**BIO 3115 CONSERVATION BIOLOGY 2014-2015 SOLUTIONS**

1. (i) The expected $\alpha$-density is given by the estimated asymptote of the species effort curve, which, from Fig. 1.1B, will be highest for marshes. Many students suggested that the greatest $\alpha$-density is shown by swamps, as they have the greatest slope of the species-area relationship (Fig. 1.1A). However, this is so only if one assumes that the species-effort relationships *are the same for each wetland type*. But clearly they are not (Fig. 1.1B) – in particular, given infinite effort, marshes will, on average, have the highest number of species per hectare.

Total = 2 marks

*Grading remarks:*

(a) *Many students said swamps, as indicated by the greater slope and/or higher asymptote of the species-area relationship – score = 1.5.*

((ii) $\beta$-diversity is given by the change in species composition over habitats. As noted in the question, the area of a wetland is a proxy for habitats – the larger the area, the more (micro) habitats within the wetland. Changes in total richness with area are thus likely to reflect the fact that larger wetland have a larger number of micro habitats, with species composition differing among micro-habitats – if it didn't, then it is unlikely that one would see any species-area relationship. Hence, $\beta$-diversity increases with the slope of the species-area relationship, with swamps having the largest slope based on Fig. 1.1A.

*Grading remarks:*

*Revised total grade for this question = 2 marks.*

(a) *Many students thought that b-diversity was related to overlap, and used the data in Table 1.1 to estimate either average overlap or the rate of decline in overlap with distance – score = 1.25.*
(b) *I suspect that some students got confused about which figure denoted alpha-versus etab-diversity, and which question they were answering. For example, one student's answer to part (ii) concerns alpha-diversity, which she says (correctly) is highest for marsh, but in her answer to part (i) she uses the species-area data to argue that swamps have the highest alpha-diversity – I think she meant (correctly) beta-diversity here, and labeled her answer incorrectly). I gave her full marks for both (i) and (ii).*
(c) *Some students thought that species-area indicated alpha-diversity, species-effort beta-diversity rather than the other way around. If, as indicated in the question, area is a proxy for habitat diversity, then species-area is a measure of species turnover (beta-diversity). On the other hand, if the habitat is uniform, it is a*

*measure of alpha diversity. Score 1.5 for (i), 1.5 for (ii) = 3 in total for (i) and (ii).*

*(d) At least one student went to Wikipedia and realized that according to Whittaker, B=y/a and concluded that bogs had greater b-diversity – score = 2.*

((iii) γ-diversity is the change in community composition within a habitat type over geographical areas. From Table 1.1, we see that overlap declines with distance most precipitously for bogs – which means that γ-diversity is highest for bogs.

Total = 2 marks

*Grading remarks:*

*Most students got this. As well:*

*(a) some students simply noted that average overlap over distance classes was smallest for bogs, rather than noting (either implicitly or explicitly) that it was the rate of decline in overlap with distance that measured gamma-diversity – score = 1.5*

(iv) Although marshes tend to have higher α-density, and swamps the greatest β-diversity, I would put higher conservation priority of bogs, for two reasons: (1) they are, by far, the least common of the three types (Fig. 1.2 – 1 mark); and (2) they have the largest γ-diversity (Table 1.1 -1 mark). This means that the loss or degradation of even one bog is more likely to result in the regional loss of a plant species than is the loss of a single marsh or swamp, because overlap in community composition is smaller for bogs than the other two wetland types (1 mark)

*Grading notes:*

*Revised total grade = 3 marks*

*(a) Many students chose bogs correctly, for the two reasons given, but did not give any explanation about why this was more important than alpha or beta-diversity – score = 2.5.*

*(b) Several students pointed out that, in some sense, alpha diversity and beta-diversity are both related to gamma diversity, and at a regional conservation level, this is what matters – score = 3.*

*(c) Some students did not take into account the comparative rarity of bogs, and based their answer on gamma and beta-diversity (as in (ii), they said that bogs had larger beta-diversity) – score = 2.*

2. The Carolinian (henceforth C) complex for the following reasons:

(1) There are, at present, far fewer Carolinian than GL-STL populations (Table 2.1 – 1 mark), and based on historical data, local extinction (extirpation) rates of local populations are higher than the in the GLSTL complex. (1 mark) The dramatically reduced number of C populations also suggests (but only suggests) a much more limited current geographical range (1 bonus mark).

