Biologists and Graph Interpretation Network

When Food Gets Scarce: How Plant-Pollinator Interactions Will Shift Under Global Change

A BioGraphI Module Lesson Guide for Instructors

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Course Information
Department/Program: University of Louisville
Level: Introductory
Course type: Lecture
Delivery mode: In-person
Students: Undergraduate majors
Number of students: 20-30, max students = 100
Estimated duration of activity: 60-75 minutes

Expected date or dates of implementation
TBD

Purpose/Background
An in-class activity during a community ecology unit of Introductory Biology for majors or Population and Community Ecology

List of materials needed for the lesson
- Link to interview on Youtube (total running time: 19:57)
  - BioGraphi Interview with Connor Morozumi
- Link to presentation slides
  - Throneburg_Biographi_Presentation

About BioGraphI modules

This lesson is a BioGraphI module. BioGraphI modules address data literacy while fostering diversity in undergraduate biology classrooms. They are lessons about graph and data interpretation, featuring the scientific contributions of biologists who are members of historically excluded groups (HEGs). They include video interviews with these biologists, allowing students to hear directly from HEGs about their discoveries. For more information about how the BioGraphI project is advancing inclusion in biology and improving data literacy, visit our webpage.

Student Learning Objectives

The BioGraphI Student Learning Outcomes (LOs) describe what students can expect to gain by the end of the BioGraphI lesson. They are written in a format that can be shared directly with students.

Content learning objective(s)

1. Explain how plant-pollinator interactions are affected by global change
2. Define and explain mutualistic relationships between plants and pollinators
3. Apply species composition concepts to species interactions

Quantitative learning objective(s)

4. Interpret box plots related to visitor richness and abundance.
5. Reflect on your perceptions about using graphs or figures in biology.

Diversity/equity/inclusion learning objective(s)

6. Reflect on your perceptions of people who do biology.
7. Compare your own interests and/or identities to those of people who do biology.

Assessments

To help the BioGraphI Project to measure the effectiveness of our modules in improving data literacy and fostering diversity in biology classrooms, we invite your students to participate in a voluntary, anonymous pre-/post-lesson survey (Geneseo IRB #202021048). This survey is designed as an opportunity for reflecting on the Quantitative and D/E/I learning objectives above and administered via LimeSurvey. Click Instructions for access to BioGraphI PrePost-Lesson Student Survey to request a survey to be set up for your students, at least 7 to 10 days in advance of your class meeting date.

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Objective(s)	Formative Assessment	Summative Assessments
1 ,2, 3	Pair/group discussions	Multiple choice exam questions Short answer exam questions
4	Students make predictions of box plot structure	Multiple choice exam questions
5	BioGraphI Student Pre-Lesson Survey (link for instructions to access survey)	BioGraphI Student Post-Lesson Survey (link for instructions to access survey)
6, 7	BioGraphI Student Pre-Lesson Survey (link for instructions to access survey)	BioGraphI Student Post-Lesson Survey (link for instructions to access survey) Short answer exam question

Lesson context

Learning goals of unit

- The application of species composition and diversity concepts to species interactions fits into a general ecology course unit of Species Diversity in Communities where the goals are to have students understand how multispecies communities are structured
- Understanding the plant-pollinator mutualism could fit into a unit on species interactions and specifically mutualisms. Here the goals would be to outline +/+ interactions and have students be able to define what constitutes a mutualistic interaction and explain how the benefits for both species (or groups) differ (e.g., the plant receives pollination services while the pollinator receives nutrition)

Prerequisite skills or knowledge

- Cursory understanding of plant reproduction (i.e., plants need gametes (pollen) to be moved from plant to plant to successfully sexually reproduce)
- Previous exposure to diversity concepts in community ecology (i.e., species richness, abundance, community composition)
- Familiarity with global change ecology (climate change, pollution, habitat loss) and examples (e.g., drought, increased fire intensity / severity, increased flooding)

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Preparation for lesson

- Assign BioGraphI Student Pre-Lesson Survey as homework for students to complete before this in-class activity.

Lesson sequence

Each row of this table is a step of the activity. Column headings reveal what the instructor, interviewee, and students do at each step.

