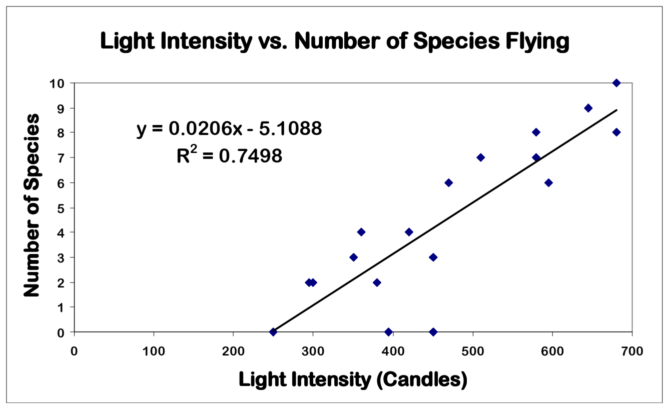
Homework 2 (chapters 3-6):

1. In 1995-1996, John Goold, a senior at Marietta College, set out to determine the diel periodicity of dragonfly activity. At a selected site in Washington County, Ohio, he observed the number of dragonfly species active under varying light and temperature conditions at various times of the day. Among his findings were the data in the table below. Take the data, and plot separate scattergrams for temperature vs. number of species flying and light intensity vs. number of species flying. Insert trendlines (and their equations) on the graphs. Answer the following questions:

A. Which variable shows a stronger correlation with the number of species flying?
B. How do you know this?
C. Does correlation always imply causation? What about in this case?

Data from Goold, 1996, and a sample graph showing what I am looking for in question 1.

Temp (C)	Light int. (Footcandles)	# Species
13	380	2
14	420	4
17	470	6
18	350	3
19	300	2
21	360	4
23	295	2
23	580	7
23	595	6
24	450	3
24	580	8
28	680	10
29	680	8
31	510	7
31	645	9



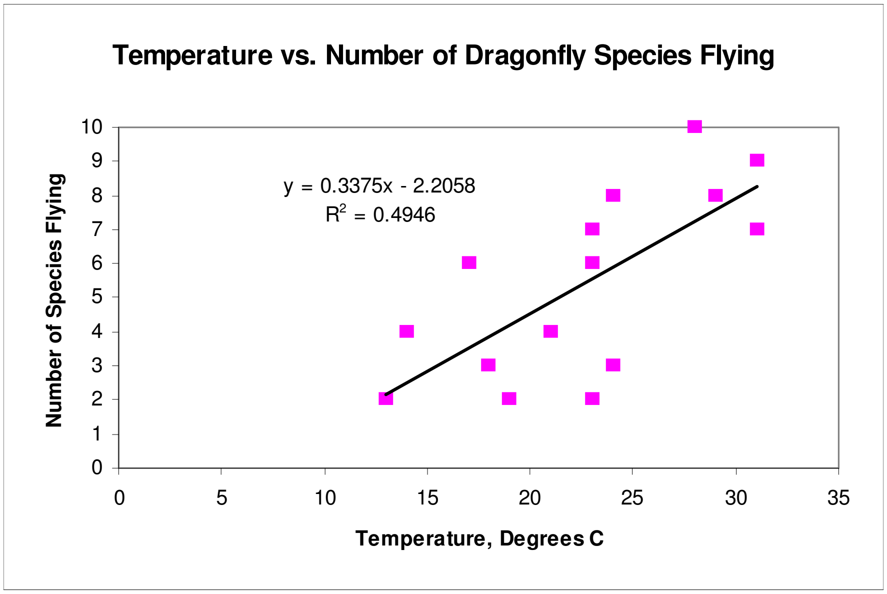


Figure 1 - Temperature vs. Number of Dragonfly Species Flying.

