BRADFORD ACADEMY

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Where excellence in education and character is the expectation.

Dear Students and Families,

Welcome to Earth and Space Science! I'm excited about the opportunity to get to know you, and I'm looking forward to an intriguing and productive school year. My name is Ms. Hatcher, and I grew up in a small town called Davison. I received my bachelor's degree and secondary education certification in 2005 from U of M. During that time I was principal bassoonist for the Flint Civic Orchestra, and traveled through India studying the education system. I received my masters in public administration for school administrators in August of 2011 from U of M.

Curriculum areas we will focus on this year include Geologic Time, The Rock Cycle, Hydrology, Oceanography, Climate, Weather, and Astronomy.

If you have any questions or concerns or if you would like to visit our classroom, schedule a conference, or volunteer to help out, you can contact me at nicolehatcher@choiceschools.com.

Once again, welcome to Earth Science. Let's work together to make this the best year ever!

Sincerely,

Ms. N. Hatcher

Lab 4 Climate Change? The Modern CO_2 Record

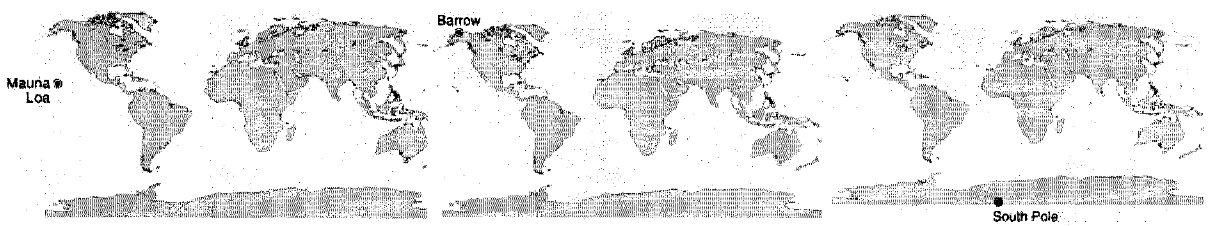
In this lab, we will focus on the levels of atmospheric carbon dioxide (CO_2) that scientists have measured at permanent observatories at Mauna Loa (Hawai'i), Barrow (Alaska), and the South Pole. We will use these data to investigate

(1) processes that might control variations in atmospheric CO_2 levels during the year, and
(2) processes that might explain the long-term trend in atmospheric CO_2 levels.

We will also briefly at another greenhouse gas that may contribute to climate change.

In 1958, scientists (notably Professor Charles Keeling) began to use high-precision equipment (e.g., infrared analyzers) to measure the abundance of atmospheric CO_2 at selected sites around the globe. Among the initial sites were Mauna Loa, a 13,000-foot mountain on Hawai'i, and a station just a few miles from the South Pole. Measurements were begun at later times at other stations (e.g., 1973 for Barrow).

1. Familiarize yourself with the locations of these three measuring stations:



Mauna Loa, Hawaii, U.S.A.
Barren lava field of an active volcano
19°32' N, 155°35' W, 3397 m above MSL

Barrow, Alaska, U.S.A.
On the coast of the Arctic Ocean
71°19' N, 156°36' W, 11 m above MSL

South Pole, Antarctica
Ice- and snow-covered plateau
89°59' S, 24°48' W
2810 m above MSL

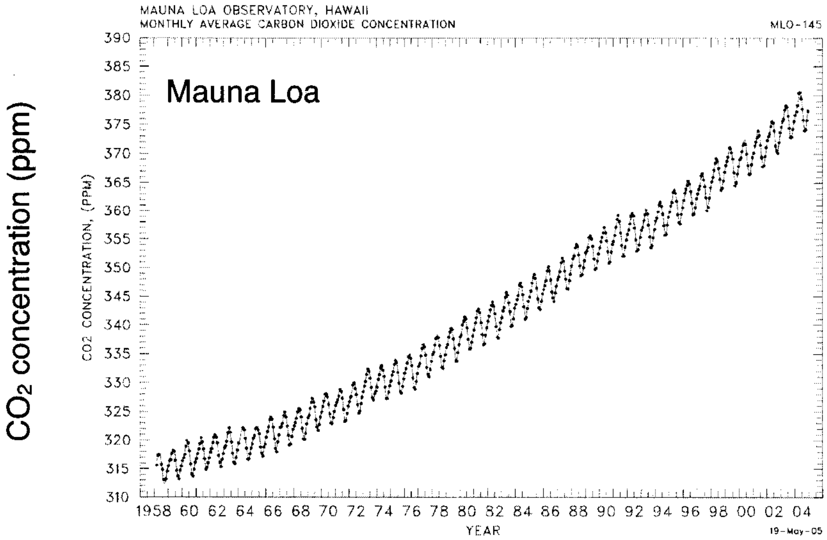
2. Examine the three graphs on p. 2. The curve on each graph connects monthly measurements, though it's difficult or impossible to see the points for individual months at this scale.

