

Vegetation O₃ damage: Impacts on plants & ecosystems

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San Francisco brown cloud. Credit: D. Lombardozzi

August 4

Potato, var. LaChipper



August 4

Potato, var. LaChipper

August 28

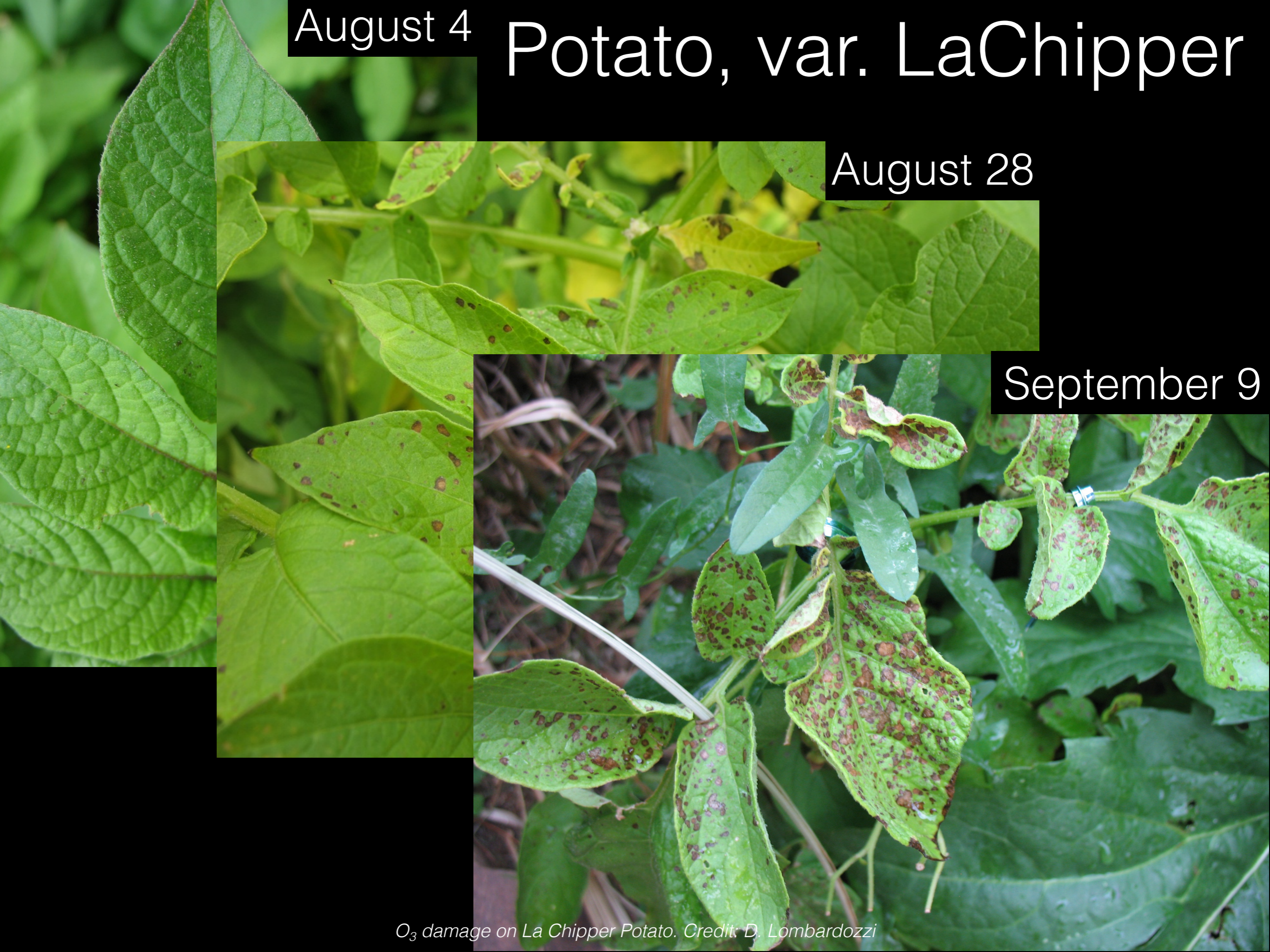


August 4

Potato, var. LaChipper

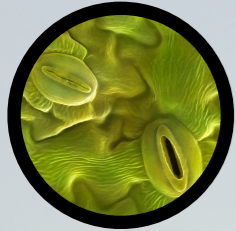
August 28

September 9



O₃ damage on La Chipper Potato. Credit: D. Lombardozzi

Questions for today:



