Development of Crop-Ozone Response Functions

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Land Model Working Group

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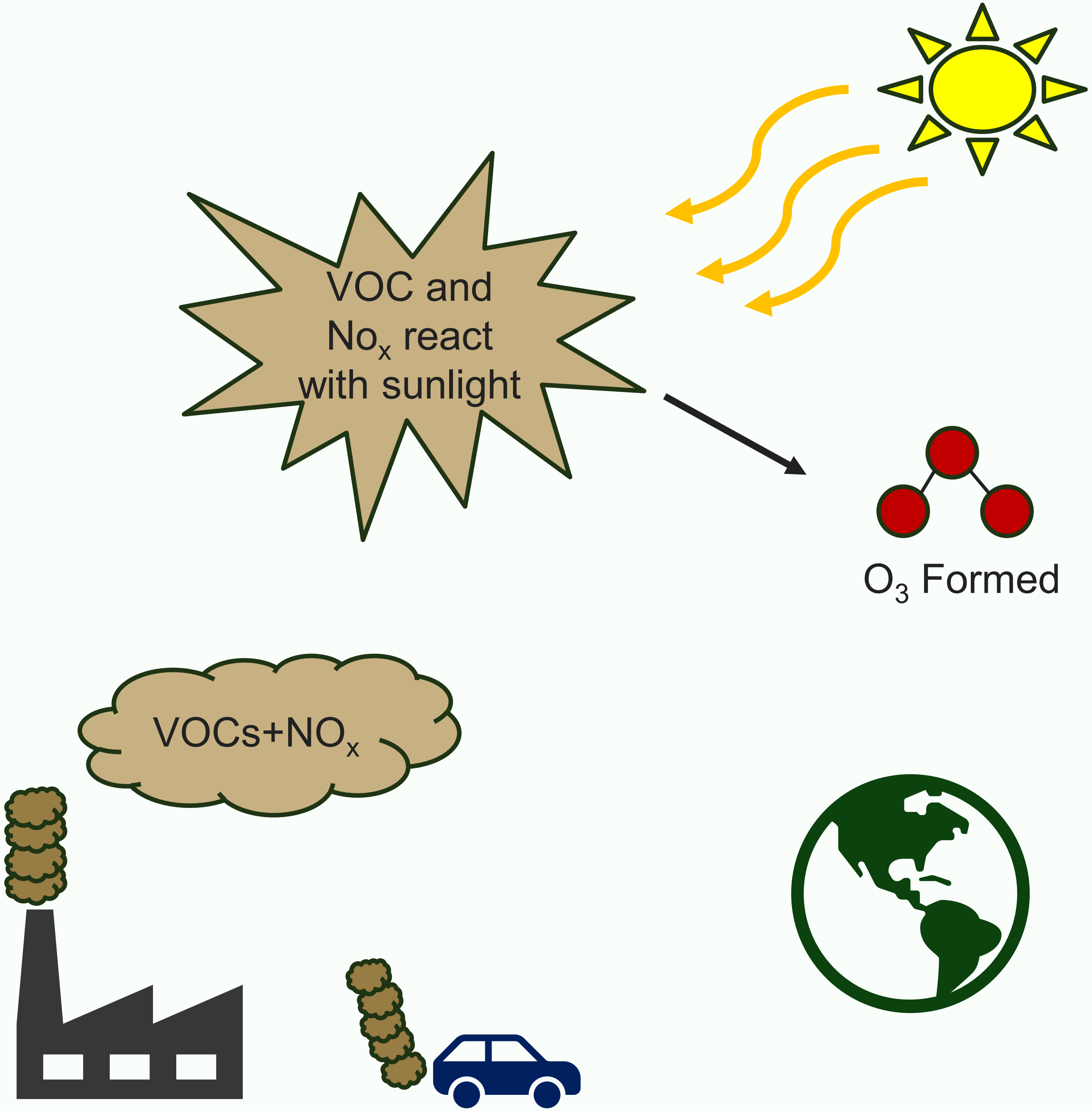
Introduction

- Two layers of atmospheric ozone
- This talk focuses on the lower layer
- Commonly referred to as tropospheric ozone or surface level ozone

Source: UN Environment Programme (UNEP), 2021. "A Tale of Two Ozones." ozone.unep.org

