O + Energy$

Lab Goals

- Think quantitatively
- Think about (across) scale
- What we understand at one level informs our understanding at other levels
- Consider environmental influences
  - Variation
  - Global change
- Think independently and creatively

Carbon Cycle

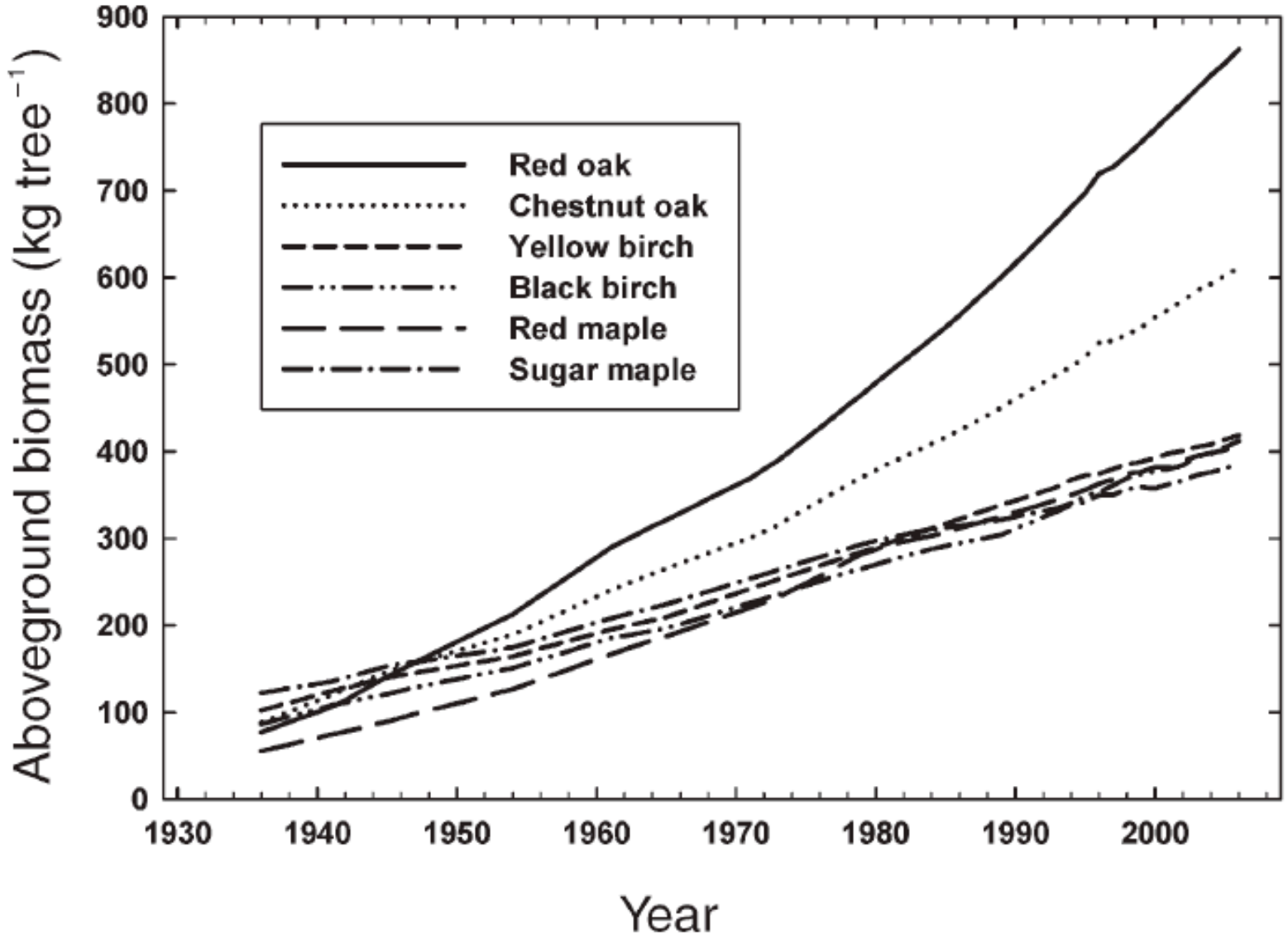


Respiration can be measured as an instantaneous
How can we scale this in both space and time?