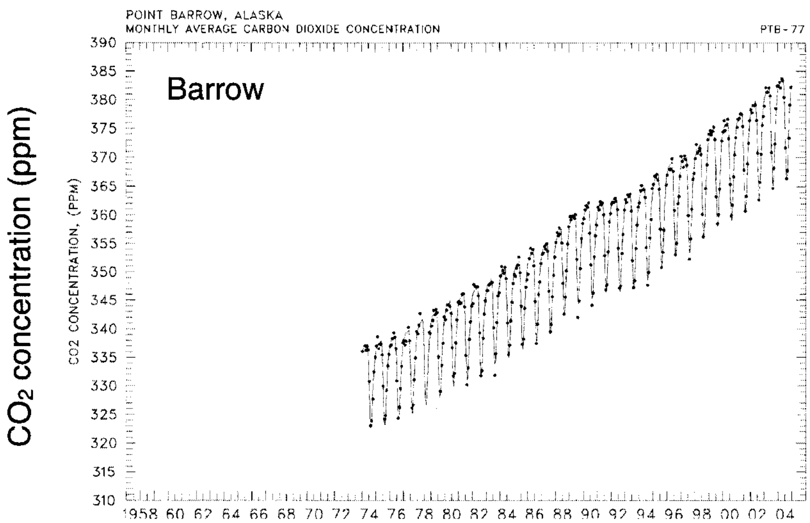
A. What is the variable being measured? ______________________________

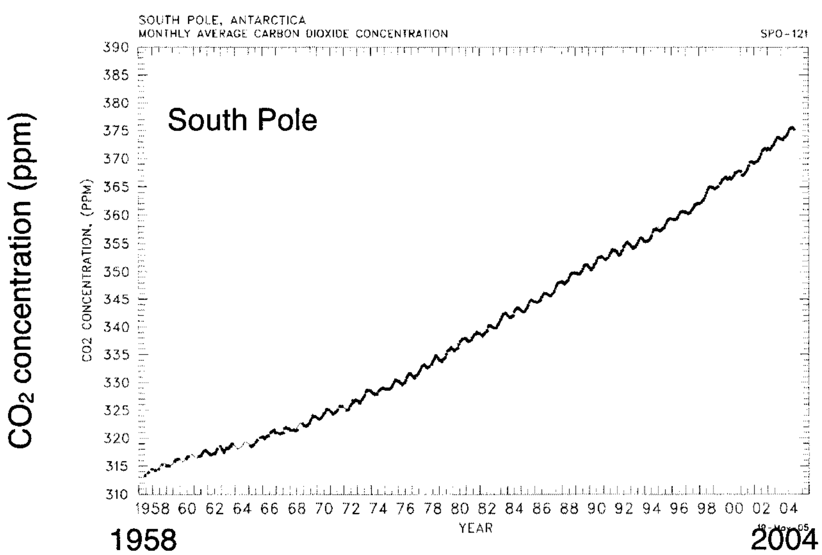
B. What units are used to express this variable? ________

C. How is this unit related to percentage (%) ?

3. Although none of the graphs shows a perfectly smooth curve, all of them show the same long-term pattern. Describe this pattern in 1-2 sentences.


MAUNA LOA OBSERVATORY, HAWAII
MONTHLY AVERAGE CARBON DIOXIDE CONCENTRATION
MLO-145
Mauna Loa
CO2 concentration (ppm)
CO2 CONCENTRATION, (PPM)
390 385 380 375 370 365 360 355 350 345 340 335 330 325 320 315 310
1958 60 62 64 66 68 70 72 74 76 78 80 82 84 86 88 90 92 94 96 98 00 02 04
YEAR
19-May-05


POINT BARROW, ALASKA
MONTHLY AVERAGE CARBON DIOXIDE CONCENTRATION
PTB-77
Barrow
CO2 concentration (ppm)
CO2 CONCENTRATION, (PPM)
390 385 380 375 370 365 360 355 350 345 340 335 330 325 320 315 310
1958 60 62 64 66 68 70 72 74 76 78 80 82 84 86 88 90 92 94 96 98 00 02 04


