CLIMATE CHANGE & ECOLOGICAL RELATIONSHIPS UNIT

Climate Change: Evidence & Choices

- What questions do you have about the climate change report?

- What are the basic messages from the report?
  - Greenhouse gases modulate earth's temperature
  - Human activities have greatly increased greenhouse gases
  - Multiple sources of evidence suggest that Earth is warming
  - There are complex climate processes that we/science do not fully understand
  - Scientific models suggest that human activity (at its current rate) will lead to more severe climatic changes

Know your sources…

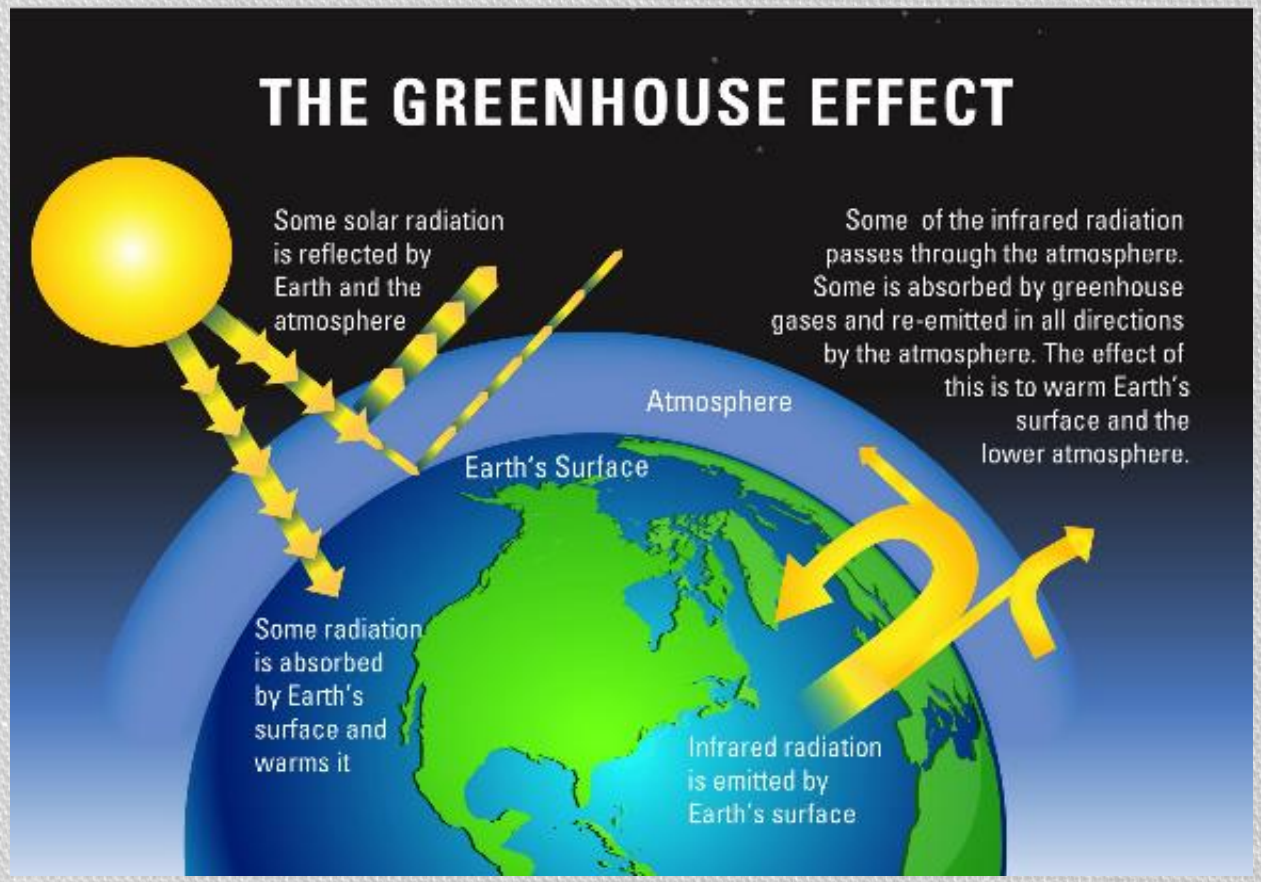
- Who is (or what organization or company) presenting the information?
- What is the purpose of the publication?
- What expertise and/or relevant experience does the author (or organization or company) have?
- What biases does the author (or organization or company) have and how might those biases affect the presentation of information?
- Does the information presented seem to be accurately reported? Are the claims made in the presentation supported? Do any facts or analyses seem to be distorted?
- Does the presentation leave important information out? Does the presentation offer information that is unnecessary (particularly if the extra information distorts the message)?

Where/who does the climate change report come from?

- Authors/publishers: 1) National Academies of Science and 2) The Royal Society
- Greenhouse effect model: US EPA
- Data/graphs:
  - Scripps CO_2 program
  - Research Journals: *Geophysical Research Letters*
  - Intergovernmental Panel on Climate Change (IPCC)
  - US National Oceanic & Atmospheric Association (NOAA)

- Group Task: Visit a website associated with 1 of the above sources and explore who they are and their credibility. Be prepared to report your findings to your peers.
- For links to the source websites, go to: http://restem4.wix.com/learning-resources

Back to the report… What does it mean?



Greenhouse Gases

- Carbon dioxide - CO_2
- Methane – CH_4
- Nitrous oxide – N_2O
- Halocarbons

Where do these gases come from?

What role do humans play in this?

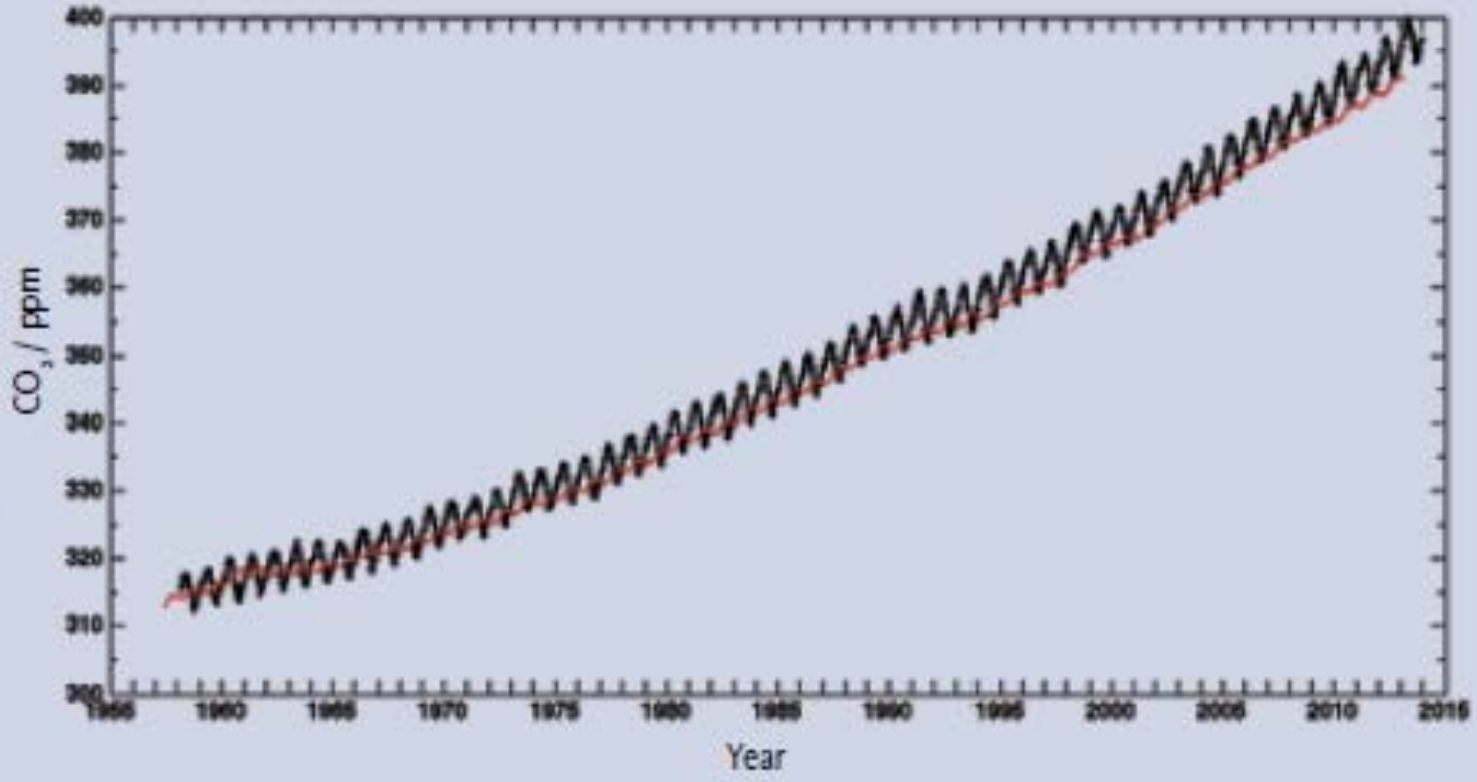
Analyzing the data

The CC report presents 4 graphs. For each graph conduct the following analyses:

1. What variables are represented in the graphs?
2. What do the axes represent? What units of measure are being used?
3. What is the scale of each axis?
4. Are the graphs based on data that have been collected or predictions from models?
5. What conclusions can be drawn from the graph?

Annual Measurements of Atmospheric CO2

FIGURE B2. Measurements of atmospheric CO_2 since 1958 from the Mauna Loa Observatory in Hawaii (black) and from the South Pole (red) show a steady annual increase in atmospheric CO_2 concentration. (The measurements are made at remote places like those because they are not greatly influenced by local processes, so therefore are representative of the background atmosphere.) The small up and down saw-tooth pattern reflects seasonal changes in the release and uptake of CO_2 by plants.
Source: Scripps CO_2 Program



Atmospheric measurements of CO2 from 1000-2000

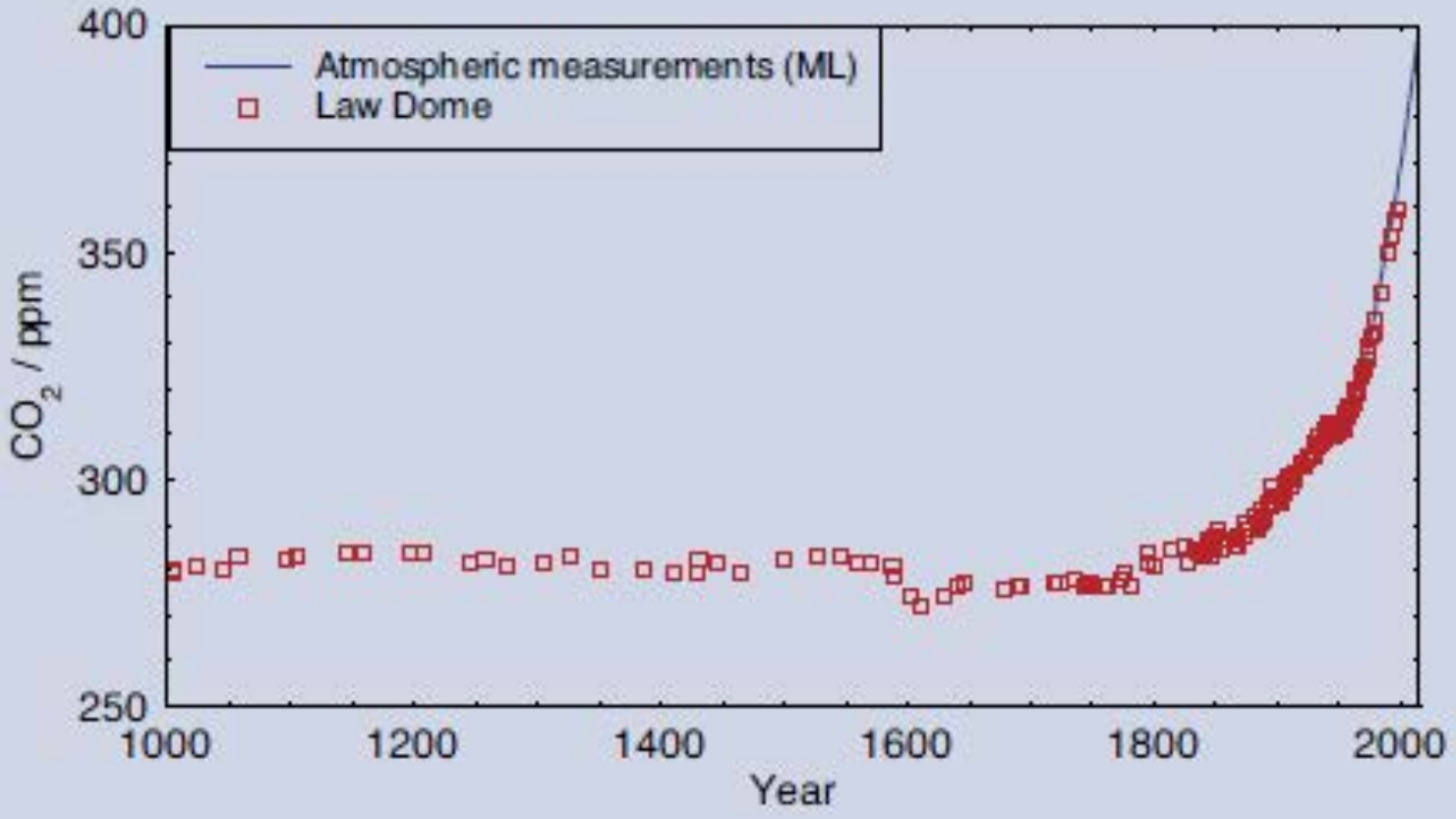


FIGURE B3. CO_2 variations during the past 1,000 years, obtained from analysis of air trapped in an ice core extracted from Antarctica (red squares), show a sharp rise in atmospheric CO_2 starting in the late 19th century. Modern atmospheric measurements from Mauna Loa are superimposed in blue. *Source: figure by Eric Wolff, data from Etheridge et al., 1996; MacFarling Meure et al., 2006.*

Average Global Surface Temperature from 1850-2012

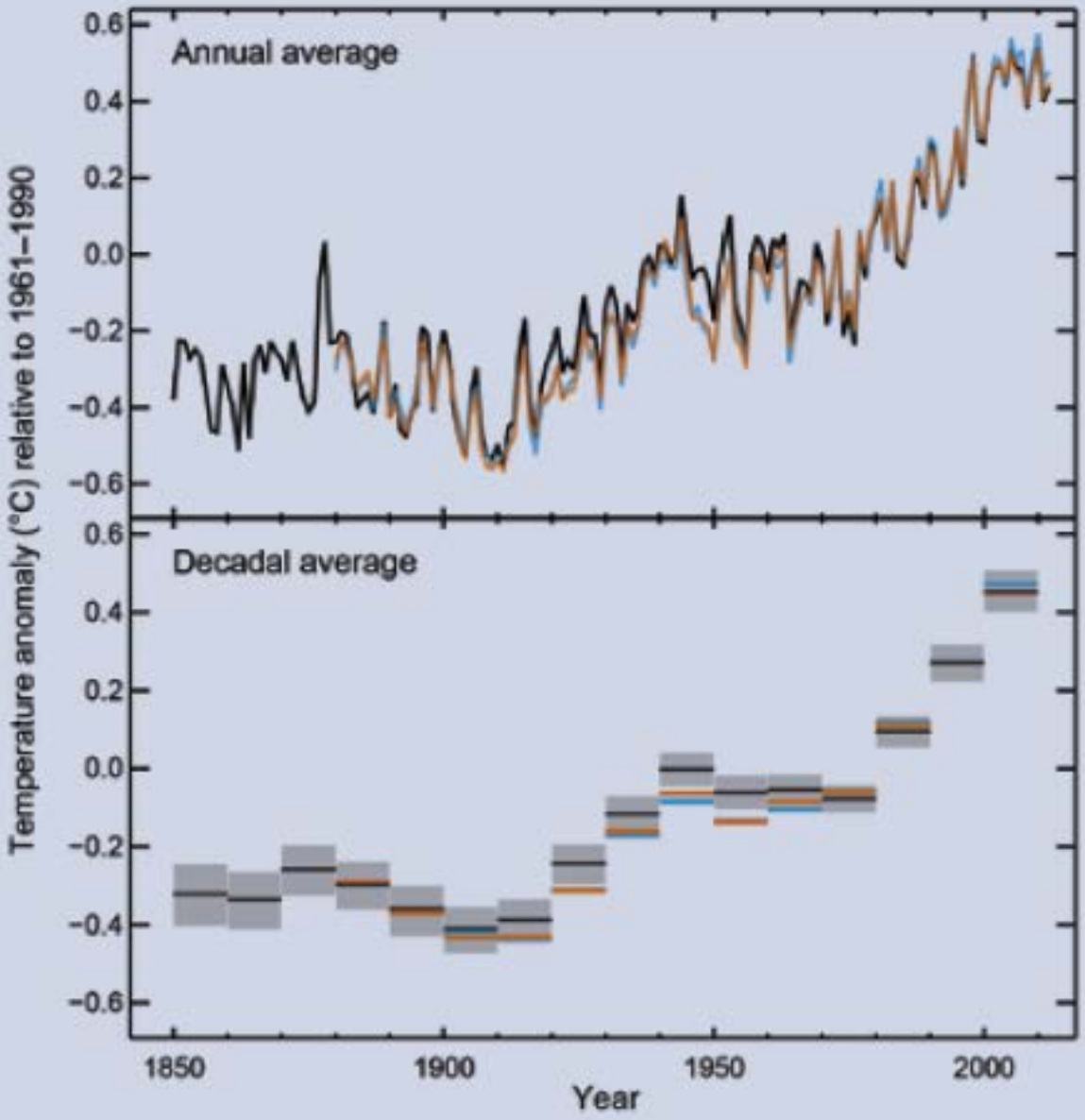
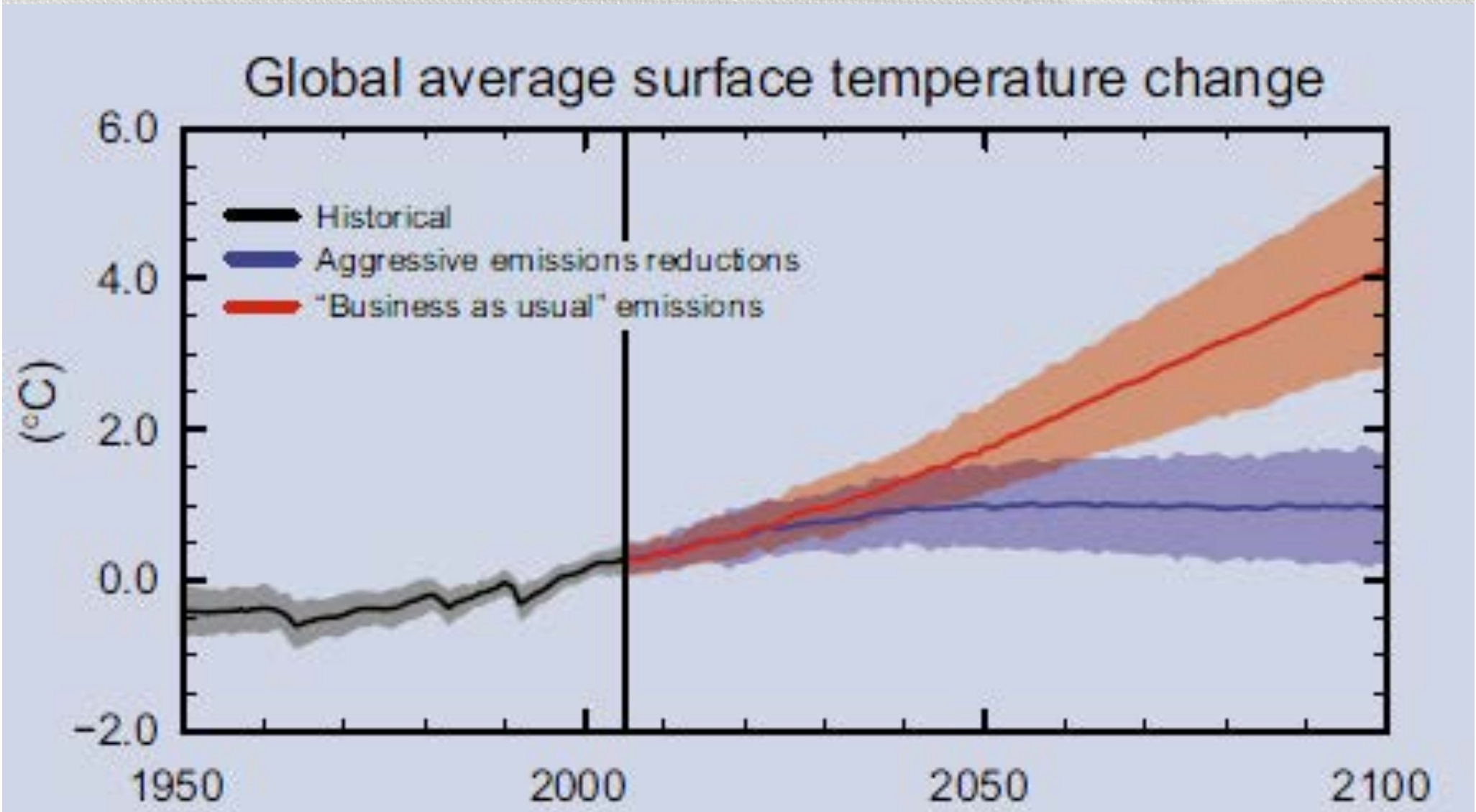


