1. TITLE SLIDE
   1. Hello! Thank you for being here. My name is Renata Diaz, and I’ll be talking to you today about energetic compensation and how it changes and breaks down over time in a desert rodent community.
2. SLIDE 2
   1. First, an overview of what energetic compensation is and why we’re interested in it. Energetic compensation is a phenomenon that occurs when species in an assemblage fluctuate In abundance such that the total amount of energy being used by the whole assemblage remains relatively stable, even though the species composition of the assemblage is changing. That is, declines in the abundance of some species are offset by increases in abundance from others.
   2. We look specifically at the total amount of *energy* being used by the assemblage. The total amount of energy being used is a direct metric of ecological function, in terms of the amount of resources being processed by the assemblage and potentially being made available to other trophic levels.
   3. Here we have an illustration of a hypothetical energetic compensation scenario. On the left, we have a “complete” assemblage of 2 species. In the middle, we have a scenario where one of those species has gone extinct or been removed from the assemblage. In this scenario, the remaining species has increased in abundance to exploit the resources that are left over now that the other species is absent.
3. ~~SLIDE 3~~
   1. ~~In particular, note that the second species has increased in abundance~~ *~~so much~~* ~~that it is using 100% of the energy that would otherwise be being used by the first species. We refer to this as 100% compensation.~~
   2. ~~When we have complete compensation, this also means that the assemblage missing the first species is using 100% of the energy being used by the complete assemblage.~~
4. SLIDE 4
   1. When we see energetic compensation, it has a couple of implications for the types of processes affecting community structure and how we think about the resilience of community-level attributes to species’ fluctuations.
   2. Energetic compensation is consistent with a zero-sum competitive dynamic, in which species are in tight competition for limited resources, and any increases in abundance from one species come at the expense of others.
   3. It also by definition means that community function, in terms of energy use, is resilient to changes in species composition.
5. SLIDE 5
   1. For energetic to be possible in an assemblage, different species need to be able to exploit the same resources under the same environmental conditions. This might be because some or all the species are identical – which could be consistent with a neutral dynamic – or because subsets of species in the assemblage differ along some niche axes, but share overlapping traits related to resource use and their fitness under the local environmental conditions.
6. SLIDE 6
   1. When compensation is happening within this kind of a niche structure, it becomes important to look at it from a specifically temporal perspective.
7. ~~SLIDE 7~~
   1. ~~One example of this is, if an assemblage doesn’t contain a species that overlaps enough with another species to compensate for that species going extinct – but a species with the right traits exists somewhere in the broader metacommunity – compensation may not occur until that species disperses to the local community. So dispersal limitation can introduce long time lags in compensation occurring at all.~~
8. SLIDE 8
   1. ~~Another important~~ **~~temporal~~** ~~consideration is that,~~ as we know, fluctuating environmental conditions often impact different competitors in different ways. Species that perform similarly under some conditions may have a very different competitive dynamic under other conditions.
9. SLIDE 9
   1. This is the angle that we’re going to dig into further in this talk.
10. ~~SLIDE 12~~
    1. ~~Specifically, we’re looking at the question of how changes in environmental conditions over time affect the energetic compensation we observe in empirical assemblages.~~
11. SLIDE 13
    1. We’ll use the Portal Project. The Portal Project is a long-running experiment that – among other things – has taught us a lot about competition, and specifically energetic compensation, in natural assemblages.
    2. There are three major groups of players in this system. First we have kangaroo rats, which are the largest species in the system and are competitively and behaviorally dominant. Since 1977, we have maintained experimental exclosure plots where kangaroo rats are removed, to study how the rest of the system responds to the loss of kangaroo rats.
    3. Second, we have Bailey’s pocket mouse. This mouse is similar in size to kangaroo rats, but is able to access the exclosure plots. Bailey’s pocket mouse was not present at the site at the beginning of the experiment, but established at the site in the mid-1990s and became quite abundant, especially on exclosure plots.
    4. Last, we have the remaining species of small granivores that have access to the exclosure plots. For the purposes of this talk, we’ll consider them as a group. They are mostly desert pocket mice.
12. SLIDE 14
    1. Previous work with Portal has found that energetic compensation occurs in this system, driven primarily by Bailey’s pocket mouse.
    2. At the beginning of the study, Bailey’s was not present in the community. While the other small granivores increased in abundance on exclosure plots, they did not come close to compensating for the loss of energy use due to the loss of kangaroo rats.