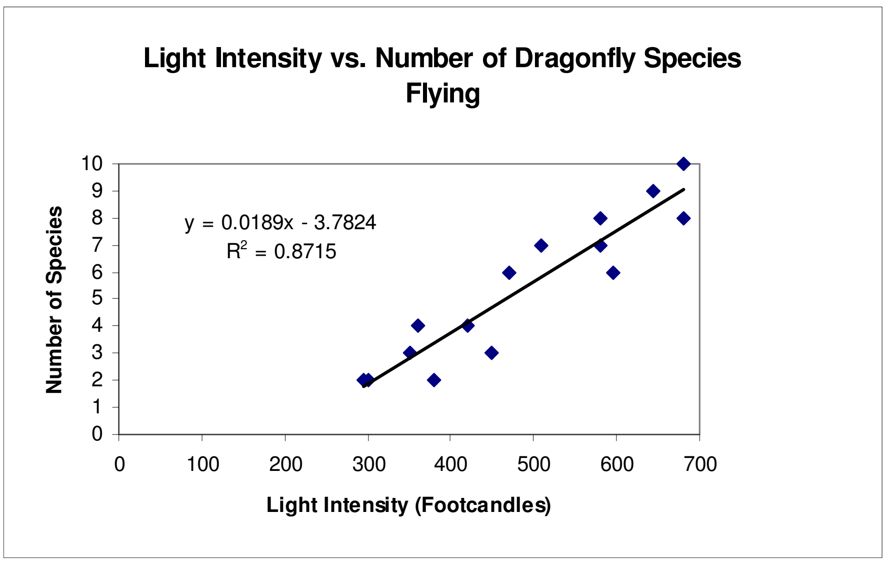


Figure 2 - Light Intensity vs. Number of Dragonfly Species Flying.

A. Which variable shows a stronger correlation with the number of species flying?

The light intensity.

B. How do you know this?

Technically speaking[i], correlation is determined by r, not r^2. In this case, for temperature, r is 0.682, and for light intensity, r is 0.934. Correlation is a measure of how well knowledge of the independent data (x) allows one to predict a value for the dependent data (y). Another way of saying this is that correlation measures the strength of the linear relationship between the two variables, in this case between light (or temperature) and the number of species flying. Values for r can range from -1 to +1; the closer the value is to 1 (or -1), the stronger the relationship. A negative value would mean that the dependent variable (number of species) decreases with an increase in the independent variable (light). In this case, an r-value of 0.934 for light intensity and number of species implies a strong linear relationship between the two. The r^2 values measures what proportion of the change in the dependent variables is due to the linear relationship (the rest is due to chance). Again, a higher value means that the x data are more useful in explaining the y data.

C. Does correlation always imply causation? What about in this case?

No. Correlation simply implies a linear relationship; it does not mean that the dependent data are affected in any way by the independent data. For instance, if you plotted your shoe size against your vocabulary, you would probably find that when your shoe size was smaller, you had a smaller vocabulary, and when your shoe size was larger, you knew more words. This does not mean that having your feet grow increases your vocabulary; in this case one might argue that both vocabulary and shoe size are values that increase together as natural outcomes of growth and development.

In the dragonfly example, one might make a strong case for causation by pointing out that dragonflies are heliothermic, so that it makes sense that more of them would be out flying at higher light intensities, when they are warmer, and hence more active. You would still have to prove that higher body temperatures are tied to higher activity, and that higher body temperatures can be attributed to higher light levels. It all makes sense, but this simple study does not prove the case by any means.

To brush up on statistics, you might also try:

http://www.anu.edu.au/nceph/surfstat/surfstat-home/surfstat.html

2. List the habitats where animals would excrete urea, uric acid, and ammonia. For each of the three molecules, list at least 3 taxonomic groups that utilize them.

Urea would be excreted in moderately dry terrestrial environments:
Mammalia, Chondrichthyes, Amphibia (some)

Uric acid would be excreted in very dry terrestrial environments.
Reptilia, Aves, Insecta

Ammonia would be excreted in aquatic environments.
Osteichthyes, Mollusca, Crustacea

Please note that there is no absolute correlation between habitat and the form of nitrogen excretion. The kangaroo rat and the sidewinder share the same, dry desert habitat, yet the mammal excretes urea and the snake uric acid. Likewise, a porpoise, a sea turtle, and a sea bass all swim in the same ocean, yet each has a different excretory molecule. Evolutionary history seems to play at least as important a role as physiology in determining which excretory molecule will be used by a given species. In terms of evolutionary history, perhaps the best way to think is to remember that most organisms started off in the water excreting ammonia. Some moved onto land, and those with shelled eggs soon switched to using uric acid for excretion, whereas mammals and a few other groups (often with internal embryonic development) used urea.