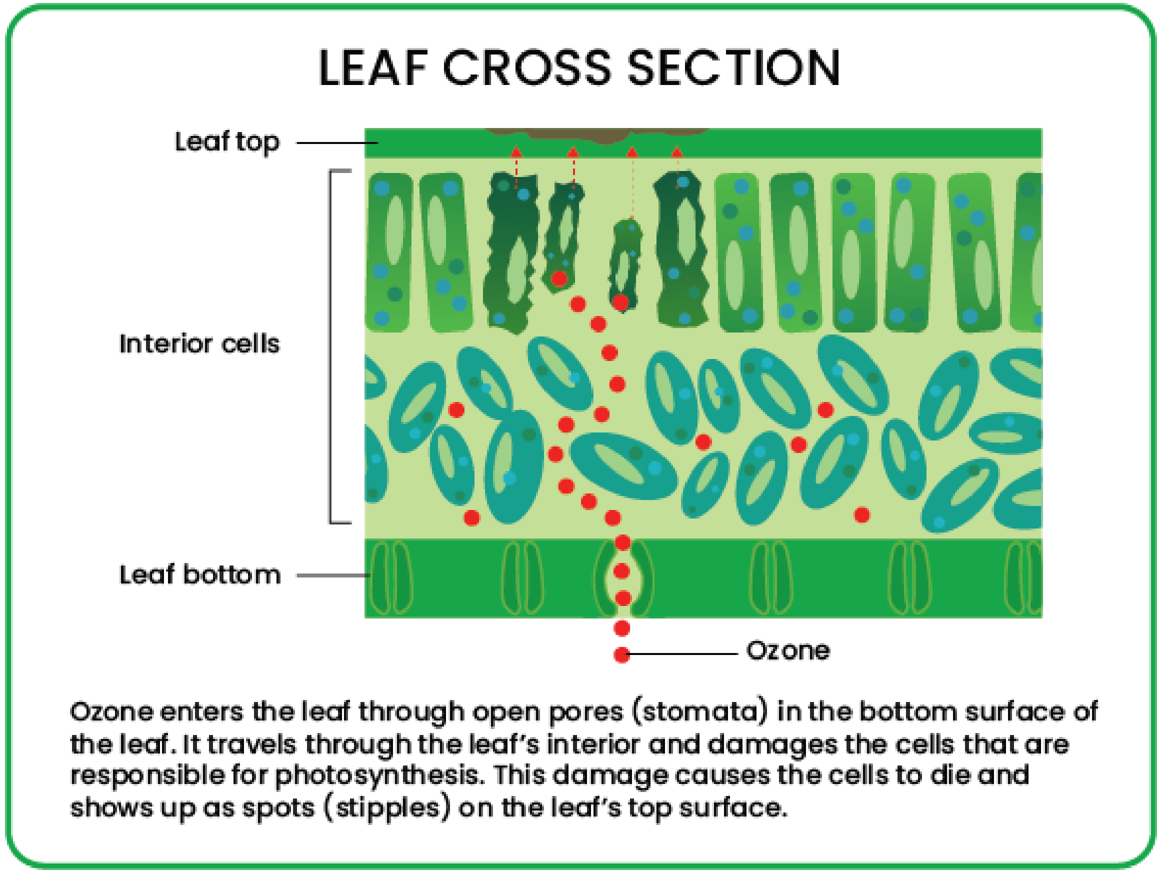
Introduction

- Surface level ozone (O_3) is created through atmospheric interactions
- Nitric Oxides (NO_x) and Volatile Organic Compounds (VOCs) are released into the atmosphere through fuel emissions
- NO_x and VOCs then react with sunlight to produce O_3
- This ozone is harmful to plants and humans
- High regional variability in surface level ozone concentrations



O_3 in Plants

- Harmful ozone enters plants through the stomata cells
- The ozone travels through the leaf and damages photosynthesis cells