1. How does O_3 pollution change leaf processes?

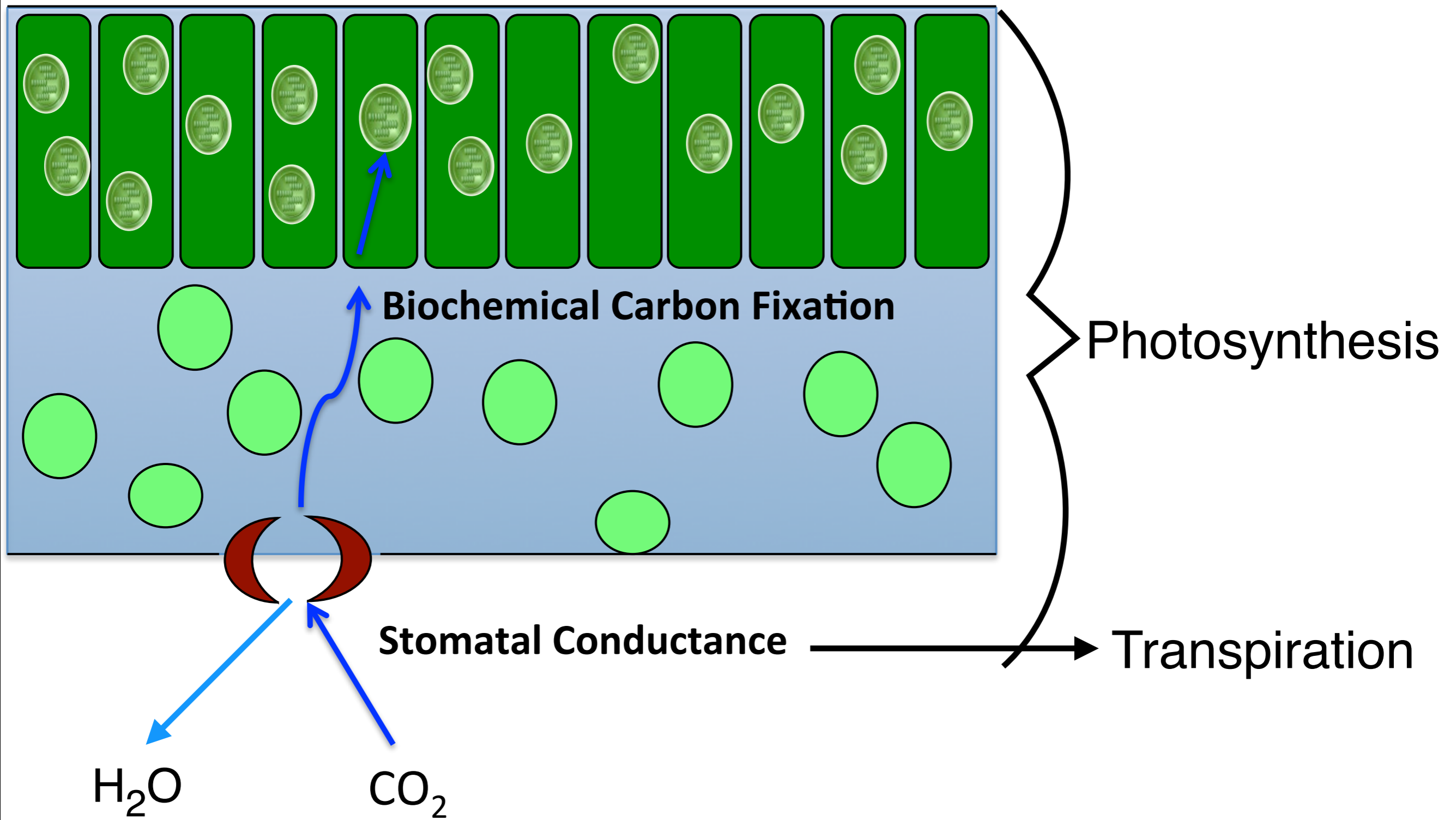


2. What are some impacts of O_3 pollution?



3. An outreach & citizen science project documenting visible O_3 damage (*if time allows*)

Leaf Cross-section

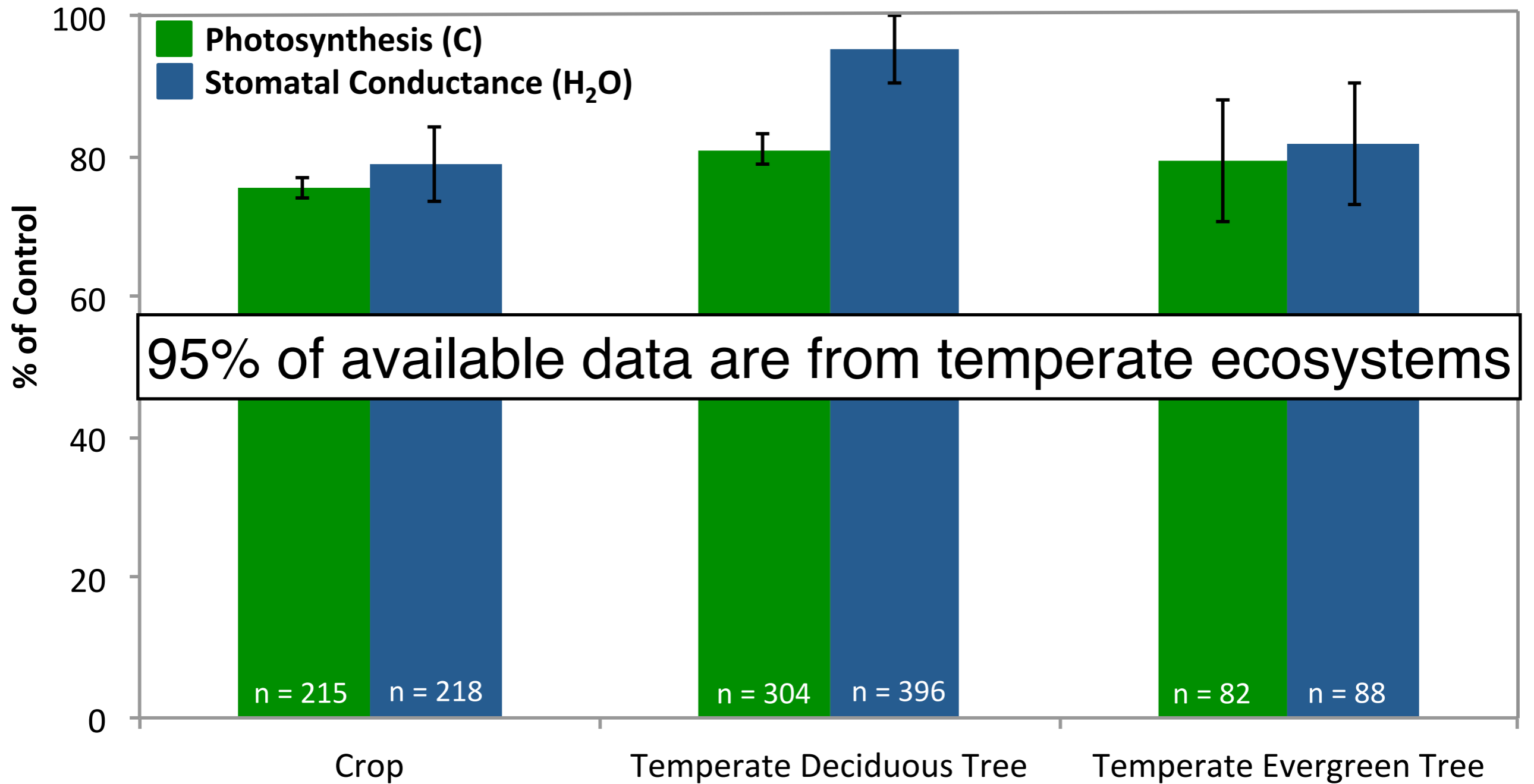




Open-top Chamber Experiment. Credit: S. Cook-Patton

Mean **photosynthetic** change = **-21%***

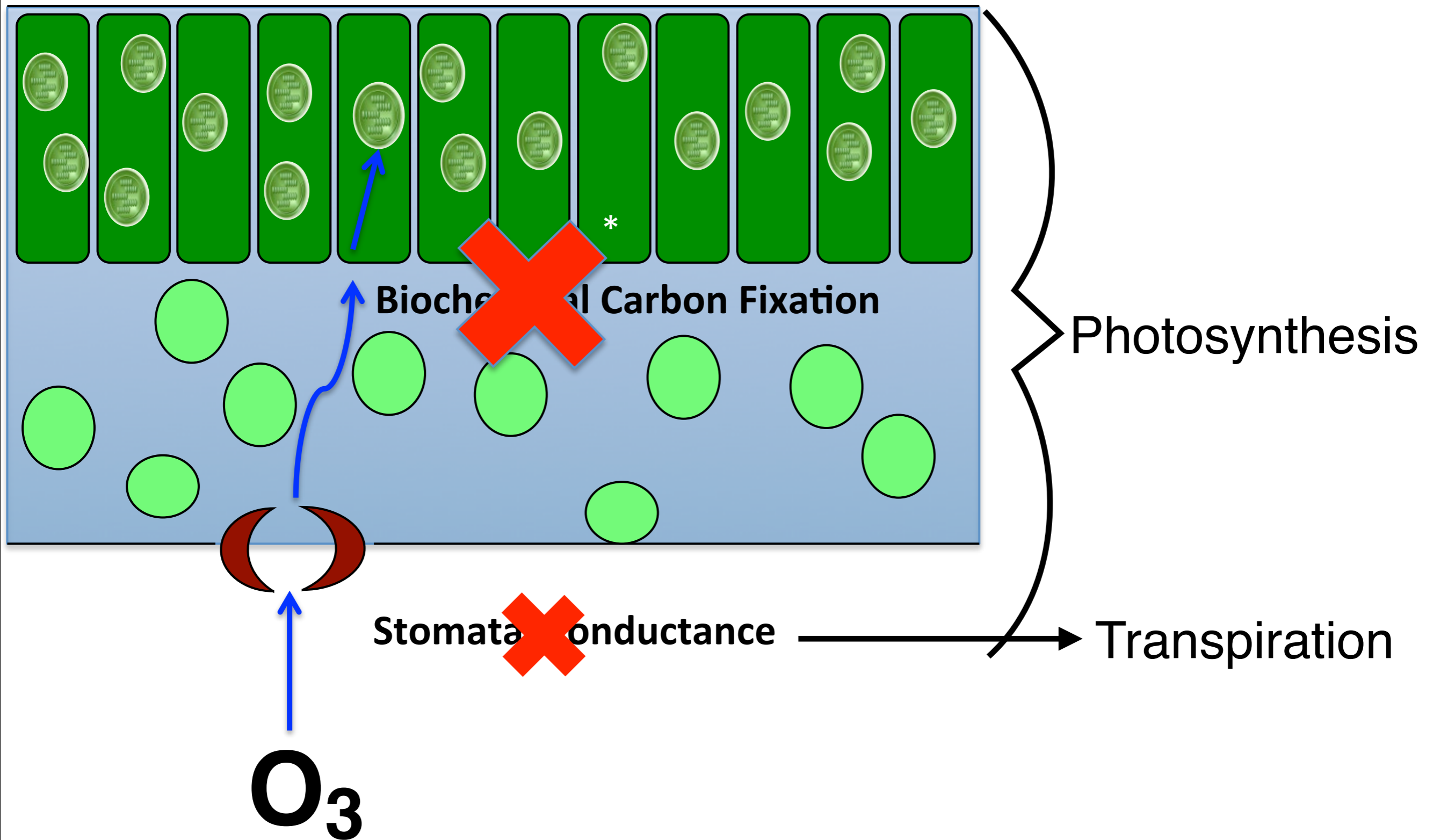
Mean **conductance** change = **-11%**



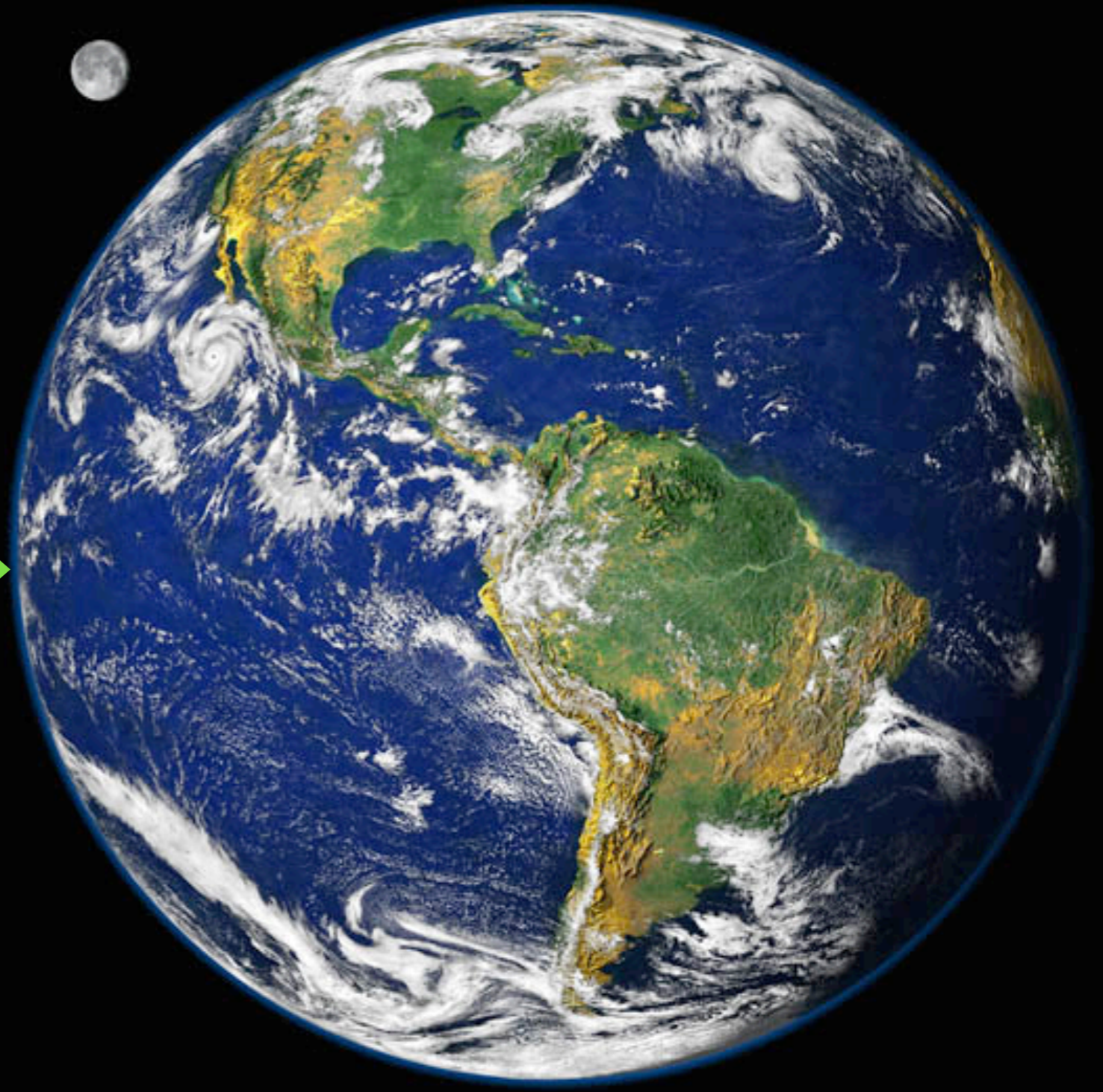
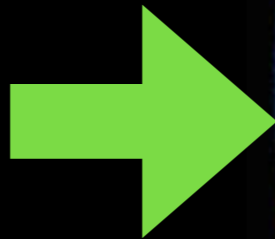
Data adapted from Lombardozzi et al., 2013 *BGS*

* Similar to Wittig et al. 2007, *Plant Cell Environ*; Feng et al. 2008 *GCB*; Morgan et al. 2003, *Plant Cell Environ*