Information from instructor (live in-class)	**Information from scientist (within pre-recorded video interview)**	**Student follow-up or transition activity**
Prior to class, assign the BioGraphi Student Pre-Lesson Survey	N/A	**Activity:** Complete pre-lesson survey for BioGraphi project (combination of reflective writing prompts and close-ended questions) ● *Purpose*: prepare for class; LO 5 & 6 - Pre-lesson reflection on data literacy and perceptions of scientists

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Introduce lesson, learning objectives, present slides 4-6	N/A	N/A
Present slide 7 and ask students questions on the slide	N/A	**Activity:** Predict how global change may affect plants and pollinators ● *Purpose*: Warm-up and icebreaker, rewards creativity ● Can be run as a think-pair-share (TPS) or call-out group discussion

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Present slides 8 & 9, incorporating student responses to slide 7 questions if applicable	N/A	N/A
Present slide 10, reviewing community structure terminology. On Slide 11, ask students to think of these terms in terms of plant-pollinator interactions On Slide 12, review definitions of visitor richness, abundance, and community composition of visitors	N/A	**Activity**: Review community structure terminology and predict what terms mean in relation to plant-pollinator interactions. ● *Purpose*: Provides opportunity for students to apply previous knowledge to new content; LO 3- Apply species composition concepts to species interactions ● Can be run as a think-pair-share (TPS) or call-out group discussion

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On Slide 13, prompt students to reflect on how visitor richness, abundance, and community composition change under drought		**Activity:** Individually reflect on how plant-pollinator interactions change under drought ● *Purpose*: Transition to activity in slides 14,15; LO 1 - Explain how plant-pollinator interactions are affected by global change
Present Slides 14 & 15 When responding to students' answers instructors should guide / respond to answers as appropriate. ● Drought made most of the other floral resources scarce while the red flower species remained abundant. This would cause pollinators to potentially switch to visiting red ● Remind students that for this scenario the amount of pollinators is constant and is not affected by the drought ● Our predictions then are that both richness	N/A	**Activity:** Make reasonable predictions to what will occur when floral resources decrease in response to drought ● *Purpose*: Check student understanding of community ecology concepts (e.g., visitor richness, LO 3) and student intuition / problem solving about making ecological predictions about plant-pollinator interactions under global change (LO 1) ● TPS, ask probing follow-up questions testing / asking for why students made specific predictions

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and abundance of pollinator visitors to red species would increase		
Slides 16 & 17: Play first video segment	***Required interview Q.*** Tell me about the research that these data came from ● Emma introduces Dr. Morozumi, who provides a background of the project	N/A

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Present slides 18 - 20	N/A	N/A
Slide 19: Orient students to empty box plot and axes, prompt students to predict box plot structure	N/A	**Fundamental activity:** Make reasonable guesses to what the graph is about, share out ● *Purpose*: Rewards creativity, normalizes errors (nearly impossible to be correct) **Advanced activity:** Make the graph using the data

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Slide 22: provide completed box plot figure and prompt students to reflect on their predictions Slide 23: Play video segment	***Required interview Q.*** Orient us to this graph we've been working on. ● Dr. Morozumi describes the results of the box plot	**Fundamental activity:** Students interpret/re-interpret the box plot from the study. Infer the hypothesis that was studied. Evaluate whether or not the hypothesis was supported. Share out. ● *Purpose*: LO 4 - Check student understanding **Advanced activity**: Students compare the graphs they made to those described by the interviewee ● *Purpose*: LO 4 - Check student mastery
Slide 24: Provide brief overview of NMDS Slide 25: Orient students to NMDS figure from study Slide 26: Play video segment	***Required interview Q.*** Orient us to this graph we've been working on. ● Dr. Morozumi describes the interpretation of the NMDS plot	**Activity:** Discuss with a neighbor what the points on the NMDS figure being more spread out during drought years means for community composition

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Slide 27: Briefly explain study results, play video segment	**Required interview Q.** What were the results of the study? ● Dr. Morozumi explains results	N/A
Slide 28: Prompt students to brainstorm answers to question on slide		**Activity:** Connect benefits of plant pollinator interactions from beginning of lesson to study results and brainstorm consequences of changes to these interactions due to climate change ● *Purpose*: Students connect results of this study to lesson concepts, LO 1 ● Can be run as a think-pair-share (TPS) or call-out group discussion

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Slide 29: Play video segment	**Required interview Q.** What's the significance of these findings? ● Dr. Morozumi explains significance of results	N/A
Slide 30: Prompt students to answer questions on slide	N/A	**Activity:** Describe how another global change event might impact plant-pollinator interactions. Identify a way you can test your idea. ● *Purpose*: Have students think creatively and apply concepts about how resource availability shapes the diversity and composition of species interactions. Have students begin to think like ecologists trying to test community ecology questions of their own. ● Can be run as a think-pair-share (TPS), call-out group discussion, alternatively can be assigned as a check-out end of lesson or take-home homework assignment