FIGURE B4. Earth's global average surface temperature has risen as shown in this plot of combined land and ocean measurements from 1850 to 2012, derived from three independent analyses of the available data sets. The top panel shows annual average values from the three analyses, and the bottom panel shows decadal average values, including the uncertainty range (grey bars) for the black (HadCRUT4) dataset. The temperature changes are relative to the global average surface temperature, averaged from 1961–1990. *Source: IPCC AR5, data from the HadCRUT4 dataset (black), UK Met Office Hadley Centre, the NCDC MLOST dataset (orange), US National Oceanic and Atmospheric Administration, and the NASA GISS dataset (blue), US National Aeronautics and Space Administration.*


Global average surface temperature change
6.0
4.0
2.0
0.0
−2.0
(°C)
Historical
Aggressive emissions reductions
"Business as usual" emissions
1950
2000
2050
2100

The science related to climate change seems to be well-understood.

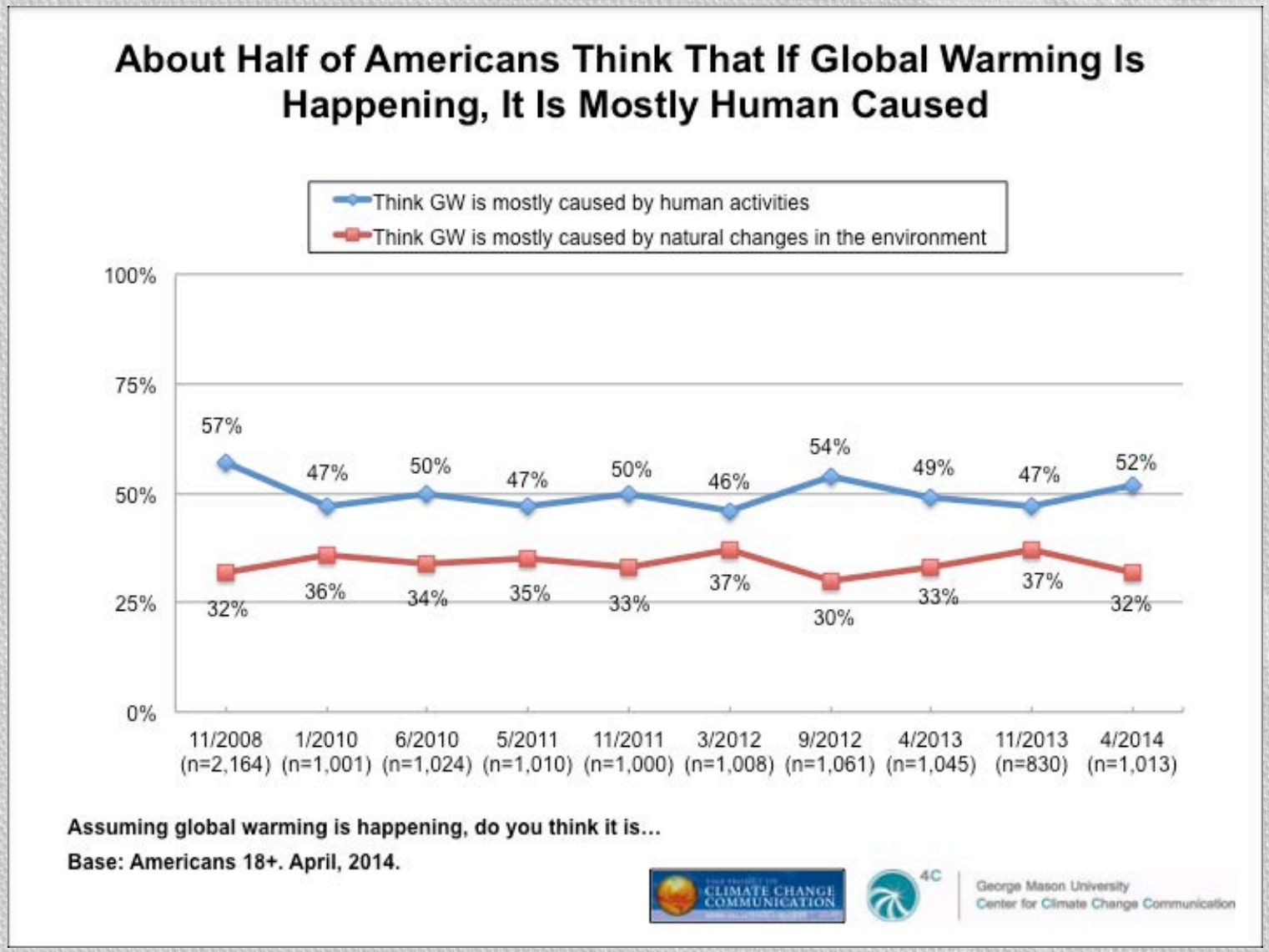
If this is the case, why is the issue controversial?

Agreement Continuum…

Position yourself along an agreement continuum to best reflect your own agreement with the following statements.

- Earth's climate is changing.
- Human activity is largely responsible for the rate of change in Earth's climate.
- Humans should make significant changes (like reducing reliance on fossil fuels) in order to limit the degree of climate change.

What do we know about how others think about climate change?



Source: Study from Yale School of Forestry & Environmental Studies

Interactive Map of Public Opinion on numerous Climate Change Questions

- http://environment.yale.edu/poe/v2014/

What do SCIENTISTS think about Climate Change?

- Analysis of 11,944 peer-reviewed scientific studies of climate change (1991-2011): 97.1% of the studies support the idea that human activity is driving climate change.

  Cook, J. et al., (2013). Quantifying the consensus on anthropogenic global warming in the scientific literature. *Environmental Research Letters, 8* (2).

- Survey of scientists who study various dimension of climate and climate change: 90% agree that human release of greenhouse gases is the primary driver of climate change.

  Verheggen, B. et al. (2014). Scientists' views about attribution of global warming. *Environmental Science & Technology, 48*, 8963-8971.

Other Voices and Perspectives

- People with various backgrounds and interests have diverse perspectives on the extent to which humans are responsible for the changing climate and the extent to which we should do anything about climate change.

A Range of Perspectives

- Climate change is real, human-induced and will have devastating consequences. We must act NOW.
- Climate change is real, human-induced and will have tough consequences. We should probably do something as soon as possible.
- Climate change is probably related to human activity but we can't be sure.
- Climate change is probably happening, but trying to stop it will have huge economic costs.
- Earth's Climate is always changing—this is just a natural part of Earth's cycles.

Exploring different perspectives

- Access and read/view at least 4 media resources listed on the "Climate Change Learning Resources" webpage (http://restem4.wix.com/learning-resources)

Writing Assignment

- Describe three different perspectives on climate change.
- Why do you think people have such varied responses to climate change and/or responses climate change?

ECOLOGY

Ecology

- The study of organisms' relationships with each other and their environment.

- Looks at the complex interactions between biotic and abiotic factors.
  - Biotic—Living
  - Abiotic—Non-living

Image from pixels.com

Levels of Organization

Individual / Organism—

a single organism;

either unicellular or multicellular

o

li

Population—a group of

of the same species

same area.

Images from pixel.com

Levels of Organization

Community—populations of organisms living in the same area

Ecosystem—communities of living things together with their non-living environment.

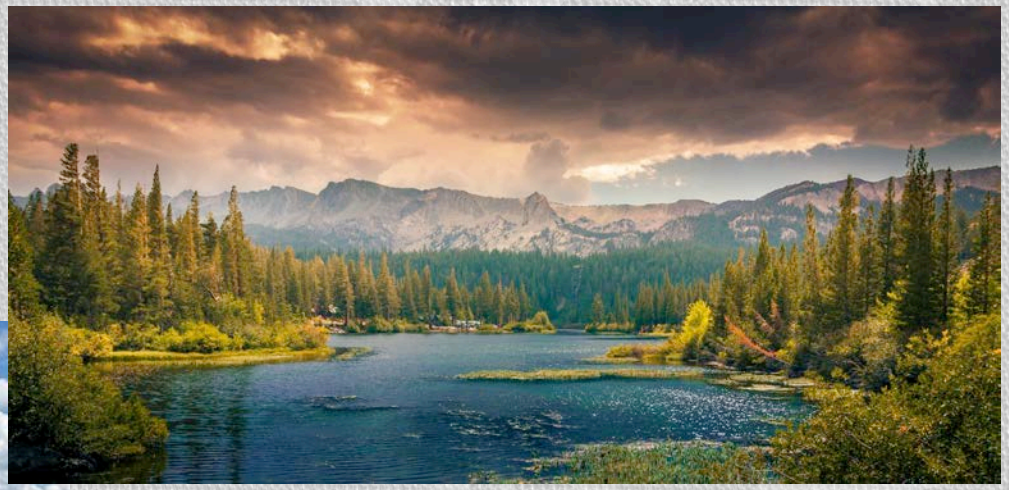
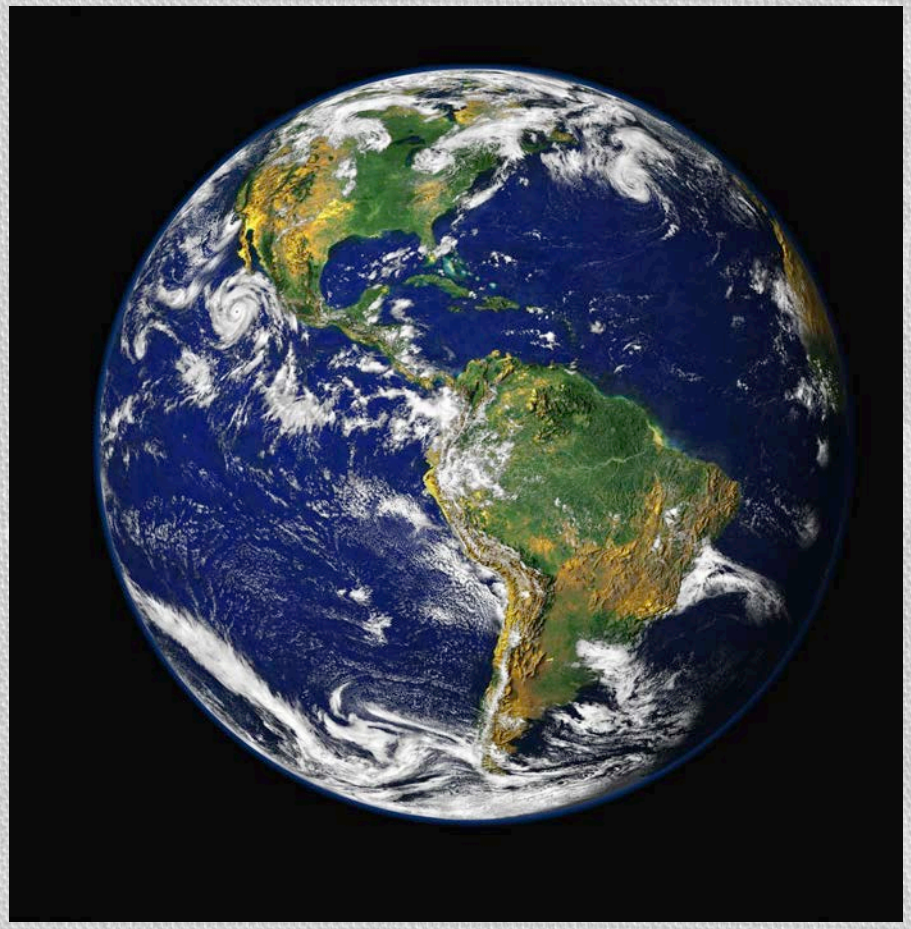


Image from: pixel.com

Image from: http://kerryg.hubpages.com/hub/Attracting-Birds-With-Prairie-Plants

Levels of Organization

Biosphere—all the parts on earth that supports life—land, water, & atmosphere. The sum of all the ecosystems.

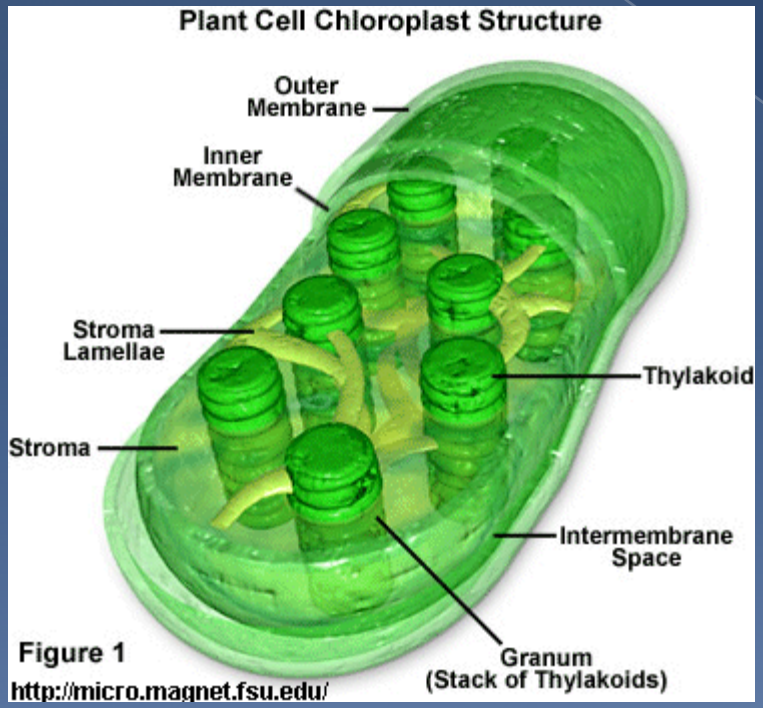


Photosynthesis

- Purpose?
  - Convert light energy into stored chemical energy (=glucose) that the plant can use
- Who does it?
  - Autotrophs
- Where does it happen?
  - Chloroplasts

Photosynthesis

- Chloroplasts



Formula:

$$6CO_2 + 6H_20 \longrightarrow C_6H_{12}O_6 + 6O_2$$

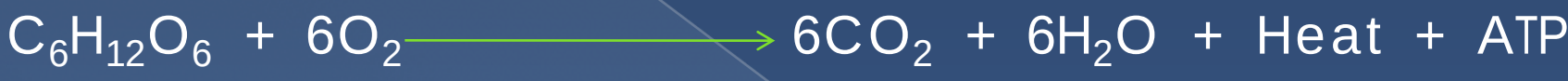
Two Major Parts to Photosynthesis

- Light Dependent Reactions
  - Occur in Thylakoids
  - Trap light energy
- Light Independent Reactions
  - Occur in Stroma
  - Traps CO_2 to make glucose

Cellular Respiration

- Purpose
  - Convert stored chemical energy into useable energy (=ATP)
- Who does it?
  - ALL organisms (even plants!)
- Where?
  - Mitochondria

Formula:



Note: Enzymes

- Enzymes involved in both reactions (PS &CR)
  - Different enzymes = specificity
  - Increase speed of chem rxns
  - Lower activation energy (so cell won't fry)