How can we estimate respiration from a forest?

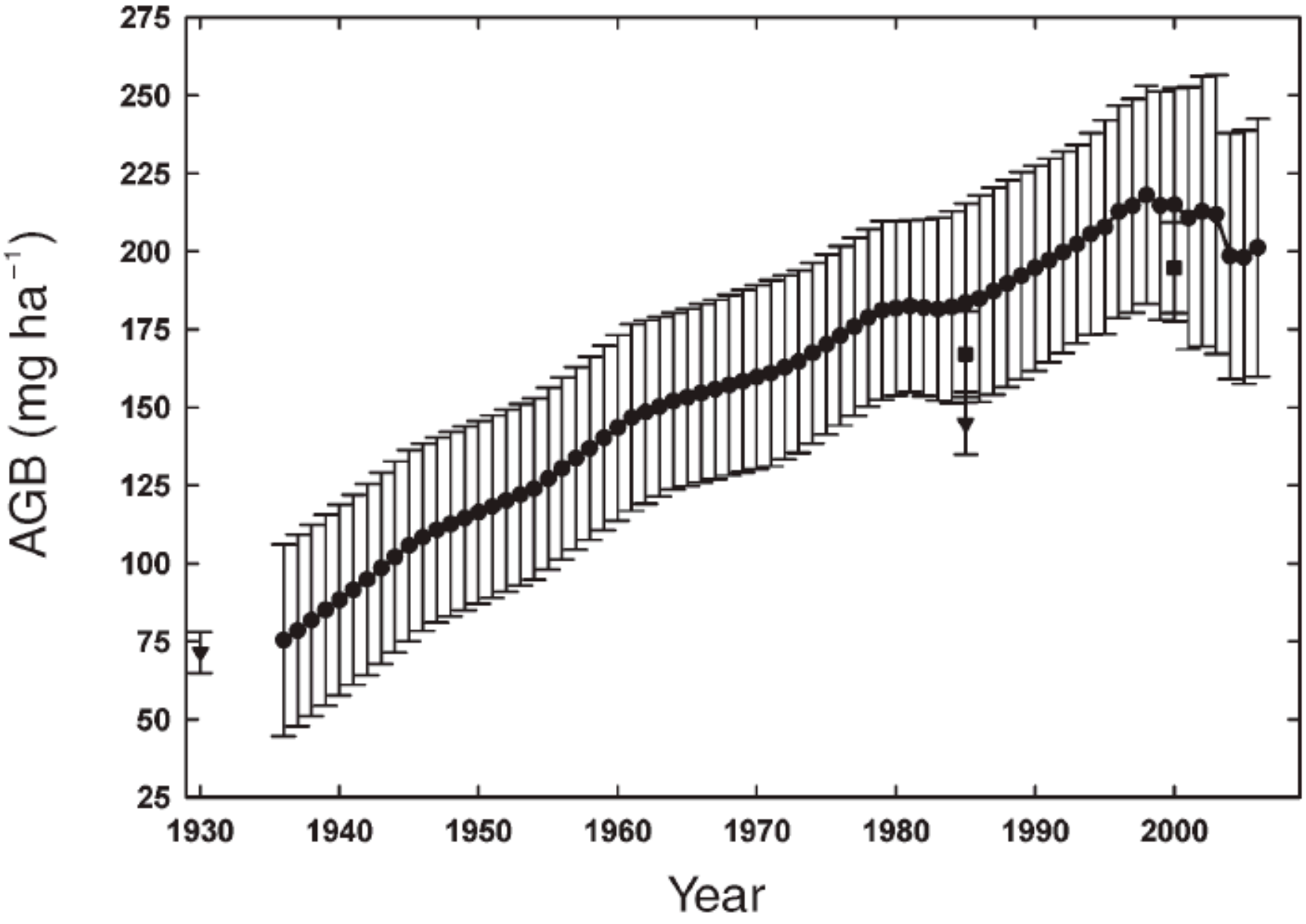
Leaf Area Index

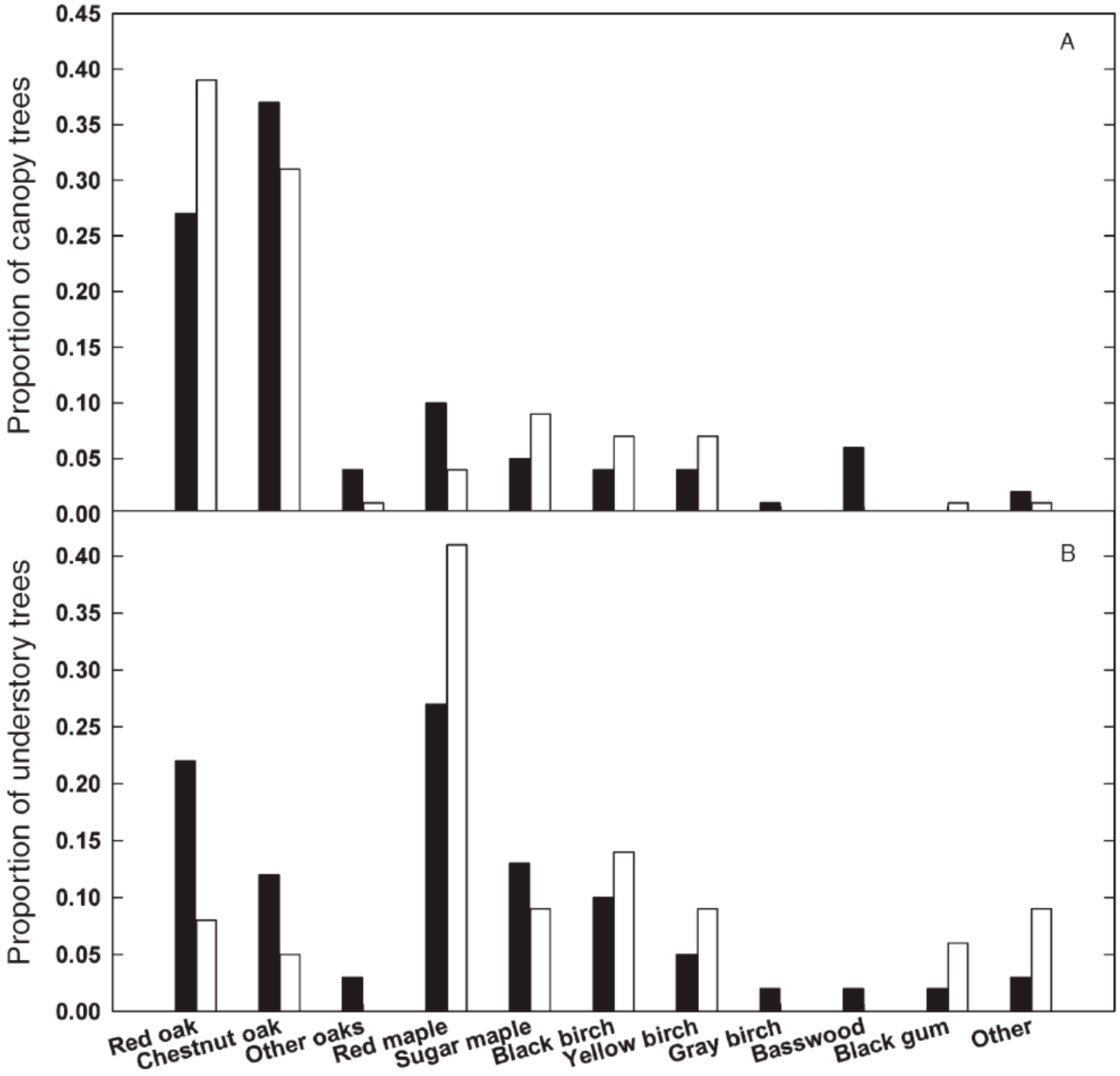
- Ratio of the total leaf surface area to the ground area its growing on
- m^2 Leaf, m^{-2} ground
- Estimated optically
- Ranges from 1-15


Aboveground biomass (kg tree^{-1})
900
800
700
600
500
400
300
200
100
0
1930
1940
1950
1960
1970
1980
1990
2000
Year
Red oak
Chestnut oak
Yellow birch
Black birch
Red maple
Sugar maple