*Total marks = 2 + 1 bonus.*

***Grading remarks – most students got both these points.***

(2) On average, current effective population sizes (and hence total population sizes) of GL-STL populations are larger than C populations (Table 2.2. – 1 mark), as is their average growth rate (1 mark), and annual variability in growth rate (Table. 2.2) (1 mark). Total = 3 marks.

*Grading remarks – most students got at least 2, and many got all three of these points.*

(3) even populations within just a couple of kms of each other seem not to have high rates of emigration/immigration – if this were the case, then we would expect genetic distance between populations in close proximity to be zero, but it is clearly not (Fig. 2.1). This suggests (but does not prove) that (a) local extirpation is unlikely to be offset by recolonization because of limited dispersal (1 mark), and (b) that immigration rates are unlikely to be high enough to substantially reduce inbreeding, especially in smaller populations whose growth rates are already near zero or declining (as they are in C versus GL-STL) (1 mark). Total = 2 marks

Grading remarks: This was the most difficult part of the problem, and many students did not know what to make of these results. Some, however, were spot-on. Gven the relative difficulty, I have reduced the total score here to 1.5 marks rather than 2.

*Possible responses:*

*(a) data indicate genetic variability among populations indicating local adaptation and/or reduced gene-flow/immigration (which is a reasonable inference) – but how this relates to conservation priority is not made clear – 1 mark*
*(b) data indicate that there genetic differentiation among populations, so that effects of inbreeding can be reduced through translocation (true), and/or that the range of variation with distance allows for "titration" of possible inbreeding/outbreeding depression (also true) – 1.25 marks*
*(c) Even with populations that are far apart, genetic distance is not large, so suggests that translocation can work to counteract inbreeding depression (i.e outbreeding depression not very likely) (the validity of this depends upon what genetic distance is "far" – which I didn't tell them. This is a variant of (b)) – 1 mark.*

*(4) There are no populations of the C complex outside of protected areas, and from Table 2.2, even those within protected areas are not doing very well (1 mark).*

*Many students recognized that there are no C complex populations outside PAs, but drew different conclusions, including:*

*(a) The fact that all C populations are in PAs make them easier to protect, so focus on them (because it's easier). Or because it is easier, focus on those outside (i.e. GL-STL complex) – score =0.75 in both cases.*

*Other marking notes:*

*Some students had many or all of the above points, but came to the opposite conclusion – namely, that because the C complex was doing so poorly, conservation priority should be given to the GL-STL complex. This is reasonable, so no mark deduction.*

3. (i) Yes. Table 3.1 shows a strong negative relationship between fledging success and F (1 mark), and a weaker, but still negative, relationship between hatching success and F (1 mark). Since both of these will determine the population growth rate, populations with higher inbreeding are likely to have a reduced population growth rate, and hence, are at greater extinction risk.

*Grading remarks: most students got both these points. However:*

*(a) Some students suggested that inbreeding was not as problem because F ratios were generally "low" or below some value – score 1. The issue is not the absolute size of F, but rather whether there is any correlation.*
*(b) Some student mentioned only 1 of the two endpoints (hatching success OR fledging success, but not both) – score = 1.5*
*(c) Some students said both "yes" and "no", by finding subsets of the data that showed a positive relationship, and another subset that showed a negative relationship, arguing that there was a relationship in some case, and not in others – score = 1.*

(ii) No. There is no relationship between levels immigration levels (I) and inbreeding (F). This suggests either than (a) natural immigration rates (which are smaller than 1/5 of one immigrant per resident adult per year) are too low to have any significant effect on inbreeding; or (b) immigrant individuals are excluded from breeding, or have low breeding success.

*Grading remarks: most students got this point (i.e. no relationship). There is no need for students to give the implications in order to get full marks.*

*Some students did as in 3(i)(c) above –score = 1.*

(iii) Inbreeding appears to be a problem, but natural levels of immigration are not mitigating this problem. Hence, the only way to reduce levels of inbreeding is to translocate unrelated individuals from donor colonies to recipient colonies. This need not work, of course, because immigrants may be prevented from breeding, or have low breeding success relative to residents (see (ii) above), in which case translocation may be quite ineffective. But the presented data suggest that the experiment is worth doing – certainly inbreeding risks will not be mitigated by "natural" immigration.

