Navigating Extremes in Savannas (NExS): Impacts of drought fire and grazing on plant communities








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Extreme events are becoming more frequent & often occur together

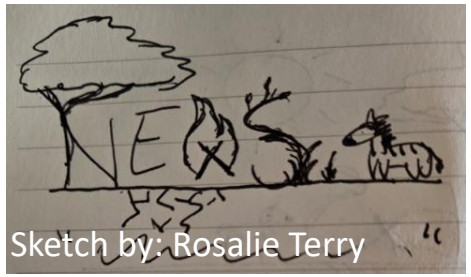
2% of the world's rarest zebras wiped out in Kenya's relentless drought

By Nimi Princewill, CNN
Updated 8:12 AM EDT, Wed October 5, 2022

Climate of chaos: the suffocating firestorm engulfing Australia

Recent droughts in the Kruger National Park as reflected in the extreme climate index

Johan Malherbe[1,2*], Izak PJ Smit[3,4], Konrad J Wessels[5] and Philip J Beukes[1]



Sketch by: Rosalie Terry

Navigating Extremes in Savannas

Pre-treatment | **Treatments** | **Recovery**

2023 | **2024** | **2025** | **2026** | **2027**

Gain empirical understanding about existing plant populations and communities

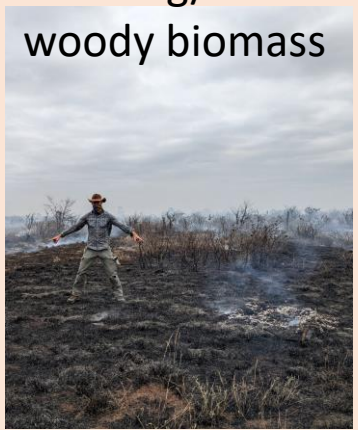

How does **IDENTITY** of traits control sensitivity to compound extremes?