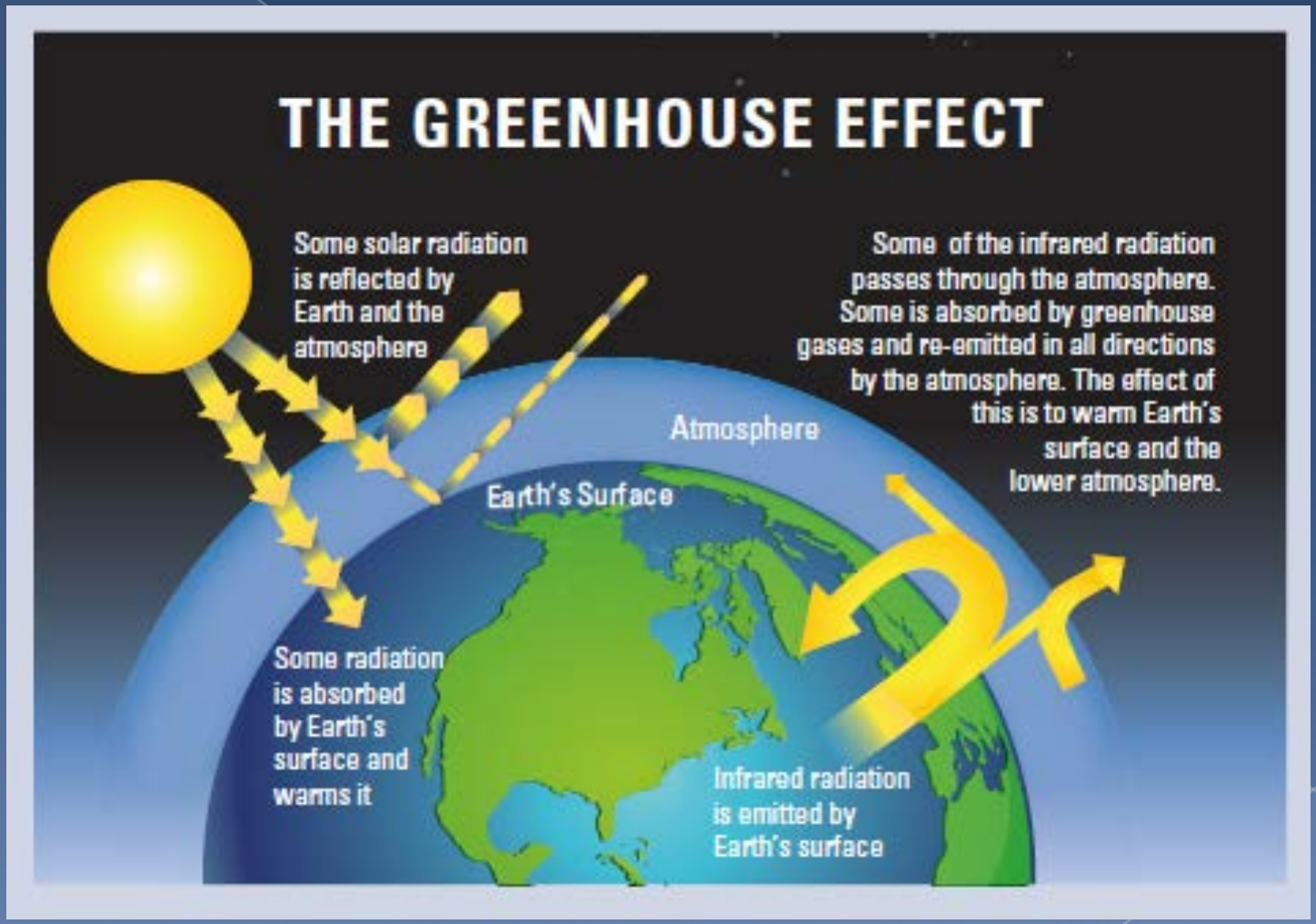
Note: ATP

- ATP= chemical energy used to do WORK
  - Usable Energy stored in bonds (A-P~P~P) that is released when bonds are broken
  - Used for movement & breakdown of molecules
  - Comes from glucose breakdown!
  - Energy not recycled, but nutrients and matter are

How does it all fit together?

- Go back to your Elodea / Fishy Models.
- Fix and add to your explanations.

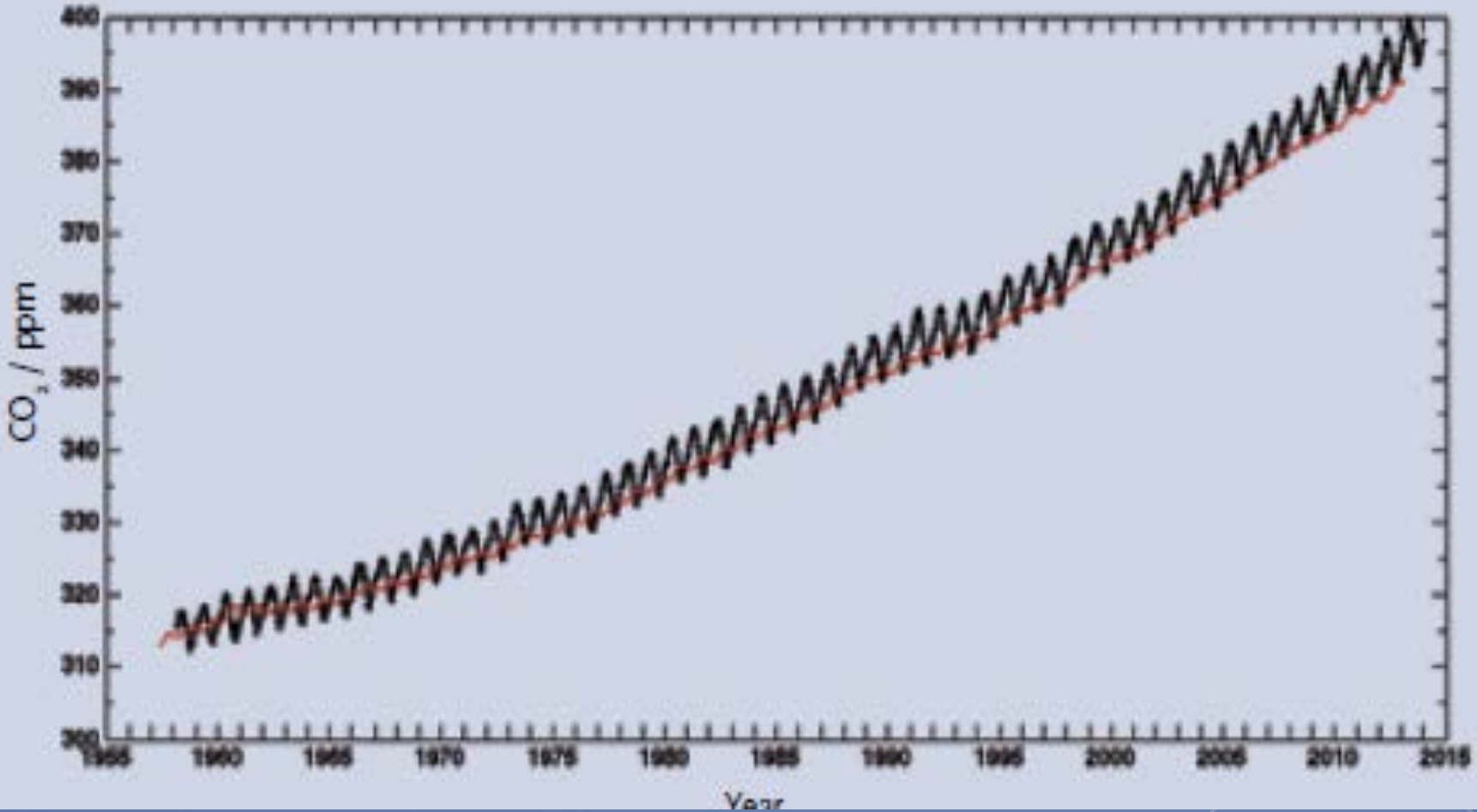
Why Climate Change?



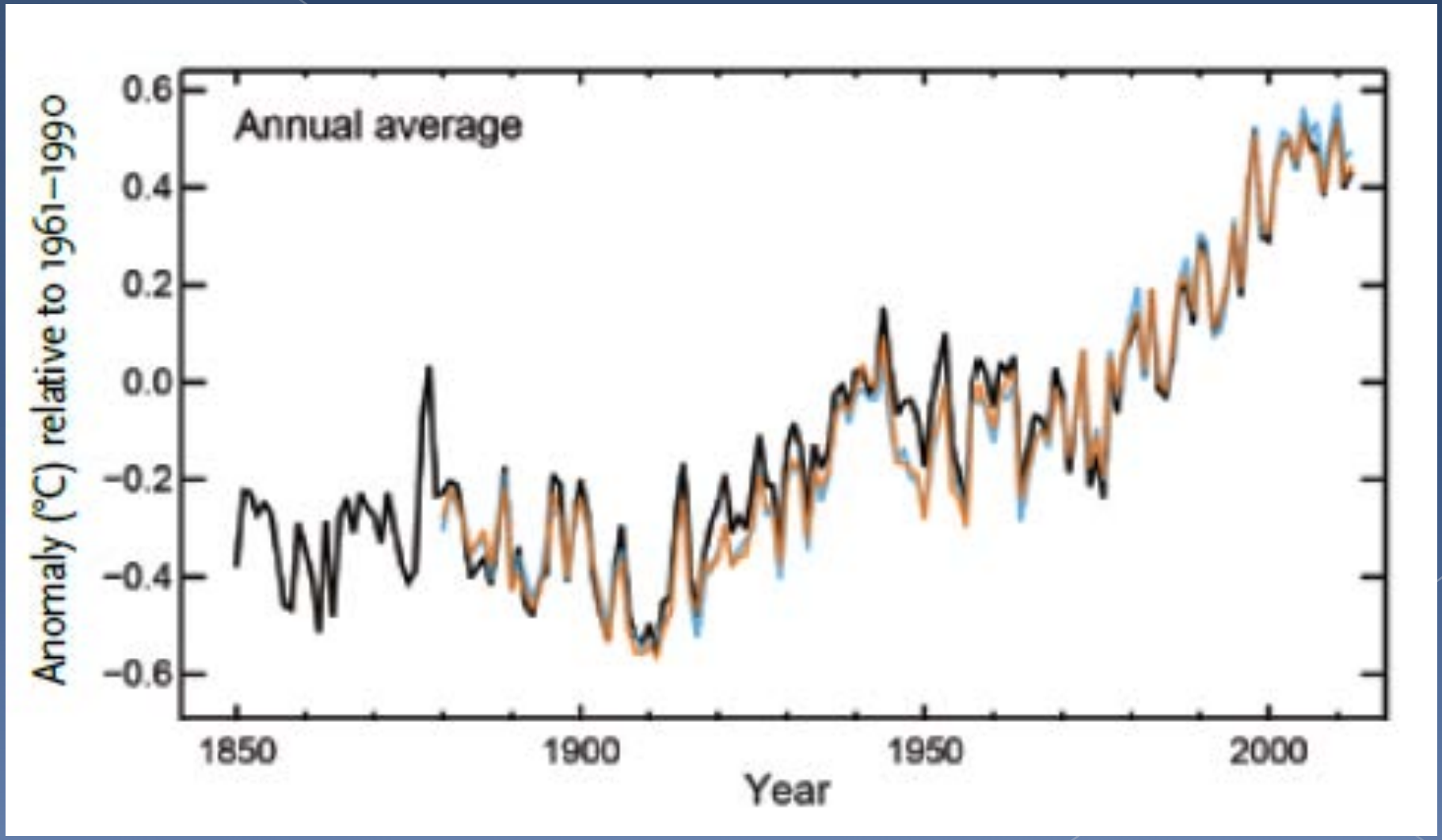
Connecting the Pieces

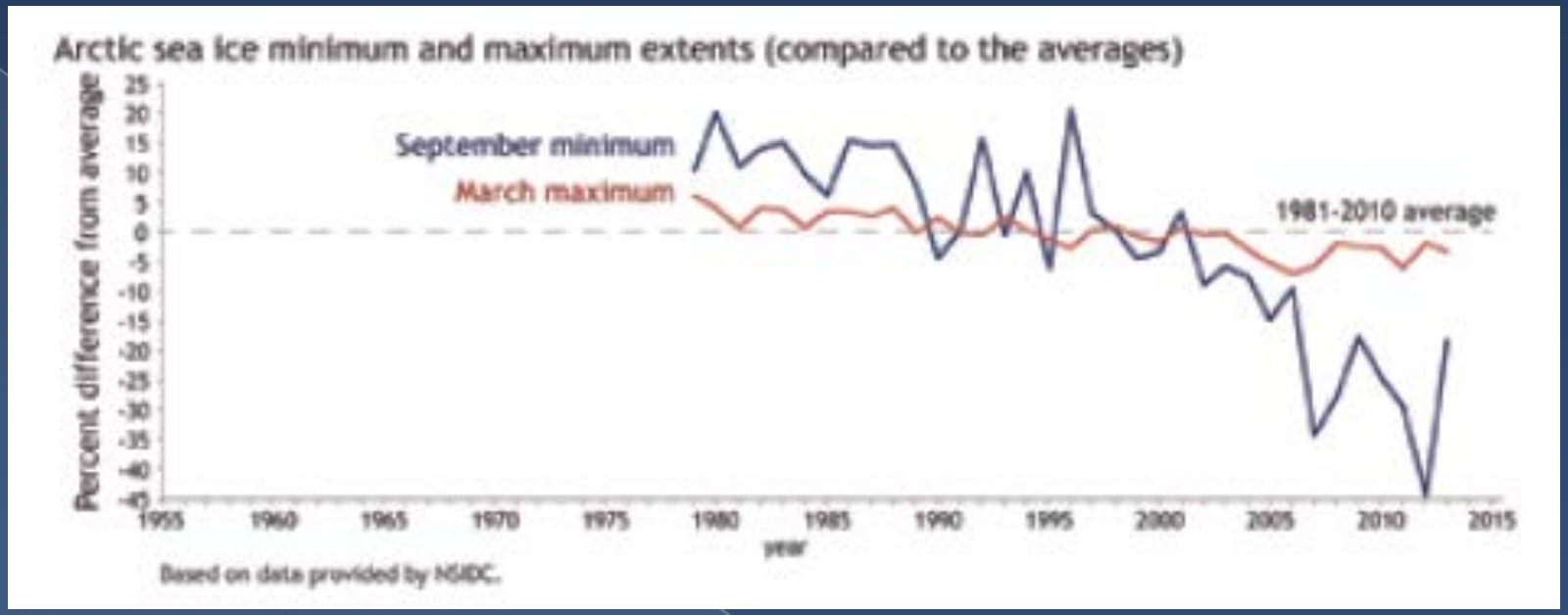
How does your Carbon Cycle Model relate to these graphs?

