Anderson, Alison <alison_anderson@fws.gov>

Laguna Mountain skipper Recovery plan comments

Robert McElderry <rmcelderry@bio.miami.edu> Sat, Mar 26, 2016 at 11:54 AM
To: "Anderson, Alison" <alison_anderson@fws.gov>

Alison,

Thank you for inviting me to review the recovery plan. I attached my comments. Overall, I found it difficult to critique what is already there, but I did list ideas about where to go from here. I hope they are helpful.

This is an interesting system, and I find the diapause aspect very interesting. If you need a collaborator to help better understand diapause for the LMS and to develop the demographic model I would be interested. Also, keep me in mind for other reviews.

Best,

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Overall, I found the recovery plan thorough and convincing. The biology of the skipper seems described well enough, and the plan details seemingly sufficient resources toward illuminating any existing knowledge gaps. The comments I do have focus mainly on the direction forward from this point, and describe a different perspective on diapause, suggestions for the demographic model, and some thoughts about how the concept of resilience may change with development of the demographic model. I found the criteria for delisting/downlisting a little vague, but in reading through both the recovery plan and status report, I cannot conceive of a better framework. These criteria seem sound given our current understanding, but may be improved in the future based on observations from captive rearing and field surveys and as the demographic model is further developed. Diapause and demographic modeling are also two of my areas of expertise, and I mainly comment on these topics. Otherwise, there were no major issues that stood out to me.

Determining the cues for diapause seems extremely important. From what I know of the literature, photoperiod (day length) is the most commonly supported environmental cue that triggers diapause. Temperature can modify this response somewhat, but day length is well supported as a primary cue. Part of the reason for this is that the annual fluctuation in day length is a regular and reliable cue. For summer diapause, a putative cue would be increasing day length, and warmer temperatures would reinforce this relationship. This sort of physiological 'switch' can be represented by an S-shaped curve with the probability of diapausing near zero for short days, near one for long days, and steeply increasing at some intermediate day length (I would guess 13-14 hours for LMS). At intermediate day lengths, a small proportion of individuals are predicted not to enter diapause, and directly develop instead. With lengthening day length, almost all individuals enter diapause. If we now think of an early spring brood with this perspective in mind, we can predict that individuals will develop during short days, and a relatively large proportion of individuals will not enter diapause, resulting in a large summer brood. This early-spring-large-summer-brood relationship is described in the recovery plan and reported in the status report.

It is important to identify the right cue for diapause of LMS because of the crucial importance of the summer brood. Theoretically, the summer brood has great reproductive value, so it is likely necessary for population resilience. However, if the summer brood were generally beneficial, natural selection would select against the 'optional' nature of this life history pathway, and all individuals would participate in the summer brood. There must therefore be some long term resilience the population achieves in having two competing life history pathways. The pathway of direct development and summer breeding is expected to have a greater per capita pay off (> 90:1) compared with the pathway in which individuals diapause during the summer, waiting until the following spring to breed. There are a number of reasons to expect that summer is not usually this productive, some of which are spelled out in the recovery plan, e.g. exceptionally hot and dry years, etc. I would add to this list the size of the spring brood. The density of larvae feeding in the spring will decrease the abundance of foliage

available for subsequent cohorts. Regardless, the pathway in which individuals diapause during the summer has a low pay off in terms of the probability of surviving until spring to reproduce, but it is likely less risky. Although a large number of individuals are need to participate in this pathway to have an adequate breeding population the next year, year-to-year variation may affect this pathway less compared with its effect on a summer brood. This is largely what is spelled out in the conceptual model, and it makes sense to me, but I would include more variability in summer brood success. The main effect of climate warming may in fact be earlier broods, which by my arguments would result in larger proportions of individuals directly developing and breeding during the summer. However, the climate projections include worsening summer conditions, which means lower success of the summer brood. In this scenario, it would be better for less individuals to participate in the summer brood.

These arguments suggest we need a better understanding of the spring to summer brood ratio. A 2:1 spring to summer brood ratio may be optimal on average, but it needs unravelling. Manipulating the demographic model to represent competing hypotheses describing the summer brood's dynamics may suggest answers to these important questions and may help direct field sampling efforts to verify model predictions. In general, I would rank development of the demographic with high priority, because it may prove very useful in making predictions to guide decisions concerning captive rearing and sampling efforts. A closely monitored and recorded captive rearing program could provide a wealth of demographic information. Equally important would be to reevaluate the delisting/downlisting criteria as they are currently written. I imagine these criteria have been difficult to define, and more information would offer considerable help.

In summary, the recovery plan seems sound from my perspective, but I would encourage rethinking diapause and focusing observations toward this phenomenon. The recovery plan details the importance of this stage to the overall demographics, and relatively little effort would be required to identify its regulators.