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Slide 31: Play video segment	**Required interview Q.** Describe future research directions/follow-up experiments**.**	N/A
Slide 32: Prompt students to answer questions on slide	N/A	**Activity**: What questions do you have about [scientist]'s path to this work/where they are today? Share out. ● *Purpose*: LO 6 & 7 - Identifying potential connections between students and scientist

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Play remaining video segments (slides 33 - 38) Must show the answers to at least the required interview Qs to students	***Required interview Qs*** **What kinds of scientific questions interest you the most?** **When and how did you know you wanted to be a scientist?** **Tell us about the paths that led you to your current job.** **What is it like being a scientist with [counterstereotypical identity or background]?** **Tell me about a moment when you felt like you really belonged in the field of science.** *Strongly suggested Q* How do you balance work with other interests?	*Purpose:* Answers the questions identified by students
Instructor shares contact info (twitter, email, etc) of scientist so that students can ask leftover questions! #BioGraphI...		Students ask their questions during class (or homework!) ● *Purpose*: LO 4 - Identifying potential connections between students and scientist. Closes the in-class portion of the lesson.

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Instructor could provide other resources on scientist (e.g., website, papers, etc.)	N/A	Students complete homework/post-lesson survey for BioGraphI project (combination of reflective writing prompts and closed-ended questions) ● *Purpose*: LO 5-7 – Post-lesson reflection on data literacy and perceptions of scientists

Alignment to Universal Design for Learning Guidelines

UDL Guideline	**Lesson Alignment**
Multiple means of Engagement	Self-regulation: Students reflect on their dispositions and knowledge of scientists and graph interpretation before and after the lesson Recruiting interest, Minimize threats and distractions: Students are provided safe ways to participate in group discussion via think-pair-share activities Recruiting interest, Optimize relevance, value, and authenticity: Students are given the opportunity to choose another climate change stressor (e.g., land-use change, fire, flooding) to predict how this will change plant-pollinator interactions and how they would test for the effects of this stressor

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Multiple means of Representation	Perception: Captions are provided on the interview video. Google Slides offers automatic captioning for presenter. Alt text for images provided in Google Slides. Comprehension: Background knowledge is supplied and applied to a new context. Discussion prompts guide information processing for graph interpretation.
Multiple means of Action and Expression	Expression & communication: Multiple types of media are used in the lesson (visual, audio, text).

Implementation notes

References/resources

Endres, K.L., Morozumi, C.N., Loy, X. *et al.* Plant–pollinator interaction niche broadens in response to severe drought perturbations. *Oecologia* 197, 577–588 (2021). https://doi.org/10.1007/s00442-021-05036-0

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Transcript of interview

0:00-1:23
Emma Throneberg (ET): Hello everyone, I'm Emma Throneberg, a PhD student at the University of Louisville. For this BioGraphI interview, I'm talking today with Dr. Connor Morizumi, who is a postdoctoral fellow at the University of Louisville. Welcome Connor!
Connor Morizumi (CM): Yeah, thanks Emma. Thanks for having me!
ET: Thanks! Connor is a first author on a paper titled Plant-pollinator interaction niche broadens in response to severe drought perturbations, published in Oecologia. Today we'll talk about the research from that paper and learn more about Connor's life as a scientist. So Connor, can you give us a brief background on your study?
CM: Yeah for sure, so we know that climate change is impacting species across the globe. One thing I'm very interested in is understanding how climate change will impact not only individual species, but also the species interactions that species relies on. So this particular study was on plants and pollinators in the Rocky Mountains of Colorado and we compared a pollinator visitation to a focal plant species called scarlet gilia in drought years and non-drought years to understand this feature of climate change that might be impacting plant pollinator interactions now and into the future.

1:28-2:40
ET: So what is this boxplot telling us?
CM: Yeah, so here we're looking at pollinator or visitor abundance and richness to our focal plant scarlet gilia in drought and non-drought years and we've plotted the raw data as scatter points and then summarized these data points into a box plot and box plots can help to understand where the the bulk of your data is distributed, right, so the thick bar across the center of the box is the median for the sample and the box itself represents the middle 50% of your data. So in panel A of this graph, we see that pollinator visitor abundance in the drought years which are in yellow and on the right is higher than in the non-drought years which are in purple and on the left of each panel. And in panel B, we see that visitor richness so that's the number of different pollinator species or visitors that we sought the scarlet gilia was also higher in the drought years versus the non-drought years.