SOUTH POLE, ANTARCTICA
MONTHLY AVERAGE CARBON DIOXIDE CONCENTRATION
SPO-121
South Pole
CO2 concentration (ppm)
CO2 CONCENTRATION, (PPM)
390 385 380 375 370 365 360 355 350 345 340 335 330 325 320 315 310
1958 60 62 64 66 68 70 72 74 76 78 80 82 84 86 88 90 92 94 96 98 00 02 04
YEAR
1958
2004

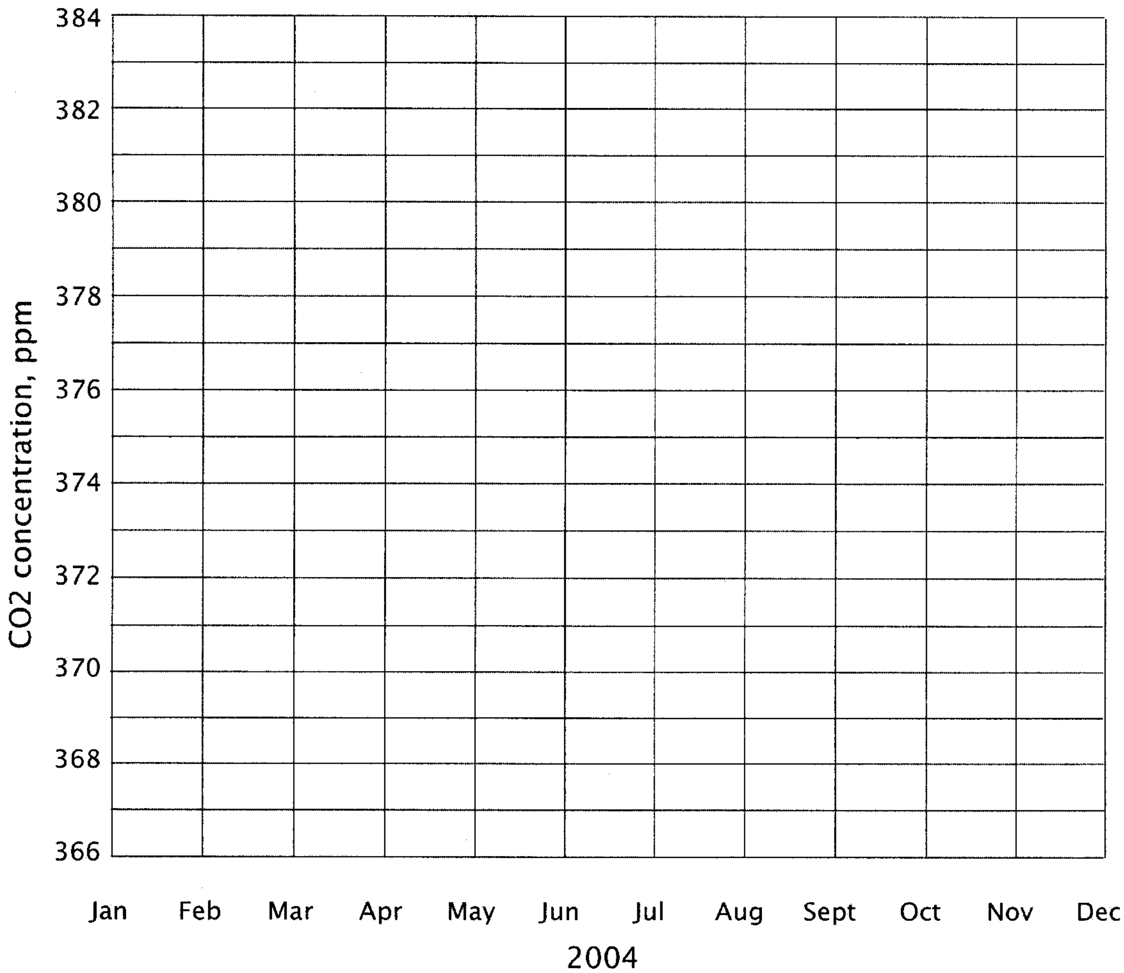
4. The numbers below show the monthly (numbered 1 through 12) readings for 2003 and 2004 at each station. The last column is the annual average.