3. How does the kangaroo rat minimize water loss for cooling (be complete)? Where does a kangaroo rat get its water?

Kangaroo rats avoid wasting water on cooling by spending the hot part of the day inside a cool, humid burrow. Under the cool conditions water loss is not needed to cool the body, and the relatively high humidity reduces water loss from respiration. Anatomical adaptations help to condense water before it leaves the body. The kangaroo rat *obtains* its water from the metabolic breakdown of sugars to CO_2 and water.

4. Distinguish between C_3 and C_4 photosynthesis.

I went to Mader (Biology, 5th edition, 1996, Wm. C. Brown Publishers) to get this answer. C_3 photosynthesis is explained on pages 126-129; the differences in C_4 photosynthesis are mentioned on pages 130-131. In C_3 plants, CO_2 is added to RuBP (ribulose biphosphate) through the action of the enzyme rubisco to form 2 molecules of PGA (phosphoglyceraldehyde). In C_4 plants, CO_2 is added to PEP (phosphoenolpyruvate) through the action of the enzyme pepcase to form oxaloacetate. The oxaloacetate is moved from the mesophyll cell in which it is formed into an adjacent bundle sheath cell where the CO_2 is released to the Calvin cycle. The C_4 cycle is advantageous to plants living in hot, dry conditions; under these conditions the stomata are kept closed and CO_2 levels drop in the mesophyll cells while O_2 levels rise. Under these conditions, O_2 competes with CO_2 for the active site on the rubisco in the C_3 plants. This does not happen in the C_4 plants because the Calvin cycle proceeds in the bundle sheath cells which have ample CO_2 delivered to them from the mesophyll cells. Also, the bundle sheath cells do not have the light reactions taking place and releasing O_2 inside the cell to bind to the rubisco.

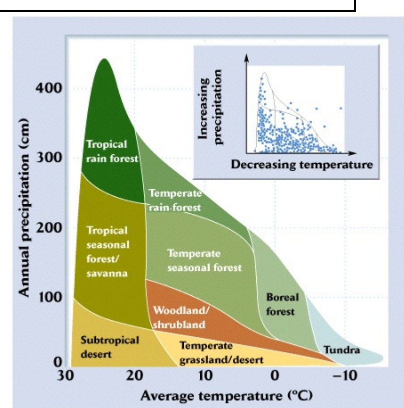
5. Why would terrestrial organisms be less likely to show temperature compensation in enzymes than aquatic organisms?

Overall, organisms have several ways to regulate temperature. Behavioral responses are the fastest; evolutionary responses are the slowest. Production of enzymes with specific optimal temperatures falls between. It takes time for an organism to manufacture a matched set of alternate forms of an enzyme. Terrestrial systems have temperature changes that can be quite rapid. Aquatic systems, because of the thermal inertia present in the water, are slower to change temperature. Often, daily temperature does not change more than 1^{O} C each day. Under these conditions of slow, predictable, change, it is possible for aquatic organisms to produce enzymes with specific optimal temperatures. Terrestrial organisms often do not have this luxury because in many habitats the temperature changes faster than the organisms can produce new enzymes.

6. What type of biome will develop under these conditions?

Annual Precipitation (mm)	Average Temperature (^{0}F)	Vegetation Type
1100 (110)	60 (15.5)	Woodland Grassland, Shrubland, (temperate forest)
2250 (225)	77 (25)	Tropical Seasonal Forest
1000 (100)	32 (0)	Taiga
1000 (100)	50 (10)	Temperate Forest
500 (50)	41 (5)	Woodland, Grassland, Shrubland
3500 (350)	70 (21.1)	Tropical Rain Forest
750 (75)	68 (20)	Thorn Forest, Savanna, Thorn Scrub