Leaf Cross-section



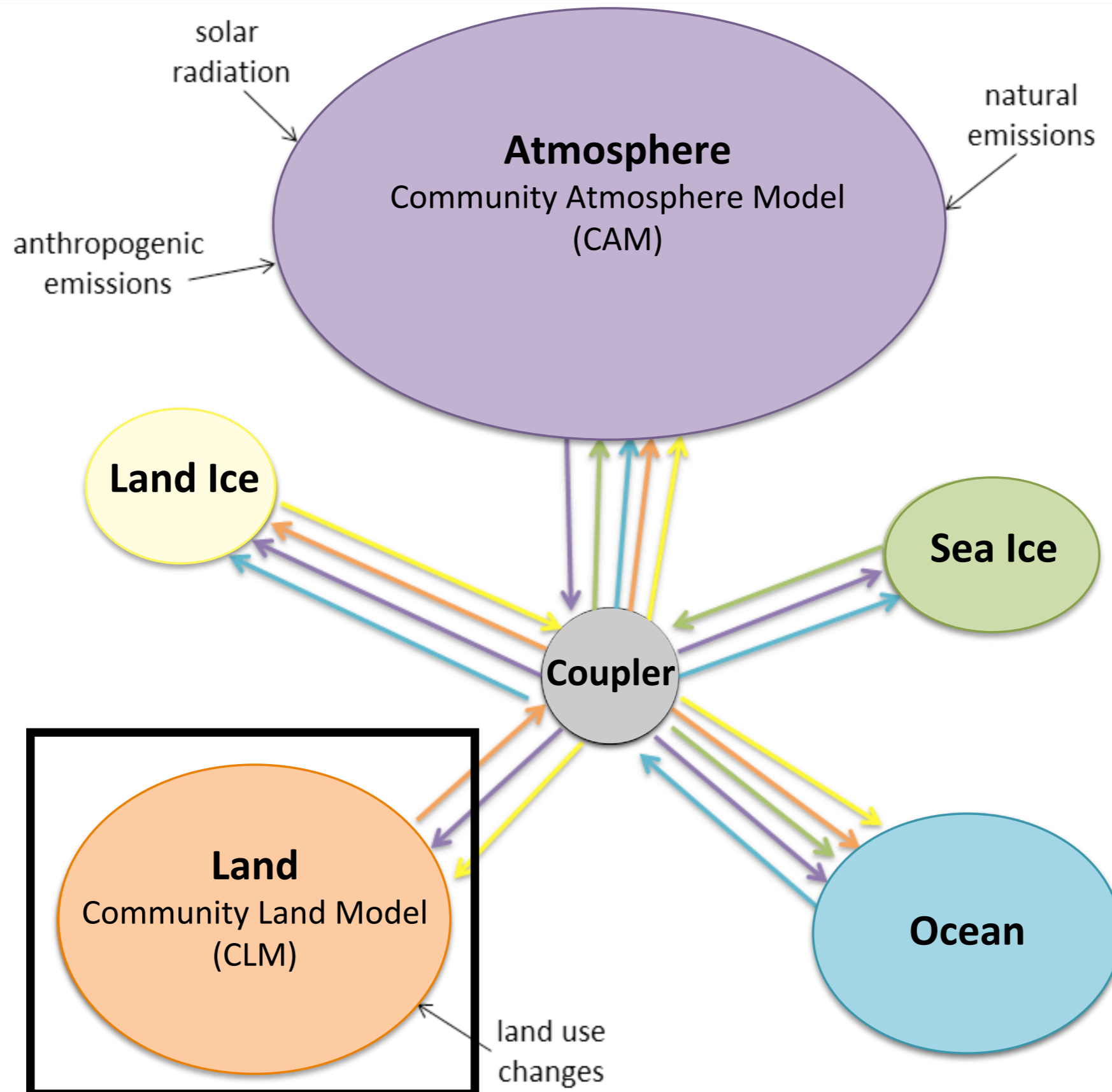
* Bortier et al. 2000, *New Phytol*; Francini et al. 2007, *Environ Exp Bot*; Fiscus et al. 1997, *J. Exp Bot*; Heagle et al. 1996 *J. Environ Qual*; Noormets et al. 2001, *Plant Cell Environ*; Sharma et al. 2003, *Ekologia*; Lombardozzi et al. 2012, *Oecologia*; Lombardozzi et al. 2014, *Biogeosciences*



Leaf. Credit: D. Lombardozzi

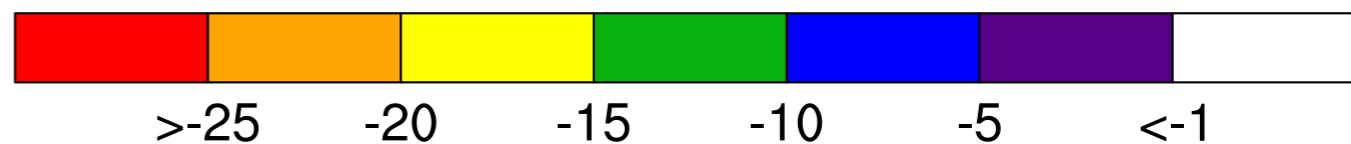
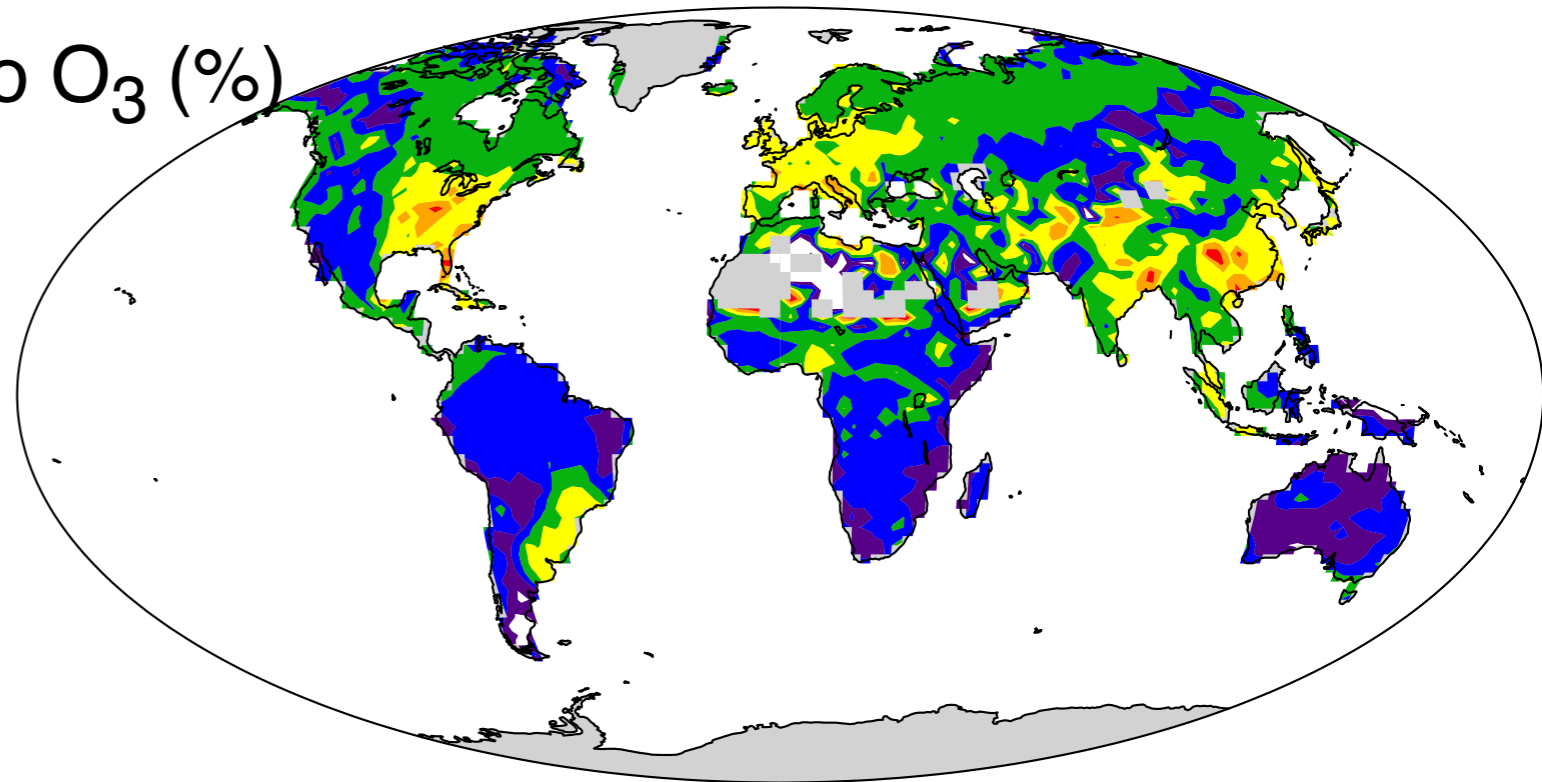
Earth. Credit: NASA

