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, using a desert rodent community as a case study.
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 community trade off 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 4
   1. When we see energetic compensation, it has a couple of implications for the types of processes affecting community structure and the stability of community level properties.
   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.
4. 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 but share overlapping traits related to resource use and their fitness under the local environmental conditions.
5. SLIDE 6
   1. I mention current environmental conditions, because as we know, competiton and compensation are inherently temporally dependent processes.
6. SLIDE 8
   1. 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.
7. SLIDE 9
   1. This is the angle that we’re going to dig into further in this talk. Specifically, we’re interested in how changing environmental conditions over time impact energetic compensation.
8. SLIDE 13
   1. We’ll use the Portal Project. The Portal Project is a long-running experiment on desert rodents 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. The core of the Portal Project is a set of experimental exclosure plots where kangaroo rats are removed, to study how the rest of the system responds to the loss of kangaroo rats.
   3. For the rest of the community, first 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.
9. 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. In the plot on the right, the purple section of bar is kangaroo rat energy use, and the yellow is small granivores. You can see that, on kangaroo rat removal plots, the yellow bar is larger – but it’s nowhere near large enough to make up for the energy use lost by removing 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. In this plot, the green bar is the energy being used by Bailey’s. You can see that, on exclosure plots, Bailey’s is making up for most of the energy use that is lost with the kangaroo rats.
10. SLIDE 15
    1. Over the decades, we have observed major environmental shifts at the site, which have had major impacts on the rodent community. Over the course of the study, the community as a whole has shifted to favor small granivores over kangaroo rats. Here we have a plot of the proportion of total community energy being used by small granivores, or all species other than kangaroo rats. These non-kangaroo-rat species have taken over a larger share of energy use over time. 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 that tend to forage in sheltered microhabitats.
    2. Also, most recently, around 2010, there was a period of low plant productivity, a community-wide population crash, and then a period of extended, severe drought. Coming out of that, Bailey’s pocket mouse has become very scarce at the site.
    3. Here we have a plot of the proportion of total community energy being used by Bailey’s over time. 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.
11. 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.
12. SLIDE 17
    1. One possibility is that other species of smaller granivores – the yellow here - have taken over for Bailey’s pocket mouse, and have maintained energetic compensation even though Bailey’s has declined.
13. 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.
14. SLIDE 19
    1. Going to the real results, we found that, since Bailey’s has declined, energetic compensation has declined. You can see here,the yellow and green are still compensating a little bit for kangaroo rat removal, but there is a much greater discrepancy than we saw before.
    2. To put this in more quantitative terms, 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 similar to the compensatory response observed in the decades before Bailey’s established at the site.
    3. 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 loss of energy caused by kangaroo rat removal is much smaller now than in the 1980s and 1990s. That is, because kangaroo rats now account for a smaller proportion of community energy use than they did at the beginning, removing kangaroo rats creates a smaller discrepancy in energy use – even though there hasn’t been an increase in the *proportion* of that discrepancy that is being offset by smaller granivores.
15. 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 the West, Portal has tended towards a more extreme climate in recent years, with longer and more severe droughts.
16. SLIDE 22 ish
    1. At the same time, even though there has been a sitewide shift favoring small granivores in general, no species other than *C. baileyi* has stepped up to compensate for kangaroo rats. Even though we see the baseline habitat conditions and community composition change, we *don’t* detect a change in the zone of functional overlap between kangaroo rats and these other species of small granivores over time.
17. 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.
18. SLIDE 22
    1. This means that a zero-sum 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.
19. SLIDE 23
    1. If this type of context dependence and temporal variability in energetic compensation is common, it means that the ability of assemblages to maintain assemblage-level function despite extinctions depends on both who else is present in that assemblage, and how the functional overlap among those species shifts with changing conditions.
20. 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 3nd, or feel free to reach out to me through email or Twitter.
21. 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.
    2. And, here are references in case you would like to follow up on anything further.