MLoa	1	2	3	4	5	6	7	8	9	10	11	12	avg
2003	374.7	375.6	376.1	377.6	378.4	378.1	376.6	374.5	373.0	373.0	374.4	375.7	375.6
2004	**376.8**	**377.4**	**378.4**	**380.5**	**380.6**	**379.6**	**377.8**	**375.9**	**374.1**	**374.2**	**375.9**	**377.5**	**377.4**

Barrow	1	2	3	4	5	6	7	8	9	10	11	12	avg
2003	379.0	382.3	381.4	381.4	382.2	380.8	371.0	364.7	368.3	372.5	378.6	382.5	377.0
2004	**382.6**	**383.2**	**382.2**	**383.8**	**383.5**	**380.5**	**371.8**	**366.5**	**367.9**	**373.5**	**379.2**	**382.3**	**378.1**

S Pole	1	2	3	4	5	6	7	8	9	10	11	12	avg
2003	371.9	371.8	371.7	372.0	372.3	372.6	373.0	373.4	373.9	373.8	373.6	373.6	372.8
2004	**373.6**	**373.4**	**373.8**	**373.9**	**374.1**	**374.5**	**374.8**	**375.4**	**375.5**	**375.6**	**375.5**	**375.2**	**374.6**

Plot the **2004 results** from all three stations on the same graph below. Connect the points for each site with a smooth curve, and label each curve with the site name.



Each of the three curves should clearly show a cycle known as a short-period oscillation. You'd have gotten nearly identical curves if you'd graphed the 2003 data instead, because the curves have 12-month periods (i.e., 12 months from peak to peak or from trough to trough).

Our goal is to determine the cause of these short-period oscillations. Let's analyze some aspects of these three curves.

5. First, in what **month** are the maximum and minimum values recorded at each station?

	Maximum (month)	Minimum (month)
Mauna Loa		
Barrow		
South Pole		

6. What is the amplitude of the oscillation? In other words, what is the difference (in ppm CO_2) of the maximum and minimum value at each station?

Mauna Loa: _______ ppm Barrow: _______ ppm South Pole: _______ ppm

7. Interpret your results (in terms of the geographic locations of the three sites) to answer the following questions.

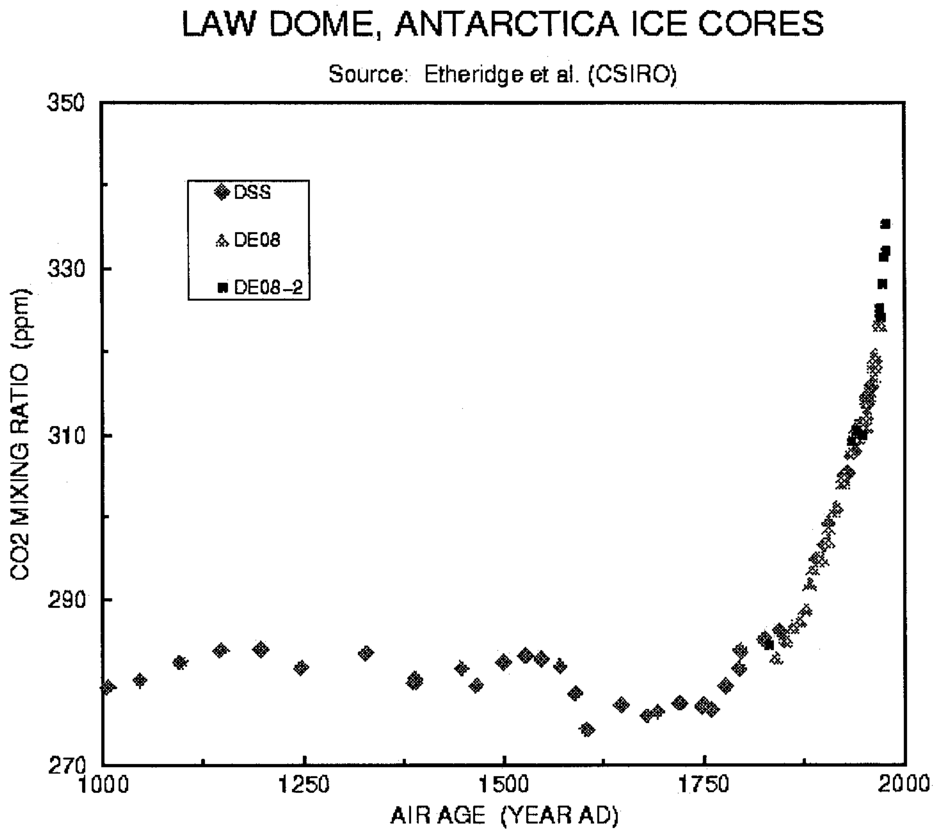
A. Why do the oscillations occur?