Community Earth System Model



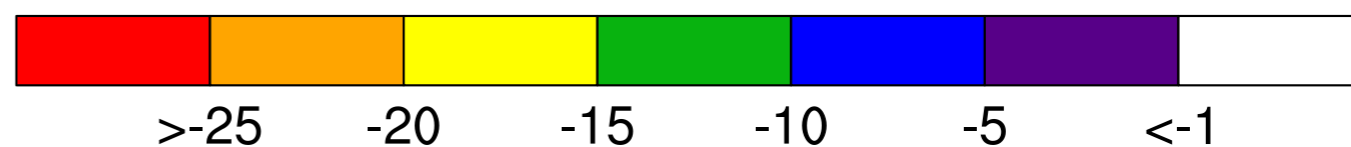
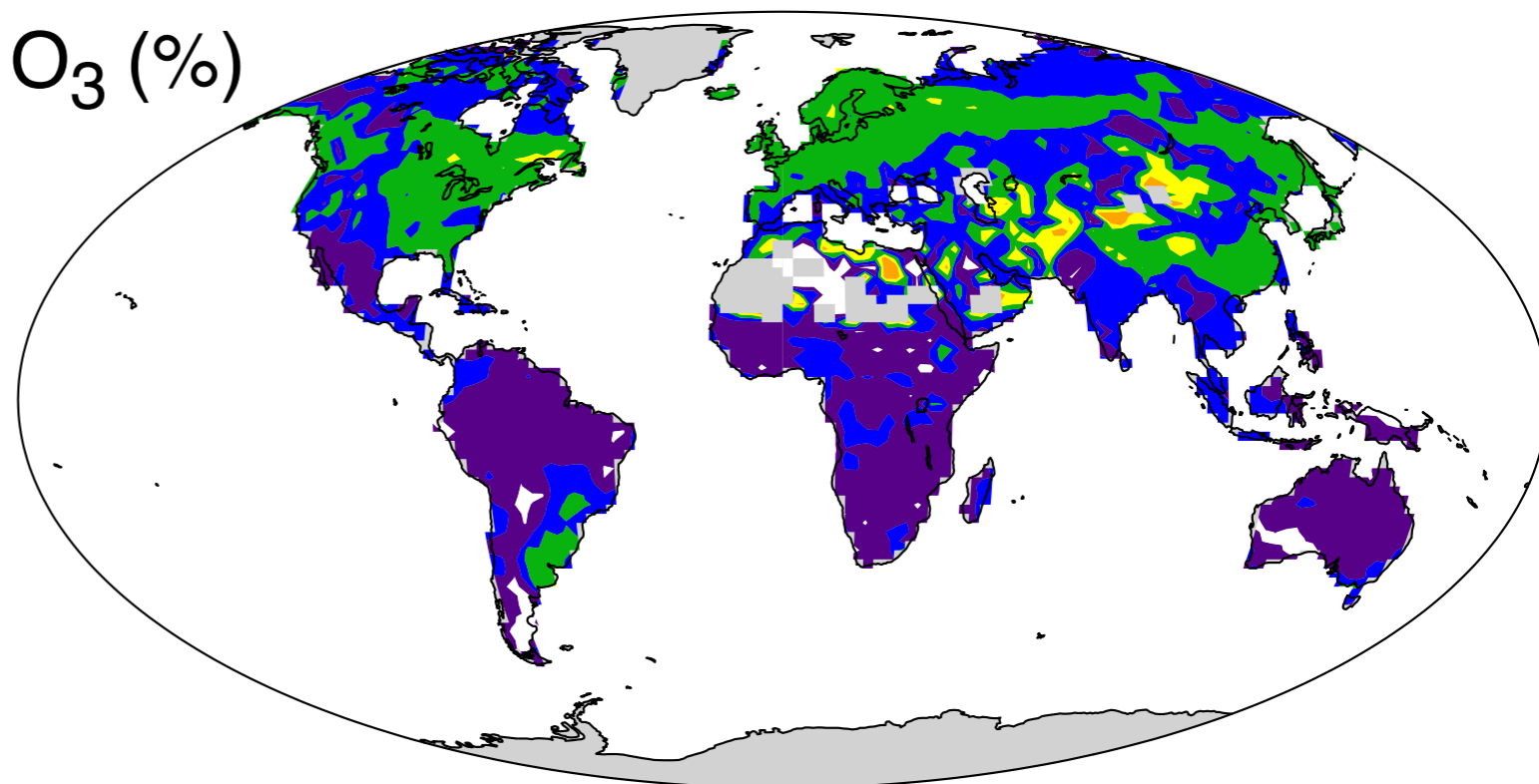
Change in **Photosynthesis** due to O_3 (%)

(change in C gain)

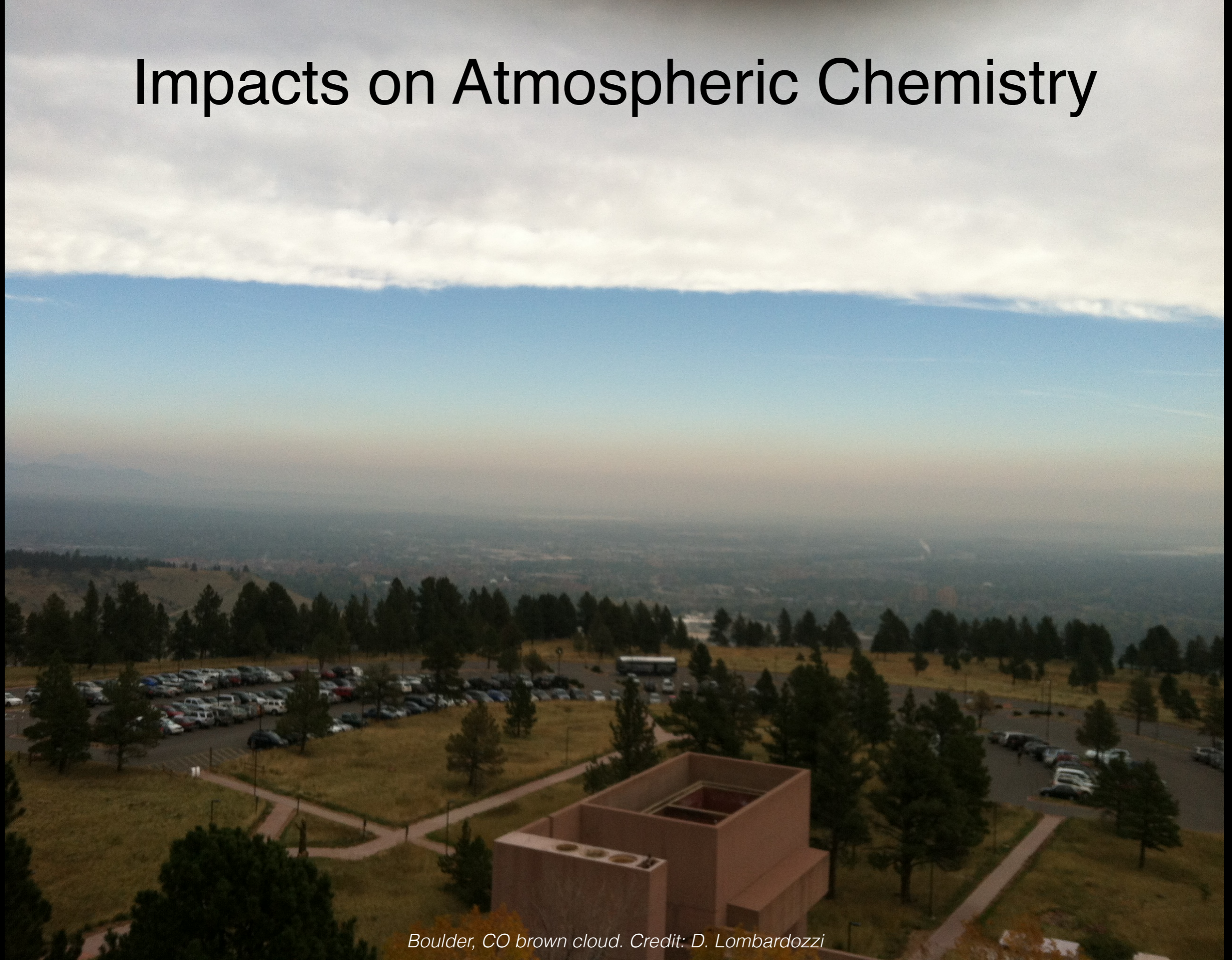


Change in **Transpiration** due to O_3 (%)

(change in H_2O loss)