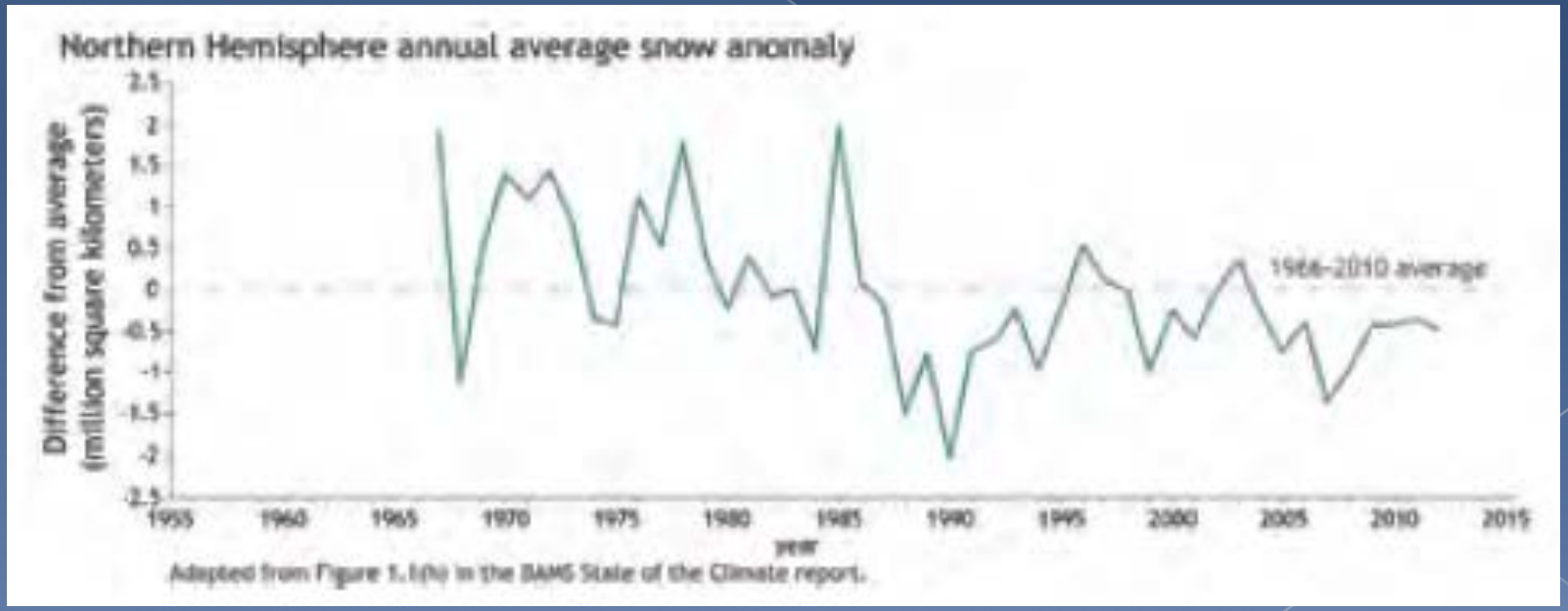
Atmospheric CO_2 1955-2014

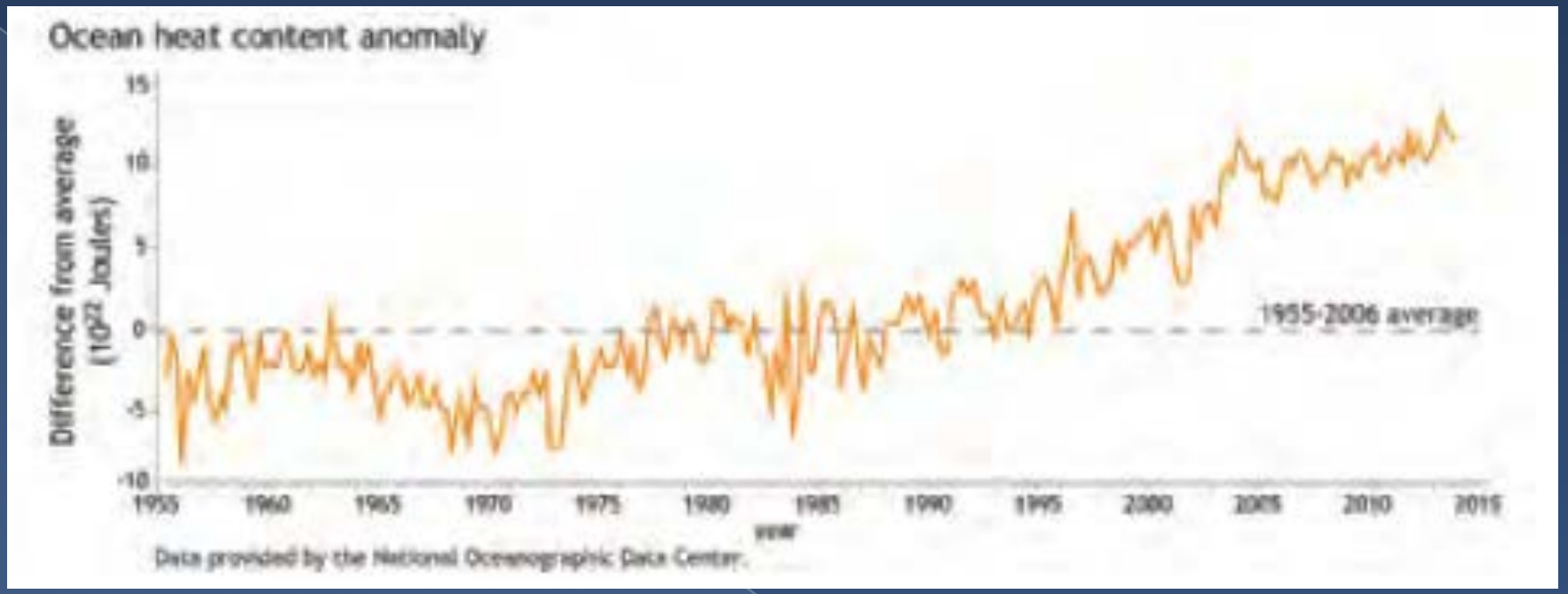


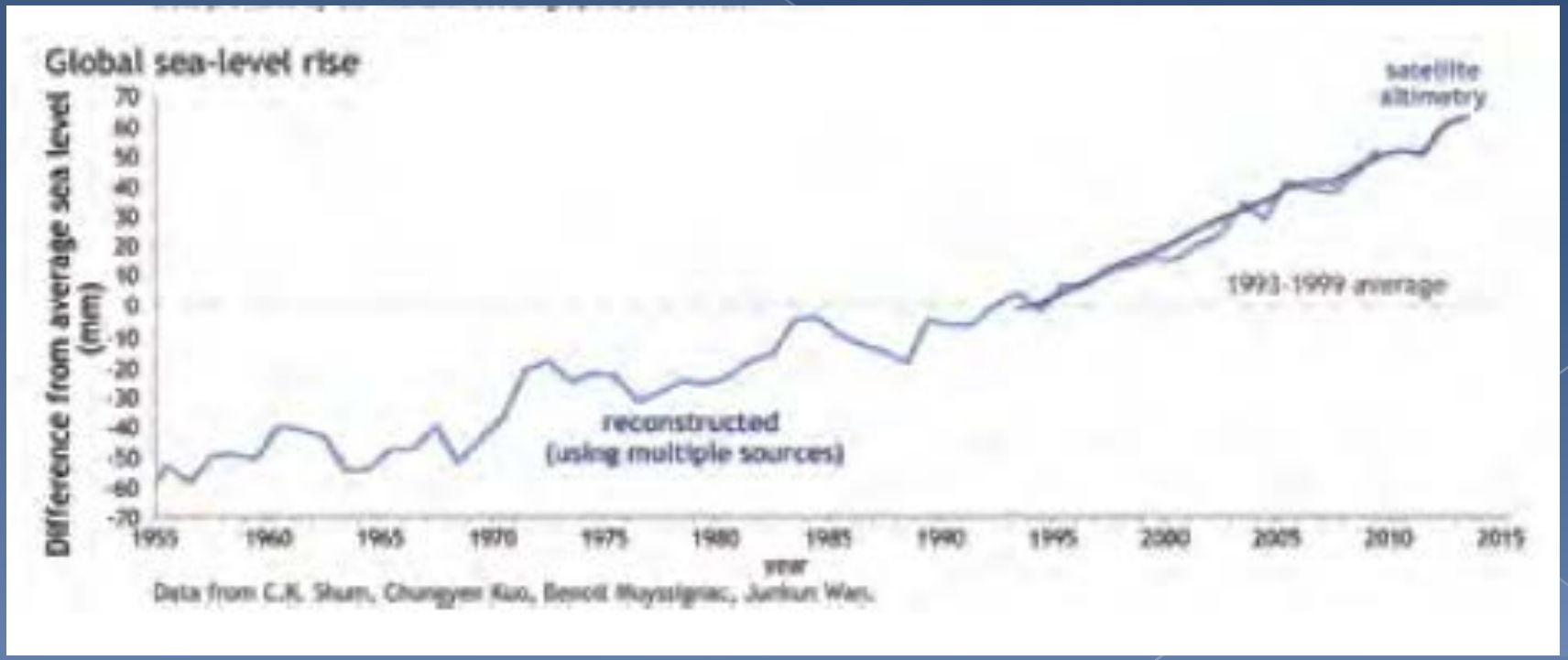
Average Annual Land & Ocean Surface Temperatures 1850 - 2012



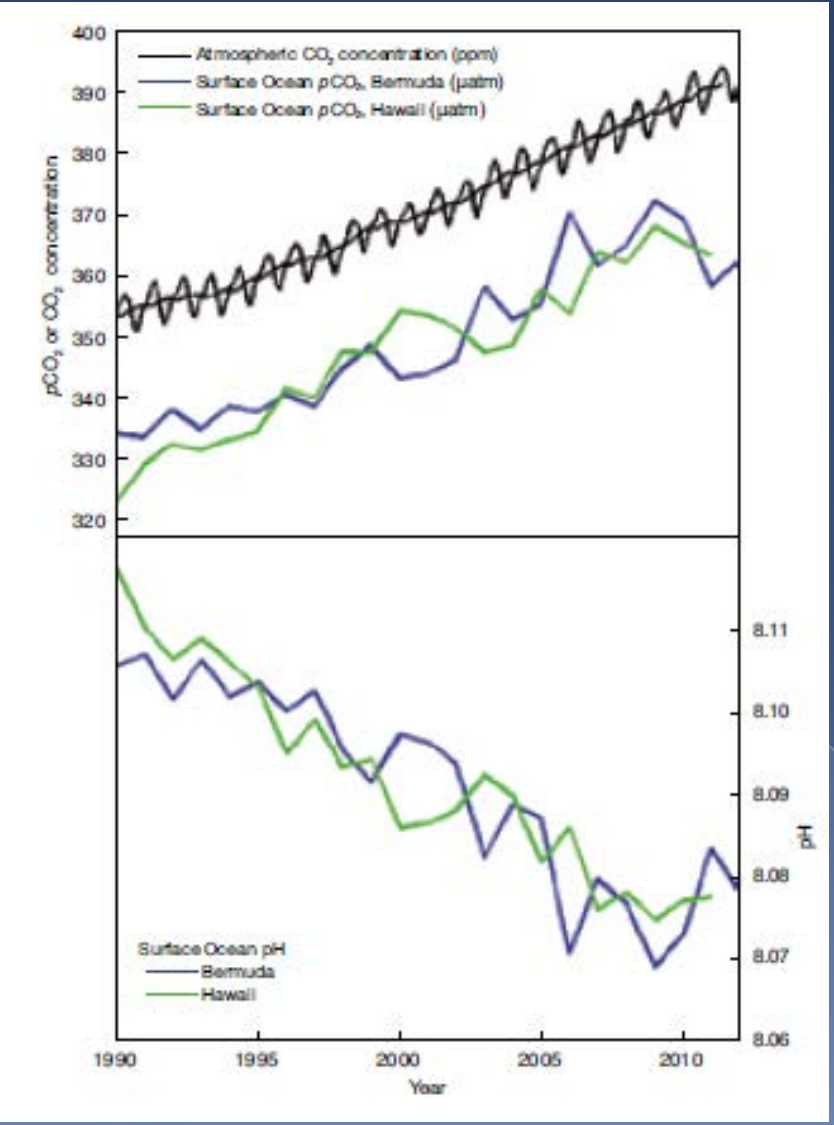

Arctic sea ice minimum and maximum extents (compared to the averages)
Percent difference from average
September minimum
March maximum
1981-2010 average
year
Based on data provided by NSIDC.


Northern Hemisphere annual average snow anomaly
Difference from average (million square kilometers)
1966-2010 average
year
Adapted from Figure 1.1(h) in the BAMS State of the Climate report.

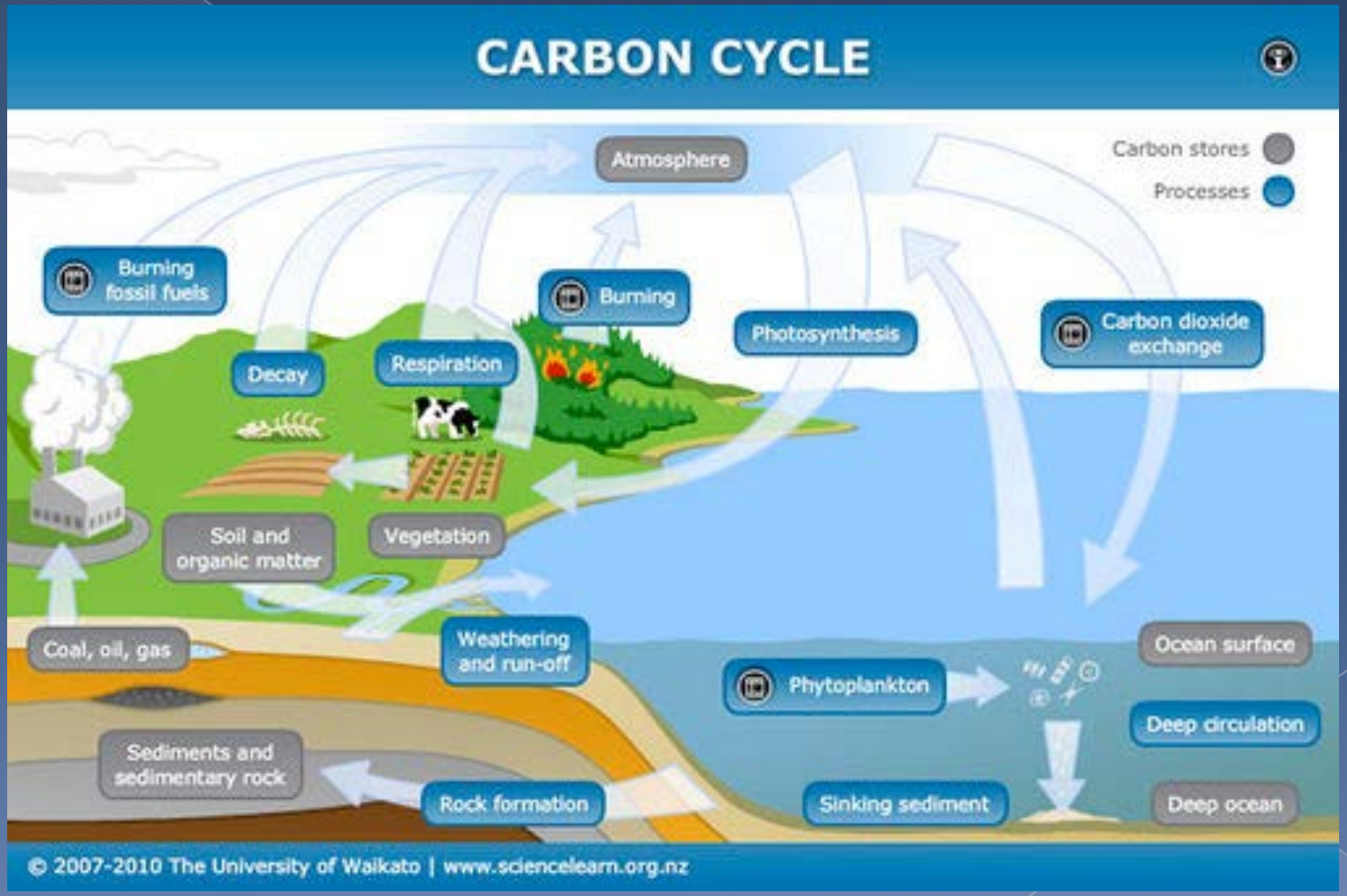

Ocean heat content anomaly
Difference from average (10^{22} Joules)
15
10
5
0
-5
-10
1955-2006 average
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
year
Data provided by the National Oceanographic Data Center.


Global sea-level rise
Difference from average sea level (mm)
satellite altimetry
1993-1999 average
reconstructed
(using multiple sources)
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
year
Data from C.K. Shum, Chungyen Kuo, Benoit Meyssignac, Junsun Wan.

Atmospheric CO_2, Ocean CO_2, & Ocean pH from 1990 to 2014



The Carbon Cycle



Explanatory Process – FINAL DRAFT (5 point rubric)

Levels	Organizing Operations
0	Does not explain carbon cycling, or does so inaccurately
1	Discusses either the effect of carbon cycling (carbon is transforming, carbon is cycling) or the causes of carbon cycling (photosynthesis, CR, decomposition, combustion, etc.)
2	Discusses both the cause and the effects of carbon cycling
3	Discusses either the effect of climate change (System is out of balance, human contribution) or the cause of climate change (C is accumulating, greenhouse effect, ocean acidification)
4	Discusses both the cause and the effects of climate change

*Should have a sequencing score ≥ 2 to score above a 0 on this rubric
*A cycle means that each component has an input and an output- you should be able to trace a single C all the way through

COMPONENTS – FINAL DRAFT

Levels	Description
0	No inputs or outputs
1	Carbon input OR output
2	At least one input and at least one output
3	Level 2 + an input or output
4	Level 3 + an explicit sink
5	Multiple inputs and outputs AND 2 explicit sinks
6	Multiple inputs and outputs AND 3 explicit sinks

Input- takes in C
Output- Puts out C

Sequences – FINAL DRAFT

Levels	Organizing Operations
0	No sequences
1	Carbon components are connected, one sequence
2	Carbon components are connected through two arrows (a chain) unidirectional
3	More than one chain
4	More than one chain with an explicit sink
5	Multiple chains, carbon is transformed/transferred multiple components have both inputs and outputs; shows both outputs and inputs indicating that carbon cycles

* A chain is three components- atmosphere can be implicit; arrows can be implicit

TUCKER PRAIRIE

Field Trip Information

- Climate change is a GLOBAL phenomenon and

  It has LOCAL impacts (everywhere).

- Evidence suggests that Climate change is impacting weather patterns and ecosystems in Missouri, but we are not sure how Missouri ecosystems are being affected.

- Dr. Rico Holdo and a team of scientists are studying the impacts of climate change on tall grass prairies in the Midwest… Tucker Prairie

Tucker Prairie

- Located east of Columbia (right off I-70)

- Last remnant of Missouri's "Grand Prairie" and one of the last examples of a tallgrass prairie in the US that has never been farmed.

- Over 200 native plant species; seeds from these plants are collected and used for prairie restoration efforts around the Midwest.

Images: http://mdc.mo.gov/ & http://opulentopossum.blogspot.com/

Why is Tucker Prairie Important?

- At one time MO was covered in over 15 million acres of Prairie
- 99% of this prairie land has been lost
- Seeds for dozens of native species are collected in Tucker Priarie and used for prairie restoration efforts around the Midwest.

Image from: http://kerryg.hubpages.com/hub/Attracting-Birds-With-Prairie-Plants

Dr. Holdo works on a weather station in Tucker Prairie.

This weather station collects data on temperature, humidity, soil moisture, light, rainfall & wind. Dr. Holdo uses these data to explore if/how climate and weather are changing in the prairie and how these changes may be related to changes in the organisms found there.

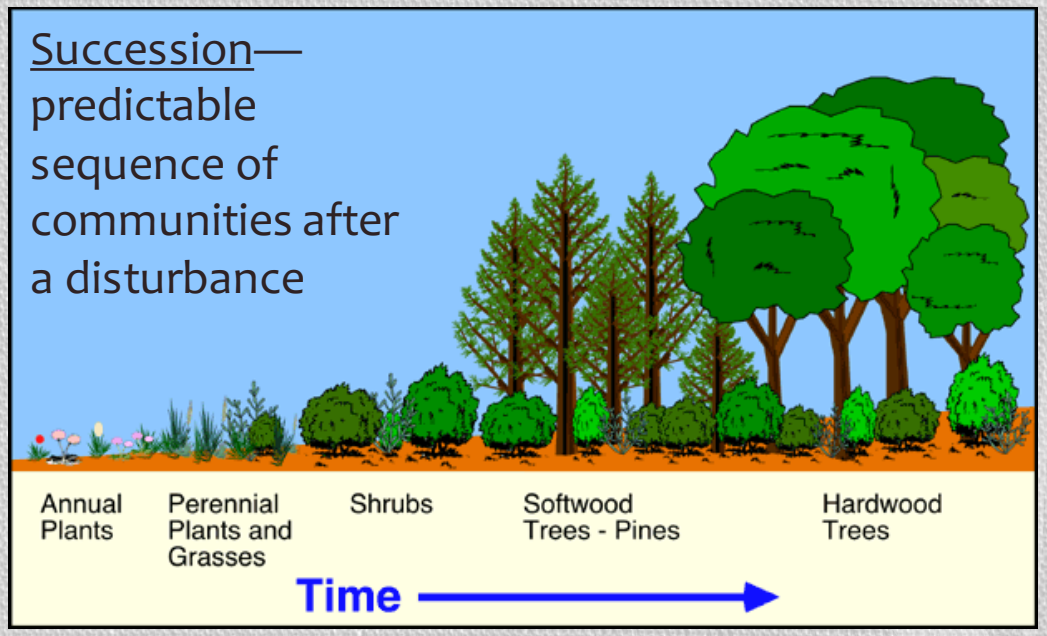
Exploring Tucker Prairie

- Tucker Prairie and Henslow's Sparrow Website—
  - Explore the website listed below. Thoughtfully answer the questions at the bottom of the website.
  - Purpose: Introduce you to the prairie ecosystem and the potential impacts of climate change on the ecosystem.

http://hcmfh3.wix.com/tuckerprairie

HOW WILL A CHANGING CLIMATE AFFECT COMPETITION IN TUCKER PRAIRIE?