Drought – **Herbivory** – **Fire**

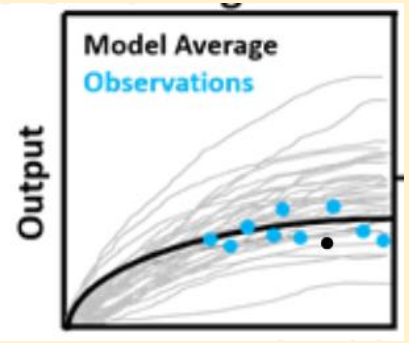
75% reduction

Monthly defoliation

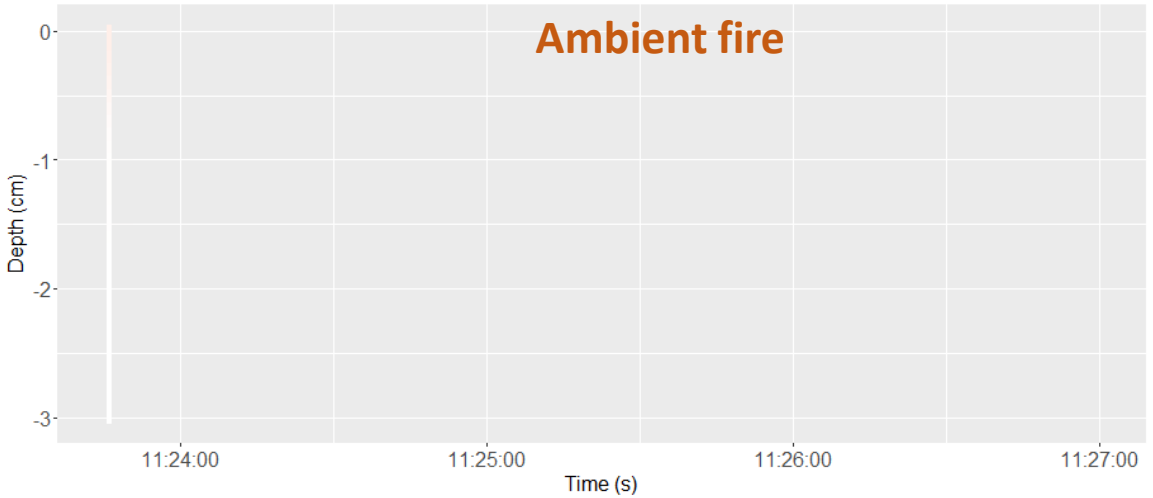