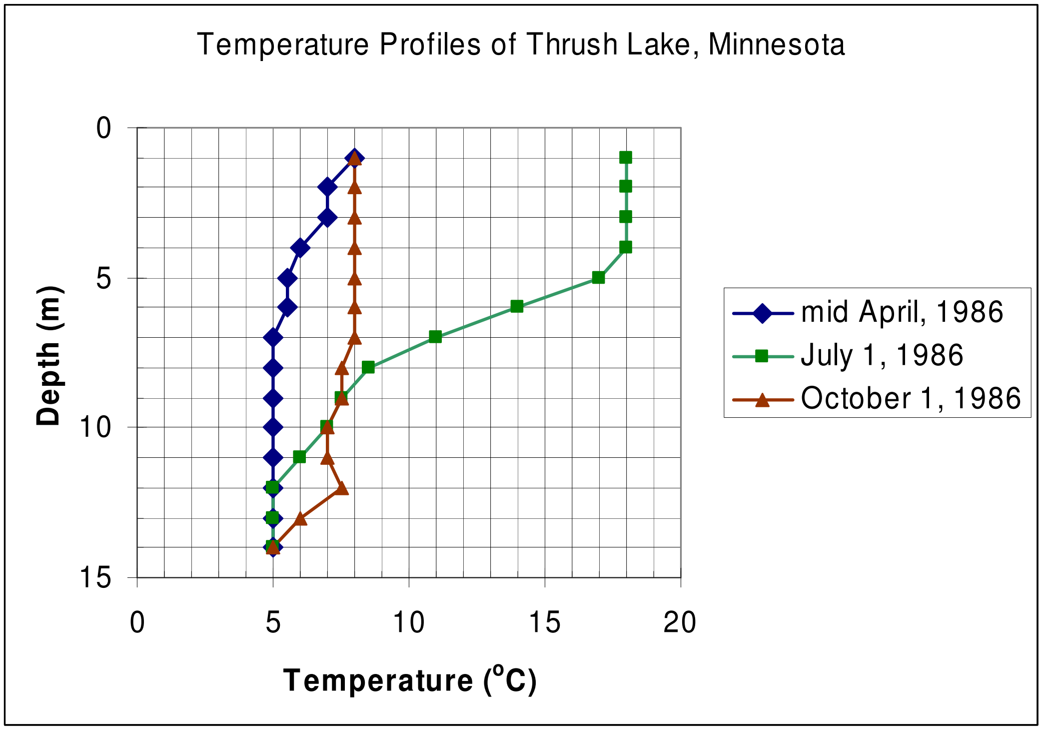
The values above were calculated by interpolating the values onto Whittaker's classification system as represented by Figure 5.9 on page 105 of the text (reproduced below). To use the table, you must first convert mm in the table above to cm, and degrees F to degrees C. I have put these converted values in parentheses in the table above. For the first set of climatic conditions, I would accept Woodland, Grassland and Shrubland, or Temperate Forest.



7. Find this article on J-Stor:

Stefan, Heinz G., et al. "Simulation of dissolved oxygen profiles in a transparent, dimictic lake", *Limnology and Oceanography*. v. 40 issue 1, 1995, p. 105-118.

From figure 2, plot the temperature profile of the lake in mid-April, July 1, and October 1. Put the depth on the y-axis and the temperature on the x-axis as in Figure 8.13 in your textbook.



8. Why would a shallow, temperate-climate pond be more likely to become anoxic in late summer as opposed to early summer?