2:45-5:05
ET: And what is this NMDS plot telling us?
CM: Yes, so in this study, we wanted to know if on the whole the community composition of pollinator visitors to scarlet gilia differed between the drought and non-drought years. So to visualize this, we created an ordination which is the kind of graph that an NMDS is and an ordination plots this similarity between each site and each here so each sample unit or dot on the graph in this study is a site in a particular year. So this graph shows us our sample units in composition space of their visitors, so on a whole who visited scarlet gilia at that site in that particular year. So the points in an organization which are close together are going to be more similar to one another, in terms of the visitors to scarlet gilia and the points farther away on this graph from each other are more dissimilar. On top of that, we plotted where in this sort of visitor compositional space the visitor categories are in their highest abundance. For example, sample

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units that are closest to the word hummingbird on the graph are going to have more hummingbird visits to scarlet gilia than sample units farther away from that label, right, and then we've also plotted these colored ellipses and those kind of represent the standard deviation of drought and non-drought site averages in terms of their composition with these we get a sense of kind of where the the bulk of our data is in each of those non-drought, drought years. And so what we can see in this graph is we see a lot of overlap, in fact, when we compare the drought and non-drought compositions of visitors we don't see a statistical difference, what we do see in this plot though is a bigger spread in the drought years versus the non-drought years this indicates a substantial variation in community composition across sites within drought years.

5:12-5:45
ET: So what were the results of the study?
CM: Yeah, so in this study we found that plant pollinator interactions can exhibit considerable plasticity in response to disturbance, in this case, drought disturbance. And specifically found that in response to drought, pollinator visits to our focal plant scarlet gilia were more varied and more abundant. Therefore we're titling this an interaction niche and that interaction niche expanded in response to drought.

5:51-8:04
ET: Can you explain the significance of this research?
CM: Yeah, we really don't have a good sense of how species interactions are going to change in response to climate change and this makes it hard to predict and conserve individual species facing this profound new world, right? So here we made some predictions of how we thought drought might affect pollinator behavior due to alterations to their floral resources, right? Drought drastically reduces the number of flowers on the landscape, that we found that pollinators altered their foraging and thus scarlet gilia was being visited by a more diverse and abundant suite of visitors or pollinators could really have large implications for this one species of plant. On the one hand, this could be beneficial for plant success, right? Pollination services by pollinators helps plants move around their pollen and gametes and so you could think that having more pollinators might be good for you, right? You're increasing the number of your pollen grains being deposited to other scarlet gilia, increasing the number of progeny, and continuing that population into the next generation. Alternatively, we know that as plants get visited by more pollinators that are also visiting other plants, right? In this diverse community, you can see behind me, we've got an example of one of our sites that this study took place at and this is not just you know one species living on its own, it's embedded into a community. And so as we get pollinators who are also visiting other plants, we run the risk of getting the wrong species of pollen dropped off by pollinators and so that is a prediction that could come true as you get this sort of jumbling up of pollinator visitors due to drought.

8:10-10:09
ET: Can you describe any potential or actual follow-up experiments to this project?
CM: Yeah, so one thing this study did was focused on just one species of plant, right, scarlet gilia and that was because to get a data set like the one we needed. We need multiple drought events across multiple sites and that's a data set that's hard to find. We did follow up this work

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with a network study of the entire community a few years later that made similar predictions, but now on the scale of the entire community, so all the plants in these sites and all the pollinators that visited them so I think that's a really nice extension of this first work. There's also some really cool work continuing at the Rocky Mountain Biological Laboratory, where this work took place. Looking at how important pollinator visitation is for the reproductive success of plants including scarlet gilia, right? Plants are not just dealing with the changes to their species interactions, they're also dealing with drought stress and physiological changes so you know in this current study we looked at visitation as a proxy for pollination services. When we see a visit to a flower we're assuming that was a pollination event, but we know that's an imperfect proxy. Not all visitation events are useful to a plant and so it would be really awesome to follow up some of this work with looking at pollinator effectiveness, we know that some pollinators are really good, effective pollen transporters like bees are very good at moving pollen around while other visitors are not so great.

