Revision questions for Problem Test #2

Q1. Drawing on a historic dataset, we have managed to estimate the size of an annual native grass population at 10-year time intervals (albeit with some missing census data) as follows:

Year	N
1910	629
1940	734
1960	712
1970	840
1980	864
1990	986
2000	1232
2010	1012

(a) What is the effective size of this population in 2010? Calculate N_e/N.

(b) We subsequently uncovered data for 1930 (N = 450) and 1950 (N = 819). Recalculate the effective population size (and N_e/N) once these data are added into the mix.

Q2. We know (full well) that the northern elephant seal experienced a bottleneck of 20 individuals in the late 19th century, and has now recovered to around 175,000. As we have worked through in lectures and tutes, asuming a population of ~175,000 individuals prior to the bottleneck gives us a projection for the current effective population of ~60 individuals.

(a) Calculate effective population size if we knew that the seal population was 1 million prior to the bottleneck (i.e., using $N_{e(1)}$ = 1,000,000).

(b) Now say that in the bottleneck generation we knew that ten females bred with only two of the available males (i.e. with two 'harem-masters'). Adjust your estimate for N_e accordingly (still using 175,000 for the first and third censuses).

Q3. Smurfs have become so threatened in the wild that they now only exist as a small captive population of 40 males and 40 females (i.e. N = 80). They are clearly not adaptively favoured in the wild by being blue...

(a) Say we paired males with females to create 40 families. Use the formula for the effective number of breeding male and female smurfs to calculate the effective size of the breeding generation (i.e., N_e).

(b) Now say that we didn't have control over the matings, but via later molecular work could determine all females mated with only 18 males (i.e., 22 males missed out!). Using the same approach as above, what would you then estimate for the effective population size of the breeding generation?

Q4. In the smurf example (above), say that all 40 females and 40 males contributed to a generation of N = 96 smurflets. We are also able to calculate the variance in smurflet family size, which is 3.16.

(a) What is the mean family size in this case?

(b) What is the effective size of the breeding population?

(c) If you had been able control the variance in offspring number among the 40 families, what value would give you maximum N_e?

(d) What is maximum N_e in this case?

Q5. As we know, the "white tiger" phenotype was originally obtained by mating a daughter with her father.

(a) What is the inbreeding co-efficient (F) for such an individual?

(b) Use this value to estimate the percentage of original genetic variation remaining after the father-daughter mating.

Q6. Having graduated as a conservation biologist, you are called in to a wildlife sanctuary to manage a captive population of 376 F1 bilbies (188 males & 188 females). They are derived from an initial sample of 216 presumably un-related individuals (of unknown gender and sex ratio) sampled from the wild.

(a) Using the demographic information provided here, estimate the effective size of your F1 population.

(b) Given this value for N_e for the F1s, what would you predict as the inbreeding co-efficient for your captive population following 6-generations of random mating?

(c) What proportion of the F1 genetic variation would then remain?

Q7. The managers at this sanctuary then decided to establish another captive colony of bilbies, and sampled 62 pregnant females from a large outbred population.

(a) If you only have the resources to handle an F1 population of 186 individuals, what average family size would you ideally aim for?

(b) If you could perfectly equalize family size, use the family size-based demographic formula to estimate N_e in the F0 generation.

Q8. If you randomly sampled 864 individuals from a large idealized population of hermaphroditic turbellerians, can you estimate the value of N_e for this sample?

Q9. Next year (2017) you're called in to manage an isolated population of Banskias. By analysing microsatellite variation you determine the heterozygosity of this population as 0.690. Everything is going well, but a devastating bushfire causes the population to completely regenerate in 2018, and then again in 2019 (the incidence of fire is on the rise...).

(a) A molecular census of the population in 2019 using the same microsatellite loci indicates a heterozygosity value of 0.683. Use these data to calculate N_e.

(b) In the process, you find two completely differentiated haplotypes and conclude that there are actually two different Banksia species (i.e., "cryptic species"). You now divide your 2019 Banksia population into **Species A** (H = 0.231) and **Species B** (H = 0.432). Going back to your 2017 data allows you to estimate H for each species as 0.243 and 0.437, respectively. Calculate N_e for each species.

(c) Use the change in H over these generations to estimate the inbreeding coefficient for each haplotype.

N.B. See appendix below to see how to rearrange formulae.

Q10. In the future, a small population of humans – let's hypothetically call them the Kardashians – are shipped off to live on another habitable planet in a very distant galaxy. The small effective population of 8 Kardashians has a low heterozygosity value of 0.232 to start with, perhaps due to a bottleneck in the past...

(a) What would you estimate heterozygosity to be in 6 generations, should they survive that long?

(b) What percentage of original H would therefore remain at this point?

Appendix

How to re-arrange formulae

(…just in case you ever wondered – Don't worry, this won't be necessary for the problem test!)

(a) If you have the formula y = mx + c, re-arranging to get x as a function of y is as follows:

$$y = 2x + 5$$

Step 1: subtract c from both sides of the equation:

$$2x = y - 5$$

Step 2: divide both sides of the equation by m:

$$x = \frac{y - 5}{2}$$

(b) If we have the formula $y = x^2$, what is x as a function of y?

Rearranging to get x is simply: $x = \sqrt{y}$

(c) Rearranging this formula $y = 1 + \frac{2}{x}$ to get x on one side:

The long way:

Step 1: subtract 1 from both sides of the equation:

$$y - 1 = \frac{2}{x}$$

Step 2: multiply both sides by x:

$$(y - 1)x = 2$$

Step 3: divide both sides by (y-1):

$$x = \frac{2}{y - 1}$$

(d) To get from this $\left(1-\frac{1}{2N_e}\right)^t = \frac{H_t}{H_0}$ to this: $N_e = \frac{1}{2\left(1-\sqrt[t]{\frac{H_t}{H_0}}\right)}$

$$\left(1-\frac{1}{2N_e}\right)^t = \frac{H_t}{H_0}$$

$$1-\frac{1}{2N_e} = \sqrt[t]{\frac{H_t}{H_0}}$$

$$\frac{1}{2N_e} = 1-\sqrt[t]{\frac{H_t}{H_0}}$$

$$N_e = \frac{1}{2\left(1-\sqrt[t]{\frac{H_t}{H_0}}\right)}$$