+ 1000 g/m2 woody biomass

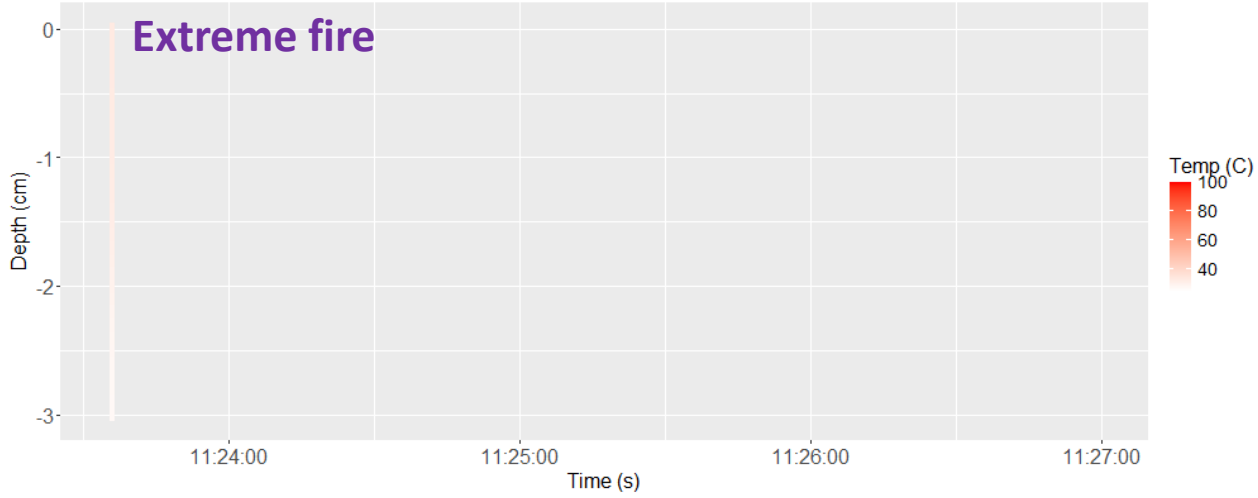


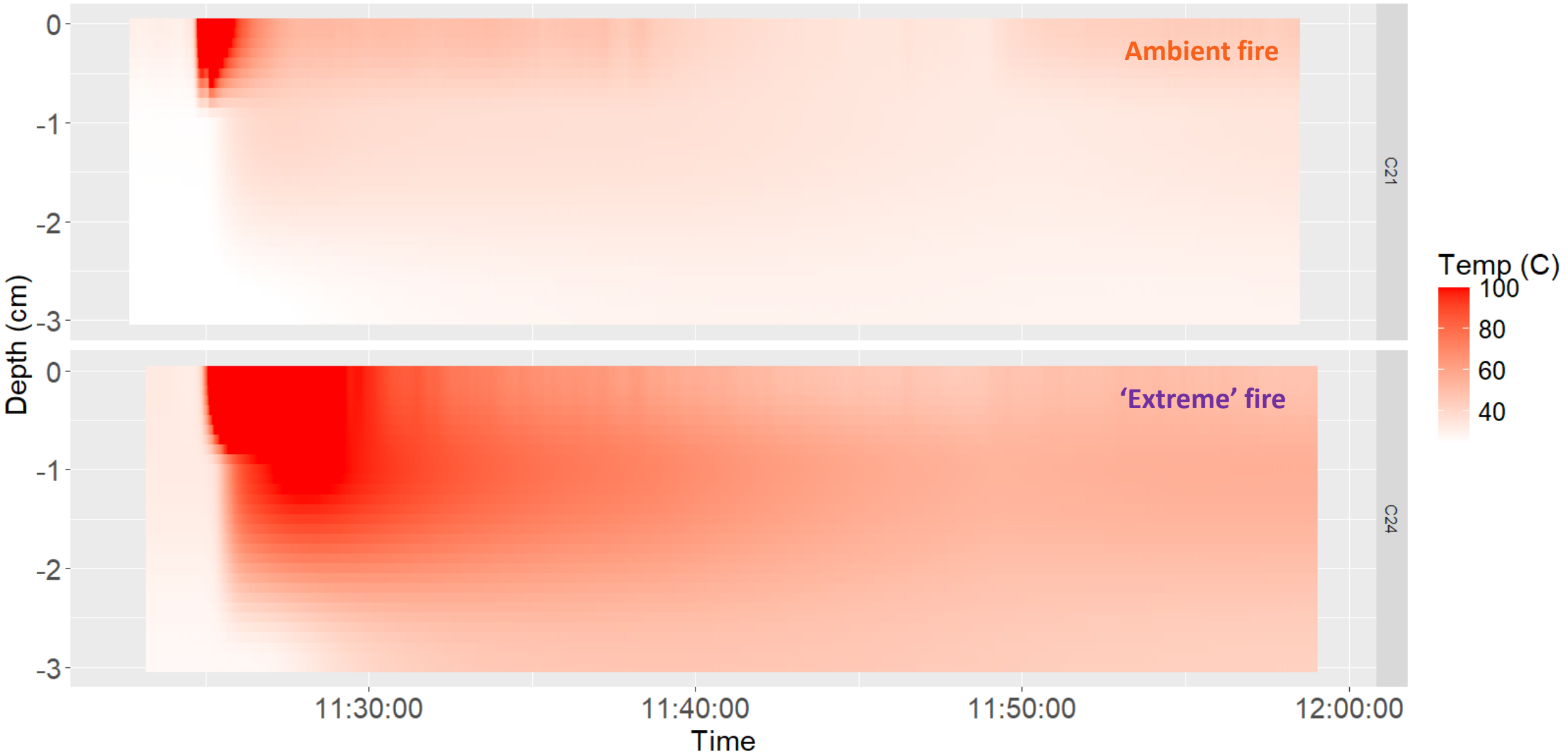
How does **DIVERSITY** control recovery?