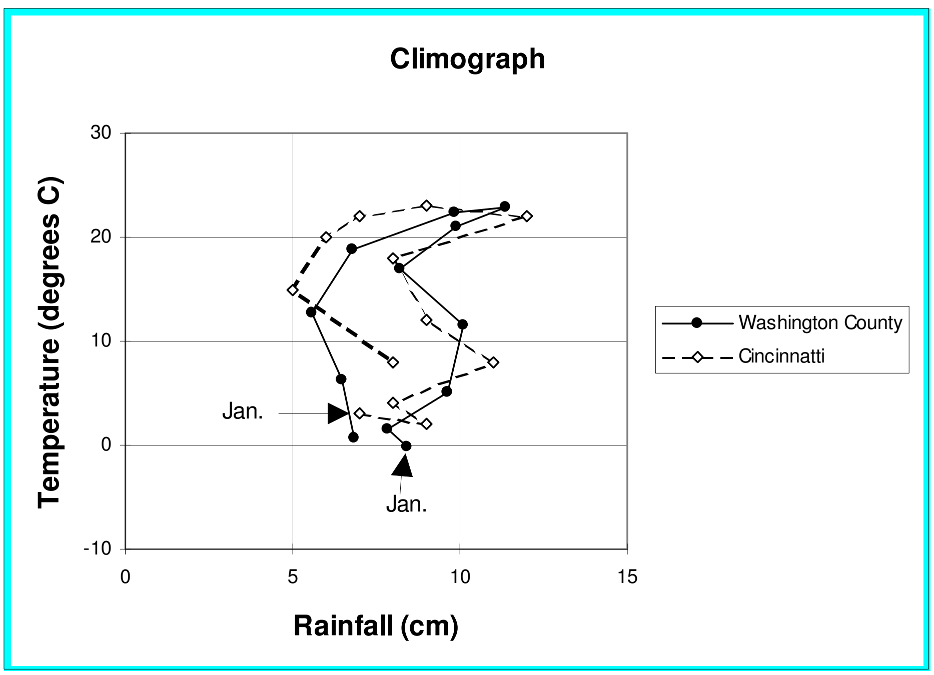
Because the pond is shallow, there is no thermocline, so we can discount that. Late in the summer, several things would be at their maximum including biomass, detritus, and temperature. Earlier there might be a lot of detritus, but it is the growth over the summer that will cause biomass and detritus mass to peak, and of course temperature goes up as well. Warm water holds less oxygen than cooler water, so there will be less oxygen present in warm, late summer water. Also, warm water will increase respiration, and hence the demand for oxygen. All of these conspire to drop oxygen levels, especially at night when there is no photosynthesis. Even here, late summer ponds are at a disadvantage as the days are shorter than they are early in the summer and thus there is less time for photosynthesis and more time that the plants are respiring.

9. Find (or calculate) the average annual temperature and precipitation for Washington County, Ohio. According to this data, which biome should develop here according to Figure 5.9 in Ricklefs? Attach a copy of your data.

First, some monthly data for Washington County:

	Precipitation		Tmax	Tmin	Tavg.	Celsius
	inches	cm				
January	3.32	8.4328	40.9	22.7	31.8	-0.11111
February	3.08	7.8232	44.8	24.5	34.65	1.472222
March	3.79	9.6266	52.3	30.2	41.25	5.138889
April	3.97	10.0838	65.1	40.2	52.65	11.47222
May	3.24	8.2296	75.4	49.7	62.55	16.97222
June	3.89	9.8806	81.6	58.1	69.85	21.02778
July	4.48	11.3792	84.3	62.2	73.25	22.91667
August	3.87	9.8298	83.3	61	72.15	22.30556
September	2.67	6.7818	78.1	53.8	65.95	18.86111
October	2.19	5.5626	67.7	42	54.85	12.69444
November	2.55	6.477	54.1	32.4	43.25	6.25
December	2.69	6.8326	42.4	24.3	33.35	0.75
	39.74	100.9396	64.16667	41.75833	52.9625	11.64583

Note that I had to convert to metric values before proceeding.



In the climograph, I have also plotted data for Cincinnati; this serves as a sort of check. In order to get data to plot, I had to average the data from the soil survey. I plotted the average of the average daily maximum and minimum temperatures for each month. I wasn't sure if this would be very accurate, but the climograph is remarkably close to that of Cincinnati, so I'm probably in the ballpark with this. I obtained the Cincinnati data by examining Figure 4.16 on page 78 of Ricklefs' (1993 edition); note that his graph has several of the months mislabeled.

Now, all of this to this point doesn't answer the question. A climograph could be used to help predict the biome, but to use Whittaker's classification, all you need are the total rainfall and the average temperature. The bottom row of the spreadsheet has these numbers:

Precipitation inches	cm	Tmax	Tmin	Tavg.	Celsius
39.74	100.9396	64.16667	41.75833	52.9625	11.64583

If the average annual precipitation is 100 cm, and the average annual temperature is 12 degrees Celsius, then the biome that should develop here is temperate forest, although we are very close to the woodland/grassland/shrubland complex.