*Grading remarks: Student responses here were variable:*

*(d) Some students argued that because there was no relationship between (natural) immigration rates and inbreeding, artificial immigration via translocation wouldn't be effective (score = 1.5 marks).*

**MORE NOTES ON STUDENT RESPONSES**

General issues:

- A number of students answered questions without really looking at the data at all – they simply revisited the patterns and conclusions drawn in class in the context of a particular problem. A good example is question 3 (iii), where a number of students simply answered that translocation was not a good strategy because it might result in outbreeding depression (yes, it might, but there is no evidence of this given in the question).
- Another common strategy is for students to simply write down everything they know (or think they know) about a particular subject (e.g. α-diversity) in the hopes that I will give them some marks for being able to copy out a definition that I gave them, and which they can simply read in their notes (the exam was open book).
- Some people, despite being told explicitly, simply gave an answer without any explanation.

All of these points are made explicitly in my "Tips" documents, posted on the course web, which I instructed all students to read carefully.

- There are a number of examples, in the papers I read, of arguments which are not the same as mine, and which result in opposite conclusions, but which nonetheless make some – at times considerable – sense. So be careful here – remember that what is critical is the logic of the argument, and not so much the conclusion (assuming the latter follows from the former), Question 1

(i) Many (most) people answered swamps based on Fig 1.1A, the slope of the species-area curve. This is only partially correct, because it assumes that the probability of finding a species in a given area, given that is present, is independent of wetland type. Fig 1.1B tells us that this assumption is NOT valid.

(ii) Some people argued that because β-diversity is species turnover along a habitat gradient, and because no information is given about habitat gradients, this question could not be answered. In fact information is given about microhabitat variation in the text (which is why it was given, in fact). Many people said that β -diversity was species turnover across a habitat gradient (true, but this is merely the definition, about which I care almost nothing), and argued that larger geographical areas will include more habitat variation, in which case changes in overlap with distance (i.e. Table 1.1) is a measure of β-diversity. There is some logic to this, but Table 1.1. deals with spatial variation within a particular habitat (wetland) type. Some people argued that Fig 1.1.B should be used, because more effort means more number of habitats encountered, so the steeper slope of the species-area curve means greater β-diversity. Again, there is some logic here – part marks.

(iii) This question was answered correctly by most people.

Overall: in my "tips" file, students are told explicitly that I do not provide extraneous information, and that if they do not use ALL the presented information in their answer, they are missing something. There were a number of students who answered this question using only the data in Fig. 1.1A, Fig 1.2 and Table 1.1 – i.e. did NOT use the data in Fig. 1.1. B. Also, there were a number of students who referred to only Fig 1.1 (not A or B explicitly) for answering (i) and (ii).

(iv) In general, students appeared to get this question correct. Others are argued that because of α and β-diversity, swamps or marshes should get higher priority, or that because they are more abundant than bogs, there is more opportunity for conservation. The latter argument I have little enthusiasm for – carried to its logical conclusion, we would put highest priority on agricultural fields, as they are the most common habitat in the landscape.

Question 2

- Some students seem to understand the relationship between various parameters (e.g. population size, growth rate, etc) and extinction risk, but think that higher priority should be given to the complex with the LOWER extinction risk, arguing that the risk for the C complex is so high that it is perhaps better to simply "write it off" and focus on the GL-STL. This logic is fine, although it is not consistent with how COSEWIC actually assigns priority (status), but this might simply be due to the fact that by “priority: I meant “COSEWIC status”, whereas clearly some students thought this meant “priority” in terms of where to focus conservation efforts on the ground. So no mark deduction.

- The interpretation of Fig. 2,1 was all over the map. A number of students concluded that from Fig. 2.1.there was no relationship between genetic distance and distance, because error bars overlapped. This might or might not be true (so no mark deduction), the issue is: what is the implication? Some said that it showed there was a lot of genetic differentiation among populations, others that it showed there was very little differentiation. (both require, of course, that absolute levels of genetic distance be meaningful) – again, with different implications. Some students said that because distances were large, translocation would be more likely to result in inbreeding depression, which is true. Some said this information was irrelevant, or irrelevant without having comparable data on the C complex, which is partially true, but implies that the information content of these data with respect to the C complex is zero (which is highly doubtful). In fact very few students correctly interpreted this, so I did not deduct marks here.

Question 3. Most people got this question right. Some people argued that translocation should not be used because of outbreeding depression, but adduced absolutely no evidence is given that this might be a problem. Some people argued that because of the lack of relationship between inbreeding and immigration shown in Table 3.1, that more immigration by translocation won’t help – a classic example of the dangers of extrapolation! Nonetheless, there is some logic here – so I gave part marks. Some people suggested that the lack of a relationship between inbreeding and immigration indicated that resident individuals would simply not mate with immigrants, in which case a bunch of new immigrants would have no effect. Certainly the latter follows from the former, and it is quite possible, so I accepted this argument.