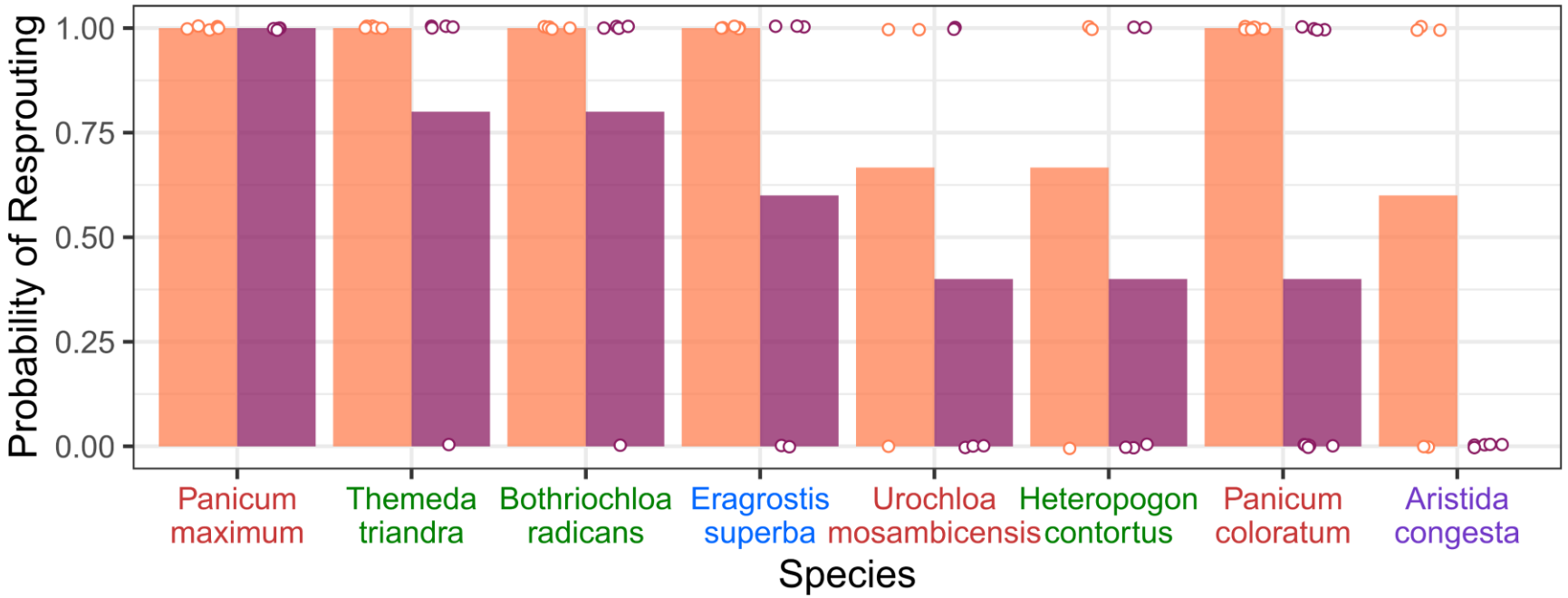

Ambient fire
Extreme fire

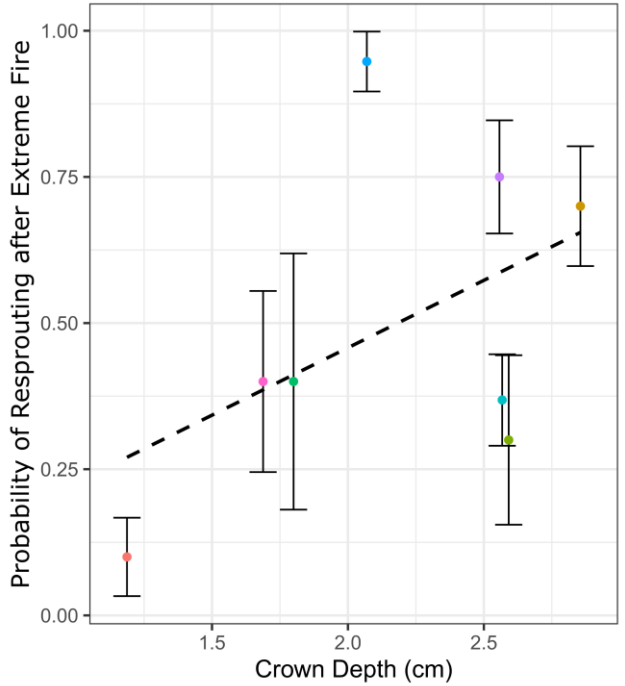

Ambient fire
0
-1
-2
-3
Depth (cm)
11:24:00
11:25:00
11:26:00
11:27:00
Time (s)
Temp (C)
100
80
60
40


Extreme fire
0
-1
-2
-3
Depth (cm)
11:24:00
11:25:00
11:26:00
11:27:00
Time (s)
Temp (C)
100
80
60
40


Ambient fire
'Extreme' fire
C21
C24
Depth (cm)
0
-1
-2
-3
11:30:00
11:40:00
11:50:00
12:00:00
Time
Temp (C)
100
80
60
40

Does resprouting/mortality depend on root traits?

