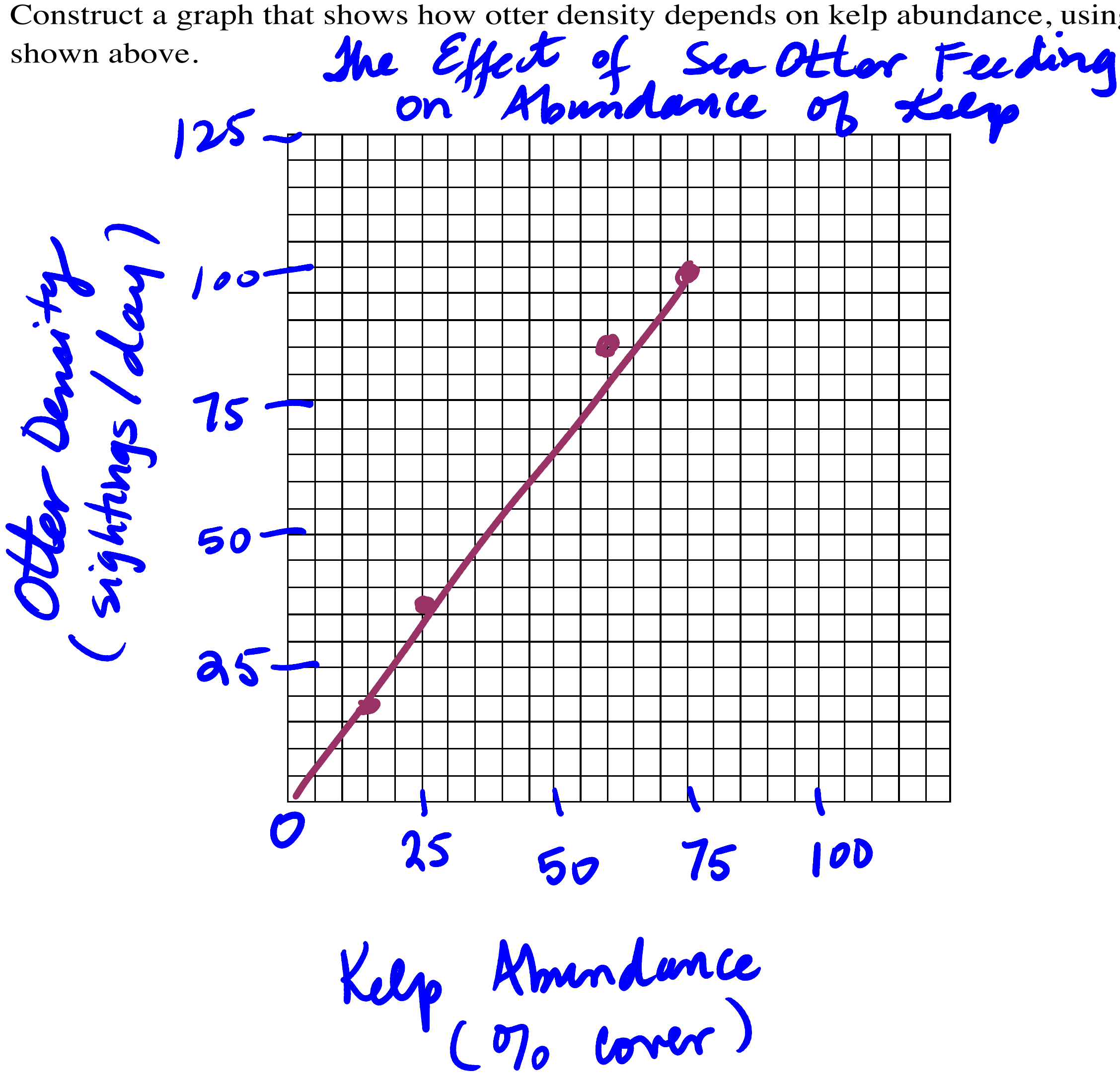
Ecology Graphing Skills Problem Set

Site	Kelp Abundance (% cover)	Otter Density (Number of sightings per day)
1	75	98
2	15	18
3	60	85
4	25	36

1. A student studies feeding relationships among sea otter, sea urchins and the abundance of kelp. Sea otters pray on sea urchins and urchins eat kelp. The student measured the kelp abundance at 4 different sites, then spent a day at each site and marked whether otters were present or absent every 5 minutes during daylight hours.