Additional Findings From Schuster *et al 2008*

- The forest canopy is dominated by red oak and chestnut oak, but the understory tree community has changed substantially from mixed oak–maple to red maple–black birch
- Over 76 years, red oak canopy trees stored carbon at about twice the rate of similar-sized canopy trees of other species
- Mean AGB on the long-term plots increased from 75 Mg ha–1 in 1936 to 218 Mg ha–1 in 1998
- There has been a significant loss of live tree biomass as a result of canopy tree mortality since 1999

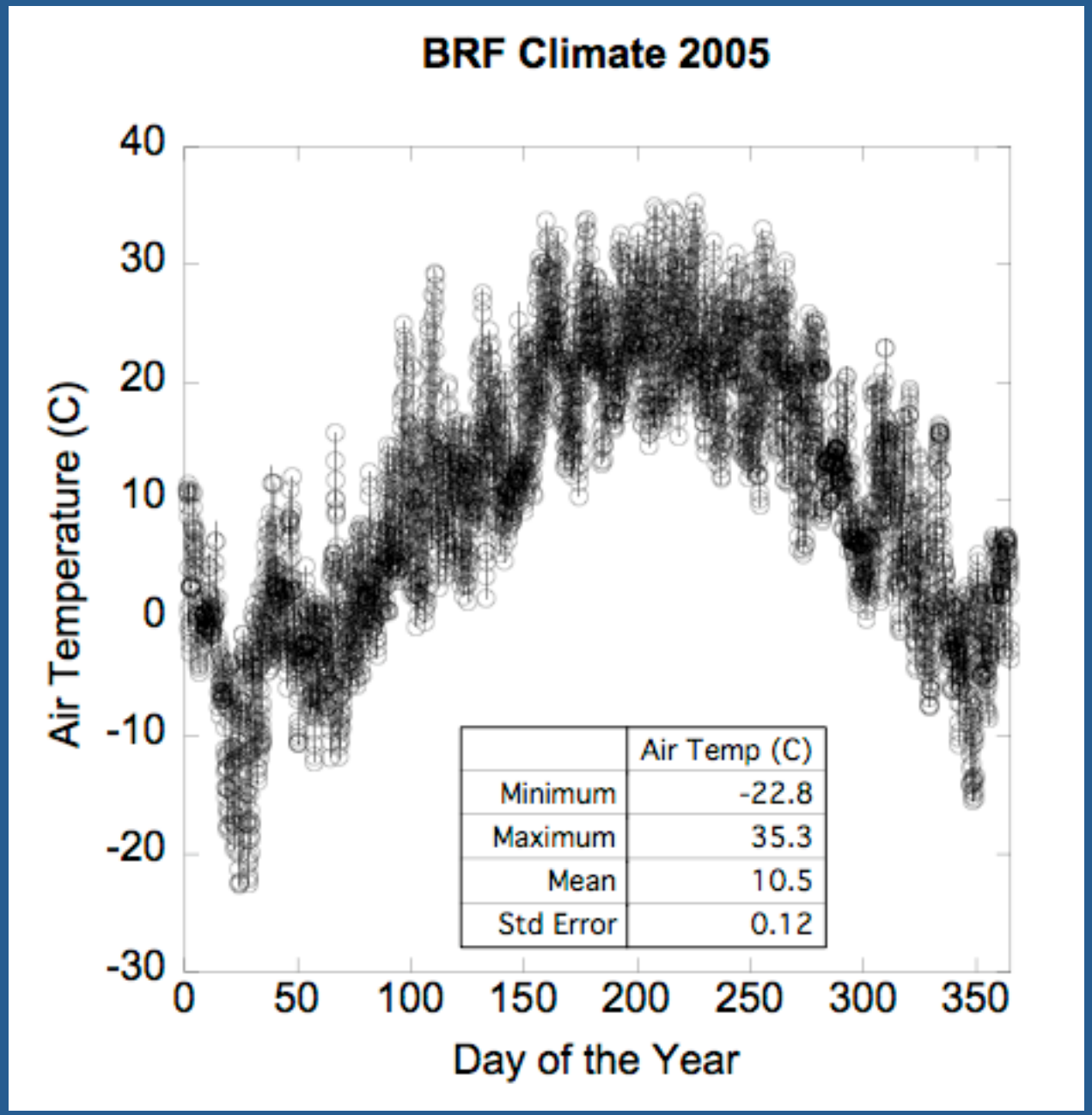

AGB (mg ha^{-1})
275
250
225
200
175
150
125
100
75
50
25
1930
1940
1950
1960
1970
1980
1990
2000
Year