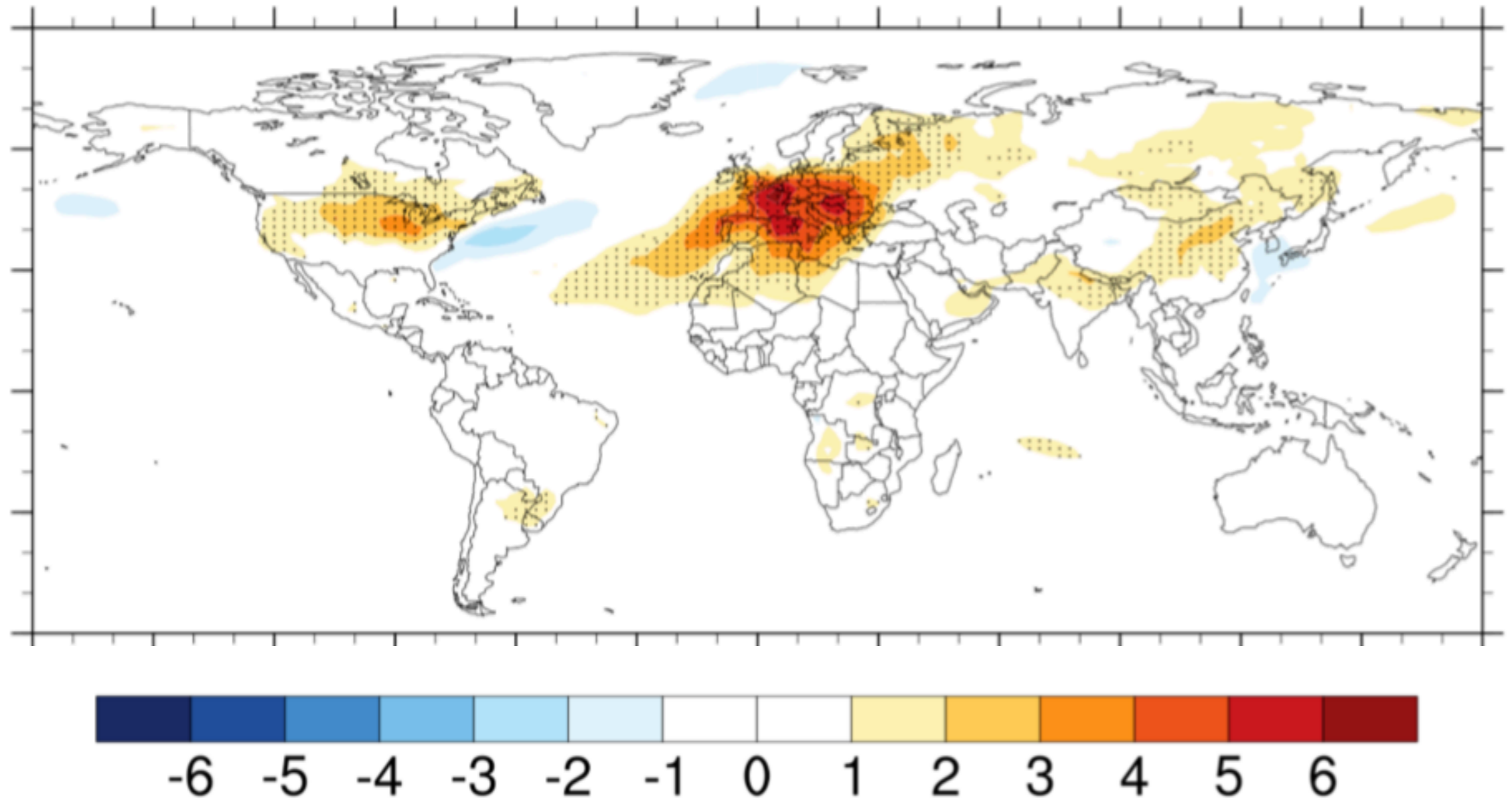


Impacts on Atmospheric Chemistry



Boulder, CO brown cloud. Credit: D. Lombardozzi

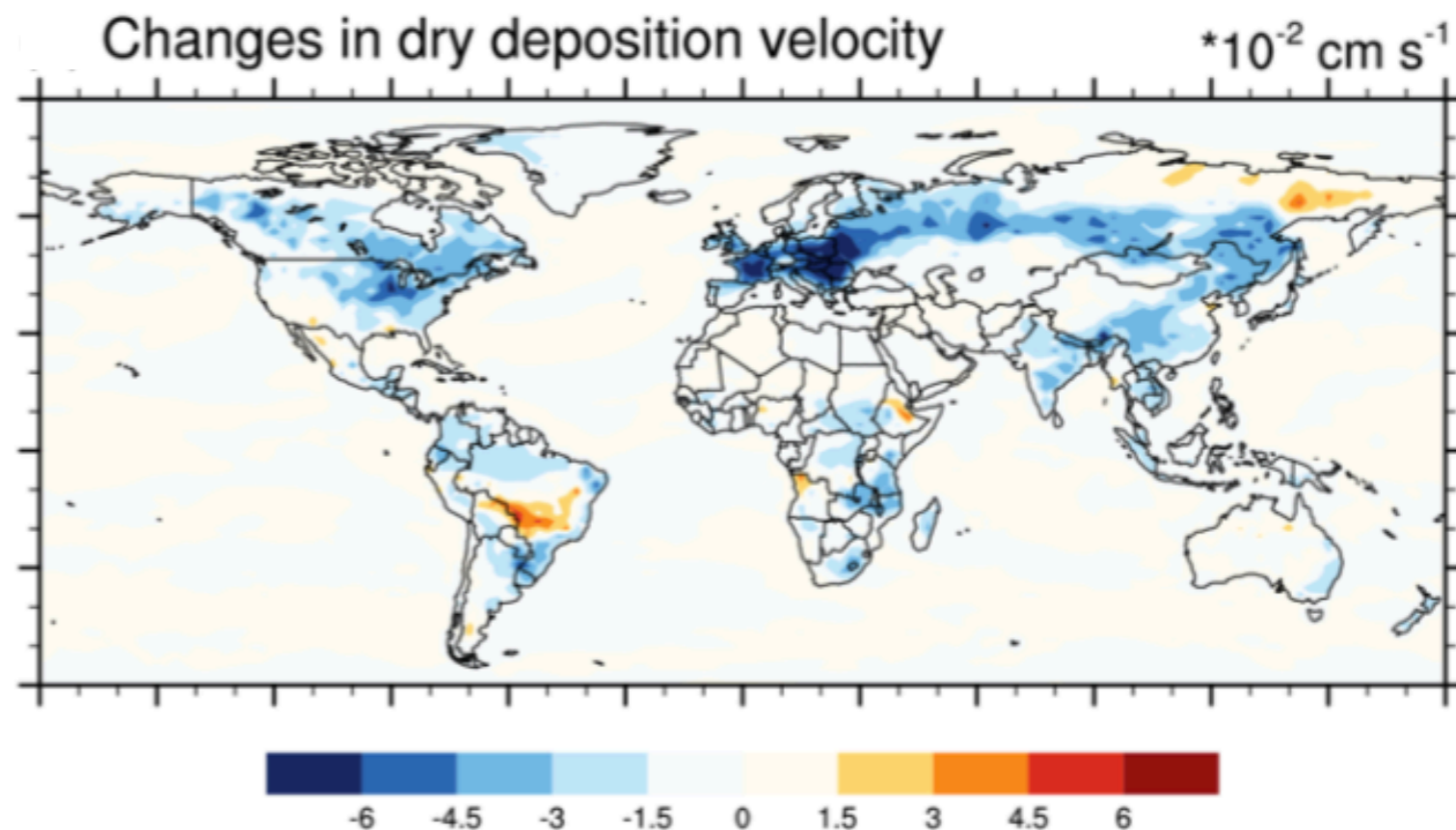
Damage to vegetation increases [O₃]



Change in summertime O₃ concentration (ppb)

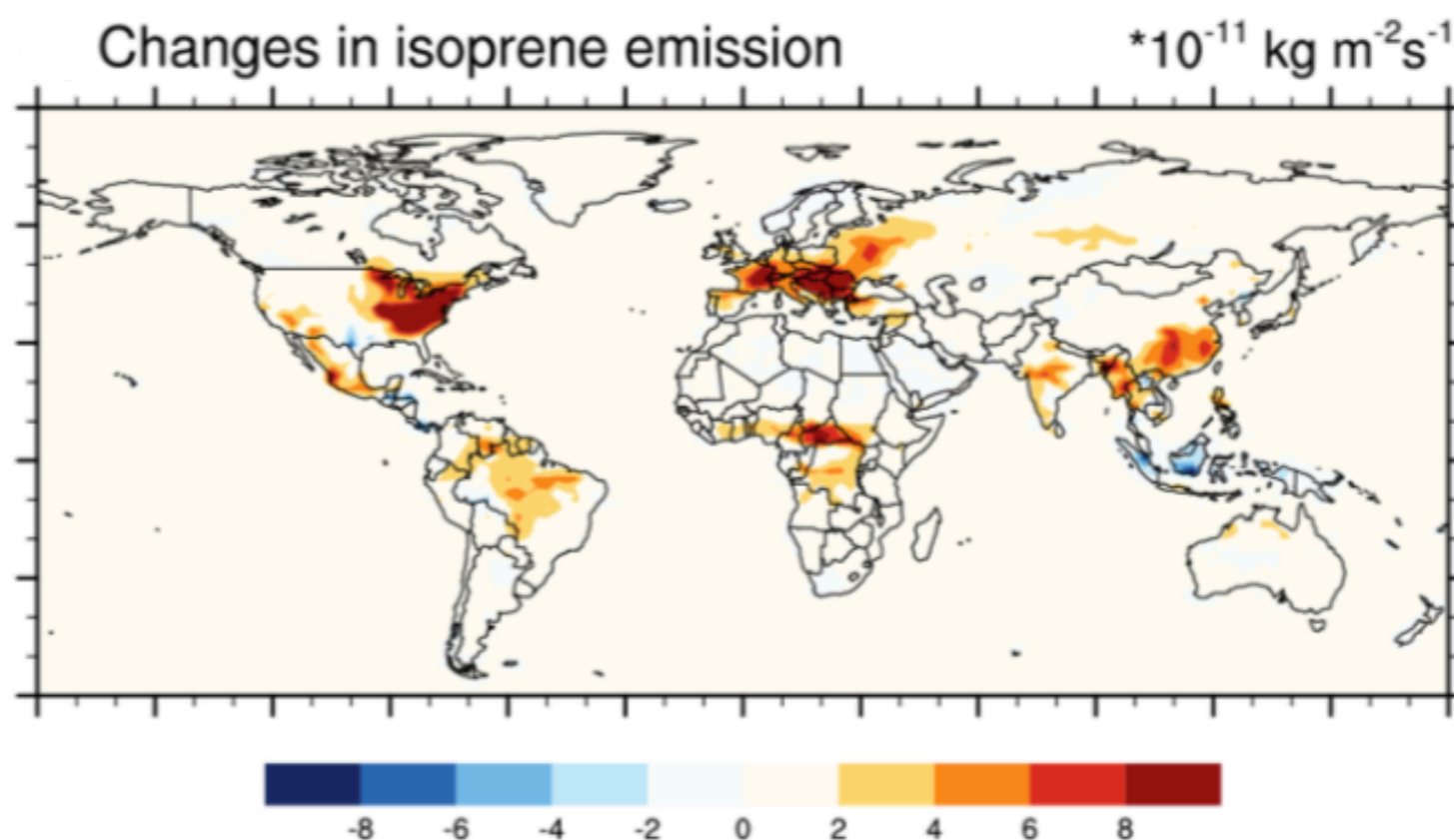
Responsible for 40-100% of
the change in O_3

Decreased dry deposition is due to
reduced conductance.



Responsible for to 0-60% of the
change in O_3

Increased isoprene emissions are due to
higher leaf temperatures.