   (a) Construct a graph that shows how otter density depends on kelp abundance, using the data shown above.

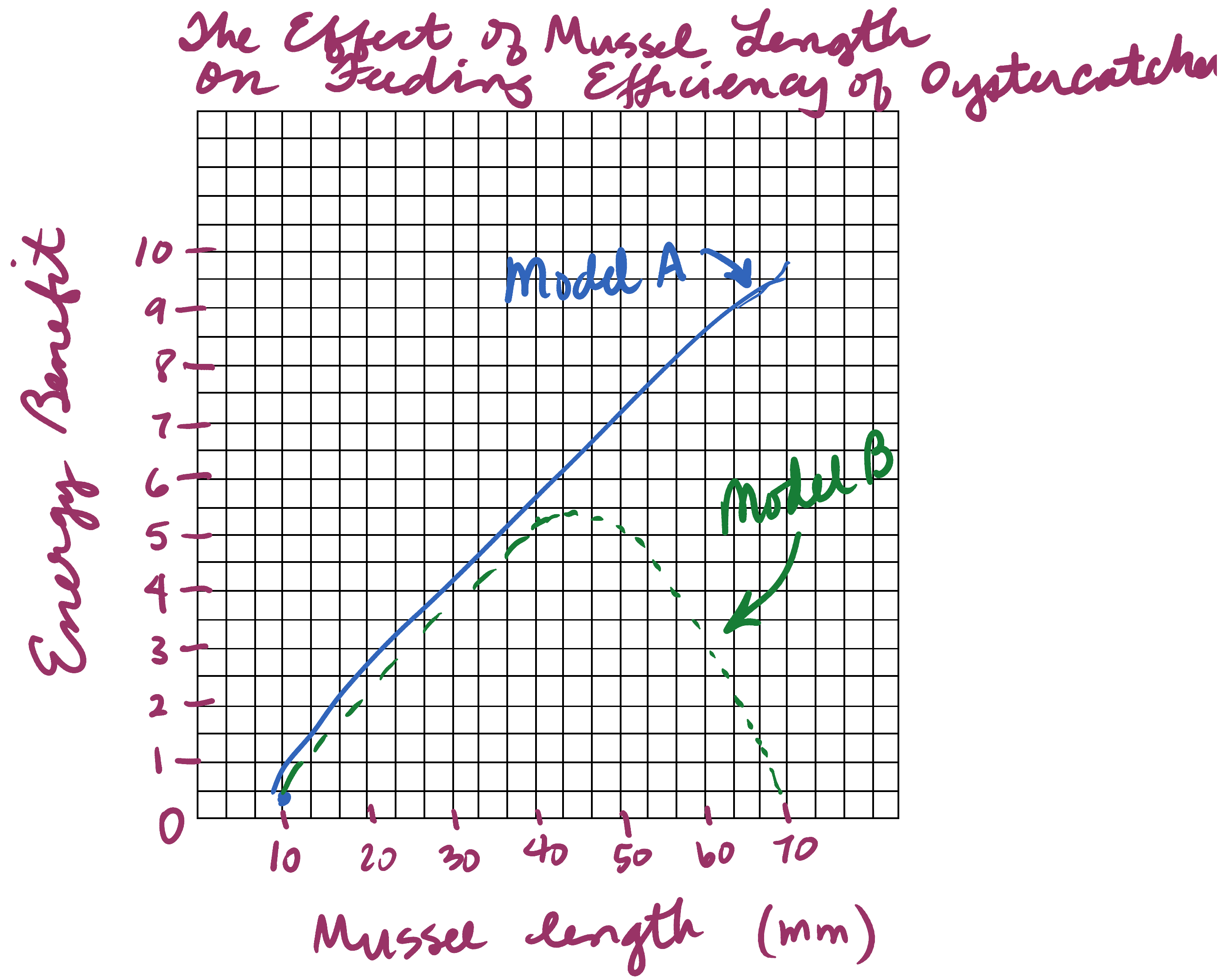


   (b) Formulate a hypothesis to explain the pattern the student observed.