- What *abiotic* factors help keep natural prairies (like Tucker Prairie) from developing into a forest?



- Fire
- Soil

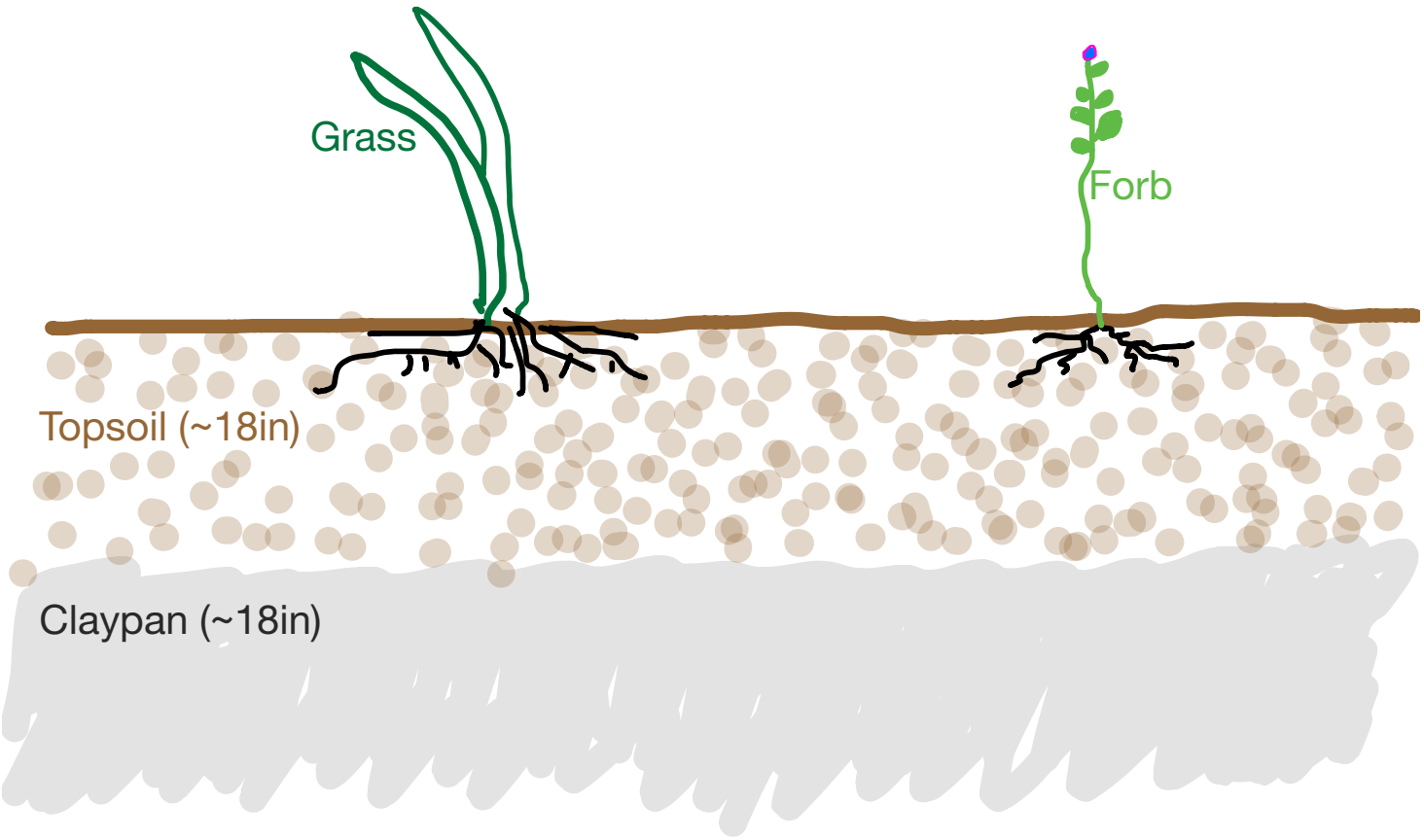
Claypan limits the movement of water past an initial layer of soil

Image from: http://www.physicalgeography.net/fundamentals/9i.html

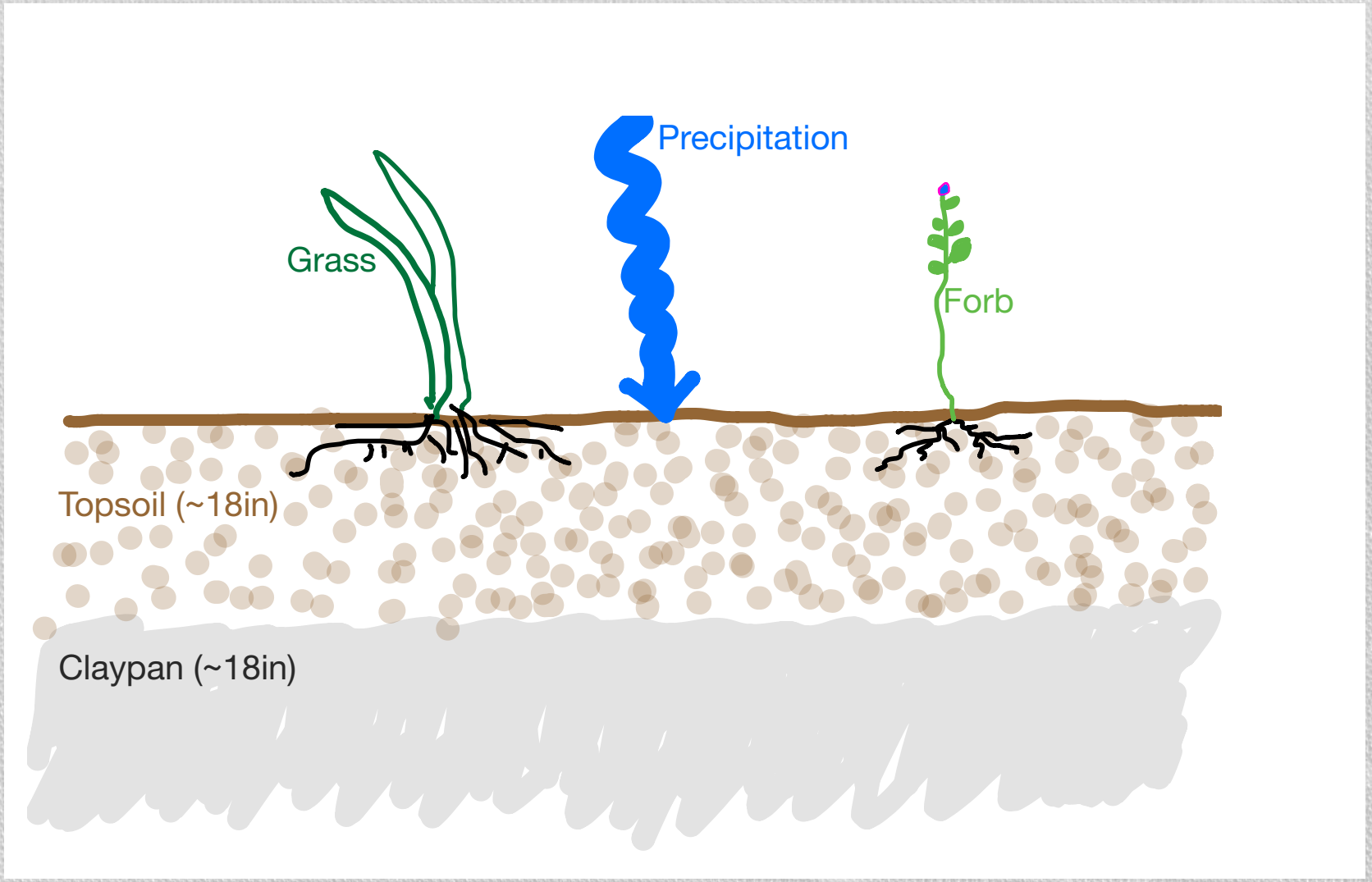
- One important aspect of soil relates to how it holds water, so SOIL MOISTURE will be a focal point for a model we build to understand prairies and competition in prairies.

Image from: http://www.cawater-info.net/all_about_water/en/?p=773

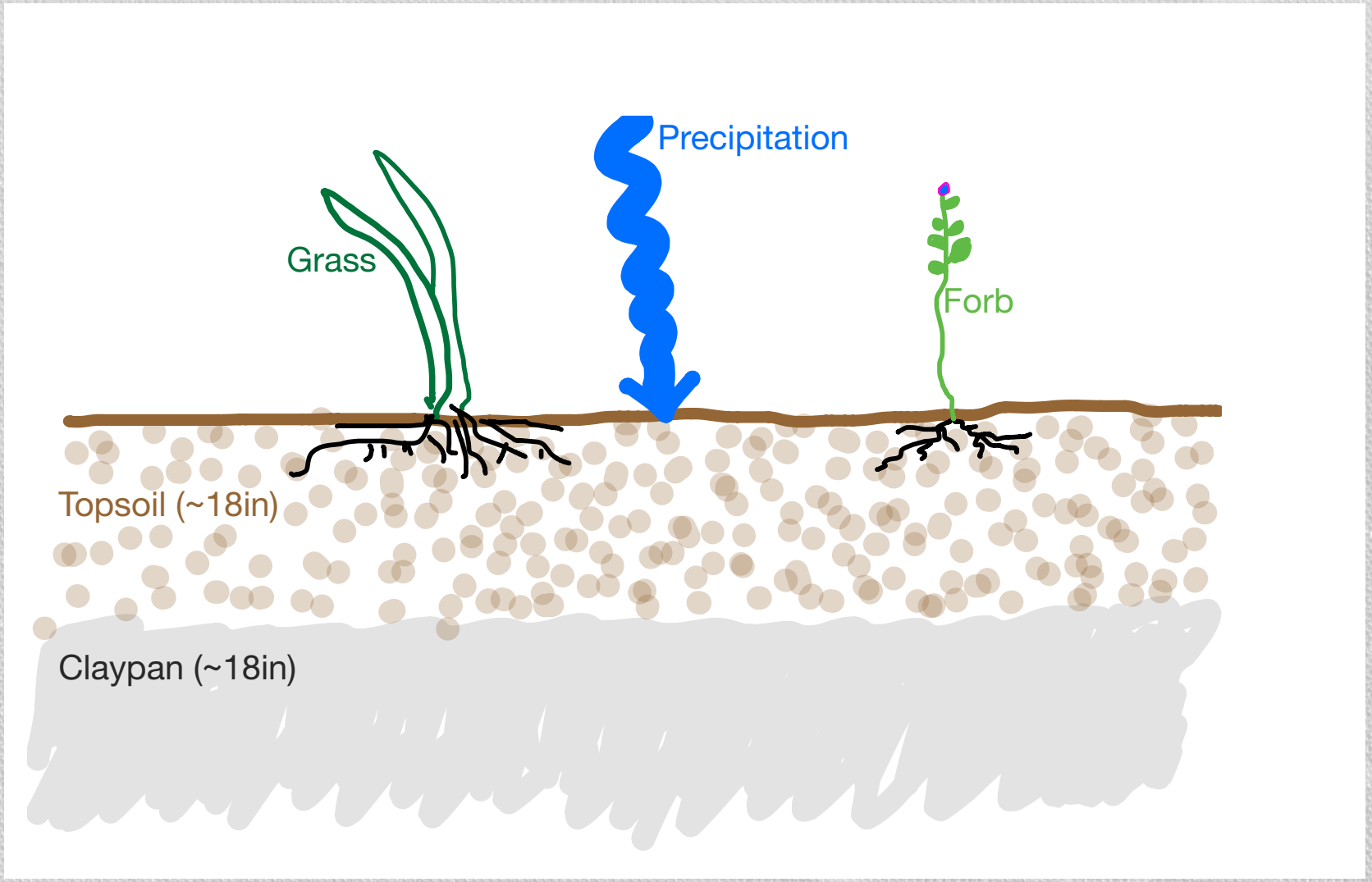
Building a model of Soil Moisture



How does water get into the system?

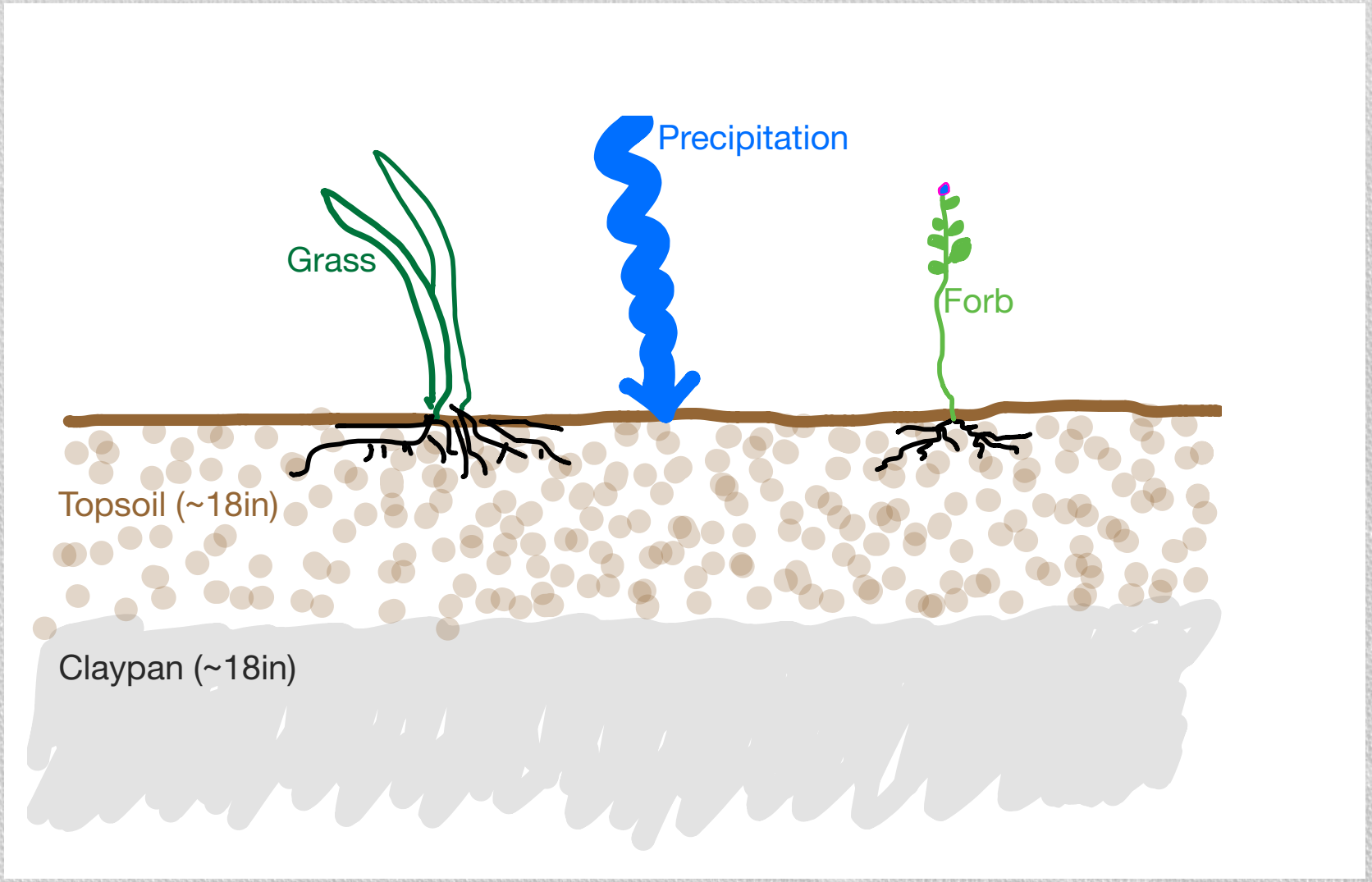


When water enters the system through precipitation, what happens to soil moisture?

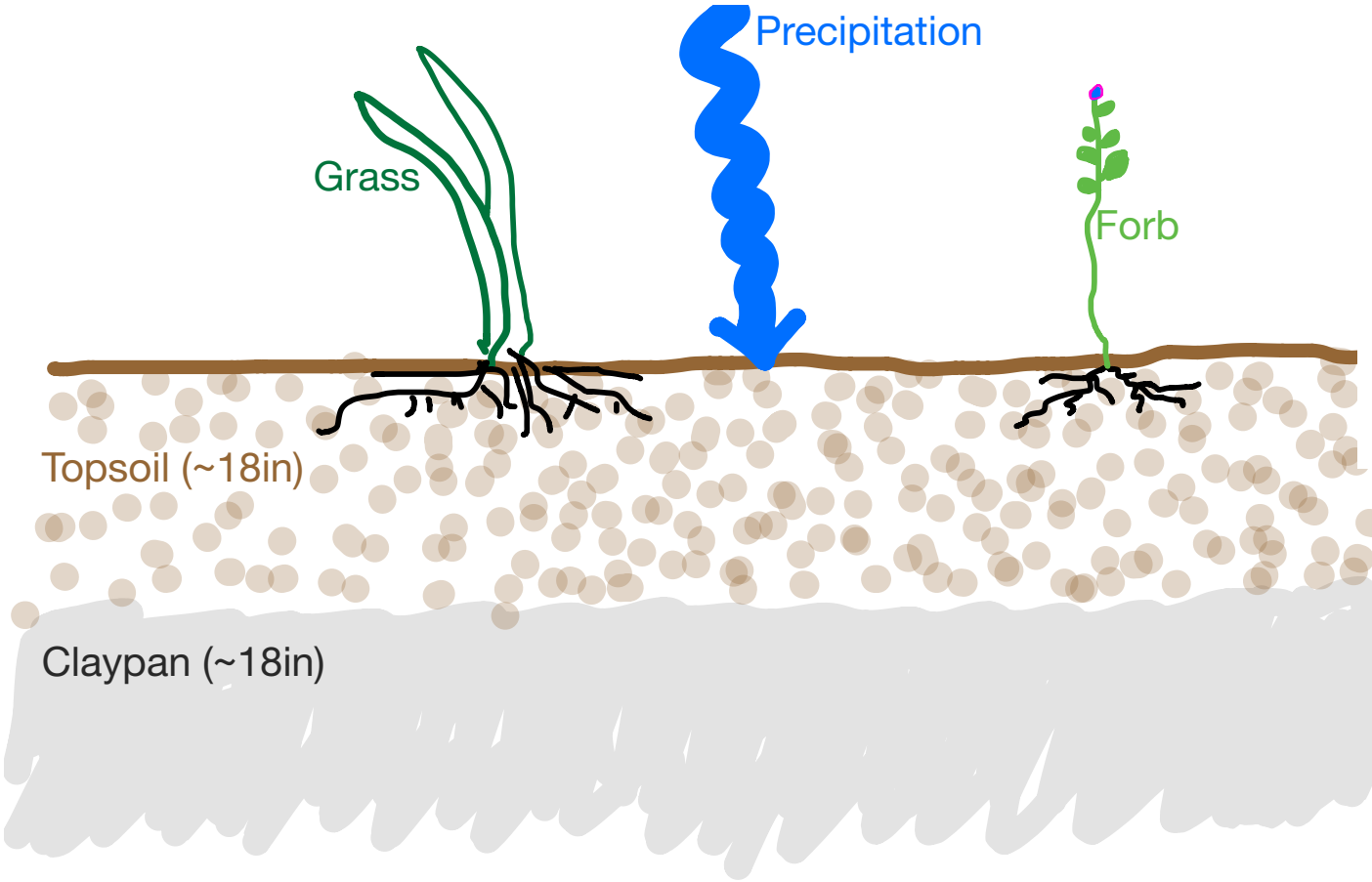


When water enters the system through precipitation, what happens to soil moisture?