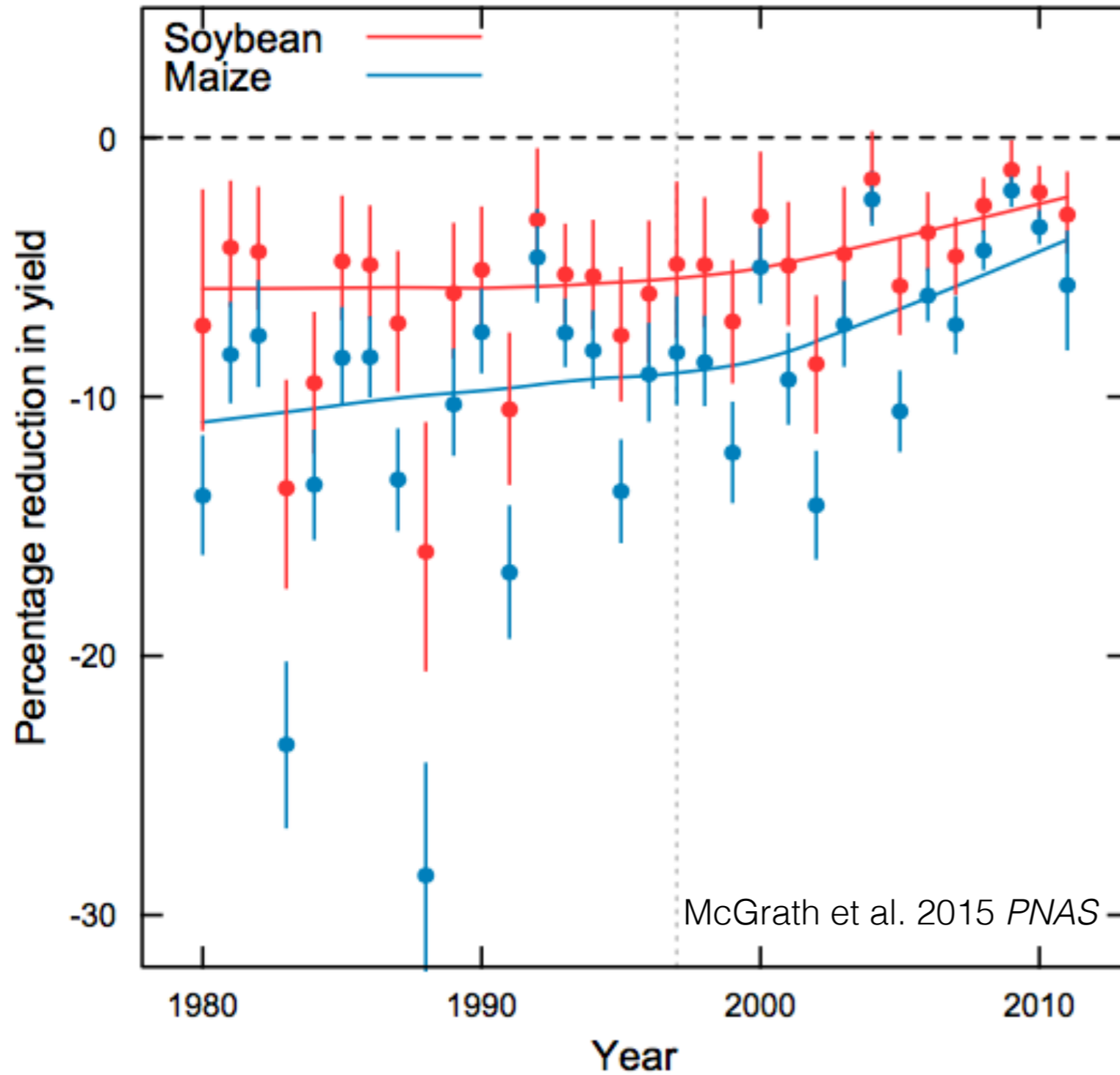


Impacts on Agriculture



Rice paddies, Bali. Credit: D. Lombardozzi

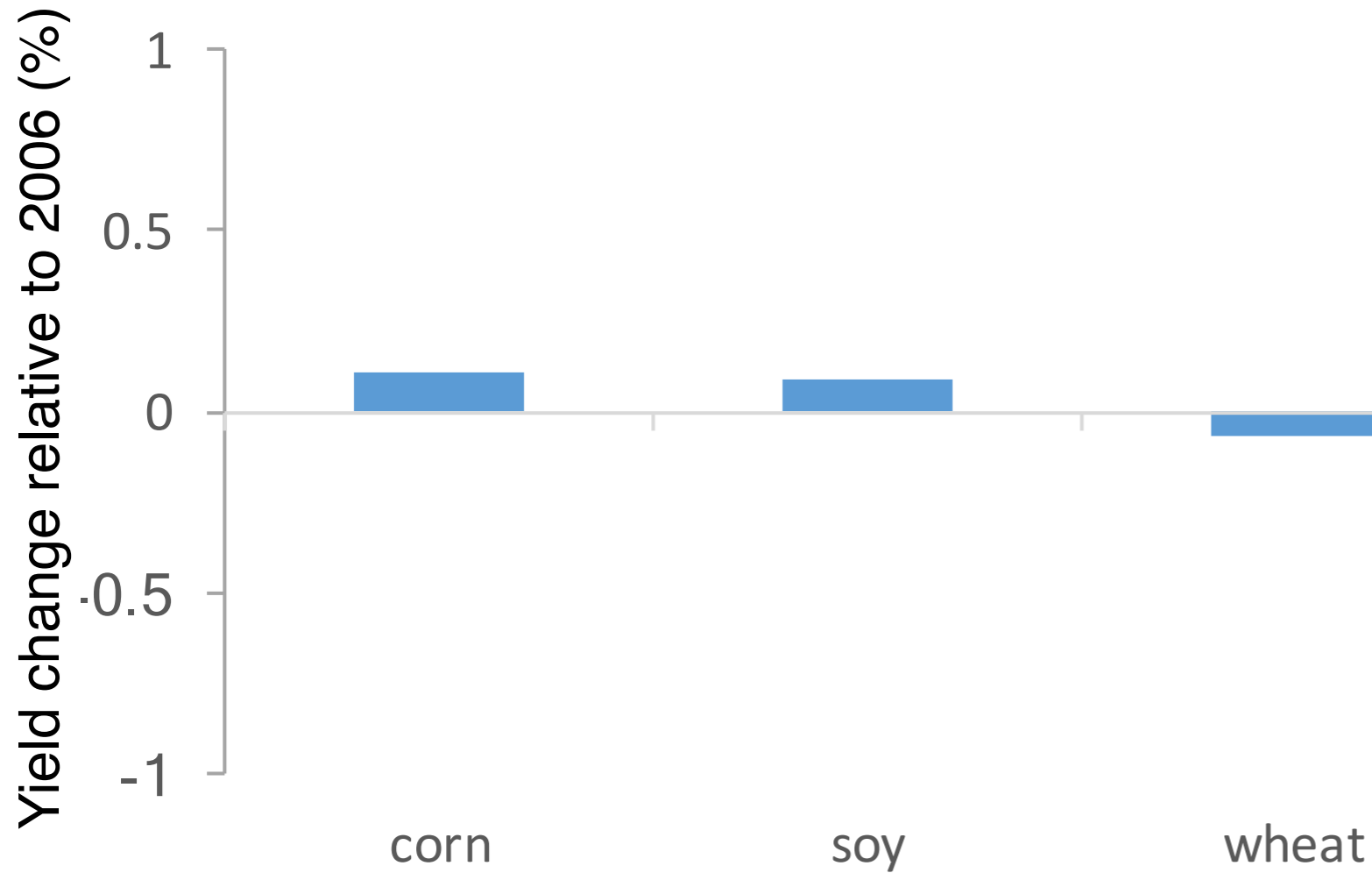
Historical Crop Yields



O_3 damage on La Chipper Potato. Credit: D. Lombardozzi

Future Crop Yields (RCP8.5)

Central U.S. in 2100



Lombardozzi et al. In Review



O₃ damage on La Chipper Potato. Credit: D. Lombardozzi

Vegetation O_3 damage:

- Damages photosynthesis more than conductance
- Changes global-scale water and carbon exchange
- Changes air quality (notably increasing O_3)



San Francisco brown cloud. Credit: D. Lombardozzi

Important considerations for future research:

- Large-scale continuous observations — on air quality & plant damage — are rare
- Most of our understanding of plant responses relies on short-term leaf-scale measurements using manipulative experiments
- Data are primarily available for temperate ecosystems, contributing to uncertainty in global projections of carbon & water cycling, air quality