There is a positive relationship between kelp abundance and otter density. A valid hypothesis would be that otters lower sea urchin density which in turn reduces the amount of urchins feeding on kelp, thus increasing the percent abundance of kelp.

2. A student is considering two optimal foraging models for the behavior of a mussel-feeding shorebird, the oystercatcher. In model A, the energetic reward increases solely with mussel size. In model B, you take into consideration that larger mussels are more difficult to open.

(a) Construct a graph of reward (energy benefit on a scale of 0-10) versus mussel length (scale of 0-70 mm) for each model. Assume that mussels under 10 mm provide no benefit and are ignored by the birds. Also assume that mussels start becoming difficult to open when they reach 40 mm in length and impossible to open when 70 mm long.

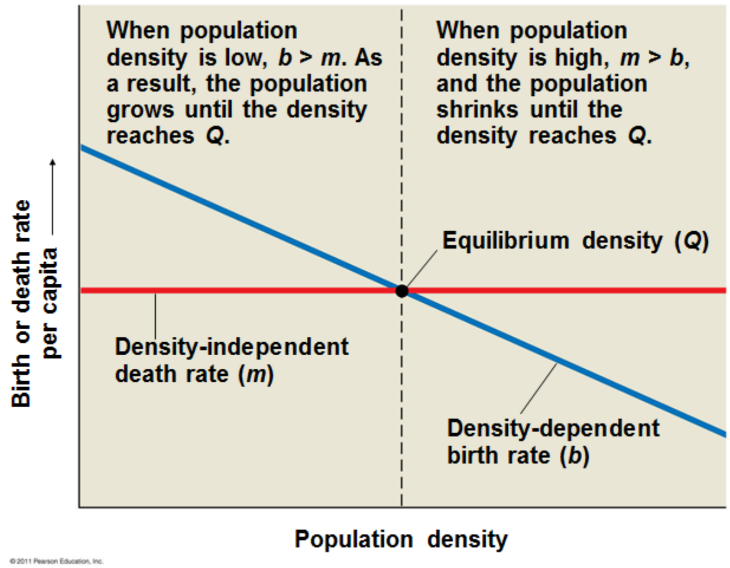


(b) Considering the graphs you have drawn, how would you distinguish between the models by observation and measurement in the oystercatcher's habitat?

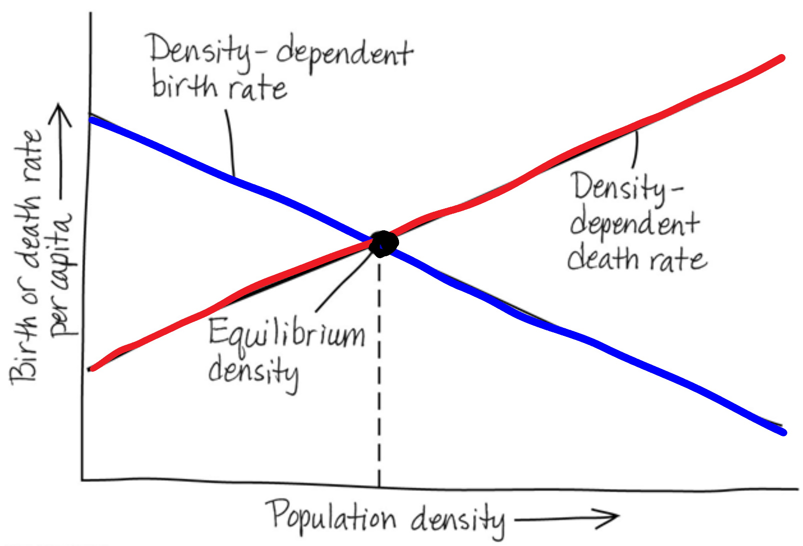
By measuring the size of the mussels that oystercatchers successfully open and compare that to the size distribution in the habitat.

Adapted from Campbell's *Biology*, 9th edition.