A
B
1936
2006
Proportion of canopy trees
Proportion of understory trees
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Red oak
Chestnut oak
Other oaks
Red maple
Sugar maple
Black birch
Yellow birch
Gray birch
Basswood
Black gum
Other

Arrhenius function

$$R = R_0 e^{\frac{Eo}{R_g}\left(\frac{1}{T_o} - \frac{1}{T_a}\right)}$$

- R = Respiration
- R_g = *Ideal gas constant*
- R_0 = Base respiration, measured at the temperature T_0
- E_0 = Energy of activation for respiration, measured at the temperature T_0
- T_0 = Base temperature
- T_a = Ambient temperature


BRF Climate 2005
Air Temperature (C)
40
30
20
10
0
-10
-20
-30
0
50
100
150
200
250
300
350
Day of the Year
Air Temp (C)
Minimum -22.8
Maximum 35.3
Mean 10.5
Std Error 0.12

Enzyme Kinetics

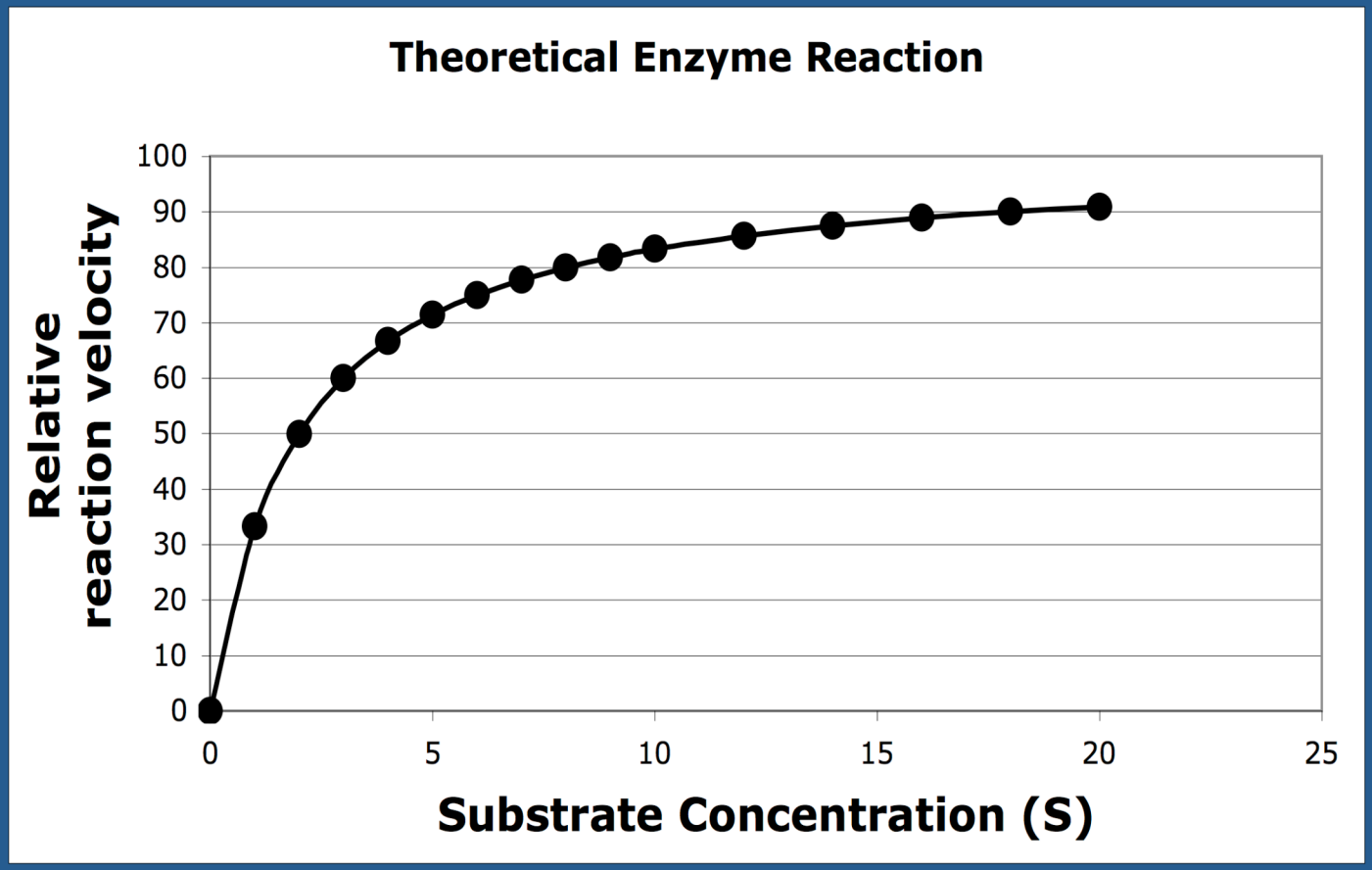
Michaelis – Menten equation:

