I am a community ecologist and artist. My transdisciplinary research focuses on understanding and predicting biodiversity maintenance, or coexistence, in natural communities. Understanding coexistence is imperative for predicting the persistence of biodiversity in response to disturbance, anthropogenic or otherwise. I am specifically interested in (1) scientifically testing the assumptions of coexistence theory using a combination of fieldwork, lab work, and simulation modeling, and (2) artistically developing new methods in and outside of science for conducting and communicating about ecology.

I believe that synthesizing observed phenomena with theory is at the core of modern scientific progress. In community ecology, theor(ies) of coexistence use population modeling to predict the persistence of interacting populations of species. Working in global hotspots of annual plant biodiversity, I test if natural communities meet common assumptions undergirding mathematical coexistence theory. To this end, my scientific work has shown:

- How demography varies as a function of environmental variation
- The extent and drivers of variation in population density and frequency dependence
- The spatial and temporal structure of species interactions, and the effects of such structure on demography

This research is crucial in completing the feedback loop between theoretical models and empirical evidence, guiding how coexistence theory can be expanded and/or refined.

I also believe that introducing artistic methodologies into scientific work creates opportunities for innovative ecological research and outreach. Methods and theory develop together out of the conventions and norms of a discipline, orienting how practitioners form questions and frame problems. I contend that we cede scientific advancement when we cede careful attention to our practices of making. Thus far my art practice has:

- Built public ecological engagement through exhibitions relating ecology to urban, natural, and psychogenic environments
- Staged artistic experimentation in ecological methodology
- Extended art-science discourse beyond data visualization

These efforts guide ecology toward more socially engaged and creative research, which I believe is vital for combatting widespread ecological blindness and the consequent loss of biodiversity through environmental destruction.

ECOLOGY AS SCIENCE AND ART

Balancing the progression of "normal science" with creative departures from convention creates tension that is essential to the advancement of scientific thought. The recent and reciprocated interest of ecological science in ecological art represents a promising turn towards such creative departures. Though nascent, the contours of art-science integration in academia suggest it is an effective strategy for improved pedagogy, outreach, and environmental justice efforts. While avocational interest in art has been linked to features of highly creative and inventive thought in science– Nobel winners often have artistic practices -- the formal integration of art in ecological research itself is far less developed, and often superficial in treatment. Below I outline three themes of my research that span scientific inquiry and artistic practice to expand and deepen the scope of ecology as a discipline. Work that I plan to conduct with students in my first three years at Deep Springs is in bold text.

<u>I. Science & Art: Linking pollinator population demography with plant coexistence in long-term ecological research</u> Understanding how plant and pollinator demography vary through time and space is fundamental for an accurate picture of diversity maintenance in natural communities. Long-term demographic research in plants is rare, but still more common than corresponding demographic studies of pollinators, even though 90% of flowering plants rely on animal pollinators for reproduction. Studies that track how populations of bees and their flowering plant mutualists covary through space and/or time are nearly nonexistent. My research in this domain has two overarching goals: (1) unite pollinator population demography with plant coexistence modeling to understand plant-pollinator biodiversity dynamics, and (2) to leverage sci-art methods for ecological outreach and engagement.

Previous work Successful application of theory to natural communities requires a solid foundation of both natural history research and mathematical modeling. I showed using simulation modeling that populations of co-

occurring annual plant species will mutually ensure each other's long-term persistence if they negatively covary in response to environmental variation through time and share a mutualist pollinator (James 2023, *Proceedings of the Royal Society B*). For such facilitation via pollinator support to proceed, the costs incurred by growing together (locally and within a growing season) must be low enough to prevent competitive exclusion. My empirical research establishes the possibility for facilitation via pollinator support in a group of four sympatric annual plant species in the genus *Clarkia* (Onagraceae): abiotic competition between species is negligible (James and Geber 2025, *Ecological Monographs*), and while *Clarkia*'s shared bee pollinators may introduce some competition (James, Geber, Toews 2022, *Molecular Ecology Resources*), neither local abiotic competition nor local pollinator-mediated competition among co-occurring *Clarkia* are strong enough to affect plant fecundity (James and Geber, 2025 *Ecological Monographs*). This body of research shows how shared pollinator populations are likely to affect flowering plant coexistence in natural communities. Its novelty is in demonstrating that pollinator sharing may affect plant coexistence via a facilitative effect on mutual persistence through time, rather than being a strong driver of competition within a growing season.

Future directions I will conduct demographic research on *Clarkia* and their specialist bee pollinators to test the facilitation via pollinator support hypothesis. *Clarkia* pollinators are predominantly ground-nesting bees, and recent advances have made the prospect of experimentally studying ground nesting bee demography viable. Conducting research in locations with long-established research populations of *Clarkia* in the Kern River Canyon (KRC) region of southern California, my aims are to:

- **In the field, estimate bee population demographic rates in *Clarkia* communities, determining environmental covariates of these rates**
- Use a combination of extant long-term field data from *Clarkia* populations and growth chamber experiments to predict the extent to which *Clarkia* species' demographic rates covary in response to environmental variation
- Parameterize a model of *Clarkia* and their bee pollinators to determine if facilitation by pollinator support is strong enough to drive *Clarkia* coexistence
- In the long-term, test the predictions of the model using ecological measurements of *Clarkia* community diversity, abundance, and pollinator population size through time

This research will impactfully marry pollinator demographic research with a model system in flowering plant research to understand plant-pollinator diversity maintenance. Along the way, it will help fill the dire gap of information about basic wild bee ecology and demography necessary for guiding pollinator conservation efforts.