As for a copy of the data, I got it from the hard copy of the soil survey; you could also locate it at:

ftp://ftp.wcc.nrcs.usda.gov/support/climate/wetlands/oh/39167.txt

10. Examine the article at:

http://www.pnas.org/cgi/content/full/97/4/1630

A. Examine figures 1-6. For each, tell me how strong you think the correlation is, and on what basis.

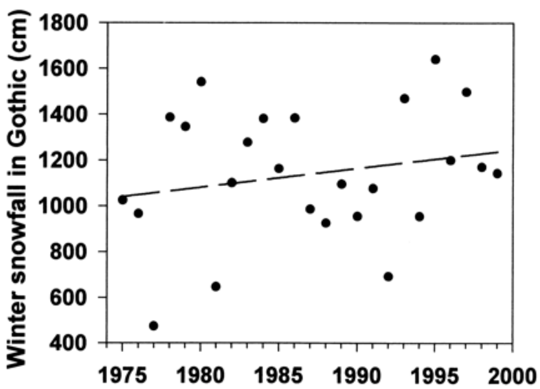


Figure 1. There are 2 arguments for stating that this is not a strong correlation. The equation for the trendline: Y = 8.225X 15,202.031, r^2 = 0.045, P = 0.311 has an r of 0.21; this is far from the value of 1 that would show a perfect correlation. In addition, the authors state the P value of the regression is 0.311; this is larger than the value of 0.05 that would be necessary to show statistical significance. Conclusion – winter snowfall has not increased significantly.

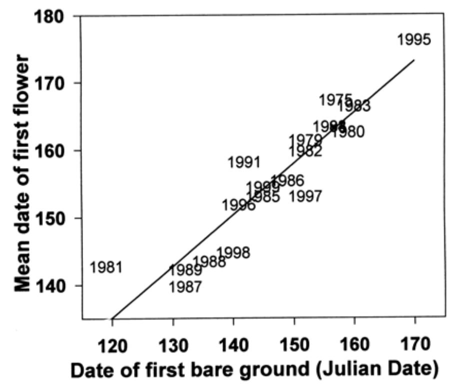


Figure 2. The case is reversed here; this is a significant regression. The equation is: Y = 0.758X 44.220, while r^2 = 0.853 and P = 0.0001. An r of 0.92 is reasonably close to 1, and the P value is less than 0.05. With a P value this low, we would expect to mistakenly conclude that the null hypothesis – that there is no correlation – is invalid less than 1 time in 10,000. Note that we cannot prove correlation; we can merely show that the likelihood of no correlation is very low. Conclusion – there is a strong correlation between the date of first flowering and the date of the first bare ground.

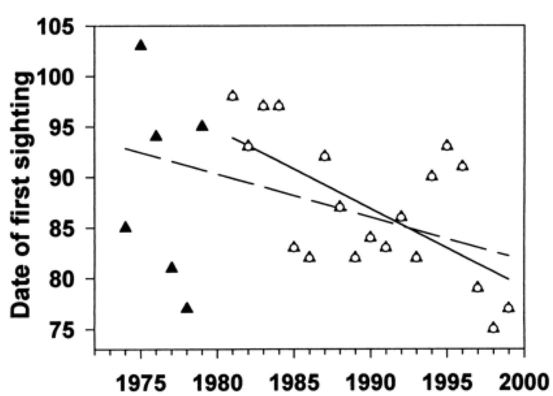


Figure 3. The solid line above represents the regression from 1981 to 1999. For this line, r^2 = 0.410 and P = 0.003. This is statistically significant but not a particularly strong correlation (r = 0.64). The dashed line represents the dates from 1974 to 1980; no r^2 value was given but the P value was 0.109, which is not significant. The text states that the overall regression has an r^2 of 0.103 and a P = 0.110. This is neither significant nor a strong correlation. Conclusion: Over the whole time span there is no evidence that robins are appearing sooner, but there does seem to be a trend for earlier arrivals in the later years.