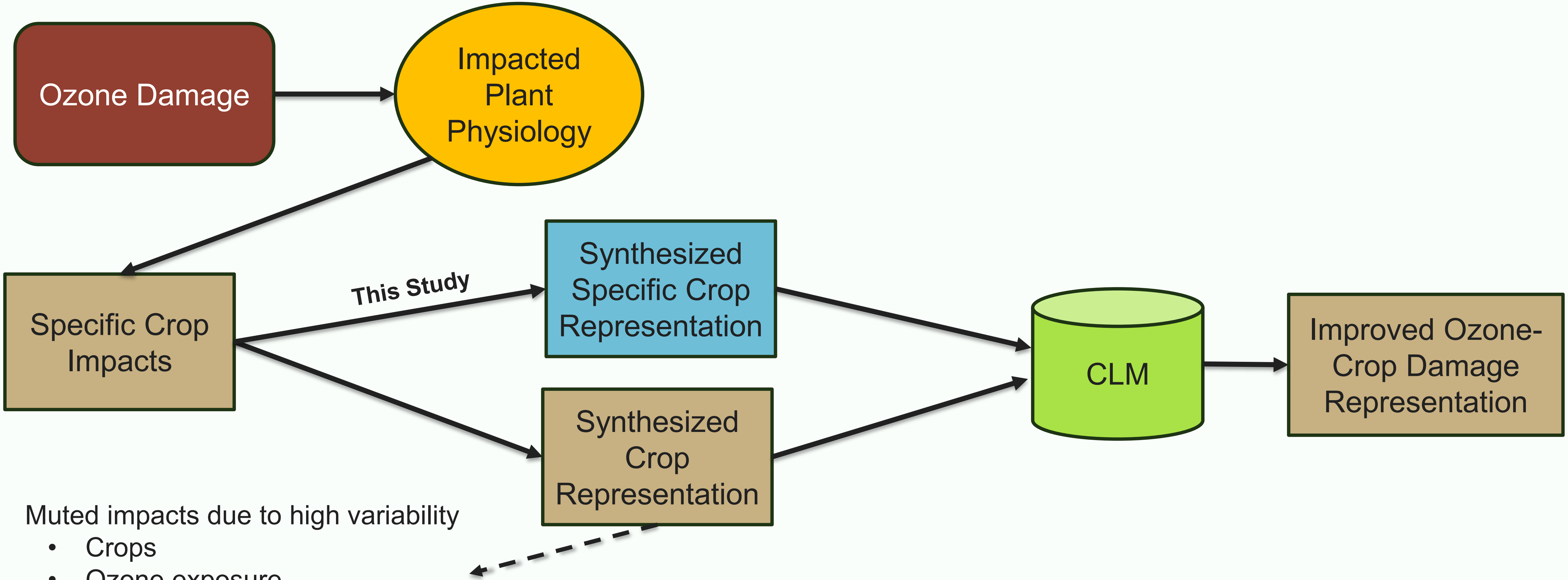


O_3 in Plants

- Harmful ozone enters plants through the stomata cells
- The ozone travels through the leaf and damages photosynthesis cells
- This results in visible damage on surface of plant leaves
- Surface level ozone also impacts plant transpiration processes
    - Impacts vary across plants

Source: NSF National Center for Atmospheric Research (NCAR) Ozone Garden Image Gallery, University Corporation for Atmospheric Research (UCAR). https://research.cgd.ucar.edu/ozone-garden/gallery/

O_3 in Crops



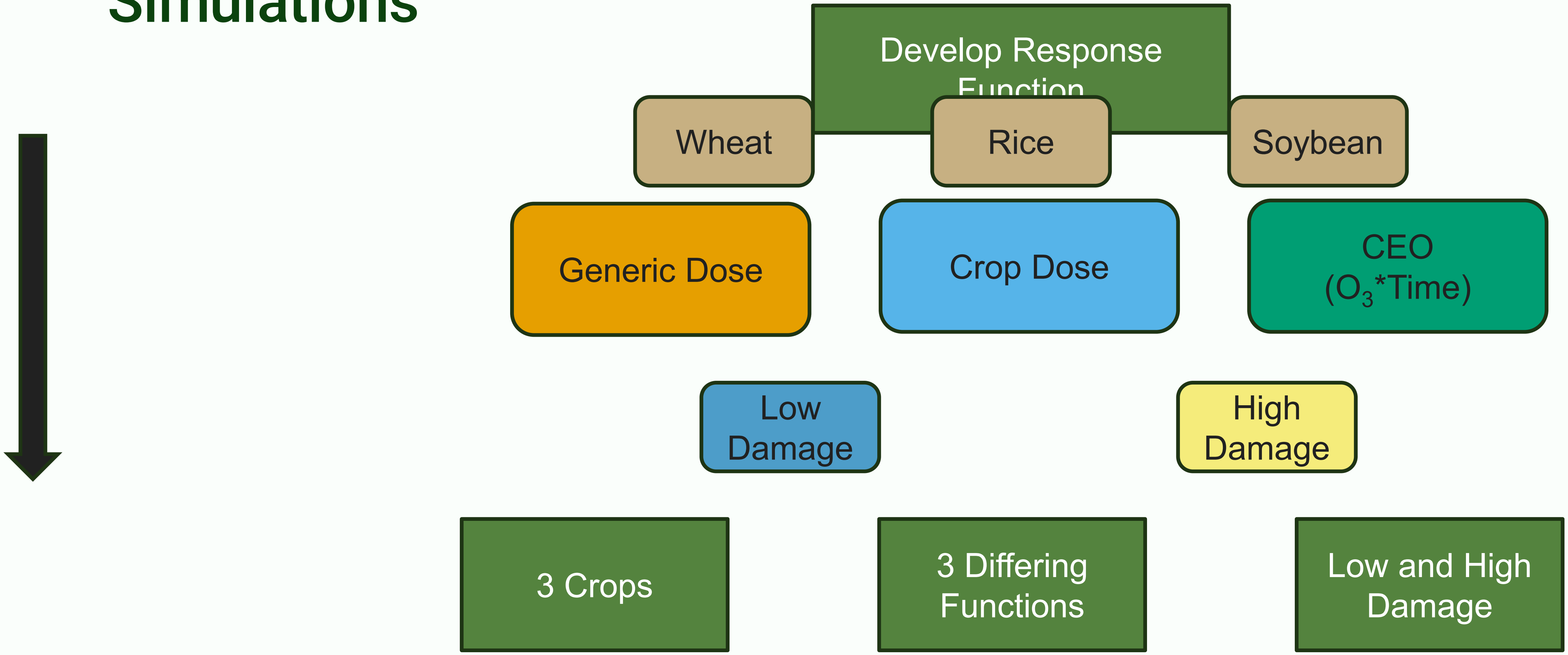
- Muted impacts due to high variability
  - Crops
  - Ozone exposure
  - Conductance measurements
- One overall crop function

