Research Statement- Dr. Christie Bahlai

General interests

I am a highly productive quantitative population and community ecologist who has published more than 25 scientific papers examining processes affecting the dynamics of organisms in disturbed systems. In general, my work focusses on understanding change in dynamic or variable systems- namely developing tools to identify changes in systems with multiple drivers and stochastic dynamics. I have particular interest in dynamics of species with traits that provide important ecosystem functions and services, such as pest control, pollination, and decomposition, in human manipulated ecosystems (i.e. agriculture, parklands, managed forests). My goal is to understand how these communities regulate themselves, how they respond to long-term disturbances, particularly invasions and climate change, and develop robust methodology for quantifying these responses. My research frequently employs large scale, collaboratively-generated databases, which are ideally suited to testing ecological theory and employing novel statistical methods or modeling approaches, and smaller scale, observational and manipulative experiments to refine our understanding.

Research focus

Communities of organisms often contain many functionally similar species. Maintenance of diversity and function within these communities depends on the particular trait in question, the degree of overlap in the functional trait between community members, and other traits possessed by the organisms within the community. In my research program, I study in the maintenance of function and diversity in communities over long time periods, with a particular focus on predator-herbivore and predator community interactions. My research is guided by several key questions.

- **How do communities maintain diversity and function?**
- **How do diversity and function respond to disturbance?**
- **When something changes, can we measure how, and when?**
- **Can we use the patterns in function and diversity recorded in the past to understand the drivers of change?**

Previous work

Insect predator communities often contain many members that are functionally similar. For example, many co-occurring species of ladybeetles share a dietary niche- they prey on small, soft-bodied herbivores- a function that makes them valued as pest-controlling beneficial insects. However, this poses a practical problem for management, specifically - *how do we measure changes to the function provided by a community of beneficial insects if we know community members contribute unequally to predation function*? In my dissertation work, I developed a metric to estimate net community prey consumption rate based on the functional responses of dominant community members (2010, PLOS One), and then developed a density-dependent adaptation of this metric to explain the connected population dynamics of a target herbivore and the predator community over the growing season (2013, Ecological Modelling).

Long-term data was needed in order to test the findings from my dissertation and delve into understanding invasion processes in predator systems. At the NSF-funded Long Term Ecological Research site at Kellogg Biological Station, a simple monitoring program for beneficial insects documents nearly 30 years of the dynamics of a 13 member predaceous ladybeetle community (including invasive species), providing an excellent opportunity to gain insight in the long-term dynamics of this community. Building on my work with within-season dynamics of predation function, I used these long-term data to investigate the long-term delivery of predation function. Interestingly, the invasion of a new, highly voracious yet functionally similar ladybeetle (*Harmonia axyridis*) had little effect on the overall delivery of predation function at the site (2013, PLOS One), however, it dramatically shifted diversity patterns, including changing habitat use of two native ladybeetle species (2015, Biological Invasions).

To link year-to-year drivers of function-diversity patterns to within season dynamics, I began investigating the role of early season interactions within predator communities. Work led by a student under my supervision found that the role of generalist foragers is dramatically underestimated in early-season herbivore suppression (2014, PLOS One). These low-density interactions can result in season-long and even multi-year consequences in the dynamics of both herbivores and the predator community. In a study examining year-to-year dynamics of *Harmonia* and its prey, my co-authors and I found that a short disturbance in the prey's dynamic resulted in a dramatic change to that of the predator's year-to-year population cycling (2015, Ecological Applications). When a management action- a short acting seed treatment that delayed colonization of host plants by the prey aphid- was taken, *Harmonia*'s population dynamics returned to r and K values identical to those prior to the prey aphid's invasion, despite the fact that the prey remained in the system and still routinely reached high densities later in the season.

Ongoing and proposed research

Forecasting diversity responses and function delivery in a disturbed community

Timings of interactions between functionally similar species are potentially sensitive to perturbations like climate and land use change, particularly when many organisms are interacting together. In insect natural enemy communities, the phenology of some members may be predominantly driven by photoperiod, while temperature or other environmental conditions may be the primary driver in other species. When drivers differ, disturbances like climate change could disrupt temporal niche partitioning in these communities, leading to increased competitive interactions between functionally similar species, and resulting in phenological mismatches between predators and prey. For example, for the ladybeetle communities in the US Midwest, I hypothesize that climate warming will exacerbate the negative impact of invaders on native ladybeetle species by increasing its spatiotemporal overlap with species active earlier in the growing season. I further hypothesize that this disruption will lead to greater variability in predation function delivered by the community, due to the capacity of invaders to over-exploit resources, leading to boom-bust dynamics.

Understanding changing function and diversity patterns at scale

Dynamics of populations and communities are most frequently studied over short time periods and at small spatial scales, yet these interactions play out over seasons and generations. Furthermore, research examining the impact of a disturbance to functionally important species is often initiated after the disturbance has occurred- making it difficult to ascertain how the system has changed from baseline conditions. To understand these communities and to adequately assess a disturbance's impact on functions delivered by these communities, both opportunistic use of long term data and robust metrics linking traits to functions are required. Suitable records may occur in a variety of sources: through LTER sites, the National Ecological Observatory Network, in USDA records, in university biodiversity collections, and in grey literature associated with research sites, or, indeed, can be produced through everyday human activities such as vacation photos (2016, Royal

Society Open Science, for example). Through my network of collaborators, I will capitalize on these resources in my research program and expand my work on long term functional dynamics to other taxa and systems. For instance, I currently curate a dataset produced by researchers at the Illinois Natural History Survey (see http://lter.kbs.msu.edu/datatables/122), which documents the abundance of 125 species of aphid over a decade-long period over the US Midwest. To date, these data have largely been used for local agricultural forecasting. Yet, this project presents a considerable opportunity for long term scale phenological modeling and provide an ideal scenario for examining the impact of climate variability on an agriculturally important group of herbivores over a large spatial range. Similarly, I recently began a collaboration with an ecotourism group based in Limuru, Kenya, to track responses to climate variability in host-herbivore interactions in Maasai medicinal plants using data generated by science-based safaris and tourist photos.

Study systems and funding approach

Although my general approach to my proposed research could capitalize on a variety of interactions, insect communities make ideal models to address my research questions. Research on insects in managed ecosystems is highly fundable because it spans basic and applied research. Thus, it is of interest to federal agencies like NSF, USDA, and DOE, as well as collaborations with state departments of agriculture or natural resources and land trusts like The Nature Conservancy. Insect predator-prey systems are ubiquitous, and are present in a wide variety of managed ecosystems, enhancing the feasibility and ease of implementation of new experimental work. However, very importantly, the ubiquity and often economic importance of insect predator-prey communities increases the availability of legacy data or historic observations, making asking questions of scale possible in these systems.

Understanding the drivers of change requires a large scale, collaborative and integrative approach to data. My work in developing novel approaches and infrastructure to support data-driven questions provides another mechanism for funding my program. Data-driven discovery advocacy and development has been well-supported by non-governmental organizations in recent years, with substantial funding available from Moore, Sloan and Gates Foundations. My recent fellowship from the Mozilla Foundation in support of work in this area was funded by the Helmsley Trust.