B. Why do the oscillations peak when they do?

C. Why is the amplitude of the South Pole station so much smaller than that of the other two?

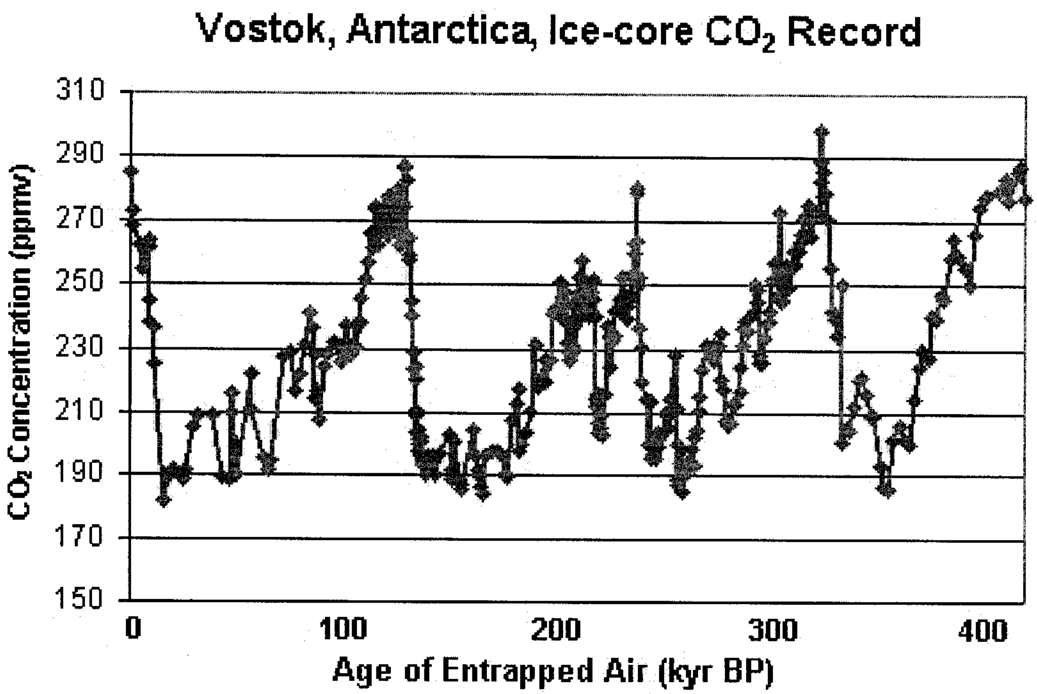
Now let's look farther back in time at atmospheric CO_2 levels. Though precise measurements only began in 1958, scientists have been able to sample "fossil air" from the early 1900s and even the 1800s in tightly sealed bottles of wine of known vintage, and in old brass buttons with sealed air gaps.

They have also been able to sample and date fossil air in ice layers. The Law Dome ice cores in Antarctica sampled ice over a thousand years old (below).



The cores from Law Dome show that the amount of CO_2 in the atmosphere was fairly constant from 1000 A.D. until about 1850, when it began to increase rapidly. Most atmospheric scientists attribute the increase to the emissions of CO_2 from the burning of fossil fuels, which accelerated dramatically in the Industrial Revolution of the mid-1800s. However, others have suggested that the increase is a natural phenomenon—one of Earth's natural cycles that simply coincides with the increased burning of fossil fuels.

In 1998, scientists drilled a 2-mile-deep ice core at Vostok, Antarctica that gives us the CO_2 record over the last 400,000 years. [Note: 400 kyr = 400,000 yr; BP = before present.]



The troughs on this graph correspond to Ice Ages, and the peaks correspond to the warmer interglacial periods.

8. What was the highest concentration of atmospheric CO_2 during any of these interglacial periods? ______ ppm

9. Using the top diagram on p. 2, estimate the current average concentration of atmospheric CO_2 (use Mauna Loa): ______ ppm

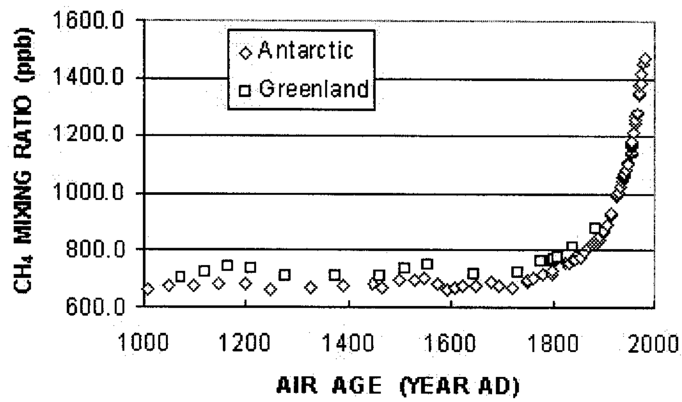
10. On the graph above, place a dot representing the modern CO2 value you estimated in #9 at age = 0. The dot will lie above the graph. Connect this dot to the rest of the curve.