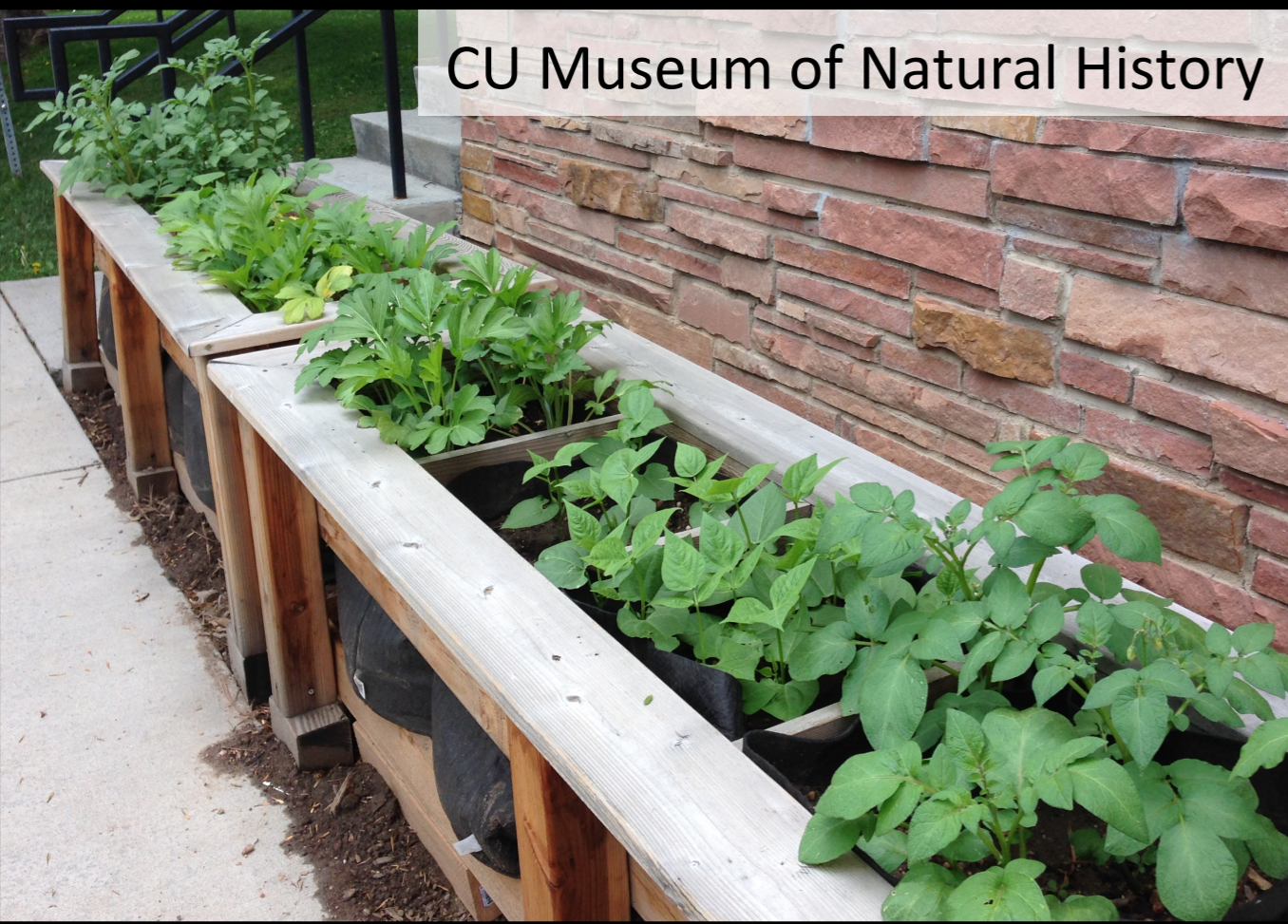
NCAR Front Entrance



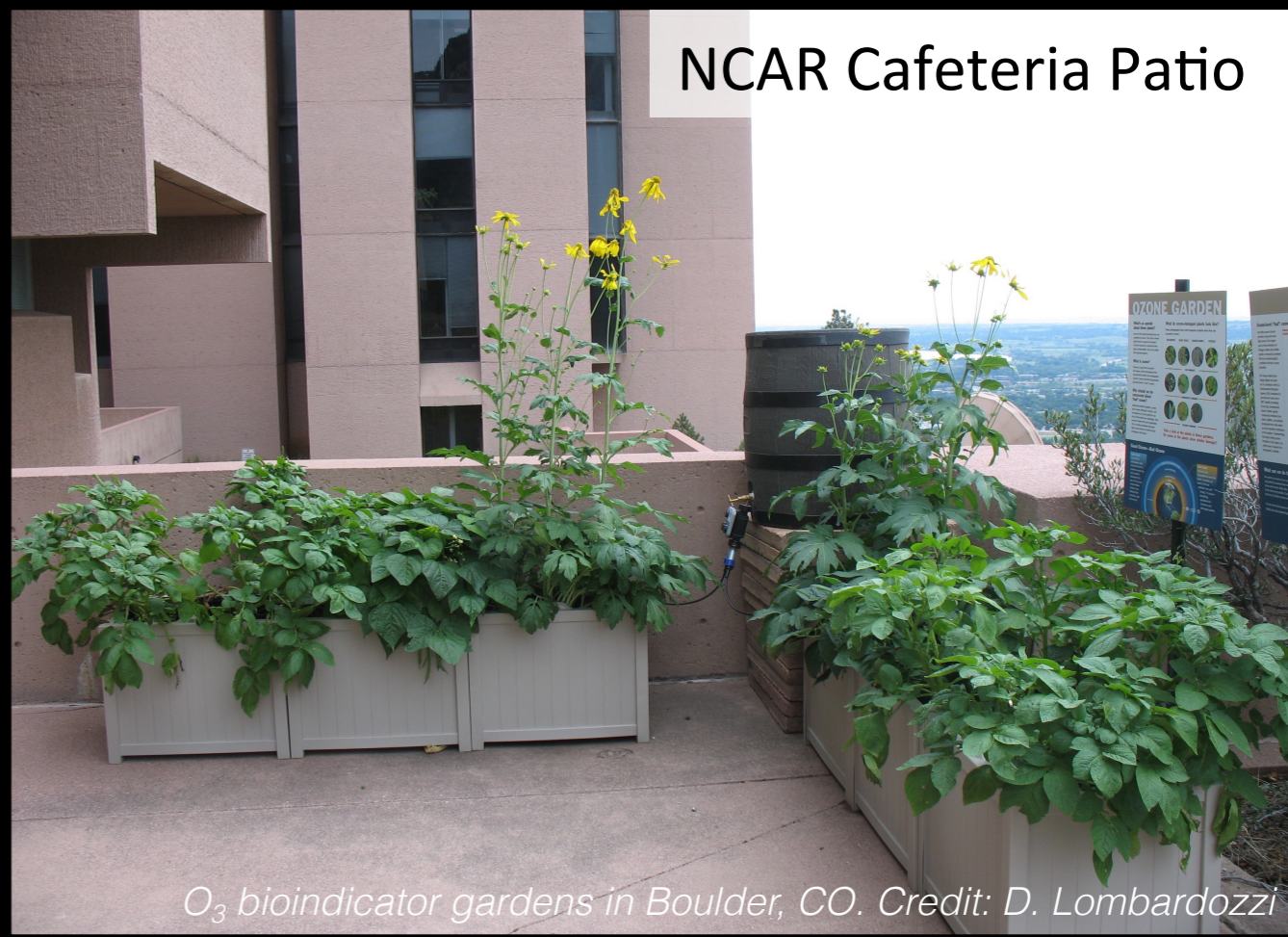
CU Mountain Research Station



CU Museum of Natural History

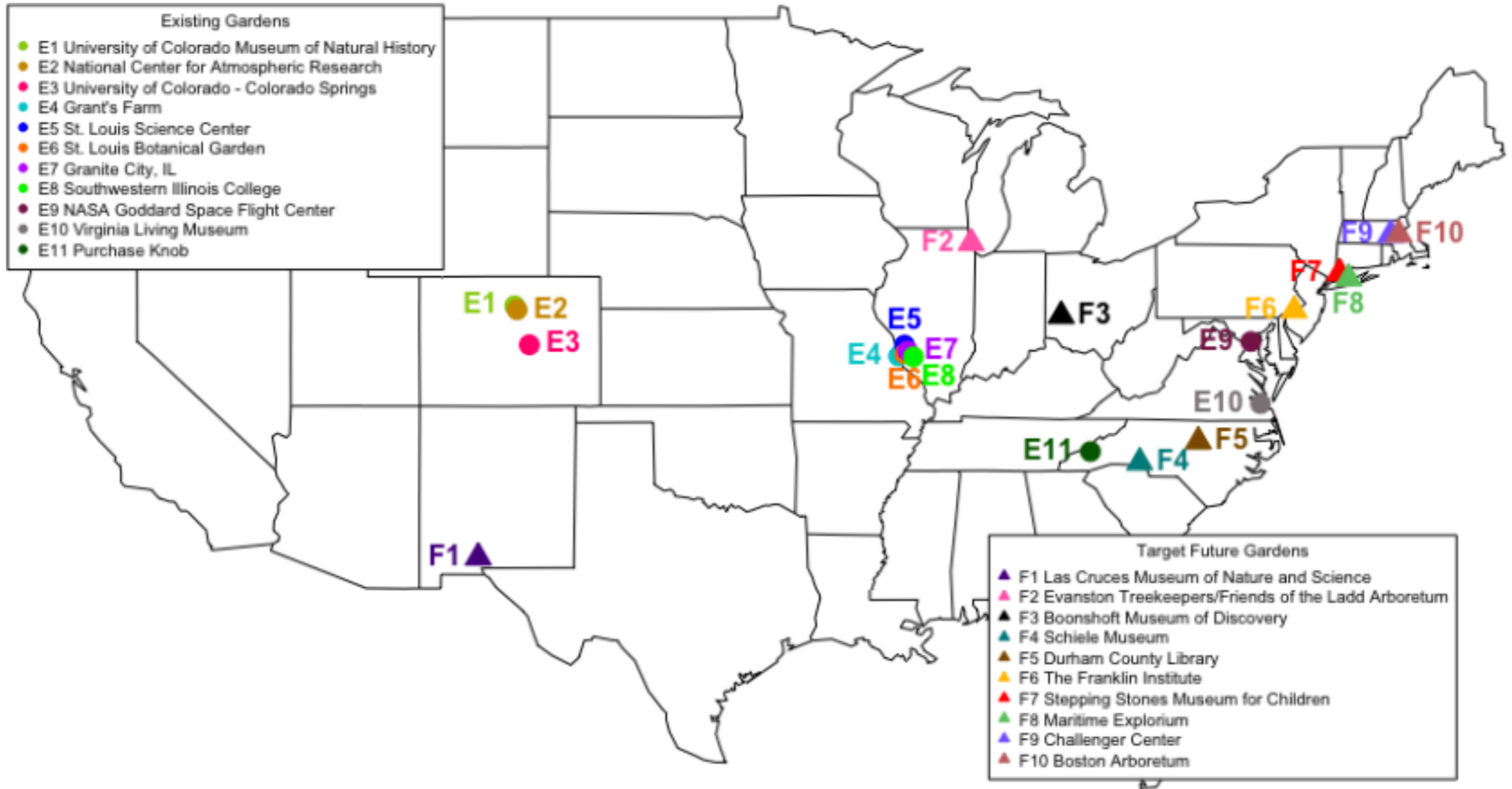


NCAR Cafeteria Patio

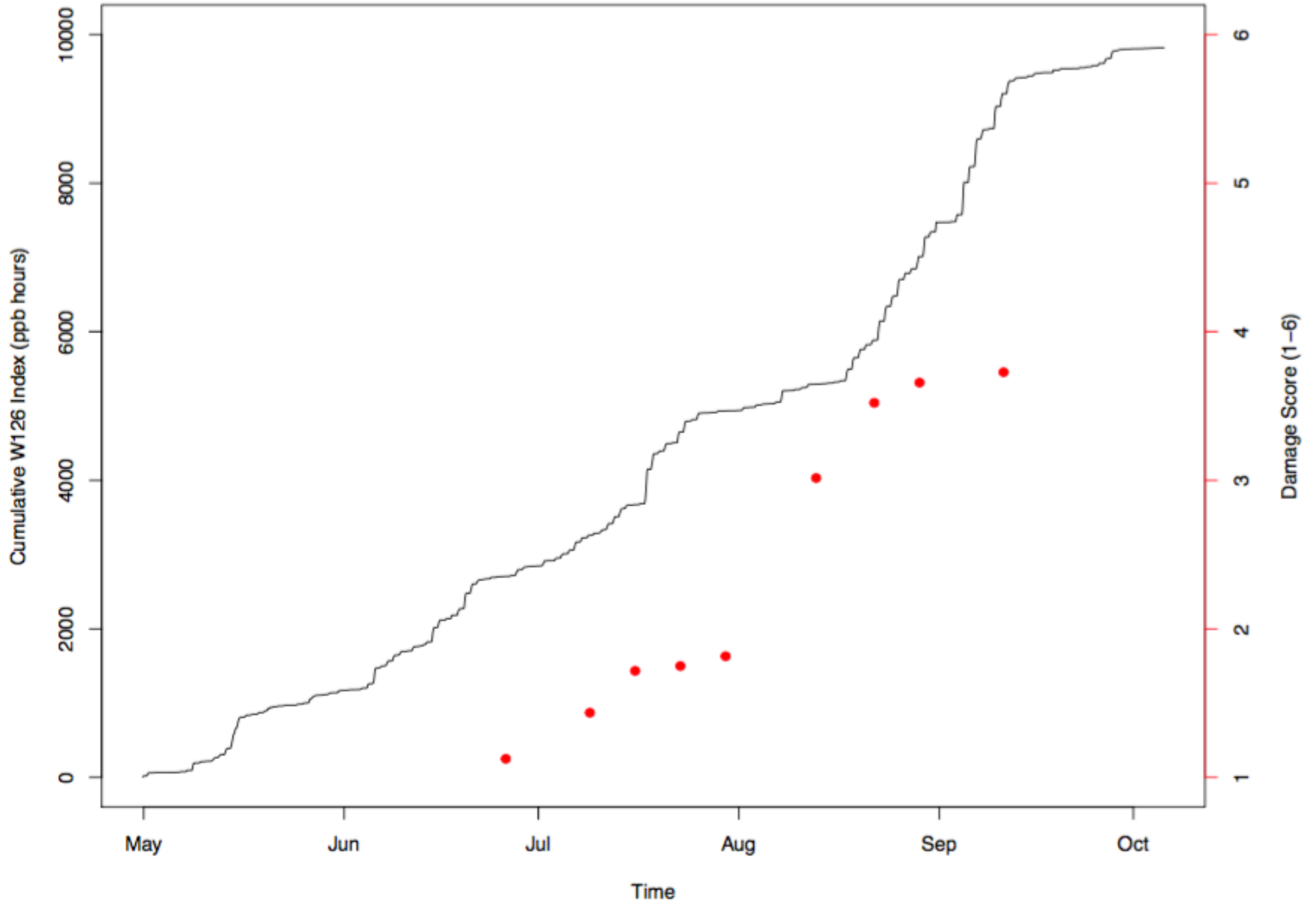


Gardens participating in the Ozone Pollution Education Network (OPEN)