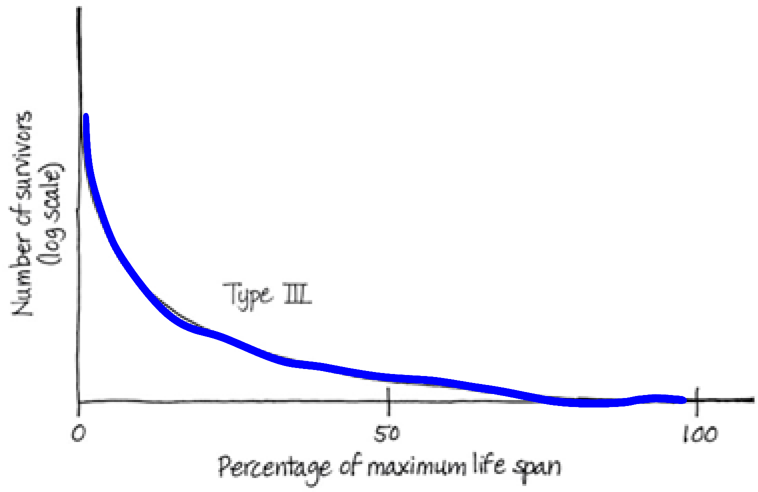
3. This simple model considers only birth (b) and death (m) rates. (Immigration and emigration rates are assumed to be either zero or equal.) In this example, the birth rate changes with population density, while the death rate is constant. At the equilibrium density (Q), the birth and death rates are equal.



Redraw this figure in the space below for the case where the birth and death rates are both density dependent, as occurs for many species.



4. Each female of a particular fish species produces millions of eggs per year. Draw and label the most likely survivorship curve for this species, and explain your choice.



A Type III survivorship curve is most likely since very few of the young probably survive.

Table 53.1 Life Table for Belding's Ground Squirrels

Age (years)	FEMALES: Number Alive at Start of Year	Proportion Alive at Start of Year	Number of Deaths During Year	Death Rate†	Average Additional Life Expectancy (years)
0–1	337	1.000	207	0.61	1.33
1–2	252‡	0.386	125	0.50	1.56
2–3	127	0.197	60	0.47	1.60
3–4	67	0.106	32	0.48	1.59
4–5	35	0.054	16	0.46	1.59
5–6	19	0.029	10	0.53	1.50
6–7	9	0.014	4	0.44	1.61
7–8	5	0.008	1	0.20	1.50
8–9	4	0.006	3	0.75	0.75
9–10	1	0.002	1	1.00	0.50

Table 53.2 Reproductive Table for Belding's Ground Squirrels at Tioga Pass

Age (years)	Proportion of Females Weaning a Litter	Mean Size of Litters (Males + Females)	Mean Number of Females in a Litter	Average Number of Female Offspring*
0–1	0.00	0.00	0.00	0.00
1–2	0.65	3.30	1.65	1.07
2–3	0.92	4.05	2.03	1.87
3–4	0.90	4.90	2.45	2.21
4–5	0.95	5.45	2.73	2.59
5–6	1.00	4.15	2.08	2.08
6–7	1.00	3.40	1.70	1.70
7–8	1.00	3.85	1.93	1.93
8–9	1.00	3.85	1.93	1.93
9–10	1.00	3.15	1.58	1.58

Source: P. W. Sherman and M. L. Morton, Demography of Belding's ground squirrel, *Ecology* 65:1617–1628 (1984).

*The average number of female offspring is the proportion weaning a litter multiplied by the mean number of females in a litter.