11. Over the last 30 years, the rate of increase of CO_2 at Mauna Loa has been ~1.5 ppm/year. If this rate continues, what will the level of CO_2 be in 2030? _____ ppm in 2050? _____ ppm

12. Compare the *rate* of CO_2 increase in the last few hundred years with the rate of increase (or decrease, for that matter) in the preceding 400,000 years.

Methane (CH_4) is another effective greenhouse gas; in fact, it's about 23 times more effective at trapping heat than CO_2 is. Fortunately, it's much less abundant in the atmosphere (measured in parts per billion instead of parts per million).

Unfortunately, atmospheric CH_4 has increased by 250% since the late 1700s (results from polar ice cores):



Methane forms when organic matter decays—which has been going on for billions of years. We need to understand why it has increased so much in the last few centuries.

Scientists estimate that 3/4 of all methane currently emitted into the atmosphere comes from human activities. Chief culprits are (1) decomposing landfills, (2) the processing of oil and gas, (3) "enteric fermentation, mainly cattle," and (4) agricultural activities like growing rice.

13. The CH_4 curve shows a dramatic upswing at 1800 A.D. Applying what you know about human history, discuss whether each of the four sources listed above is likely to have increased in the last 200 years. In other words, evaluate the proposal that the increase in CH_4 is due to human activities. Identify specific trends, activities, etc. that support your ideas.

Week 4 Web Assignment: Changes in Patterns of Land Use

Background
At least two broad categories of human activities are probably altering global climate:
(1) accelerated emissions of greenhouse gases like carbon dioxide and methane, and
(2) land-use changes like urban sprawl, deforestation, reforestation, and agriculture.

Many interrelated factors are influenced by land-use patterns. These include
* how much of the Sun's radiation is absorbed or reflected
* the level of transpiration (release of water) by plants
* the level of evaporation of water from soil
* the surface and air temperature
* the amount of water vapor in the atmosphere

These and other factors are so complexly interrelated that we currently can't explain or predict the short-term and long-term effects of a particular land-use change. Almost all researchers, though, have concluded that the scale of the effects due to land-use changes is similar to that due to human-produced greenhouse gas emissions.

The Maps
In this Web-based component of Lab 4, you'll analyze a set of world maps that show land-use patterns at different times in the last 300 years or so. The maps come from a recent NASA study that used land surveys, census data, tax records, and (for the late 1900s) satellite imagery to track changes in the Earth's land surface around the globe.

URLs for the eight maps are written out below, but you'll save time if you link to them via the course Web site (http://geosun.sjsu.edu/~sedlock/4L/4L.html). If you have enough screen space, try opening two or more of these files in separate windows, which will enable you to compare them more easily. Viewing the maps with two or more tabs may be effective, also.

Land use in 1700: http://geosun.sjsu.edu/~sedlock/4L/4L.html/landuse1700.jpg
Land use in 1750: http://geosun.sjsu.edu/~sedlock/4L/4L.html/landuse1750.jpg
Land use in 1800: http://geosun.sjsu.edu/~sedlock/4L/4L.html/landuse1800.jpg
Land use in 1850: http://geosun.sjsu.edu/~sedlock/4L/4L.html/landuse1850.jpg
Land use in 1900: http://geosun.sjsu.edu/~sedlock/4L/4L.html/landuse1900.jpg
Land use in 1950: http://geosun.sjsu.edu/~sedlock/4L/4L.html/landuse1950.jpg
Land use in 1970: http://geosun.sjsu.edu/~sedlock/4L/4L.html/landuse1970.jpg
Land use in 1990: http://geosun.sjsu.edu/~sedlock/4L/4L.html/landuse1990.jpg

You can also view these maps here http://www.ngdc.noaa.gov/paleo/ctl/landuse.html) as an animation; however, the animation loops continuously and can't be paused.

Questions

1. Cropland obviously expanded dramatically since 1700. What land-use types did it replace?

2a. What other land-use type has expanded greatly since 1700? ____________________

2b. What land-use types did it replace?