Data

Author	Studies	Datapoints	Years	Crops
Lombardozzi (2013)	21	219	1971 -2011	Wheat Rice Soybean Corn Cotton
Singh (2024 in process)	36	433	2011-2022	
Total	57	652	1971-2022	

Controlling for Variability	
Previously Collected	Added
Exposure System	Leaf Age
Rooting Environment	Plant Stage
Control Air Type	

Simulations



Response Functions

Generic Dose	All Crops
Photosynthesis	−
Conductance	↔

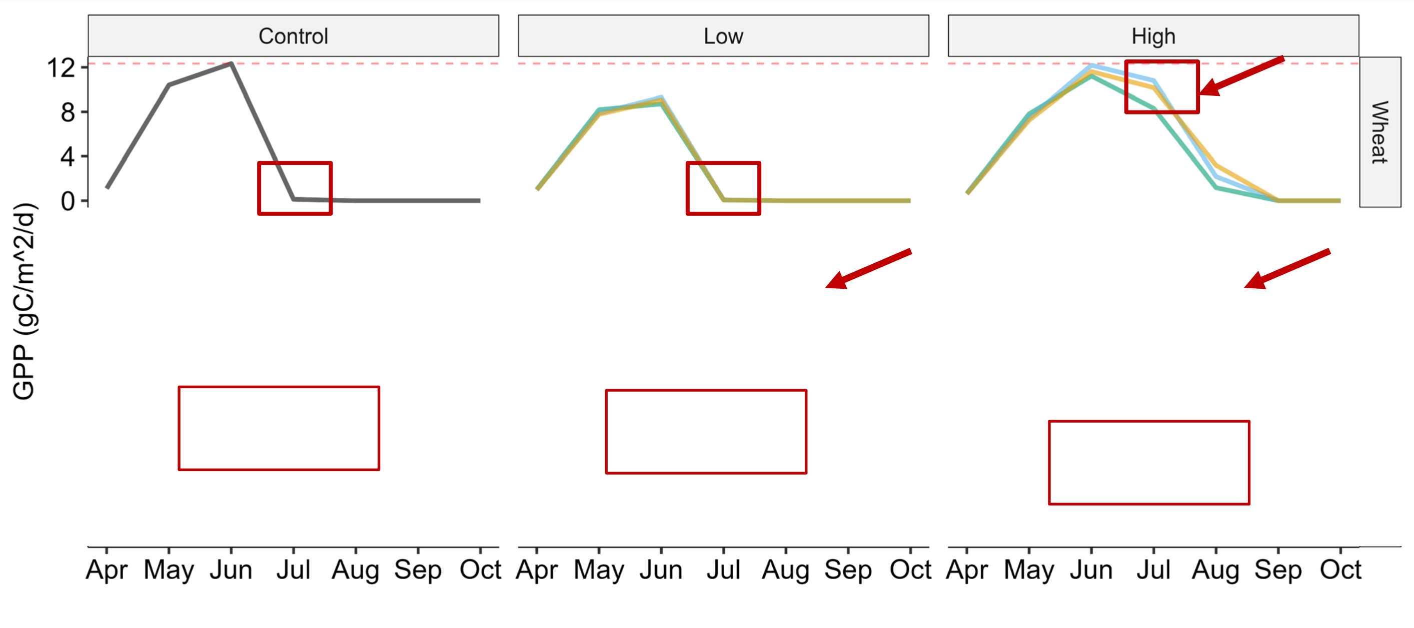
Crop Dose	Wheat	Rice	Soybean
Photosynthesis	+	+	−*
Conductance	+*	−	−