↑precipitation ⟶ ↑soil moisture



Precipitation is one water process. What other water processes would likely affect this system?



Important Water Processes

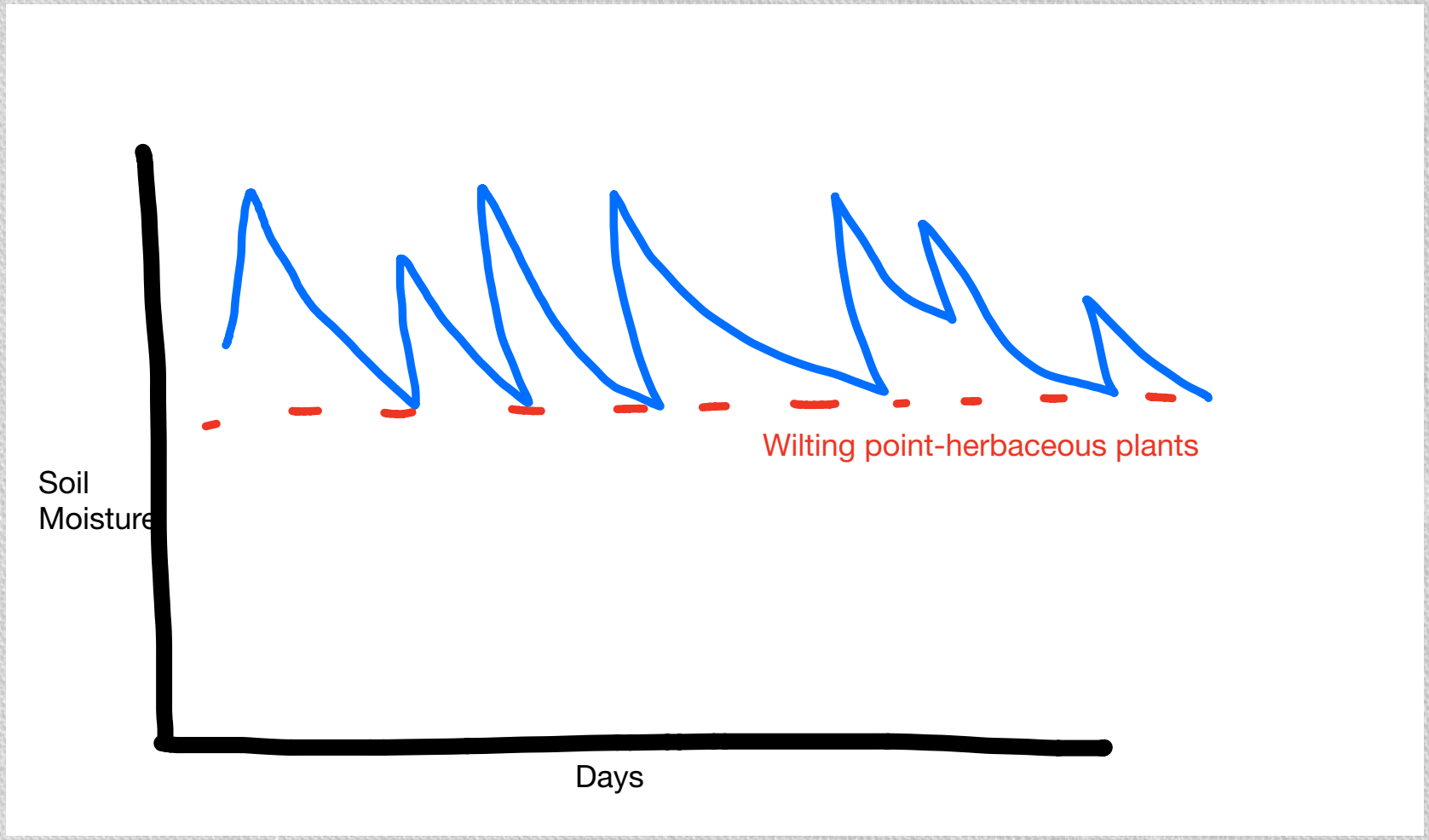
- Infiltration
- Runoff
- Evaporation
- Transpiration

Small Group Work: Create a model of soil/soil moisture that includes precipitation, infiltration, runoff, evaporation and Transpiration. As you work on this, complete the "Tracking Soil Moisture" worksheet, side A.

- Woody plants have a hard time getting established because of fire, BUT what if a woody plant does start growing?

- Woody plants have hardier root structure. These roots can go deeper into the soil. In some cases, they may be able to get through cracks in the claypan.

If the Prairie receives the same amount of precipitation why does it matter how frequently it rains?



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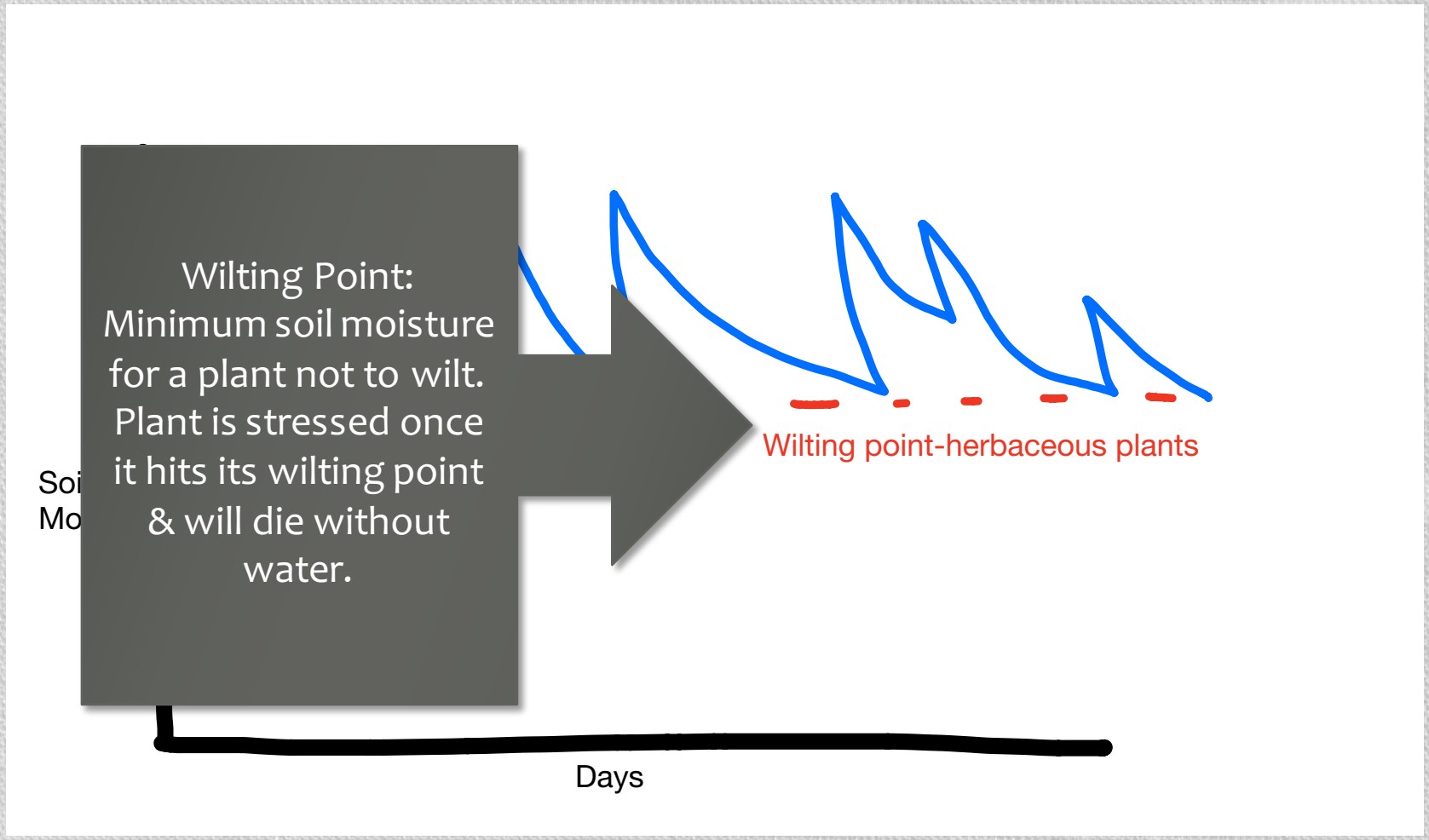
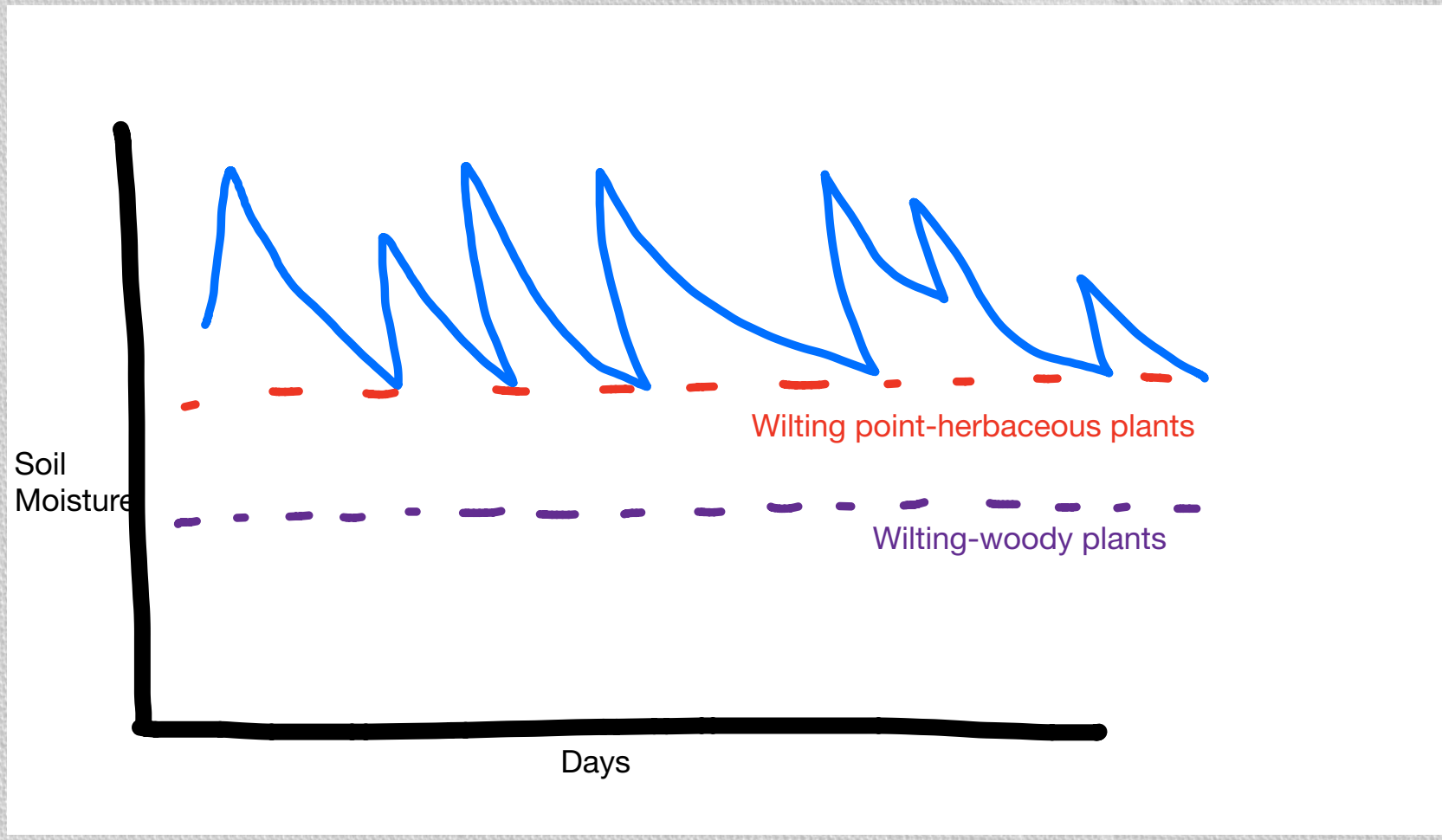
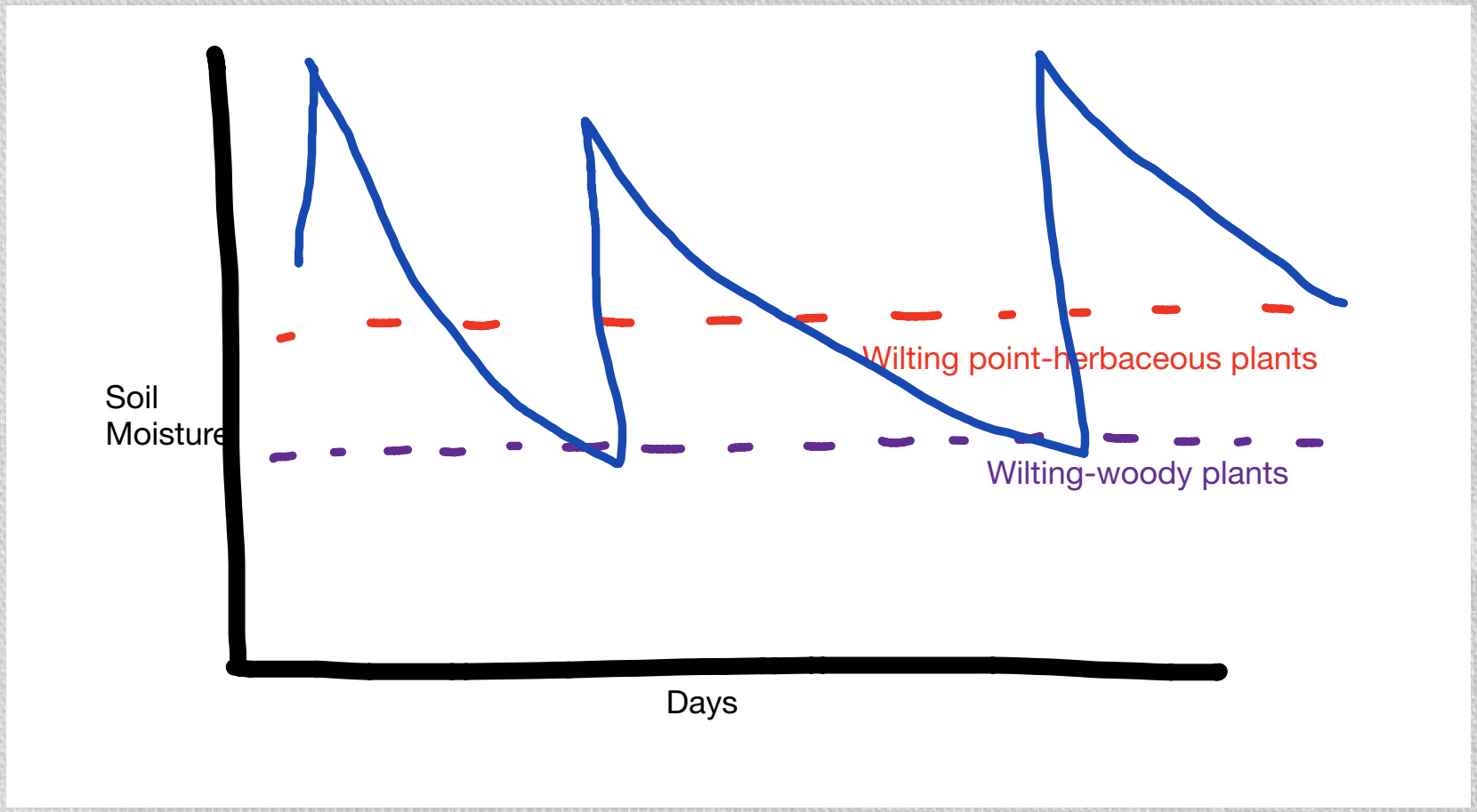


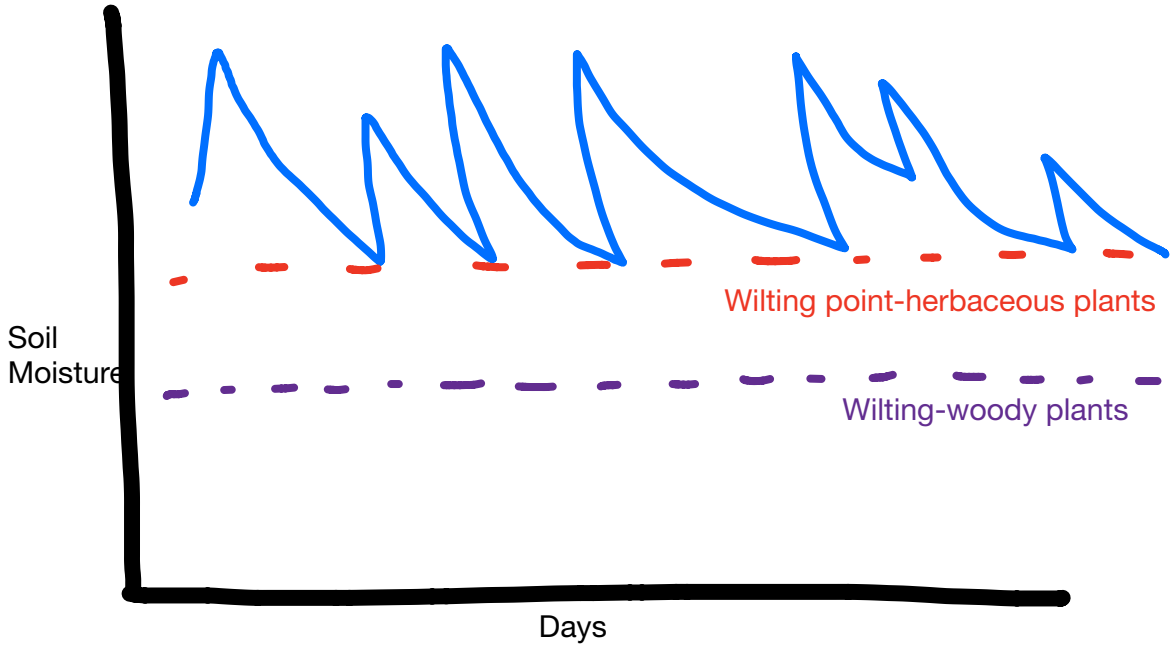
Why might we expect woody plants to have a lower wilting point?