Ecology as a socially engaged art practice Throughout art history, the walk as a medium has been used to explore the relationship of body to the environment. Walking is also a method for conducting ecological fieldwork. My eco-art work has used guided walking to encourage ecological connection to landscapes (e.g. *Land Portal* (2025) and *Shoreline Dérive* (2023)). Anecdotally, walking repeatedly along the same paths also disturbs soil in such a way that ground-nesting *Clarkia* bees find attractive for nesting (James, *pers. obs*). To complement the scientific research proposed above, I will hold a series of workshops about the ecology of KRC with local students and community members. I will then plan a set of transects through the landscape, where the shape/design of the transects will be informed by workshop discussions. I will invite the community on walks along these transect paths, co-led by members of my research team and leaders in the community. Participants will be invited to make ecological observations as we walk. In disturbing the ground, our activity will create areas along which bees may nest. These community walks will create an ephemeral art installation that will be visible using satellite imagery (see, for example, *Kingsnake* (2019)). In addition to serving as pilot transects for searching for new research sites, the form of this work will call to mind ancient geoglyphs. In its execution, the work will constitute citizen science and outreach as socially engaged eco-art. The documented results will be curated for exhibition and display locally in the KRC and at Deep Springs College.

II. Science: Testing coexistence assumptions for better predictions of diversity maintenance. Explaining and predicting how biological interactions shape patterns of diversity is crucial for understanding the long-term stability of biodiversity. Community ecology places particularly high value on the correspondence between mathematical models and empirical research. However, mathematical models can struggle to accurately predict coexistence.

Previous work Refining coexistence theory into something that is explanatory and predictive of diversity maintenance requires testing the validity and ubiquitousness of model assumptions. For example, theoretical

work shows that spatial coexistence can operate if co-occurring annual plants spatially partition germination rates. My experimental work demonstrates that spatial variation does in fact differentially affects species' germination, and thereby population growth rates, in an annual plant community (James et al. 2020, *Journal of Ecology*); such confirmatory evidence motivates ongoing efforts to develop the mathematical tools necessary to assess spatial coexistence. I have also discovered apparent departures from common model assumptions, showing for example that plant fecundity commonly exhibits non-monotonic (hump-shaped) patterns of density dependence (James et al. 2023, *Ecology*), a finding that strains a foundational assumption of coexistence models that growing alone is better than growing with neighbors. I also explore both spatial scale and facilitation (i.e. the positive effects of co-occurrence on performance) as potentially foundational for understanding plant coexistence, despite being mathematically underdeveloped in theory. My experimental work shows that local and large-scale spatial variation jointly contribute to structuring annual plant demography and community diversity, providing evidence that coexistence is a larger-than-local phenomenon (Siu et al., *submitted*). Furthermore, I lay out an argument and approach to enact "facilitation thinking" in coexistence theory, addressing the longstanding issue that positive interactions rarely factor into coexistence analyses (James et al. 2025, *Ecology Letters*).

Future directions Understanding the extent to which natural communities depart from theoretical assumptions is crucial for building models that are accurate, predictive, and fruitful for studying biodiversity maintenance. My future research under this theme will:

- Quantify variation in annual plant performance as a function of spatial environmental variation and scale using data from recently concluded experiments in southern California and Western Australia
- **Build a global, collaborative repository of plant performance data in response to neighborhood density to characterize variation and patterns of density dependence, with particular focus on facilitation**
- Use simulation modeling to determine the extent to which departures from model assumptions change our predictions of coexistence

This research is essential for building theory that is informed by and speaks to empirical realities.

III. Art: Artistic research for ecological theory and outreach Feminist scholarship proposes that leveraging alternative training may enlighten our understanding of non-epistemic influences shaping ecological theory (Simha et al. 2024, *Bull. Eco. Soc*). Being aware and intentional about how these influences shape scientific practice is of increasing value to ecologists; for example, incorporating traditional ecological knowledge has made for stronger, more socially engaged ecological research. Similarly, art can be used to engage with different ways of developing, taking and sharing ecological perspectives in and outside of scientific and academic domains.

Previous work My art practice explores how ecology can be conducted to expand both scientific thought and ecological literacy in the public sphere. This has ranged from making interventions in experimental design to probe the relationship of scientists to landscapes (i.e. designing field experiments as land art: *Bodysnatch (Bush conspiracy)* (2021); *Who's the loneliest?* (2020)), to exhibitions, installations, and public events that encourage ecological awareness for non-ecologists. For example, I created a sculptural prosthesis for microbial communities to move at the scale of human perception (*Eros Feeding Thanatos Feeding (Eros)* (2023)); exhibited series of works about ecology, memory, colonization and indigeneity of the MIT landscape (*shore/lime/line/light* (2023)) and designed an walk for ecological attunement through an art sculpture park (*Land Portal* (2025)).

Future directions The aim of this theme is to use art to gain new perspectives for scientific research and outreach; however, research outcomes are less predictable in art as compared to science. In the near future I will:

- Work with collaborators in Guatemala to generate new orchid "hybrids" using machine learning algorithms (*Bolus* (2025)). These forms will be 3d printed to explore the use of AI in generating biological form. Beginning as artistic investigations to produce art objects, it will form the groundwork for conducting structured scientific research into orchid reproduction and pollination biology.
- **Develop art-science collaborations with Deep Springs colleagues for exhibition in and outside of academic and scientific contexts**

The promise of this work is to engage the public with ecology while expanding the scope of ecology as a discipline.