CEO	Wheat	Rice	Soybean
Photosynthesis	−*	+	−*
Conductance	+	−	−*

* Indicates significant p value <0.05 in new functions

Simulations

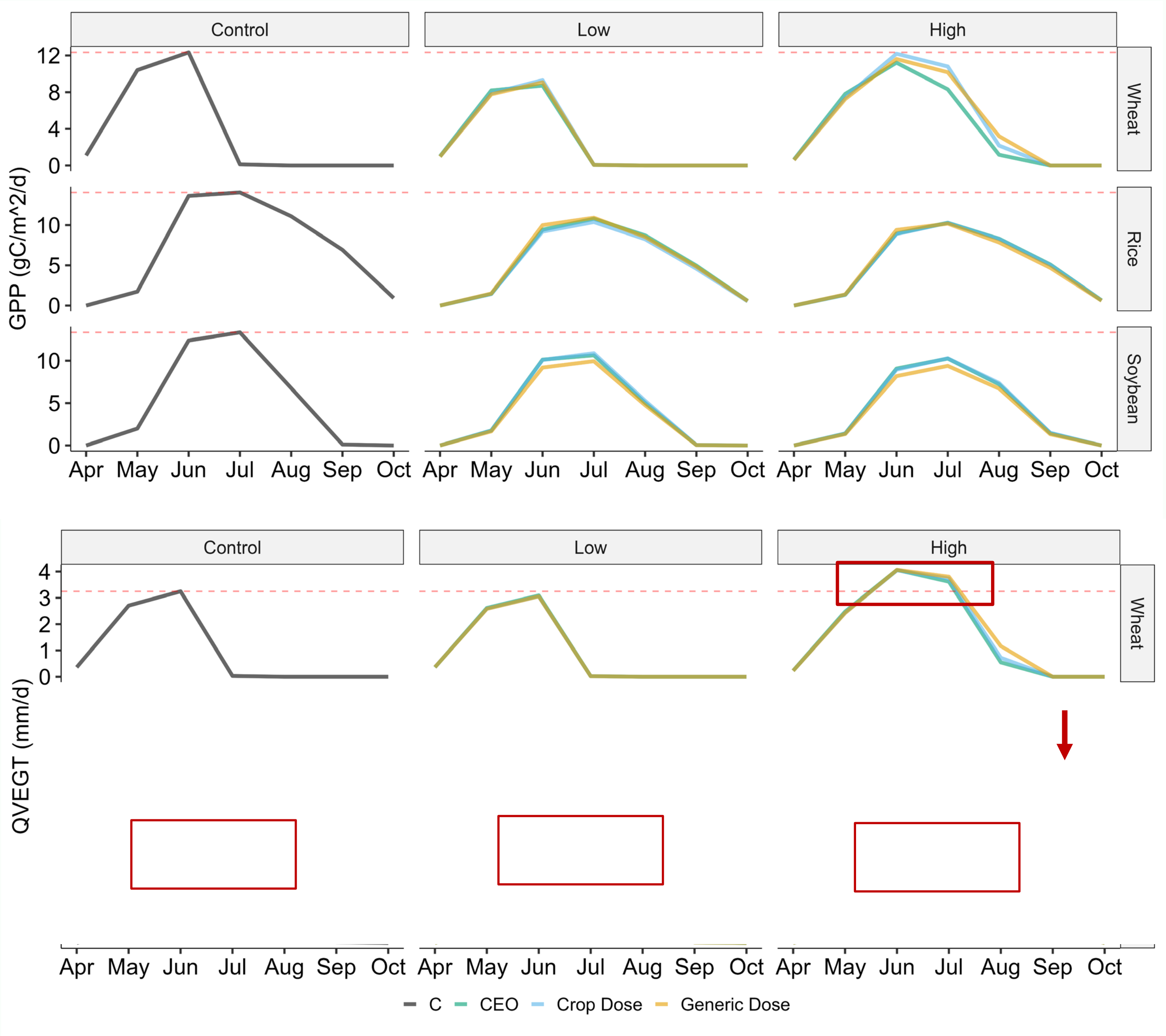
IV Results



Crop	Response	Amax	Gs
Wheat	CEO	−	+
	Crop Dose	+	+
	Generic Dose	−	↔
Rice	CEO	+	−
	Crop Dose	+	−
	Generic Dose	−	↔
Soybean	CEO	−	−
	Crop Dose	−	−
	Generic Dose	−	↔