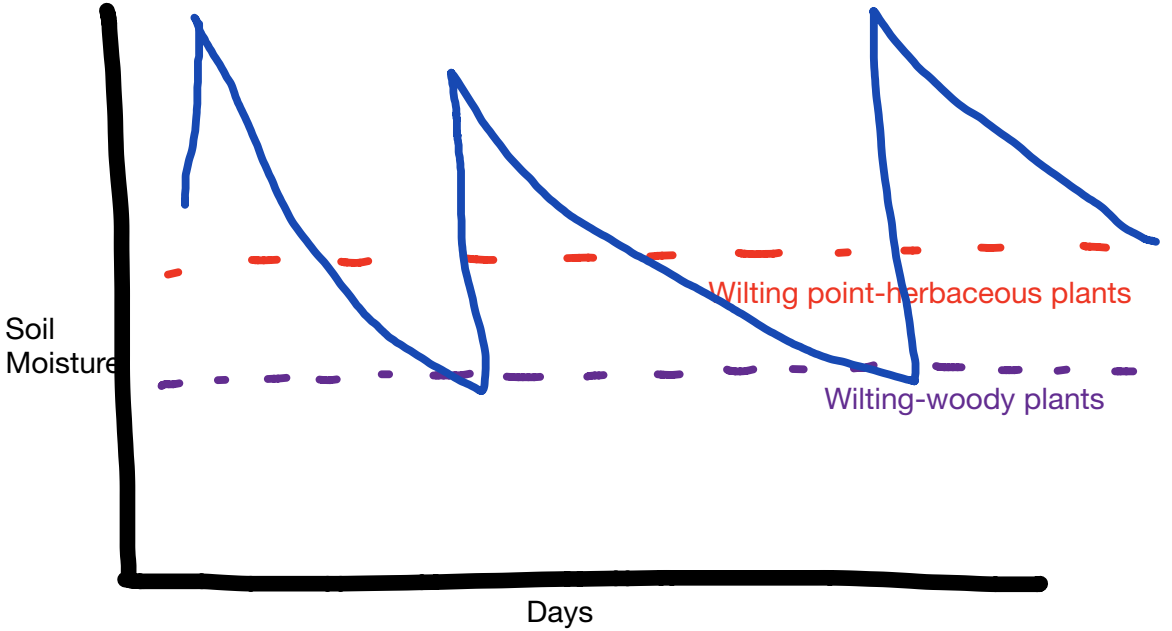
Infrequent rain events are hard on herbaceous plants because they have a higher wilting point.



Frequent rain events



Infrequent rain events



An important qualifier…
This is what we think is happening in Tucker Prairie based on what we know about plants, weather and climate, BUT we are not sure.

Dr. Holdo is conducting research in order to test these ideas. His findings will help us understand how climate change may impact natural ecosystems in the Midwest.

Honors Biology
Indicator Species Follow Up

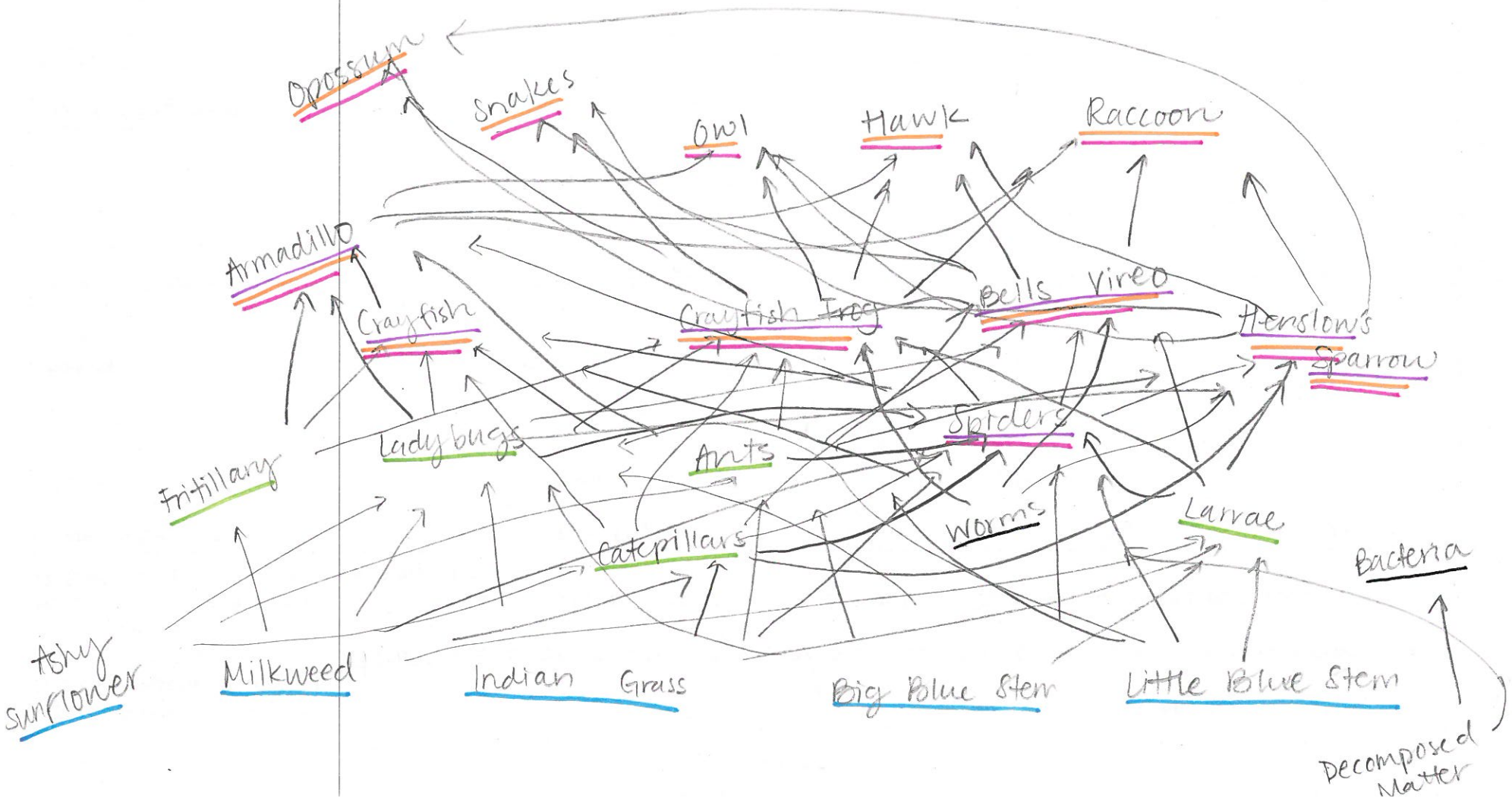
Name: Key

1. *In small groups, share information regarding the species you researched. See the definitions below to help describe your species to your classmates.*

Niche: the role of the organism in its environment (could be general or specific; ex: how it contributes, position in the food chain, etc.)
Habitat: the specific place where an organism lives

Name of Organism: Crayfish Frog **Niche:** burrows of other organisms, eats invertebrates, eaten by mammals & birds of prey **Habitat:** grasslands (especially moist &/or temp. H_2O sources) **Potential climate change effects:** ↓ frog pop. / leave T.P.; b/c their habitat is rare = ↓ pop.; more mammals could also ↓ pop.	**Name of Organism:** Fritillary **Niche:** symbiotic relationship w/ plants / pollinator, eat violets, eaten by insects, birds, small mammals **Habitat:** grasslands **Potential climate change effects:** ↓ pop. / leave T. P.; b/c habitat is rare = ↓ pop.; ↓ in pop. due to ag. (GMOs & pesticides)	**Name of Organism:** Bells Vireo **Niche:** migratory, eats insects, eaten by mammals & birds of prey **Habitat:** Summer = plains/SW; winter: Mexico / Central Am. → nests in thickets (often in transitional areas) **Potential climate change effects:** ↑ pop. due to ↑ in shrubby areas; may ↓ w/ full switch to woodland ↓ in pop. due to ag.
Name of Organism: Henslow's Sparrow **Niche:** migratory, eats insects, eaten by mammals & birds of prey → nests in grasses (moist prairies) **Habitat:** summer = plains/Ohio valley; winter = gulf / Carolinas **Potential climate change effects:** ↓ pop. / leave T. P.; b/c their habitat is rare = ↓ pop; could impact breeding grounds ↓ in pop. due to ag.	**Name of Organism:** Meades Milkweed **Niche:** host to butterflies, provides nectar to insects/birds, producer **Habitat:** tallgrass prairie (moist), ideal = reg. burning/grazing **Potential climate change effects:** ↓ pop. / extinction; would also cause a major ↓ in other species, too ↓ pop. due to pesticides	**Name of Organism:** Nine-banded Armadillo **Niche:** generalist, eat invertebrates (but adapt based on availability), sometimes eaten by large mammals or birds of prey, **Habitat:** broad - just can't withstand extended cold **Potential climate change effects:** if burning limited & con't. ↑ in temp. = ↑ in pop.; may cause lots of impacts due to their generalist nature

2. *Next, using the six indicator species along with their predators and prey and organisms you saw/know live in Tucker Prairie, create a food web that outlines the flow of energy within this ecosystem.*

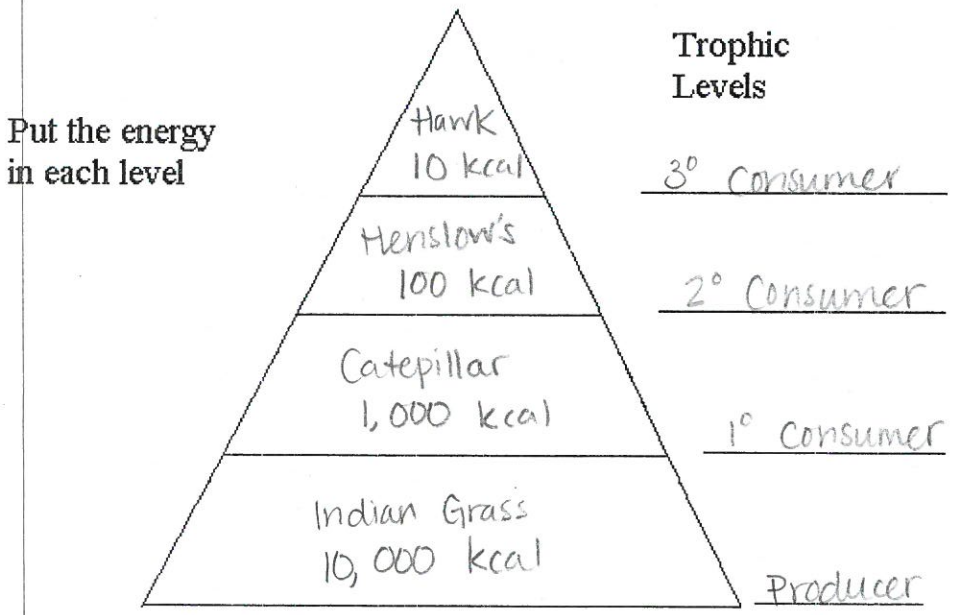


3. *Go back to your food web and label, color code, symbolize, etc. the following individuals:*
   - Producer- autotrophs, organisms that can make their own energy
   - Consumer- heterotrophs, organisms that must intake their energy
     - Primary consumer- eats producers
     - Secondary consumer- eats primary consumers
     - Tertiary consumer- eats secondary consumer
     - NOTE: organisms can be at multiple tropic levels
   - Herbivore- consumers that only ~~each~~ eats plants
   - Carnivore- consumers that only eat other animals
   - Omnivore- consumers that eat both plant/animals
   - Decomposer- organisms that break down dead organic matter (recycle nutrients back to soil)

4. *Outline one food chain (include a producer, primary, secondary, and tertiary consumer) below.*

   Indian Grass → Catepillar → Henslow's Sparrow → Hawk

5. *Use your food chain to create an energy pyramid that shows the amount of available energy at different trophic levels. Assume that 1,000,000 kcal of energy from the sun fuels this food chain. Only 1% of this energy gets stored in the producers. Only 10% of the energy at one trophic level is available to the next level, while the rest is "lost" as heat energy (think about what you know about cellular respiration).*



Northern Crayfish Frog: *Lithobates areolatus*

IUCN (International Union for the Conservation of Nature) status: **Near threatened.**

Natural History:

This species hides in crayfish, reptile, or rodent burrows when inactive. Shows ability to adapt somewhat to loss of native habitat (sometimes found on golf courses, hay pastures), but does not fair well with high intensity agriculture (corn, soybeans, etc). Feeds on invertebrates including insects, spiders, crayfish, larvae. Sometimes preyed upon by mammals such as raccoons, opossum, or birds of prey such as hawks or owls. Primary population threat is loss of habitat.

Habitat:

Dependent on grassland ecosystems, especially seasonally moist grasslands and those with temporary water sources.

Range:

Links:

http://mdc.mo.gov/discover-nature/field-guide/northern-crawfish-frog
https://en.wikipedia.org/wiki/Crawfish_frog
http://www.iucnredlist.org/details/58546/0
https://www.youtube.com/watch?v=cQ1IaoUSnus
http://maps.iucnredlist.org/map.html?id=58546

Guiding questions for predicting the future of this species at Tucker Prairie:

1. Does this species account lend evidence to support the ability to adapt to changing vegetation, soil moisture, and climate?
2. Are the habitat requirements for this species broad or specific?

3. What is your prediction for the success of this species at Tucker Prairie if climate change results in a gradual conversion of Tucker Prairie from native prairie to shrubs and eventually woodland?
4. What does this species eat? What other species eats the Northern Crayfish Frog?
5. Why should we care about changes in the population of an amphibian like the Northern Crayfish Frog? Socially is this important or not? Why?
6. Refer to the rangemap shown above. Why is there a large area in southeast Missouri in which this species is absent? How might this apply to the situation of a changing climate at Tucker Prairie?

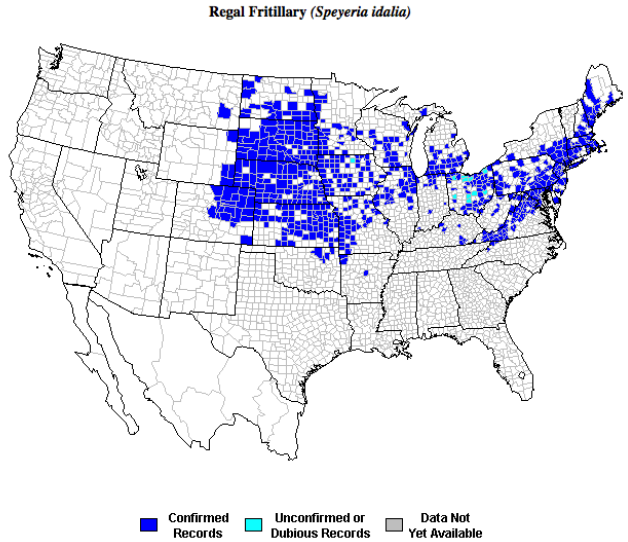
Instructor guide for climate change prediction:
Because the Northern Crayfish Frog has such specific habitat needs, (Tallgrass prairie with crayfish burrows), a conversion of TP a woodland would likely result in this species leaving the area. Furthermore, because these habitats are so rare, climate change at TP would contribute to the overall decline of this species. Movement into the area by mammal predators could also negatively influence this population.

Regal Fritillary: *Speyeria idalia*
Missouri status: **Vulnurable**
IUCN status has not been determined.

Natural history:
Primary population threat is loss of habitat. Genetically Modified Organisms such as BT corn and soybeans as well as the long duration of Neoniconitoid (Neonic) insecticides also play a role in their decline. Larvae (caterpillars) feed on members of genus Viola (Violets). Usually bird's-foot violet and prairie violet here in Missouri. There is a significant symbiotic connection with both host and nectar plants in larval and adult stages. Adults feed on the nectar of a variety of prairie plants and in doing so, fulfill a pollinator role for those plants. Examples: Milkweed, Thistle, Coneflower, Liatris, Sunflowers, Goldenrods, & Ironweed. Thistle and Milkweed provide large nectar contributors for this species due to the staggered blooming times for these two large groups of plants. This species (caterpillar and adult) is preyed upon by other insects, birds, and small mammals.

Habitat:
Dependent on grassland ecosystems. Range is estimated to have been reduced by at least 30%

Range:
Isolated to remnants of tall grass prairies from Montana to Maine. Range map difficult to calculate.



http://www.abirdshome.com/resource/usa/80.htm
http://www.butterfliesandmoths.org/species/Speyeria-idalia

Links:
http://mdc.mo.gov/discover-nature/field-guide/regal-fritillary
http://www.xerces.org/regal-fritillary/
http://www.butterfliesandmoths.org/species/Speyeria-idalia
http://www.nature.org/newsfeatures/specialfeatures/animals/insects/regal-fritillary-butterfly.xml

https://en.wikipedia.org/wiki/Regal_fritillary

Guiding questions for predicting the future of this species at Tucker Prairie:

1. Does this species account lend evidence to support the ability to adapt to changing vegetation, soil moisture, and climate?
2. Are the habitat requirements for this species broad or specific?
3. What is your prediction for the success of this species at Tucker Prairie if climate change results in a gradual conversion of Tucker Prairie from native prairie to shrubs and eventually woodland?
4. What does this species eat? What other species eats the Fritillary?
5. Consider your answers to the previous three questions. Given the complex symbiotic relationship between host/pollinator plants and this species of butterfly, what are some implications for the overall prairie ecosystem with a changing climate at Tucker prairie?
6. Why should we care about changes in the population of a butterfly like the Regal Fritillary? Socially is this important or not? Why?