$$v = \frac{V_{\max} S}{K_m + S}$$

- Where:
- v = velocity of the reaction
- V_{max} = Maximal velocity of a reaction, occurs at high substrate concentrations when the enzyme is saturated (emperical)

Operational definition of K_M

- When [S] = K_M, $v = 1/2V_{max}$, so that:
- K_M is the substrate concentration at which the reaction velocity is half-maximal.



Michaelis – Menten equation

- K_M describes how curved the line is

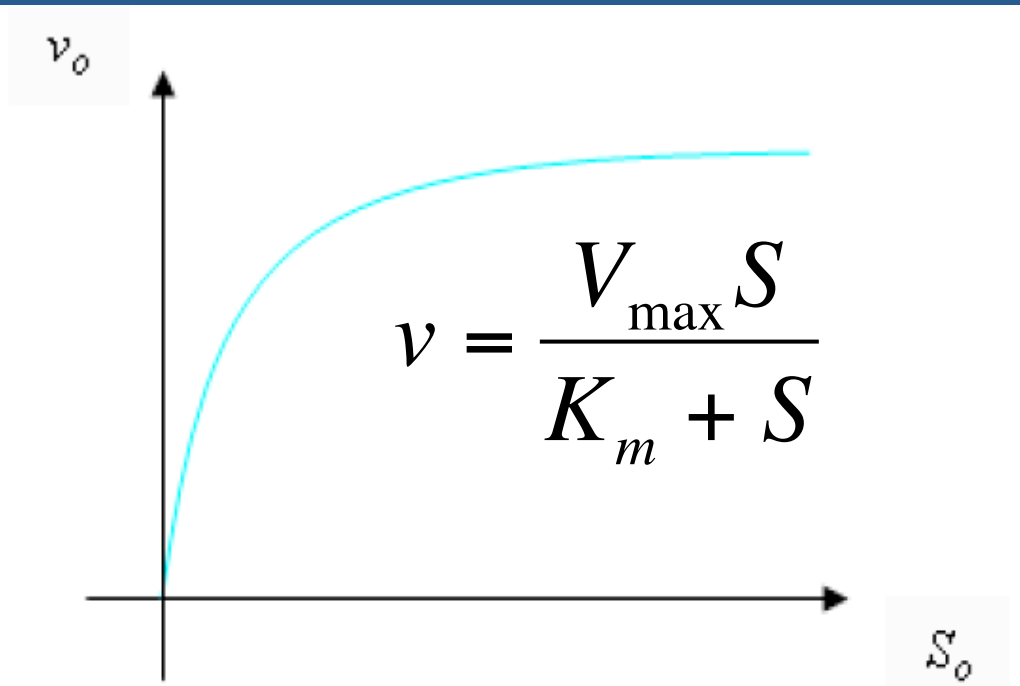


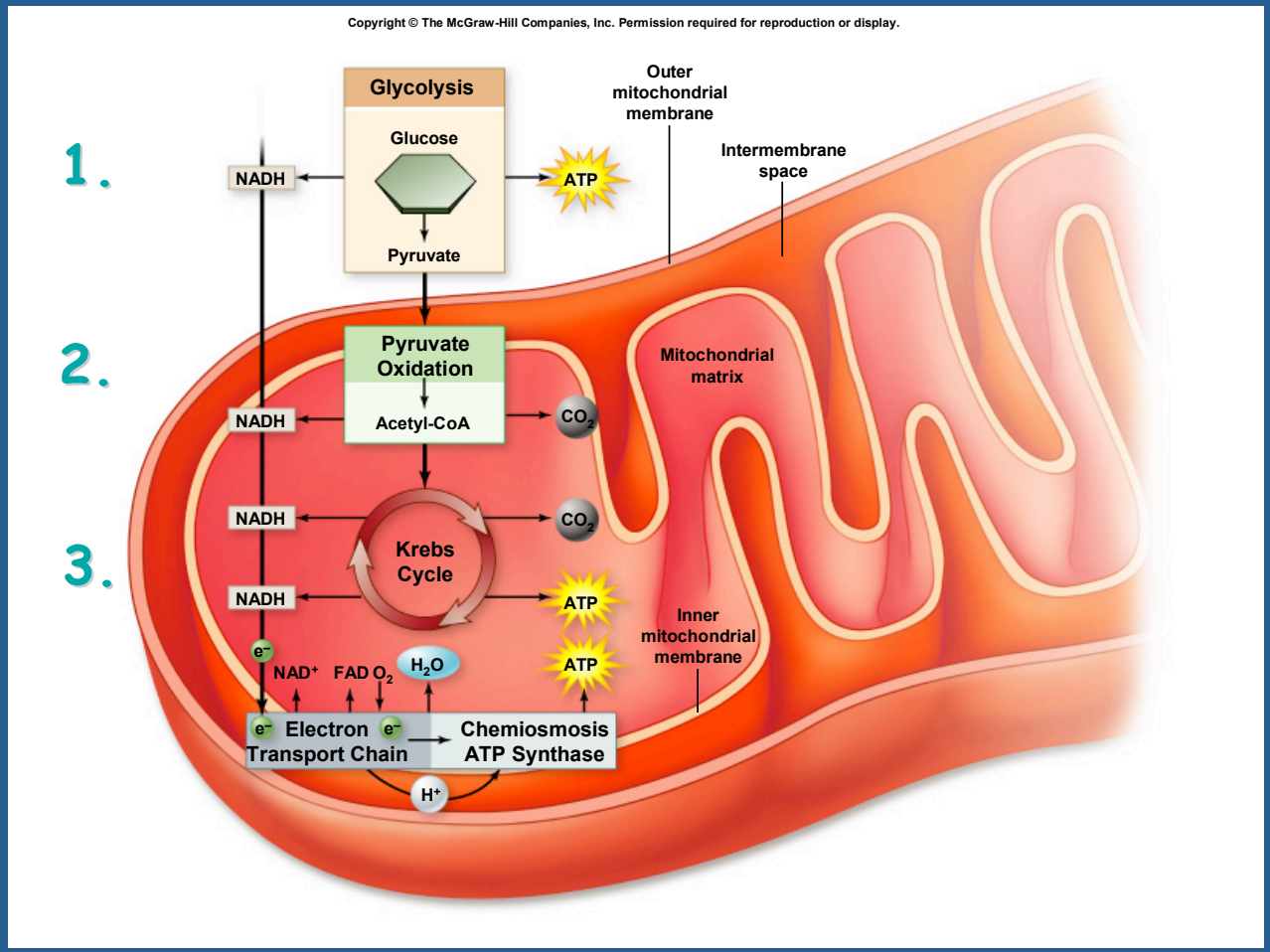
Figure 1. Initial rate as a function of initial concentration of substrate

Factors Affecting Enzymatic Reactions

- Temperature
- pH
- Concentration of Enzyme
- Concentration of Substrate(s)
- Presence and Concentration of Inhibitor(s)
- Concentration cofactor(s)

