Effects of Global Change Drivers on the Susceptibility of Wild Plants to Pathogenic Diseases

Syeda Aiman Nadeem[1], Theresa Konnovitch[2], Mark Nessel[2], Angélica González[1,2]

1. Department of Biology, Rutgers University, Camden, NJ.
2. Center for Computational and Integrative Biology, Rutgers University, Camden, NJ.

Background

- Human activities have intensified over the last two hundred years, resulting in major global environmental changes, which are negatively affecting Earth's ecosystems.
- Major drivers of ecological changes:
  1. Warming (Figure 1)
  2. Nutrient enrichment
  3. Shifts in precipitation levels
- These drivers have been shown to severely affect plant-pathogen interactions and the extent of disease they cause (Figure 2).
- Pathogenic diseases affecting plants are predicted to disrupt the functioning of ecosystems and the services they provide to human populations.

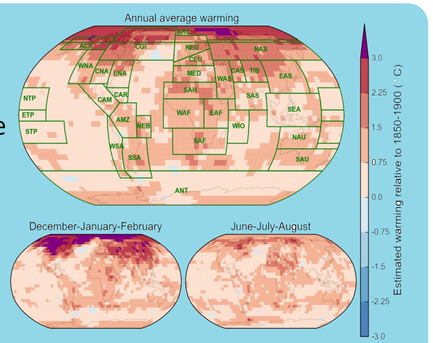

Fig. 1. Spatial and seasonal pattern of warming between 2006-2015 (IPCC 2022)

Fig. 2. Fungus *Hemileia vastatrix* (Source: Remsburg via Getty images)

Questions / Predictions

How does nutrient enrichment, warming, and drought affect the susceptibility and severity of diseases caused by bacteria, fungi, or viruses in wild-plants?

- As nutrient enrichment, warming, and drought become more intense, both wild plant species and pathogens will response through changes in plant defensees or pathogen virulence (Figure 3).
- Under **high nutrients** and **warming**, pathogens will increase in prevalence and virulence, but plants can also increase their defenses, while **nutrient limitation** and **precipitation changes** will cause plants to decrease their defense mechanisms against pathogens and become more susceptible to diseases.

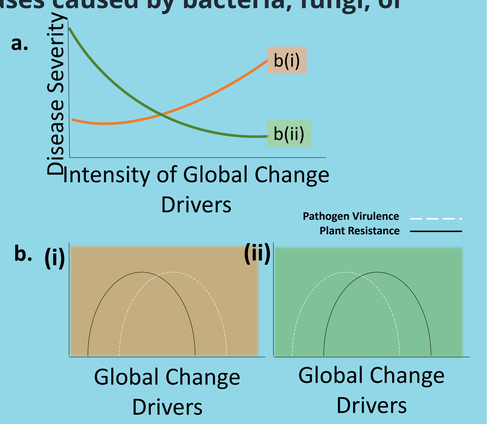

Fig. 3. predictions on response of plant disease severity (DS) to global change drivers (GCD) **a.** shows two potential scenarios **b. (i)** indicates increase in DS due to stronger sensitivity of plants to GCD **(ii)** indicates decrease in DS due to stronger sensitivity of pathogens which decreases their virulence

Methods

- To test our hypothesis, we used a **meta-analysis**, (Figure 4), which is a statistical method that allows us to synthesize scientific information and seek for general responses.
- We conducted a search on all scientific papers published to date measuring the impacts of **warming**, **precipitation**, and **nutrient enrichment** on plant-pathogen interactions.
- We excluded crops because the majority of Earth's plants are **wild** with uncontrolled microorganism populations. Crops are frequently under the effects of multiple chemicals (e.g., pesticides, fungicides) while wild plants are more susceptible to pathogenic diseases.

Fig. 4. Flowchart displaying the step-by-step process of Meta-Analysis

Preliminary Results

- Our analysis shows that warming and changes in precipitation significantly increased the severity of plant disease virulence, while all other treatments had no significant effect (Figure 5).
- The effects of increased temperature are stronger than those from increases or decreases in precipitation. All these effects scored as robust.

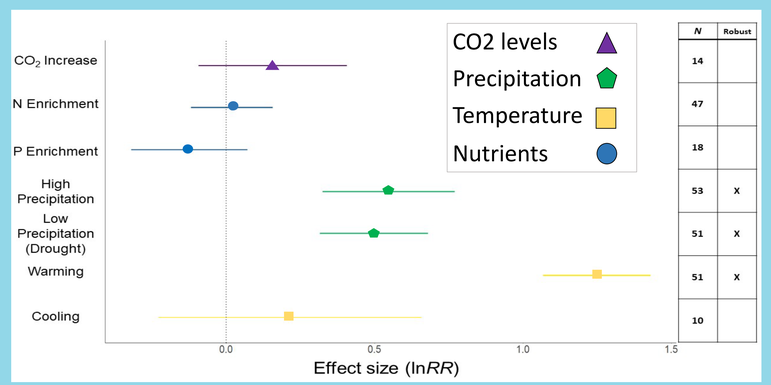

Figure 5. Effect size plot showing the average response of plant-disease interactions, separated by treatment. Error bars show 95% confidence intervals. The number of studies (N) is shown for each effect size. Effect sizes scored as robust are indicated with an X.

Remarks and Ongoing Work

- Global change drivers are significantly affecting how plants interact with pathogenic diseases.
- These responses may be explained by pathogens increasing their prevalence or plants decreasing their defenses in responses to changes in their environment.

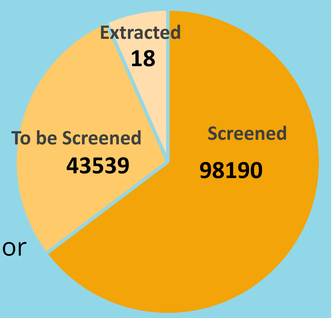

Fig. 6. Total number of studies found (141,747) split in number of studies screened, data extracted, and those remaining to be screened.

Ongoing Work:

- Finish screening papers (Figure 6)
- Finish extracting data from papers
- Generate models for moderators (e.g., habitat, disease vector)

Acknowledgements

Gonzalez Lab, Rutgers Biology Department, SURG, CCIB