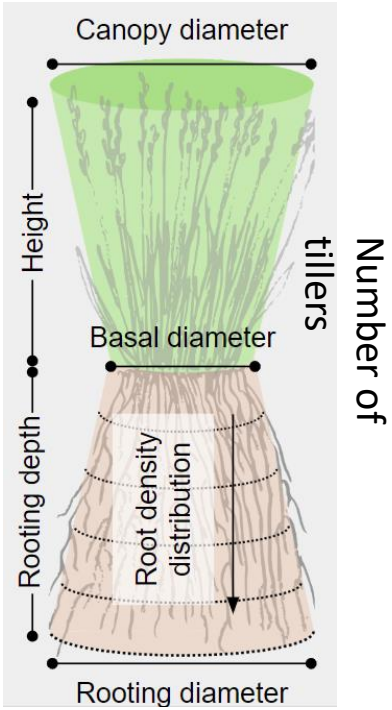


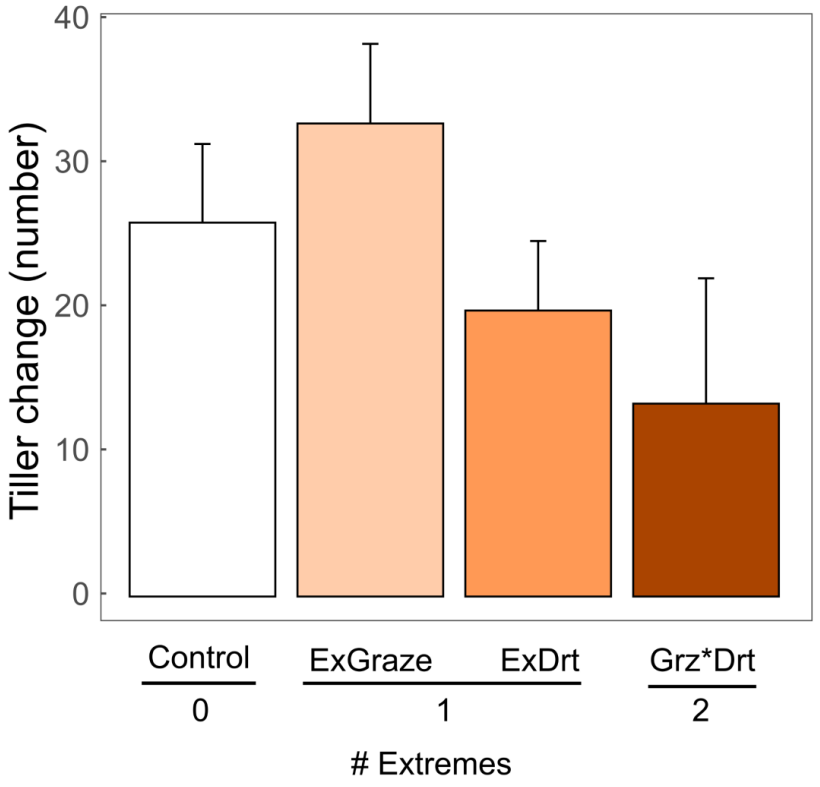


How do compound extreme differ from single extremes?

Grazing

Drought





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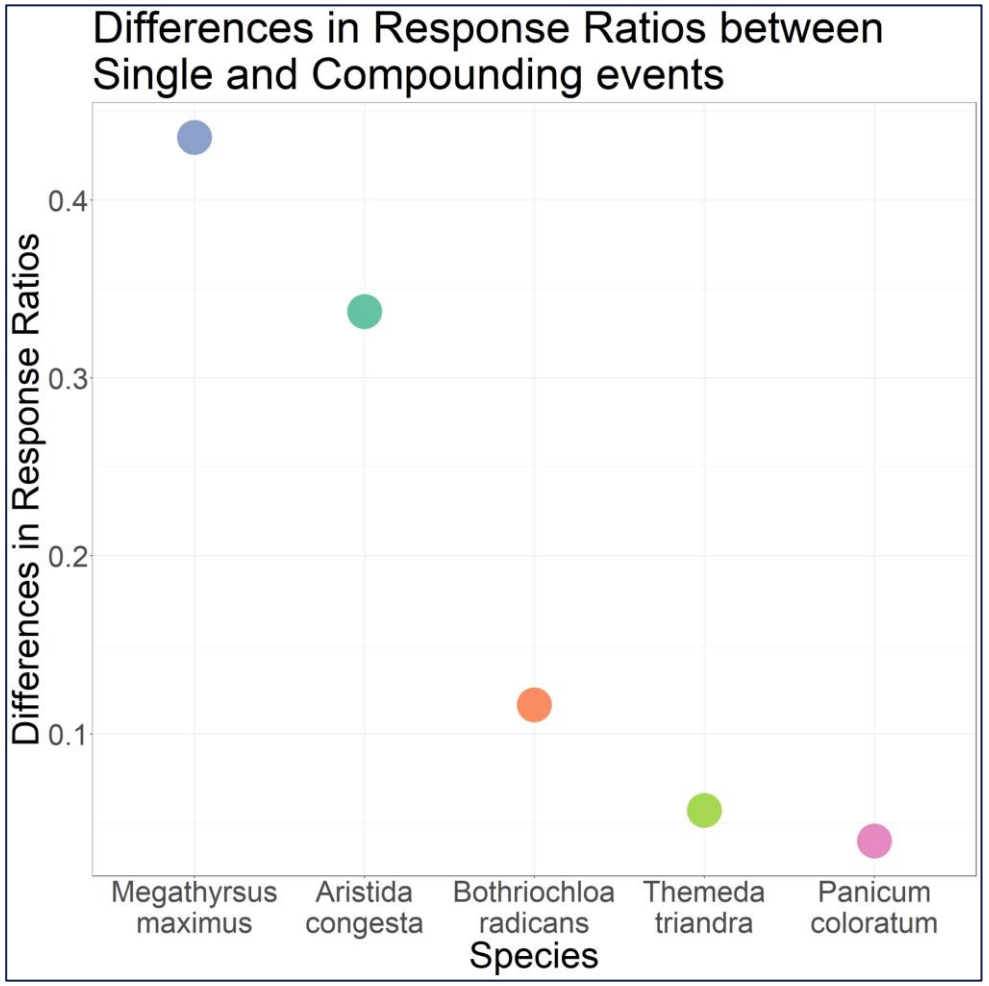