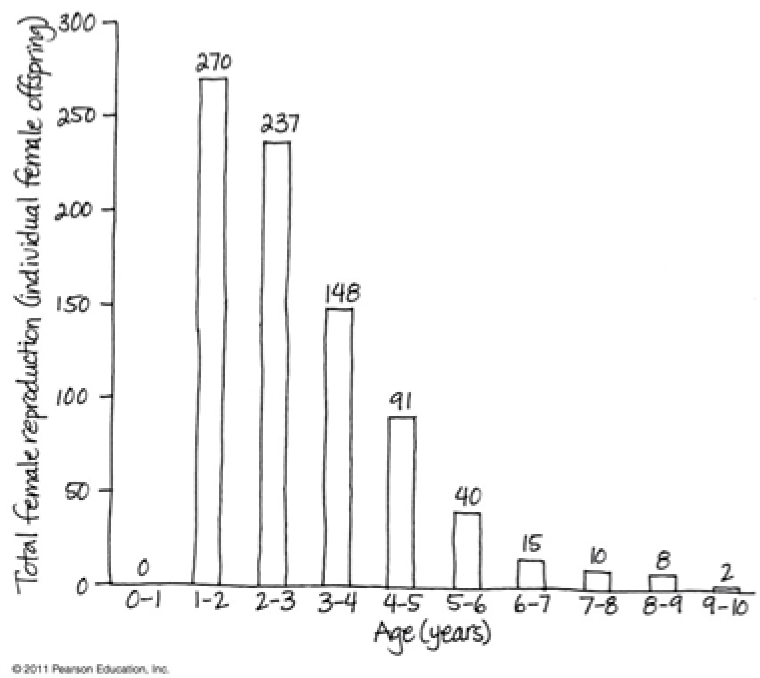
5. Use the data presented above to estimate which age cohort in a population of females produces the most female offspring, you need information about the number of offspring produced per capita within that cohort and the number of individuals alive in the cohort.

   (a) Make this estimate for Belding's ground squirrels by multiplying the number of females alive at the start of the year by the average number of female offspring produced per female.

Sample Calculation for age 1-2: $252 \text{ ~~individuals~~} \times 1.07 \frac{\text{female offspring}}{\text{~~individual~~}} = 270 \text{ female offspring}$

Adapted from Campbell's *Biology*, 9th edition.

(b) Draw a bar graph with female age in years on the *x*-axis (0-1, 1-2, etc.) and total number of female offspring produced for each age cohort on the *y*-axis.



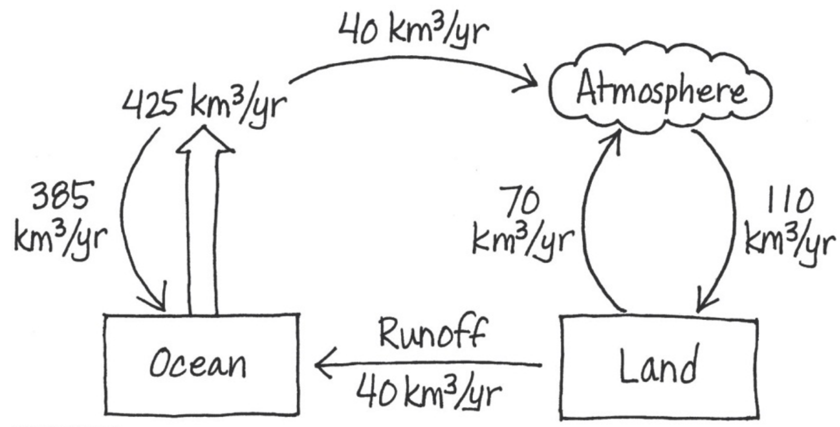
(c) Which cohort of female Belding's ground squirrels produces the most female young?

The total number of female offspring produced is greatest in females 1-2 years of age.

Sample calculation for females of this age group:

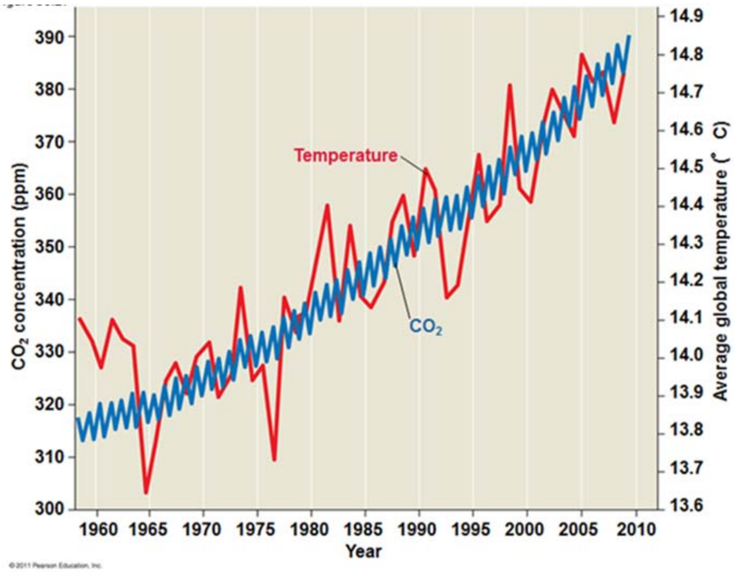
$$252 \text{ female } \cancel{\text{individuals}} \times \frac{1.07 \text{ offspring}}{\cancel{\text{individual}}} = 270 \text{ female offspring}$$