    3. This changed beginning in 1996, when Bailey’s pocket mouse established at the site. Bailey’s became especially abundant on exclosure plots, effectively absorbing most of the energy left over due to kangaroo rat removal.
13. SLIDE 15
    1. Over the decades, we have observed major environmental shifts at the site, which have had major impacts on the rodent community.
    2. Most recently, there was a period of extended, severe drought ending around 2010. Coming out of that drought, Bailey’s pocket mouse has become very scarce at the site.
    3. Here we have a plot of the composition of the rodent community on control plots throughout the duration of the study. The blue line is the proportion of total community energy use being used by all non-kangaroo-rat species, including Bailey’s pocket mouse. The red line is the proportion of total community energy use accounted for by just Bailey’s. The remainder is the energy being used by kangaroo rats.
    4. We can see that Bailey’s was absent until the mid-1990s, and became quite abundant from the 1990s to the early 2000s. Since 2010, it has declined so sharply that it is nearly absent on control plots.
    5. We can also see that the overall composition of the rodent community has shifted since the beginning of the study. At the beginning of the study, kangaroo rats accounted for a greater proportion of the total community energy use than they do now. This is probably because the habitat at the site has shifted from a relatively open grassland to a shrubland, which provides better habitat for smaller granivores.
14. SLIDE 16
    1. We wanted to know how the combined effects of the decline in Bailey’s pocket mouse, and the community-wide shift favoring smaller granivores, have affected energetic compensation since 2010.
15. SLIDE 17
    1. One possibility is that other species of smaller granivores have taken over for Bailey’s pocket mouse, and have maintained energetic compensation even though Bailey’s has declined. ~~This is a hypothetical representation of what that might look like.~~
16. SLIDE 18
    1. Another possibility is that compensation is still mostly dependent on Bailey’s, and that, since Bailey’s has declined at the site, compensation has broken down.
17. SLIDE 19
    1. Going to the real results, we found that, since Bailey’s has declined, energetic compensation has declined. Small granivores on exclosure plots are now absorbing only about an average of 20% of the energy made available through kangaroo rat removal, down from more than 50% when Bailey’s was dominant. This is comparable to the compensatory response observed in the decades before Bailey’s established at the site.
    2. However, we haven’t completely reverted to the earlier state space. Because of the whole community now contains a larger proportion of smaller granivores, the actual net loss of energy caused by kangaroo rat removal is much smaller now than in the 1980s and 1990s.
18. SLIDE 20
    1. The key observation here is that something must have changed between the early 2000s and now, that now prevents Bailey’s from having the same compensatory function that it did before the drought.
    2. Bailey’s is still present in the system, and there are still significant resources being left unused on kangaroo rat exclosure plots. Under earlier conditions, Bailey’s would have increased in abundance to exploit those resources and turn them into more pocket mice.
    3. It may be that recent environmental conditions are less favorable for Bailey’s pocket mouse. As in a lot of places, Portal has tended towards a more extreme climate in recent years, with longer and more severe droughts.
19. SLIDE 21
    1. These findings have implications for how we think about energetic compensation more broadly.
    2. First, it illustrates that compensation varies over time as the competitive dynamics between species changes. As conditions fluctuate, compensation may come and go, even within the same set of species.
20. SLIDE 22
    1. This means that a zero-sum competitive dynamic, and the implications that would have for ecological and evolutionary dynamics, isn’t necessarily a consistent feature of a system, but may be an intermittent constraint that depends on both the species in the system and how their current context modulates their competitive dynamic.
    2. Observations at Portal indicate that these fluctuations occur over relatively long temporal scales – to the scale of decades. These kinds of dynamics would be very hard to pick up in a purely observational timeseries, or by looking at patterns of covariation in species abundances.
21. SLIDE 23
    1. Finally, if this type of dynamic is common, it means that the ability of assemblages to maintain assemblage-level function depends on both who else is present in that assemblage, and how the functional overlap among those species shifts with changing environmental conditions.
22. SLIDE 24
    1. With that, I’d like to thank you for taking the time to watch! I’ll be happy to take any questions during the scheduled discussion period, which for this talk is from 2-3 PM EST on August 2nd.
23. SLIDE 25
    1. Thank you again for watching, and a particular thank you to the institutions who have supported my work and the decades of work that has sustained Portal all these years.