3. What driving force do these two "big winners" have in common?

4a. Name three types of land surface (not including ice!) that have experienced very little change since 1700.

4b. Why do you think they have changed so little?

The area of "hot desert" decreases over time, especially in the 1900s (see Australia and Arabia).

5a. What land-use type most commonly "replaces" it? ____________________

5b. How did this happen?

6a. Why does the North American map have a north-south line in the mid-continent in 1700?

6b. How did this line affect later land-use changes?

ACT Practice + Answers

Abandoned cornfields have been the sites of investigations concerning ecological succession, the orderly progression of changes in the plant and/or animal life of an area over time (see Figure 1).

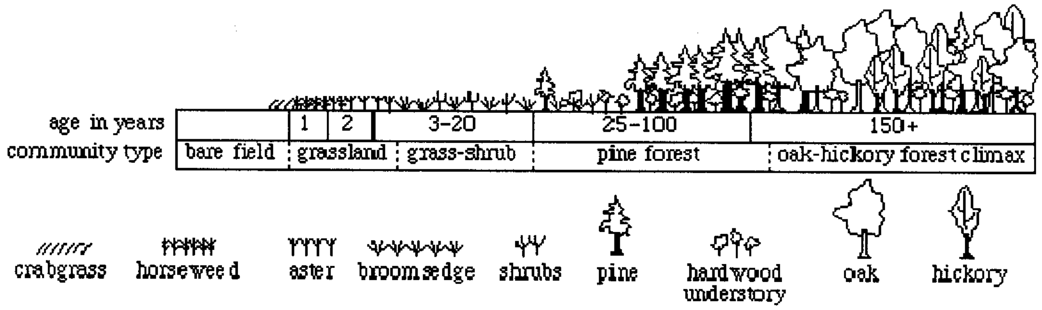


Figure 1

During the early stages of succession, the principal community (living unit) that dominates is the pioneer community. Pioneer plants are depicted in Figure 2.

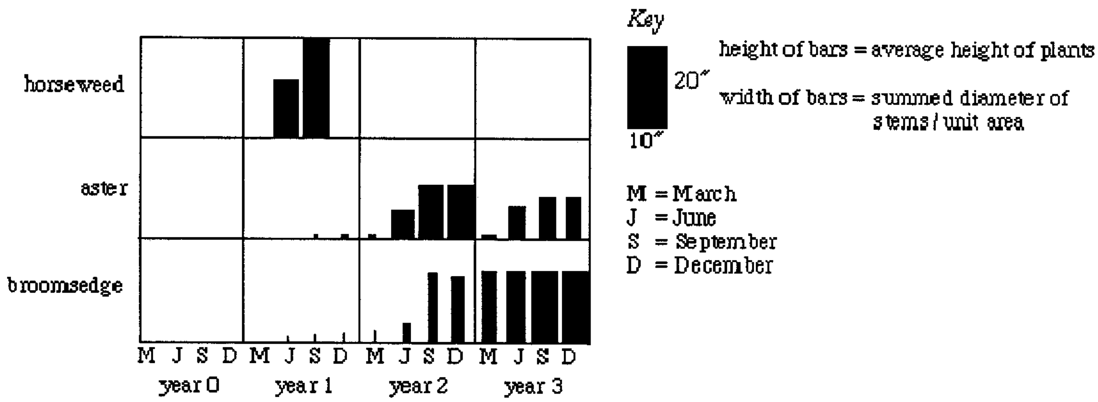


Figure 2

The final stage of ecological succession is characterized by the presence of the climax community, the oak-hickory forest. Figure 3 depicts the gradual change from pine to hardwoods.

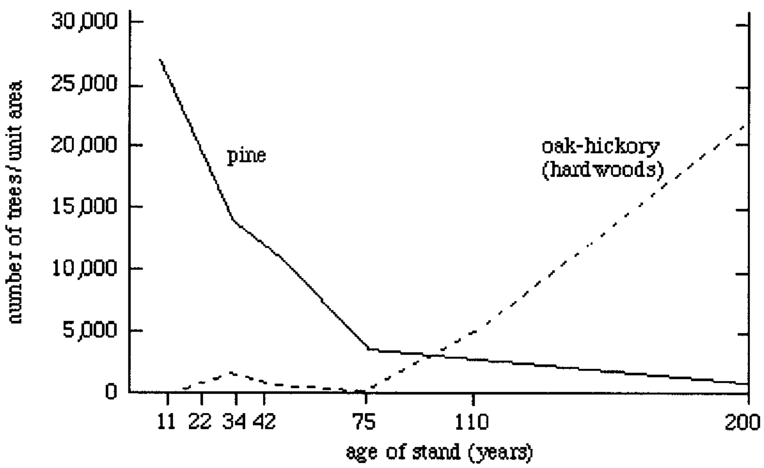


Figure 3

Following are some act sample questions on the above passage:

1. **On the basis of the data presented in Figure 1, approximately 80 years after the abandonment of cropland, the land would contain:**

A. pine seedlings only.
B. oak-hickory hardwood forests only.
C. early invading species like horseweed, aster, and broomsedge.
D. large pine trees with an understory of hardwood trees.