Simulations

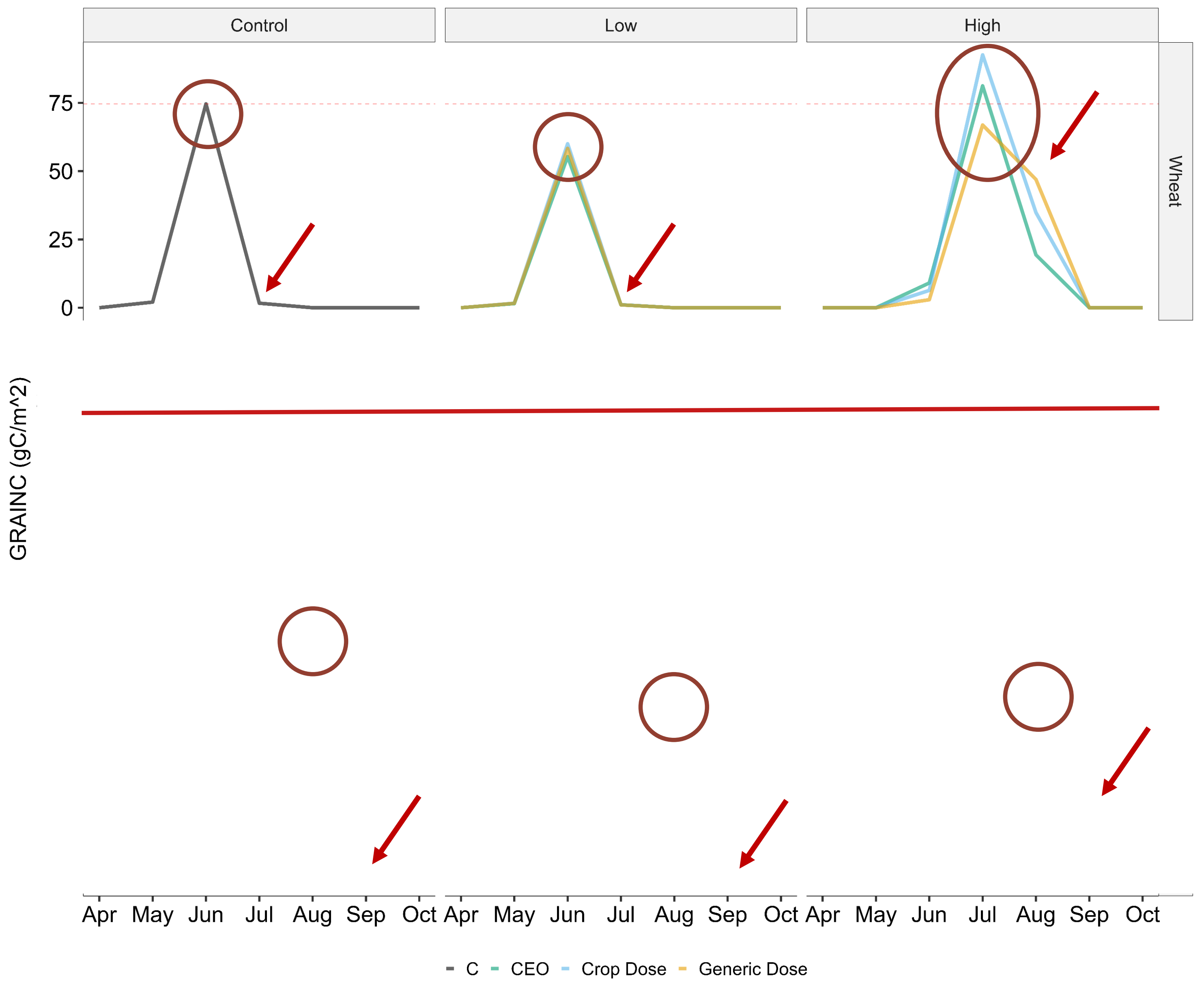
IV Results



Crop	Response	Amax	Gs
Wheat	CEO	−	+
	Crop Dose	+	+
	Generic Dose	−	↔
Rice	CEO	+	−
	Crop Dose	+	−
	Generic Dose	−	↔
Soybean	CEO	−	−
	Crop Dose	−	−
	Generic Dose	−	↔