6. Draw a simplified global water cycle showing ocean, land, atmosphere and runoff from the land to the ocean. Add these annual water fluxes to the figure: ocean evaporation, 425 km^3; ocean evaporation that returns to the ocean as precipitation, 385 km^3; ocean evaporation that falls as precipitation on land, 40 km^3; evapotranspiration from plants and soil that falls as precipitation on lane, 70 km^3; runoff to the oceans, 40 km^3. Based on these global numbers, how much precipitation falls on land in a typical year?



Adapted from Campbell's *Biology*, 9th edition.

Increase in Atmospheric Carbon Dioxide Concentration at Mauna Loa, Hawaii and Average Global Temperatures



7. Examine the data shown above.

(a) Calculate the rate of increase in CO_2 production from 1974 to 2009.

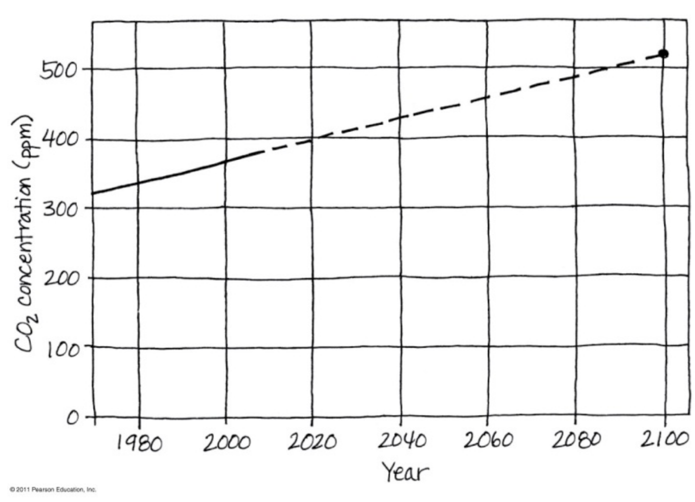
$$rate = \frac{\Delta y}{\Delta t} = \frac{dy}{dt} = \frac{(390-330)\,\text{ppm}}{(2009-1974)\,\text{yr}} = \frac{60}{35}\frac{\text{ppm}}{\text{yr}} = 1.7\frac{\text{ppm}}{\text{yr}}$$

(b) What will be the approximate CO_2 concentration in 2100?

Assuming a rate of $1.7\frac{\text{ppm}}{\text{yr}}$ for an additional 91 years, yields $1.7\frac{\text{ppm}}{\cancel{\text{yr}}}\times 91\ \cancel{\text{yr}} = 154$ ppm which is added to the 2009 value of 390 ppm to give a total of 544 ppm in 2100.

(c) Construct a graph that extends the x-axis to the year 2100. Assume that the CO_2 concentration continues to rise as fast as it did from 1974 to 2009.

Projected Increase in Atmospheric Carbon Dioxide Concentration at Mauna Loa, Hawaii and Average Global Temperatures 2010 - 2100



Adapted from Campbell's *Biology*, 9th edition.

(d) What ecological factors and human decisions will influence the actual rise in CO_2 concentration?

It could be larger or smaller depending on Earth's human population, per capita energy use, and the extent to which societies take steps to reduce CO_2 emissions, including replacing fossil fuels with renewable or nuclear fuels.

(e) How might additional scientific data help societies predict this value?

Additional scientific data will be important for many reasons, including determining how quickly greenhouse gases such as CO_2 are removed from the atmosphere by the biosphere.

Adapted from Campbell's *Biology*, 9^{th} edition.