Instructor guide for climate change prediction:
Because Regal Fritillary butterflies have such specific symbiotic connections with tallgrass prairie plants, a conversion of TP to a woodland would likely result in this species leaving the area. Furthermore, because these habitats are so rare, climate change at TP would contribute to the overall decline of this species. This species tied to Meades Milkweed as a pollinator and illustrates cascading impact of CC at TP on the prairie foodweb. Habitat loss more than future predation with invading species is the key reason for the decline in this species.

Bells Vireo: *Vireo bellii*

IUCN (International Union for the Conservation of Nature) status: **Near threatened.**

Natural history:

Neotropical Migrant bird. (migratory between north and central/south America) This species summers in the great plains and desert southwest. Winters in Mexico and Central America. Insectivorous. Primary population threat is habitat loss due to intensive agriculture and human development of old fields and barren areas. Preyed upon by mammals such as raccoons, opossum, or birds of prey such as hawks or owls. All birds are susceptible to the accumulation of neonic insecticides within the food chain.

Habitat:

Shrubby, early-mid successional growth. Nests are built in thickets 2-3 feet off the ground. Favored habitat are shrubby thickets and old abandoned fields. Is not commonly found in pure grasslands or thick forests, but often in the transition period of succession between the two.

Range:

http://maps.iucnredlist.org/map.html?id=22705156

Links:

http://www.allaboutbirds.org/guide/Bells_Vireo/id
https://www.audubon.org/field-guide/bird/bells-vireo
http://climate.audubon.org/birds/belvir/bells-vireo
https://en.wikipedia.org/wiki/Bell's_vireo

Guiding questions for predicting the future of this species at Tucker Prairie:

1. Does this species account lend evidence to support the ability to adapt to changing vegetation, soil moisture, and climate?
2. Are the habitat requirements for this species broad or specific?
3. What is your prediction for the success of this species at Tucker Prairie if climate change results in a gradual conversion of Tucker Prairie from native prairie to shrubs and eventually woodland?
4. What does this species eat? What other species eats the Bell's Vireo?
5. Thinking long term, apply your answers to the previous three questions to 100 years or more if Tucker Prairie eventually becomes a forest woodland.
6. Why should we care about changes in the population of a birds like the Bell's Vireo or Henslow's sparrow? Socially is this important or not? Why?

Instructor guide for climate change prediction:
Bell's vireos thrive in successional shrubby areas. A conversion of TP a woodland would likely result in this species multiplying in the area. They are currently found in low numbers in the plum thickets and shrubby fence edges of the area. Predicted increase in population with expansion of plum thickets at TP. Currently Near threatened showing a decline of ~ 3% annually. Audubon climate change models predict 366% increase in summer habitat, and 544% increase in winter habitat.*Globally this species is declining due to intensive agriculture and loss of habitat. Climate change at TP may increase its population locally until succession continues to a woodland condition, at which point this species would again face decline.*

Henslow's Sparrow: *Ammodramus henslowii*

IUCN (International Union for the Conservation of Nature) status: **Near Threatened**

Natural history:

Neotropical Migrant bird. (migratory between north and central/south America) Summers in great plains east through the Ohio valley. Winters on the gulf coast north to the Carolinas. Insectivorous. Primary population threat is habitat loss. It is a very secretive species rarely seen, but often heard singing in the early mornings or especially at dusk. Preyed upon by mammals such as raccoons, opossum, or birds of prey such as hawks or owls. All birds are susceptible to the accumulation of neonic insecticides within the food chain.

Habitat:

Native prairies that experience regular burning. Nests are built hidden within 3-5 foot tall stands of native grasses. This species prefers moist tallgrass prairies such as Tucker Prairie.

Range:

http://maps.iucnredlist.org/map.html?id=22721138

Links:

http://www.allaboutbirds.org/guide/Henslows_Sparrow/id
https://www.audubon.org/field-guide/bird/henslows-sparrow
http://climate.audubon.org/birds/henspa/henslows-sparrow
https://en.wikipedia.org/wiki/Henslow's_sparrow

Guiding questions for predicting the future of this species at Tucker Prairie:

1. Does this species account lend evidence to support the ability to adapt to changing vegetation, soil moisture, and climate?
2. Are the habitat requirements for this species broad or specific?
3. What is your prediction for the success of this species at Tucker Prairie if climate change results in a gradual conversion of Tucker Prairie from native prairie to shrubs and eventually woodland?
4. What does this species eat? What other species eats the Henslow's Sparrow?
5. Using your answers to the previous three questions as a guide, compare and contrast the storylines for Henslow's sparrows and Bell's vireo in a changing climate. How are they similar and different?
6. The range map shows the summer and winter migratory areas. Given the use of two distinct habitat areas, how might climate change be especially challenging on a migratory species such as the Henslow's sparrow?

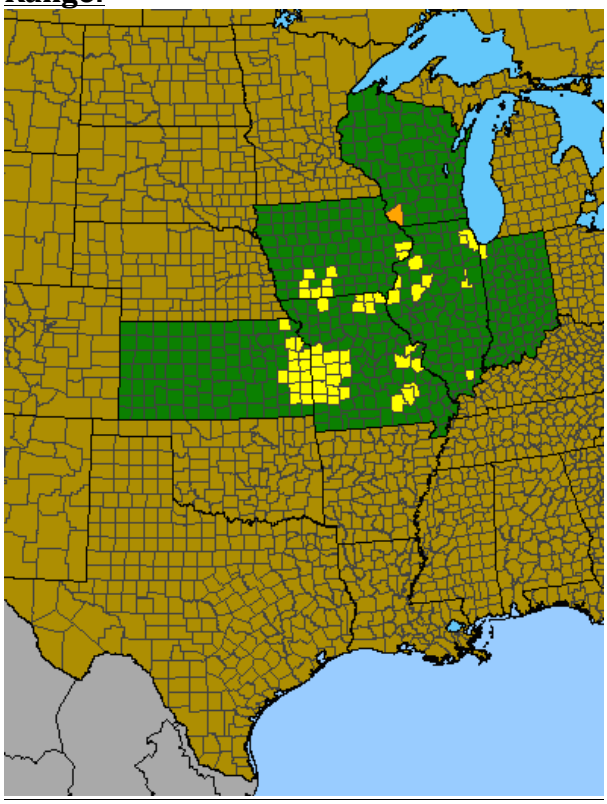
Instructor guide for climate change prediction:
Because Henslow's sparrows have such specific habitat needs, (Moist tallgrass prairie), a conversion of TP a woodland would likely result in this species leaving the area. Furthermore, because these habitats are so rare, climate change at TP would contribute to the overall decline of this species. Climate change has a double impact for migratory species such as Henslow's impacting breeding and wintering grounds.

Meades Milkweed: *Asclepias meadii*
Missouri status: **Endangered**
IUCN status has not been determined.

Natural history:
A member of the larger Apocynaceae family of milkweed plants. This species is native to tallgrass prairies and requires moist conditions with regular burns. A unique milkweed with yellowgreen flowers, this species serves as the host to monarch butterflies as well as several other Lepidoptera. The flowers provide nectar as well for insects and birds. Viewed as a weed by many people, this species is often sprayed with roundup and other herbicides.

Habitat:
This species is very sensitive and not found in habitats other than moist tallgrass prairie. Regular burning and/or periodic grazing reduces competition for sunlight and promotes conditions ideal for the growth of this milkweed.

Range:



http://bonap.net/MapGallery/County/Asclepias%20meadii.png

Links:
http://mdc.mo.gov/discover-nature/field-guide/mead-s-milkweed
http://www.fws.gov/Midwest/endangered/plants/meads/index.html
http://www.centerforplantconservation.org/collection/CPC_ViewProfile.asp?CPCNum=308
https://en.wikipedia.org/wiki/Asclepias_meadii

Guiding questions for predicting the future of this species at Tucker Prairie:

1. Does this species account lend evidence to support the ability to adapt to changing vegetation, soil moisture, and climate?
2. Are the habitat requirements for this species broad or specific?
3. What is your prediction for the success of this species at Tucker Prairie if climate change results in a gradual conversion of Tucker Prairie from native prairie to shrubs and eventually woodland?
4. What does this species eat? What other species eats Meade's Milkweed?
5. Consider your answers to the previous three questions. Given the complex symbiotic relationship between host/pollinator plants and insects such as butterflies, what are some implications for the overall prairie ecosystem with a changing climate at Tucker prairie?
6. Why should we care about changes in the population of a plant like Milkweed? Socially is this important or not? Why?

Instructor guide for climate change prediction:
This species is critically endangered throughout its range in the US. It is not adaptable to changes in the prairie ecosystem and almost certainly will not survive a woody conversion at TP. The negative impact is two fold to this ecosystem in the loss of a host plant for monarch butterflies as well as providing nectar for many pollinator species. This species tied to Regal Fritillary as a nectar source as well as Monarch butterfly as host plant for larvae. Illustrates cascading impact of CC at TP on the prairie foodweb.

Nine-banded Armadillo: *Dasypus novemcinctus*
IUCN (International Union for the Conservation of Nature) status: **Least Concern.**

Natural history:
A generalist mammal that has expanded northward from Mexico since the early 1900s. They primarily feed on invertebrates such as grubs, beetles, ants, and worms but will adapt their diet as food is opportunistically encountered. They have been documented eating bird eggs, lizards, amphibians, and occasionally tubers and roots of plants. They are occasionally preyed upon by other mammals or large birds of prey, but they are well protected with their armored shell.

Habitat:
This species has shown to be extremely successful. Traditionally associated with the tropical or desert southern states, they now are found in woodland, grassland, and even suburban areas. Their poor eyesight and defensive jumping posture leads to frequent roadkill. They cannot hibernate and do not fair well with extended snow/ice cover. They have a high reproductive rate.

Range:
First seen in Missouri in the mid 1990's they have expanded their range north to Nebraska and east into the Carolinas.

http://maps.iucnredlist.org/map.html?id=6290

Links:
http://animals.nationalgeographic.com/animals/mammals/armadillo/
https://en.wikipedia.org/wiki/Nine-banded_armadillo
http://www.iucnredlist.org/details/6290/0
http://armadillo-online.org/expansion.html

Guiding questions for predicting the future of this species at Tucker Prairie:

1. Does this species account lend evidence to support the ability to adapt to changing vegetation, soil moisture, and climate?
2. Are the habitat requirements for this species broad or specific?
3. What is your prediction for the success of this species at Tucker Prairie if climate change results in a gradual conversion of Tucker Prairie from native prairie to shrubs and eventually woodland?
4. What does this species eat? What other species eats the armadillo?
5. What cascading impacts might the introduction of this generalist species have on the ecosystem at Tucker prairie?
6. Why should we care about changes in the population of a mammal like the armadillo? Socially is this important or not? Why?

Instructor guide for climate change prediction:
Armadillo's are currently at TP in limited numbers. Harsh winters and the burning regime limits their population. If TP converts to a woodland and winters continue becoming milder due to climate change it can be expected that Armadillo numbers will increase at TP. Because they are generalists, they may cause a series of cascading impacts in the ecosystem.

Ecology Unit Final Project Teacher Notes

The nine organisms on the website range in difficulty, and it may be necessary to steer students in one direction or the other.

Organism	Difficulty	Overview
Monarch Butterfly	**	Loss of host milkweed due to habitat changes and human development. 5th instar migrates to Mexico, very isolated mountain habitat there susceptible to climate change
Mountain Pine Beetle	**	Increased temperature results in accelerated life cycles, rise in population, increased pine death
Burrowing Owl	*	Loss of habitat due to precipitation changes, and temp increase & development. Florida population showing some ability to adapt, western population more imperiled.
Greater Sage Grouse	*	Loss of habitat due to precipitation changes, and temp increase, increased fire, insect consumption of sage. Also habitat is key area for new energy developments - shale oil, etc
Plant disease	***	Increased temperatures result in selection for fungal varieties with increased germination, shorter latent periods, and that can infect previously resistant wheat isolates
Harp Seal	*	Increased temperature results in less ice for reproduction, pups die, population declines
Loggerhead Sea Turtle	*	Rising sea level impacting nesting areas. Increased temp also has potential to change gender selection for hatchlings. Also development of coastal areas.
Coral Reef Impacts	*	Rising water temperature and ocean acidification (pH change) causes stress (bleaching-loss of algae) and they can die
Blue Crabs	**	Increased temp reduces larvae survivability. Also rising sea level impacts breeding grounds.

*easy, **moderate, ***difficult

Each set of web links provided consists of credible sources and a Wikipedia link. Students can be encouraged to locate additional information through the reference sections of the credible links. Students should understand that the Wikipedia pages can include useful information but they can also be edited by anyone, so information from this source should be viewed skeptically or double-checked. It may be helpful to compare multiple Wikipedia pages to show the variability of information provided. For example, the wheat yellow rust page is minimal and has a warning at the top of the page that "the article has multiple issues" with a few references, while the coral reef Wikipedia page is very in depth, and provides a lot of information with 142 references. Even though the rust page is not a credible source, some of the references are credible, and can provide a starting point for more in depth research.

Monarch Butterfly
http://www.fs.fed.us/wildflowers/pollinators/Monarch_Butterfly/index.shtml
http://monarchwatch.org/biology/index.htm
http://www.learner.org/jnorth/monarch/index.html
http://www3.cec.org/islandora/en/item/2350-north-american-monarch-conservation-plan-en.pdf
http://animals.nationalgeographic.com/animals/bugs/monarch-butterfly/
http://monarchlab.org/
https://en.wikipedia.org/wiki/Monarch_butterfly

Mountain Pine Beetle & Pine trees
http://www.climate.org/topics/ecosystems/beetle-battle.html
http://www.nps.gov/romo/learn/nature/mtn_pine_beetle_background.htm
http://www.fs.fed.us/rmrs/docs/bark-beetle/faq.pdf
http://www.pc.gc.ca/eng/docs/v-g/dpp-mpb/sec2/dpp-mpb2c.aspx
http://www.pc.gc.ca/eng/docs/v-g/dpp-mpb/sec2.aspx

https://en.wikipedia.org/wiki/Mountain_pine_beetle

Blue Crabs
http://chesapeakebay.noaa.gov/fish-facts/blue-crab
https://sta.uwi.edu/fst/lifesciences/documents/Callinectes_sapidus.pdf
http://www.bioone.org/doi/full/10.1651/09-3241.1
http://www.vims.edu/research/topics/blue_crabs/index.php
http://www.chesapeakebay.net/fieldguide/critter/blue_crab
http://www.sms.si.edu/irlspec/callin_sapidu.htm
https://en.wikipedia.org/wiki/Callinectes_sapidus

Burrowing Owl
http://www.allaboutbirds.org/guide/Burrowing_Owl/lifehistory/ac
http://people.oregonstate.edu/~rosenbed/articles/Brochure.pdf
http://www.blm.gov/pgdata/etc/medialib/blm/wy/wildlife/animal-assessmnts.Par.52462.File.dat/WesternBurrowingOwl.pdf
http://outdoornebraska.ne.gov/wildlife/programs/legacy/pdfs/assessments/BurrowingOwl11202013.pdf
http://climate.audubon.org/birds/burowl/burrowing-owl
http://www.stateofthebirds.org/2014%20SotB_FINAL_low-res.pdf
http://www.stateofthebirds.org/2010/pdf_files/State%20of%20the%20Birds_FINAL.pdf
https://en.wikipedia.org/wiki/Burrowing_owl

Greater Sage Grouse
http://www.allaboutbirds.org/guide/Greater_Sage-Grouse/lifehistory
http://www.fws.gov/greatersagegrouse/
https://www.audubon.org/conservation/issues/greater-sage-grouse
http://climate.audubon.org/birds/saggro/greater-sage-grouse
http://www.stateofthebirds.org/2014%20SotB_FINAL_low-res.pdf
http://www.stateofthebirds.org/2010/pdf_files/State%20of%20the%20Birds_FINAL.pdf
https://en.wikipedia.org/wiki/Greater_sage-grouse

Plant
Plant disease Wheat Stripe Rust
http://www.ars.usda.gov/Main/docs.htm?docid=9918
https://extension.usu.edu/files/publications/factsheet/wheat-stripe-rust08.pdf
https://www.sciencenews.org/sites/default/files/13081
http://www.k-state.edu/pdecology/GarrettNita2009.pdf (p425-429, p434-435)
https://en.wikipedia.org/wiki/Wheat_yellow_rust

Harp Seal
http://www.nmfs.noaa.gov/pr/species/mammals/pinnipeds/harpseal.htm
http://animals.nationalgeographic.com/animals/mammals/harp-seal/
http://www.iucnredlist.org/details/41671/0
http://www.scientificamerican.com/article/climate-change-life-harder-baby-harp-seals/
https://en.wikipedia.org/wiki/Harp_seal

Loggerhead Sea Turtle
http://www.fws.gov/northflorida/seaturtles/turtle%20factsheets/loggerhead-sea-turtle.htm
http://www.nmfs.noaa.gov/pr/species/turtles/loggerhead.htm
http://www.conserveturtles.org/seaturtleinformation.php?page=climate_change

http://news.nationalgeographic.com/news/2014/03/140317-turtles-green-turtles-scattered-islands-europa-mayotte-glorieuses-longlining-bycatch-world/
http://seaturtlestatus.org/sites/swot/files/report/033111_SWOT6_p12-13_Climate%20Change.pdf
https://en.wikipedia.org/wiki/Loggerhead_sea_turtle

Coral Reef Impacts

http://www.bbc.com/news/science-environment-34473371
https://www.iucn.org/about/work/programmes/marine/marine_our_work/gmpp_coral_reefs/
http://www.defenders.org/coral-reef/basic-facts
http://www.pmel.noaa.gov/co2/story/What+is+Ocean+Acidification%3F
https://en.wikipedia.org/wiki/Coral_reef