Simulations

IV Results



Crop	Response	Amax	Gs
Wheat	CEO	−	+
	Crop Dose	+	+
	Generic Dose	−	↔
Rice	CEO	+	−
	Crop Dose	+	−
	Generic Dose	−	↔
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	Crop Dose	−	−
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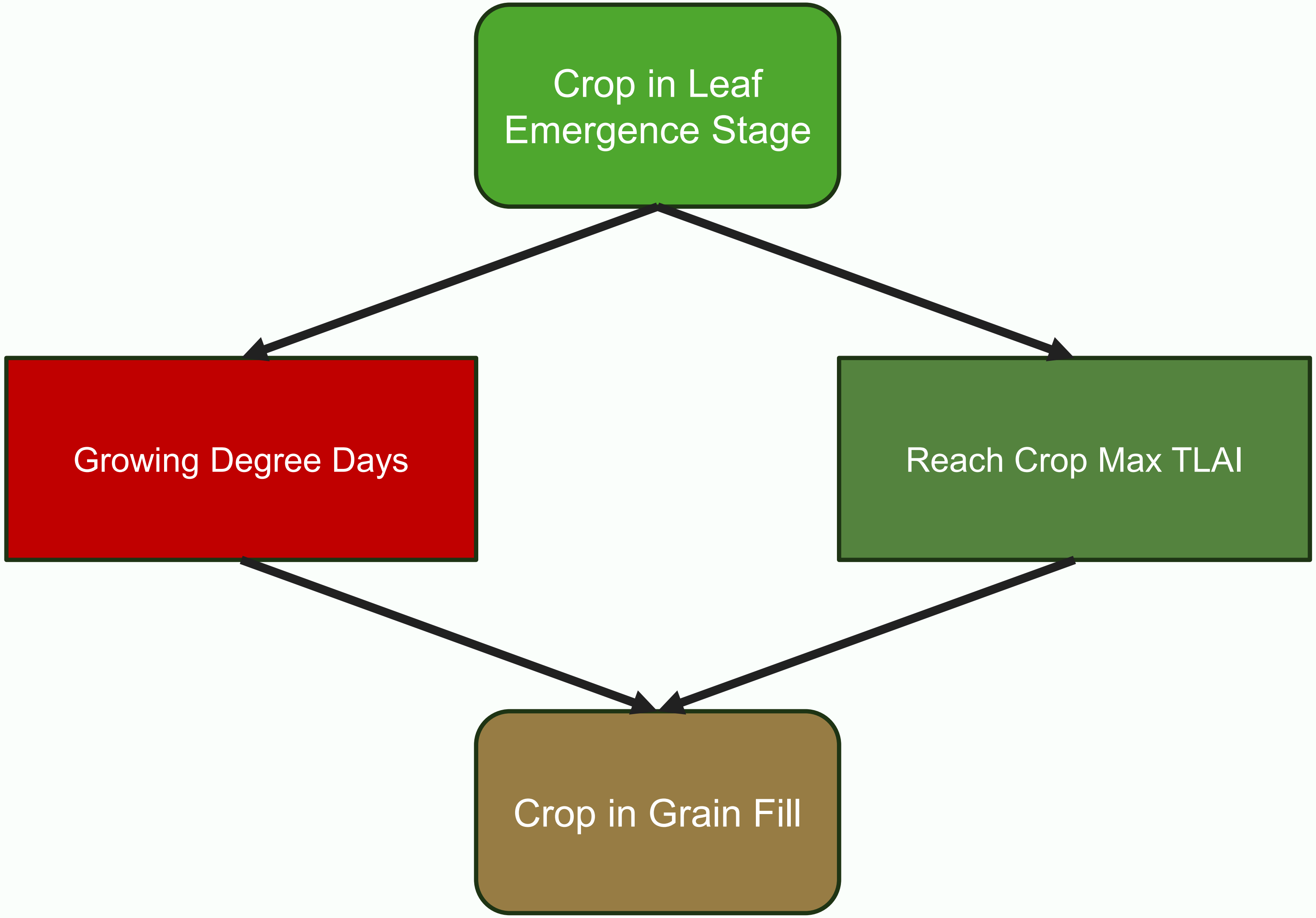
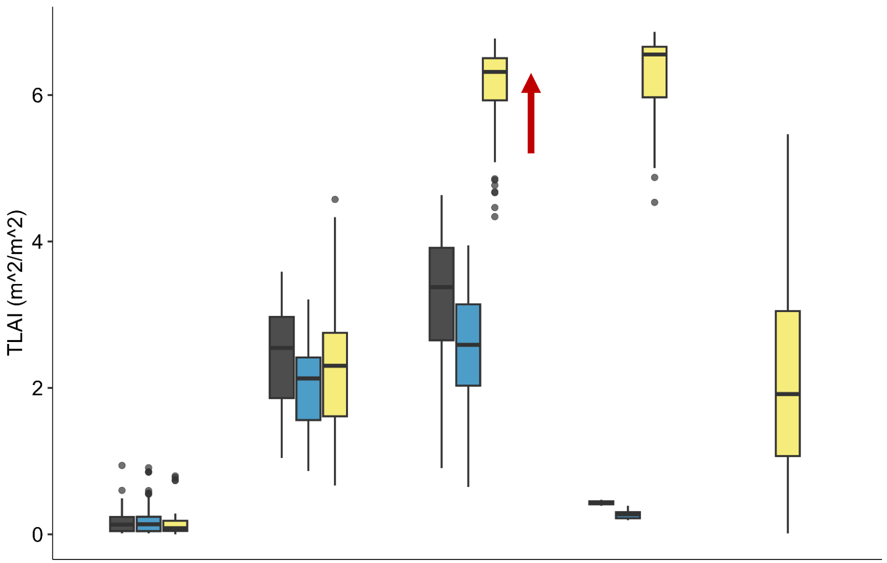
Simulations