Answer: D

2. **According to the information in Figure 3, a 150-year-old climax community would contain oak and hickory trees with a density of approximately:**
   A. 3,000 trees per unit area.
   B. 5,000 trees per unit area.
   C. 15,000 trees per unit area.
   D. 20,000 trees per unit area.

   Answer: C

3. **On the basis of the data depicting the gradual change from pine forest to an oak-hickory forest, after 100 years, as the density of the pine trees:**
   A. increases, the density of the oak-hickory trees increases.
   B. increases, the density of the oak-hickory trees decreases.
   C. decreases, the density of the oak-hickory trees increases.
   D. decreases, the density of the oak-hickory trees decreases.

   Answer: C

4. **Given the information in Figure 1, which of the following conclusions concerning ecological succession in an abandoned cornfield is most correct?**
   A. Succession in an abandoned cornfield begins on bare rock.
   B. Succession is characterized by the replacement of one plant community by another until a climax community has been achieved.
   C. The height of the plants in the communities decreases as succession progresses to the climax stage.
   D. The plant species change continuously during succession, but the change is more rapid in the later stages than in the earlier stages.

   Answer: B

5. **According to Figure 2, pioneer plant(s) showing a progressive increase in summed diameter of stems per unit area over the course of several years of succession is(are):**
   A. horseweed only.
   B. broomsedge only.
   C. aster and broomsedge only.
   D. horseweed, aster, and broomsedge.

   Answer: B

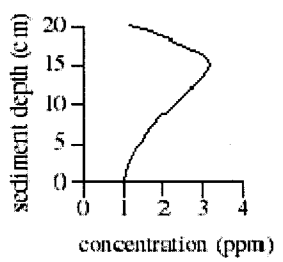
Depth(cm)	Temperature(C)	pH	Concentration in sediment (ppm)					
			SO_4^{2-}	S^{2-}	CO_2	Fe^{3+}	Fe^{2+}	O_2
0	4	7.0	7.0	0.0	1.0	4.0	0.5	2.0
5	5	6.5	5.0	2.0	1.5	3.0	1.5	1.0
10	7	6.0	3.5	3.5	2.0	2.0	2.0	0.0
15	9	5.5	3.3	3.8	3.0	0.8	3.8	0.0
20	10	5.0	3.0	4.0	1.0	0.5	4.0	0.0

Following are some act sample questions on the above passage:

6. **According to the information provided in the table, the concentration of which of the following ions and dissolved gases is constant for sediment depths of 10 cm or more?**
   A. Sulfide (S^{2-})
   B. Carbon dioxide (CO_2)
   C. Ferric iron (Fe^{3+})
   D. Oxygen (O_2)

   Answer: D

7. **The graph below best represents the relationship between concentration and sediment depth for which of the following ions and dissolved gases?**



   A. Ferrous iron (Fe^{2+})
   B. Oxygen (O_2)
   C. Carbon dioxide (CO_2)
   D. Sulfate (SO_4^{2-})

   Answer: C

8. **If the trends indicated in the table were to continue, one would predict the pH of the sediments at a depth of 35 cm to be:**
   A. 1.5.
   B. 3.5.
   C. 4.5.
   D. 6.0.

   Answer: B

9. **A certain type of bottom-dwelling microorganism thrives under the following environmental conditions: low concentrations of Fe^{2+}, high concentrations of O_2, and a neutral pH. Based on the table, at which of the following sediment depths would one most likely find this microorganism?**
    A. 0 cm
    B. 5 cm
    C. 10 cm
    D. 15 cm

Answer: A

10. **A researcher wants to determine whether an unidentified sediment sample was drawn from a depth of 15 cm or 20 cm. Based on the information in the table, which of the following would NOT confirm the depth of the sample?**
    A. O_2 concentration
    B. Fe^{3+} concentration
    C. S^{2-} concentration
    D. pH

Answer: A