Existing and Target Future Ozone Garden Locations in the United States

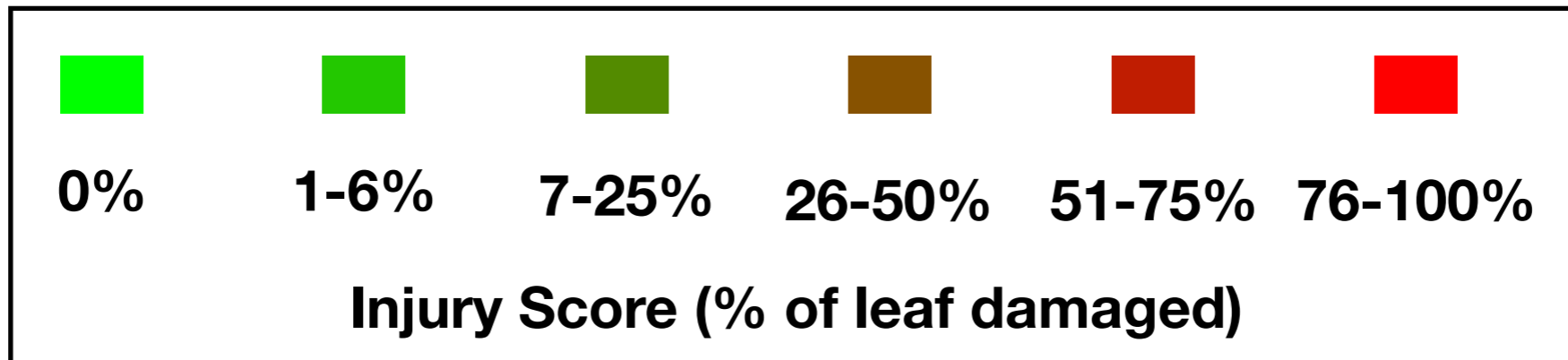
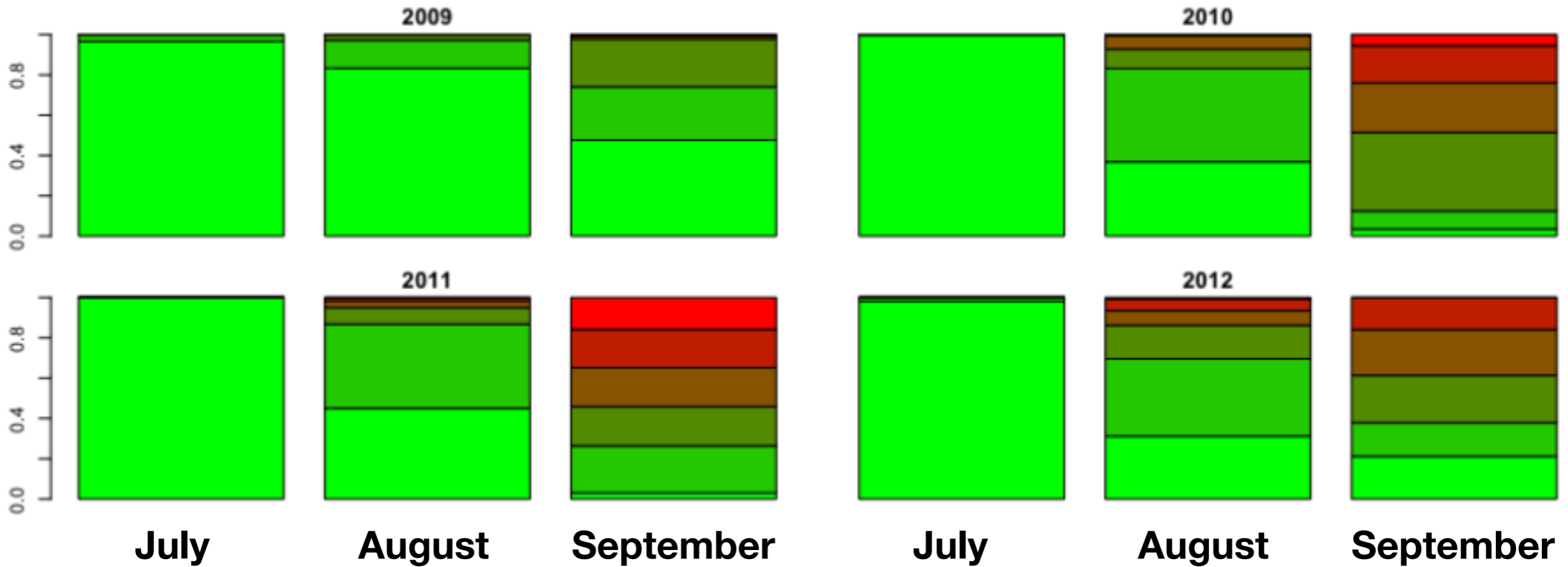


Cumulative W126 Indices

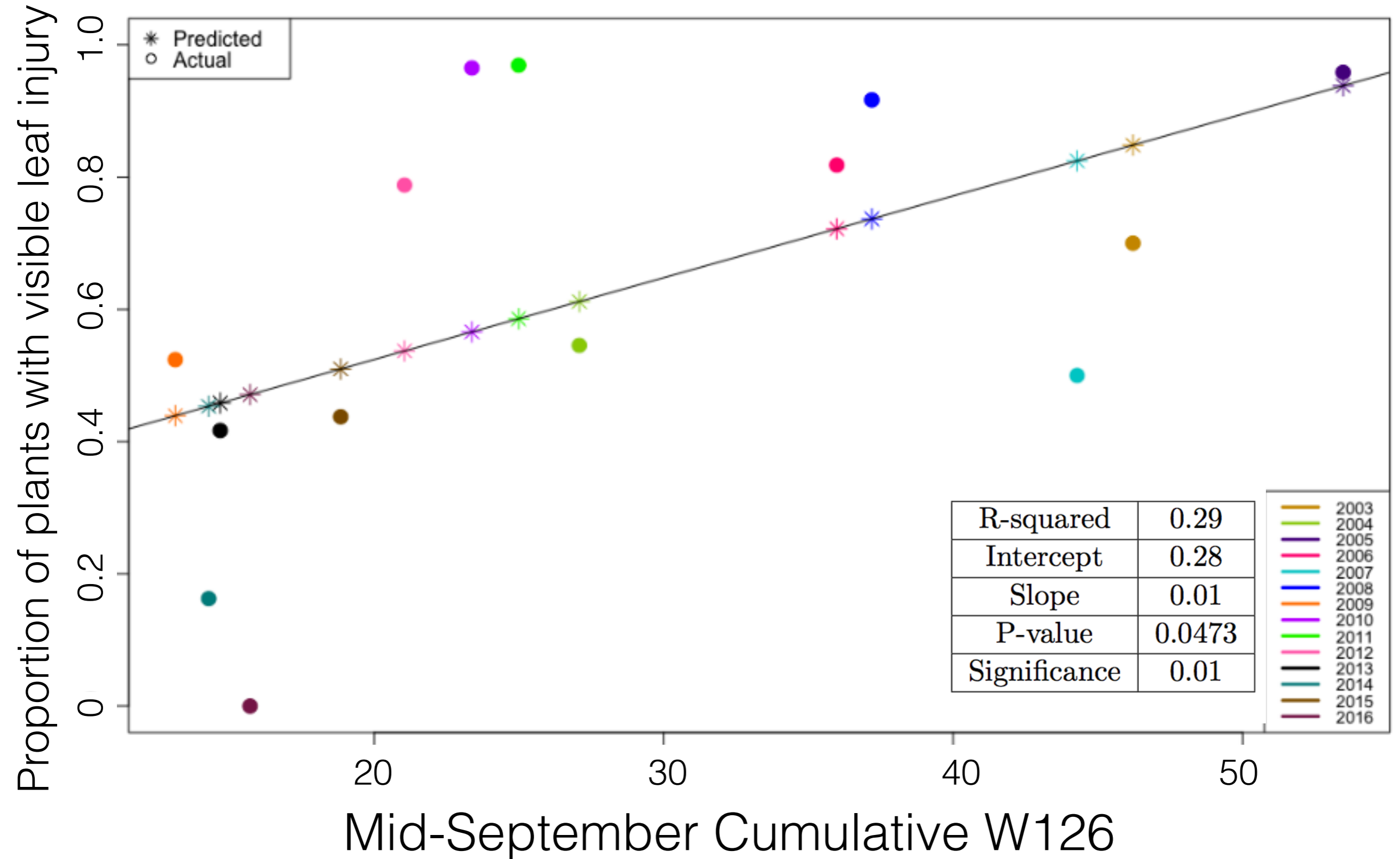


Purchase Knob Garden (North Carolina)

Proportion of leaves injured



Purchase Knob Garden (North Carolina)



Contact me for more
information:
dll@ucar.edu



O₃ bioindicator garden, Rocky Mountain National Park. Credit: D. Lombardozzi