10:11-11:44
ET: What kind of scientific questions interest you the most?
CM: Yeah, as some of my previous answers have probably indicated, I'm really interested in species interactions and especially mutualism, so these interactions where both partners in their interaction appear to be gaining from that interaction. I've taken a bit of a turn since this work, which was part of my PhD and in my current work I'm looking at mutualisms using plant fungal interactions which allow us to manipulate the partnerships, in ways that are very challenging for bees and plants in high elevation meadows. I also think of myself as a community ecologist and so I'm drawn to questions about multispecies interactions and throughout my career, I've been interested in understanding how global change is going to shape species interactions and so you know this work is firmly in that interest as well. I'm really wondering and interested in how we can understand species interactions like mutualism and with the hope to make better predictions of how we mitigate the effects of climate change on vulnerable species, communities, and ecosystems.

11:54-12:50
ET: So when and how did you know you wanted to be a scientist?
CM: That's a hard question. Sometimes I don't know if I've always or if I've struggled every day wondering if I am a scientist. I think maybe one example, I didn't know really I made a switch sort of late in my undergraduate career I was premed and actually got a health science degree before kind of gradually figuring out that I didn't want to be in healthcare studies and I did a study abroad program in tropical biology, really sort of cemented to me that I wanted to be an ecologist and that like being a scientist sort of matched my interest better.

12:56-14:20
ET: Tell us about the path that led to your current job.
CM: Yeah so I did that tropical bio study abroad and came back to UC Santa Cruz, where I was doing my undergrad and knew that I wanted to be more involved in ecological research. I became a research assistant and then a lab manager for a lab there that was doing really cool biodiversity ecosystem function research, as well as species conservation research, looking at

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some impacts of anthropogenic change to ecosystems like nitrogen, fertilizer, deposition, and pollution. From those experiences, I realized that I really wanted to focus on species interactions in community ecology and specifically wanted to learn more about mutualisms and so for my PhD, I focused on plant-pollinator interactions, where this lesson comes from and then by the end of my PhD I realized I really wanted to find systems where we could manipulate them with a bit more ease. Jury still out if plant fungal interactions are that, but I'm enjoying it so far, so yeah that's led me to my current postdoctoral research right now.

14:28-16:23
ET: You've mentioned previously that you identify as a queer ecologist, can you share your experience with this?
CM: Yeah I think in many ways the field of ecology has largely felt really supportive of me as a queer scientist. I transitioned in my graduate training and that was mostly a positive experience, I do think that this varies widely across programs and locations for folks, but I felt pretty fortunate to conduct my field research during my PhD at Rocky Mountain Bio, the field station was a really inclusive space and one that also recognized and was willing to do better on certain like policies and practices you know. We know that STEM fields can be isolating for people with queer identities and that trans and gender non-conforming folks don't tend to persist in STEM fields at the same rates as their cisgender peers so I think that there's still work to be done in this in this realm, but I've found ecology to be on a more progressive side of of STEM field. My identity does give me pause in terms of where in the world I would feel safe enough to be a scientist, right now so friends and gender non-conforming folks are living through a pretty scary moment and while that's not exactly related to my career as a scientist it does you know limit where I can feel safe enough and feel like my rights aren't going to be taken away and it does shape like the kind of scientists that I can be and where I can be in the world.

16:41-18:42
ET: Tell me about a moment that you felt like you really belonged in science.
CM: Yeah good question, I think maybe this is kind of counterintuitive, but when I was finishing up one of my undergrad degrees, in health science, I had to do an internship in my last year and it was you know in a hospital setting, where I was shadowing a doctor and scrubbing in for these procedures and I was not loving it and there was in my mind, so little creativity and curiosity in it and I already knew that healthcare settings probably wasn't for me but in that moment I just felt like maybe I belonged in science because I was experiencing other possible STEM paths. I had picked up the second environmental studies degree and was already in the ecology lab doing research where I just saw a lot more creativity and ingenuity happening around you know the grad students and postdocs and the advisor in the lab. I guess for me sometimes to feel like you belong somewhere it's useful to sort of be removed from that environment and I felt in my path there was a lot of inertia for bio students to just be premed without really exploring or knowing what the other option career options out there look like and I'm glad I searched around and I'm really glad that I did the tropical bio study abroad and found something that fit my interest and my personality better.

18:52-19:46

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ET: How do you balance science with other interests?
CM: Well actually I think that maybe I have few many hobbies, some people in my life would argue that but I do think on the whole ecologists often do a better job than average in kind of balancing science and outside interests. For me, I do enjoy a lot of non-science things, so I do a lot of rock climbing and recently more like arts and crafts type things, getting into making things with my hands which just kind of new, lots of some ill faded wood furniture projects and some sewing projects and recently got into some drawing and some watercolor as well.

19:48-19:57
ET: Well great, thank you for sharing your experience with us Dr. Morizumi.
CM: Yeah, happy to do it. This is fun!

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