INTRODUCTION

For the Special Issue: Plant–Environment Interactions: Integrating Across Levels and Scales

Novel methodologies to disentangle plant–environment interactions

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INTRODUCTION

Due to their sessile nature, plant species are forced to interact with the biotic and abiotic factors of their surrounding environment, forming complex webs that either promote or inhibit growth and reproduction. These intricate interactions may be expressed at different trophic, spatial, or temporal scales. Consequently, the evolutionary history, community structure, and geographical distribution of plant species are shaped by their interactions with the surrounding environment. Therefore, plant–environment interactions are integral components of a wide array of plant-based disciplines, and the researchers trying to untangle these complex webs may employ a variety of methodologies to address their questions of interest.

Different facets of these plant–environment interactions take the stage in this unique collaboration between three academic journals: the International Journal of Plant Sciences (IJPS), the American Journal of Botany (AJB), and Applications in Plant Sciences (APPS). Manuscripts contributed by IJPS focus specifically on the paleobotanical (edited by Dr. Selena Smith, University of Michigan) and morphological (edited by Dr. Dan Chitwood, Michigan State University) aspects of the plant–environment spectrum. Contributions from AJB focus on three subjects pertaining to plant–environment interactions: plant responses to stressful environments (edited by Dr. Regina Baucom, University of Michigan), environmental impacts on plant–microbe mutualisms (edited by Dr. Katy Heath, University of Illinois), and changes in plant reproduction driven by environmental conditions (coedited by Drs. Regina Baucom, Jannice Friedman [Queens University], Katy Heath, and Sharon Kessler [Purdue University]).

Given that APPS is a journal dedicated to newly developed methodologies and protocols, the articles featured in this issue focus on new ways that researchers are investigating plant–environment interactions. In general, a variety of approaches are used to understand the degree to which environmental factors impact various aspects of plant biology. Techniques can be used in the field, in a laboratory setting, or may even be computational in nature. Collectively, these methodologies are useful for the investigation of plant–environment interactions under a variety of temporal and spatial scales. The three articles summarized below feature novel approaches used to examine plant–environment interactions under contemporary, paleobotanical, and future scenarios.

FIELD-BASED MANIPULATION

Methodologies used in the field to examine plant–environment interactions may involve the manipulation of a single environmental factor. These approaches are especially common when the goal is to examine plant responses to global climate change. For instance, manipulations in the field may be undertaken to simulate elevated drought conditions in areas where this is predicted to occur. However, these approaches are often expensive, labor intensive, and only suitable for certain types of plant species. Cranston et al. (2020) specifically discuss the difficulties in simulating drought conditions in a dense mature forest composed of large trees. To study the impacts of drought on the charismatic conifer Agathis australis (D. Don) Loudon, the authors developed a novel, inexpensive
A novel throughfall exclusion design is collapsible and portable, making it relatively easy to transport, which is critical when working in complicated terrain. The authors installed a variety of data loggers to determine if the design does in fact simulate drought conditions and if the trees exhibit any responses that differ from control trees. Roughly one year after installation, Cranston et al. found differences in soil moisture patterns between control and drought-induced trees, as well as differences in physiological responses between these two treatments.

**COMMON-GARDEN ENVIRONMENTAL SIMULATION**

Members of the family Apocynaceae are notorious for their complex floral morphologies and intricate pollinator interactions. Insects of different guilds are known to visit the flowers of different species in this family; however, these visitors differ in their probability of effectively pollinating a particular species. After documenting plant–pollinator interactions in the field, Koptur et al. (2020) set out to determine which visitors may be the most effective pollinators for three Apocynaceae species by simulating pollination events in a common garden setting. Four different diameters of fishing line were used to mimic the proboscis widths of different insect visitors originally observed in the field. Pollen capture was estimated by inserting 12 cm of the four different fishing lines and counting the number of pollen grains obtained by each, while pollen deposition was determined by the amount of area stained by each of the four different fishing lines when preloaded with pollen and subsequently dyed. The authors found a significant relationship among plant species and the number of pollen grains captured by each line. They also uncovered differences in pollen deposition among plant species and line diameters. These results suggest that fishing line may serve as a useful and inexpensive proxy when trying to disentangle plant–insect interactions in search of effective pollinators.

**PREDICTING PALEO-ENVIRONMENTS**

Computational modeling has become a widely used tool for examining plant–environment interactions across a variety of temporal scales. Most readers will likely be familiar with species distribution models, which are commonly used to understand how plants interact with environmental factors, such as temperature and precipitation, and how their distributions will shift in the future as these factors change. By utilizing contemporary community records, Harbert and Baryiames (2020) have demonstrated that their new R package, cRacle, reliably estimates a variety of temperature and precipitation conditions. The authors especially encourage those working in the paleobotanical community to utilize this package to estimate climatic conditions of the past based on the fossil record.

Plant–environment interactions are complex and multifaceted, spanning trophic levels as well as spatial and temporal scales. Novel methodologies are critical to advance our understanding of these interactions and how plants respond when shifts occur. The articles featured here highlight some of the new ways that researchers are investigating these relationships, which will help address a broad array of plant biology questions.

**ACKNOWLEDGMENTS**

Many thanks to Drs. Regina Baucom, Robert Grese, Cora McAllister, Jillian Meyers, David Michener, and Selena Smith (University of Michigan) for initiating this cross-journal special issue; Dr. Theresa Culley (University of Cincinnati, editor-in-chief of *Applications in Plant Sciences*) and Beth Parada (managing editor of *Applications in Plant Sciences*) for their editorial assistance and expertise; and Dr. Chris Caruso (University of Guelph, editor-in-chief of the *International Journal of Plant Sciences*) and Dr. Pamela Diggle (University of Vermont, editor-in-chief of the *American Journal of Botany*) for their contributions to this special issue. Finally, many thanks to all of the individuals who assisted with the review process.

**LITERATURE CITED**

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