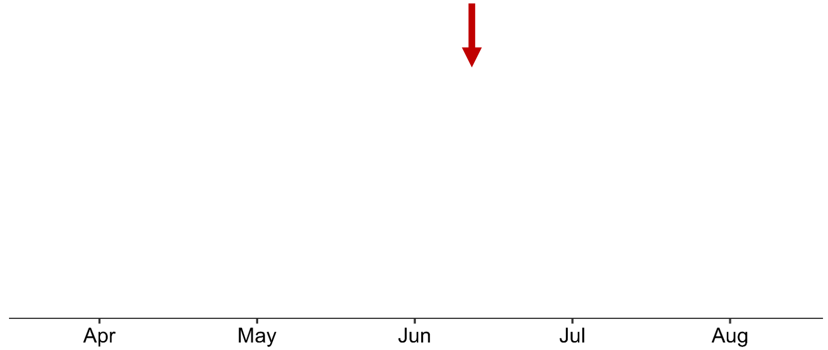


Simulations

IV Results

Damage Level: Control | Low | High





Higher Damage

Higher **TLAI**

Increased shading lowers **Soil Temps**

Higher **TLAI** + **some** positive responses increases **Transpiration**

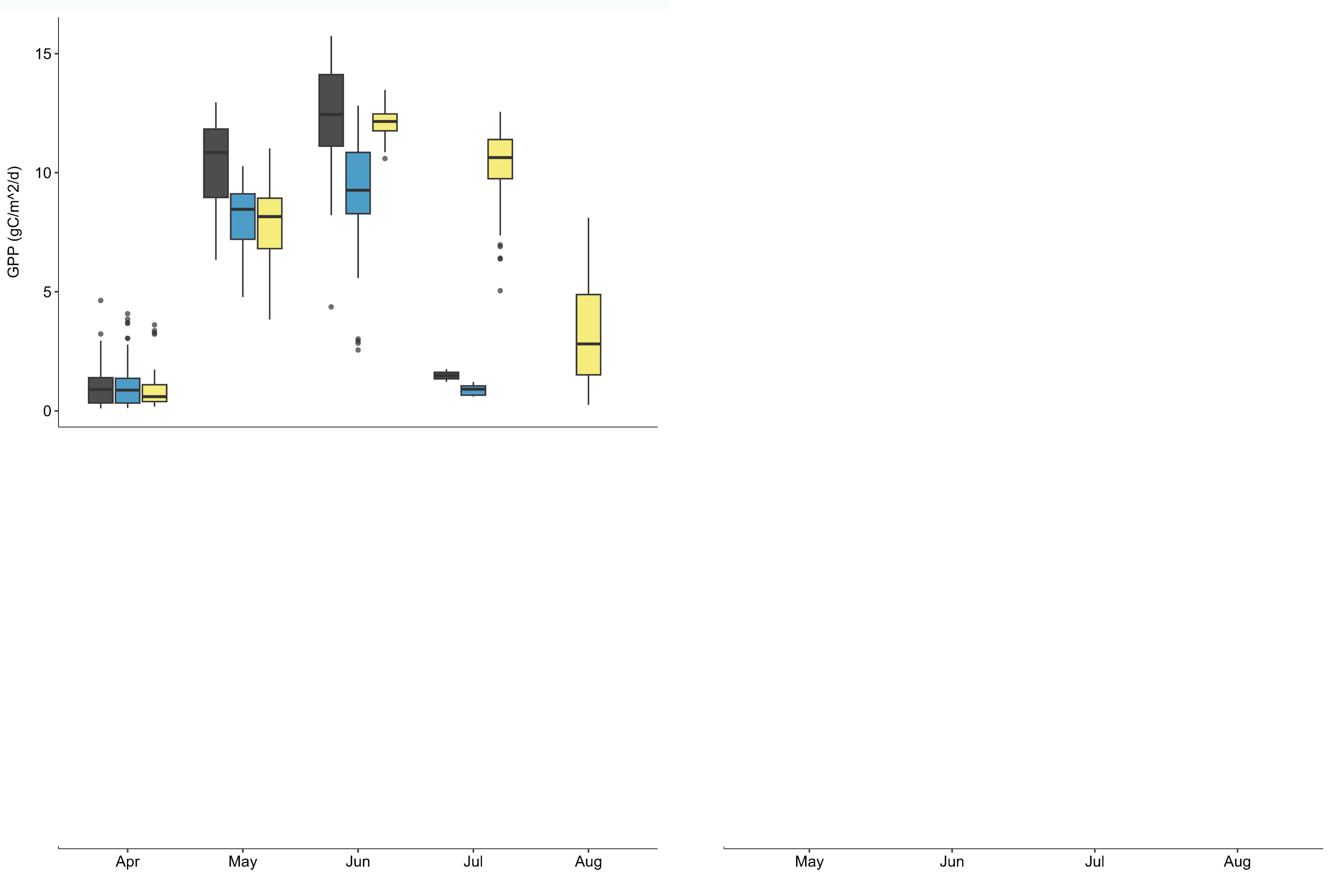
Increased **Transpiration** causes more evaporative cooling, reducing **2m Air Temps**

Lower **2m Air Temps** reduces the accumulated GDD, lengthening the growing season

Simulations

IV Results

Damage Level: Control Low High



Higher Damage

Higher **TLAI**

↓

Increased shading lowers **Soil Temps**

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Higher **TLAI** + **some** positive responses increases **Transpiration**

↓

Increased **Transpiration** causes more evaporative cooling, reducing **2m Air Temps**

↓

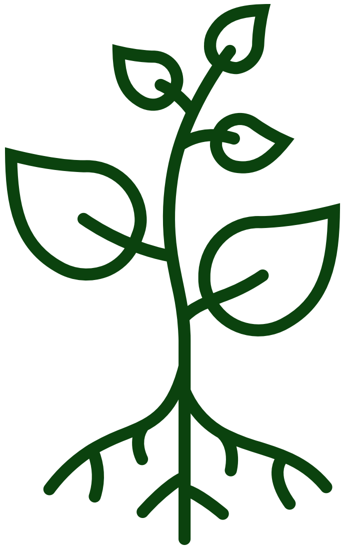
Lower **2m Air Temps** reduces the accumulated GDD, lengthening the growing season

↓

Results in higher total **GPP**, **Transpiration**, **TLAI**, and **Yield**

Conclusion

- Different ozone predictors do not appear to improve predicting physiological crop damage to ozone exposure.
- Individual crops show variability in their responses to ozone damage within CLM.
- Need to develop individual crop response functions.
- Work is still in progress, more to come!



Thank you

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