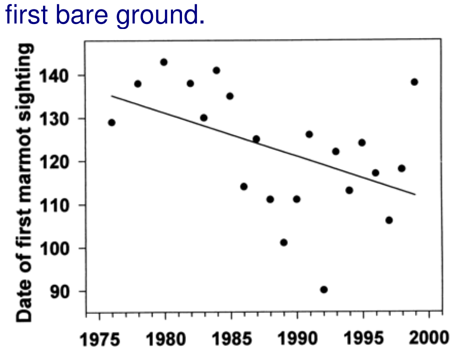


Figure 4. In this case, the results are significant (P = 0.029) although the correlation isn't particularly good (r^2 = 0.226, r = 0.48). Conclusion: marmots are coming out of hibernation somewhat earlier, although it is difficult to predict exactly when they will appear.

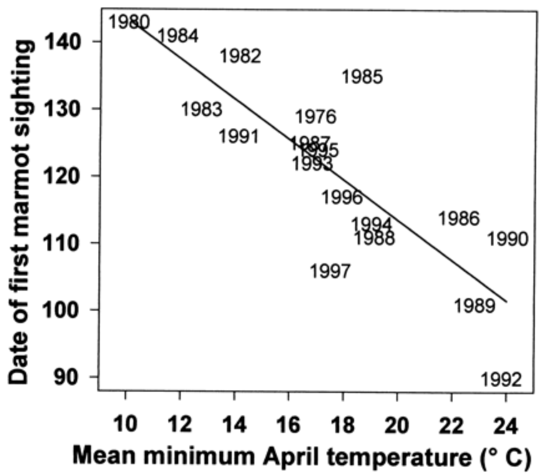


Figure 5. The previous graph plotted the first emergence of marmots against the year; a better fit occurs when the emergence date is plotted against the mean minimum April temperature. Here, the results are r^2 = 0.596, P = 0.0001; this shows stronger, statistically significant correlation (r = 0.77). Conclusion: The warmer the year, the earlier the marmots will appear. With this data, you could measure the mean minimum April temperature and predict fairly accurately when the marmots would appear.

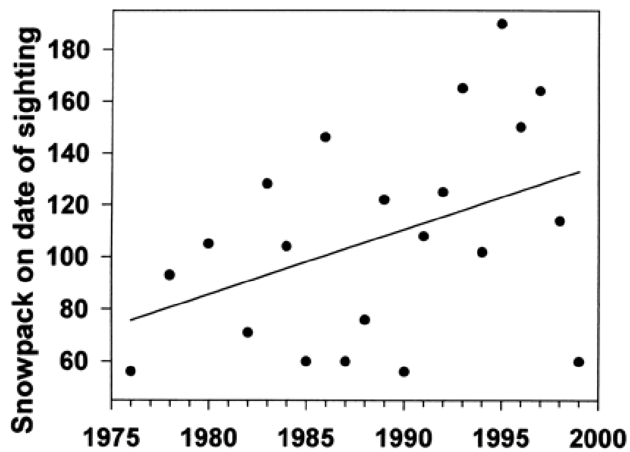


Figure 6. No r^2 value is given for this graph, making it difficult to determine the strength of the correlation. It is "marginally" significant (P = 0.07). Conclusion: This seems to indicate that snowpack is increasing, but it's hard to tell without all the numbers. The authors seem to be changing their criteria for statistical significance as well; earlier they used a value of 0.05 for P. Something is either significant or it is not.

Note that in the previous discussions I avoided "eyeballing" the data when hard data (r2, P values) was provided. It is always better to run statistics than to trust your eyes.

B. In a paragraph, summarize the authors' conclusions.

The authors found that, perhaps because of increased winter precipitation, that the average date of snowmelt at high altitudes in the Rockies has not changed significantly in the recent past. This is in contrast to a marked warming trend at both higher and lower altitudes. Since snowmelt controls the growing season, however, the average start to the growing season has not changed, although migrants such as the robin are arriving earlier, most likely cued by warmer temperatures. Likewise, marmots are emerging from hibernation earlier, and the interval between the emergence of the marmots and the beginning of the growing season is lengthening, as is the interval between the arrival of the robins and the beginning of the growing season. Such disruptions may prove detrimental to these and other animals. Note that the authors based some of their conclusions on data that was not significant.

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[i] McClave, James T. and F.H. Dietrich, II. 1979. Statistics. Dellen Publishing Co., San Francisco. 681pp., see Chapter 12.