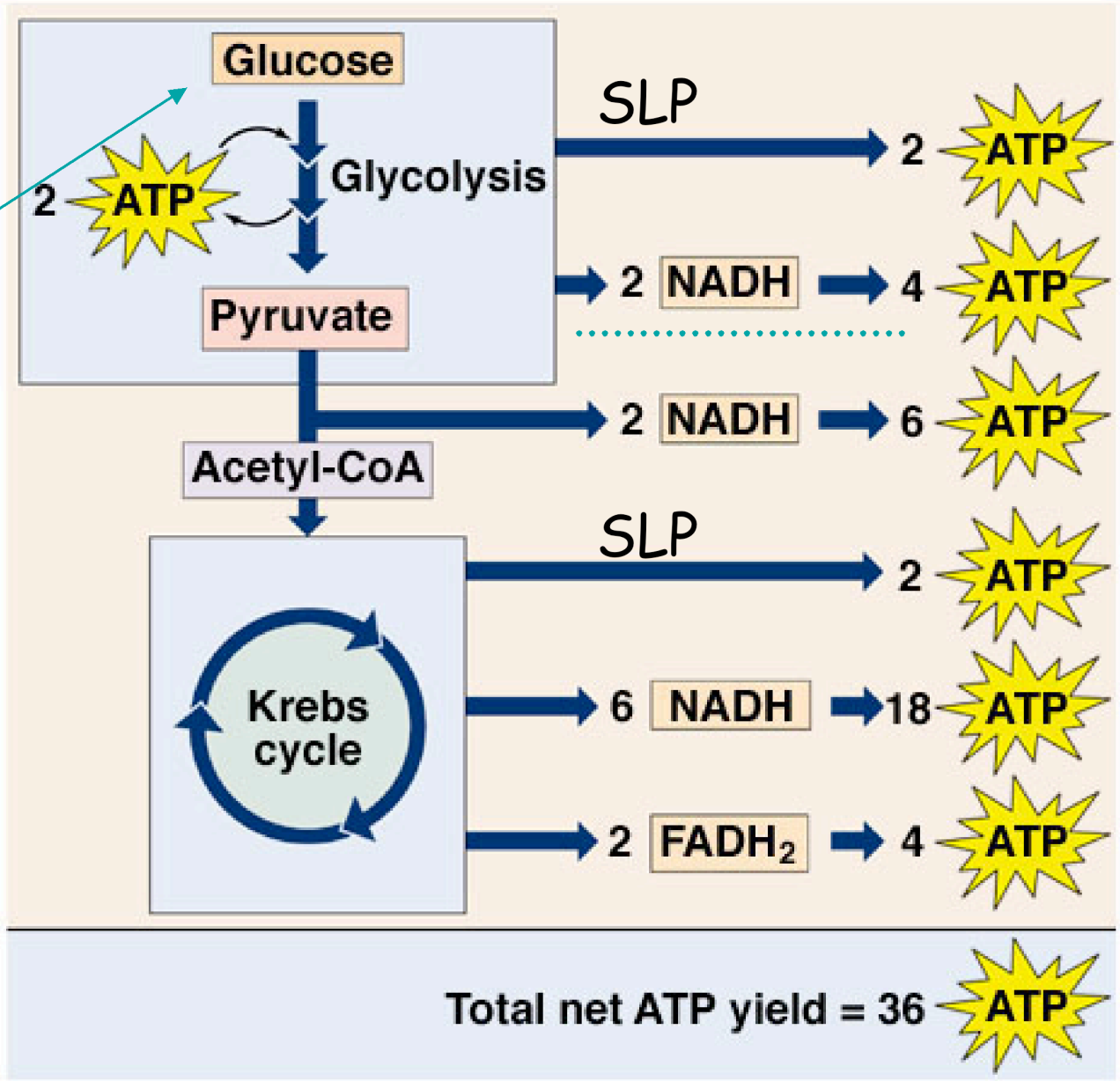
Respiration & Energy

$C_6H_{12}O_6 + 6H_2O + 6\ O_2 \rightarrow 6\ CO_2 + 12\ H_20 + 36$ ATP



ATP Theoretical Yield

NADH – 3 H^+
$FADH_2$ – 2 H^+



How much energy is in a chocolate bar?

ATP

Today's Lab

Exercise 1: Energy efficiency
Calculate energy in a candy bar

Exercise 2: Enzymes
Using the Michaelis-Menten equation you will evaluate how changing K_m and V_{max} influence the rate of a reaction (you will produce 3 graphs)

Exercise 3: Forest Respiration and Climate Change
Using a modified Arrhenius function you will examine respiration as a function of temperature and tree species

Please complete a short survey for the Tree Respiration module you used in Part III

- http://www.surveymonkey.com/s/HVDBTN2