[BRIEF] Takeaways

- Extreme fire has different impacts on savanna herbaceous plants than typical fire
- Compound extremes have compounding effects
- These effects vary by species, potentially predictable through plant traits
- Year two and recovery likely to produce additional insights

Thanks!
Come find us








Funding

NSF-RAPID (1712786); NSF-Integrative Biology (2128302), UNCG Kohler international research fund

Field work

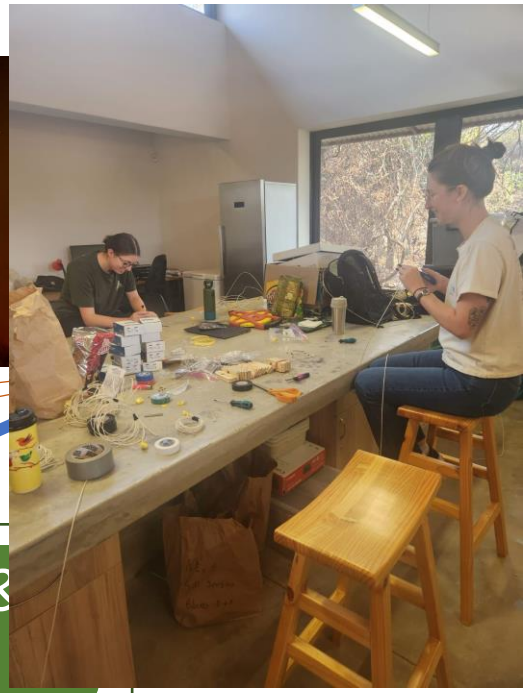
NDZI Ltd. T. Dlamini, M. Mashele, J. Noble, A. Post, A. Carrigy, A. Rodgers, J. Hanson, R. Terry, S. Williford, S. Cloud, E. M. Schmitt, M. Smith, A. Knapp, S. Collins, K. Kirkman, K. Freidenburg, and O. Zitha, Elijah, Carter Berry, Sam Mathieu, Mac Gissup, Kathryn Bloodworth

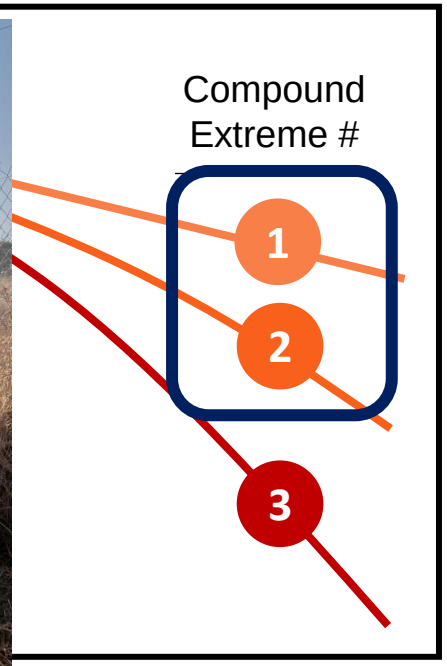
Kruger National Park support

S. Thompson, Tercia Strydom, SAEON Ndlovu Node for logistical support

1. How will compound extremes affect performance of plant populations?

Drought x **Herbivory** x **Fire**





- Severity of perturbation +

Plant populations & communities

Ecosystem Function and Services

2. How does biodiversity alter responses?

Tracking mini-populations

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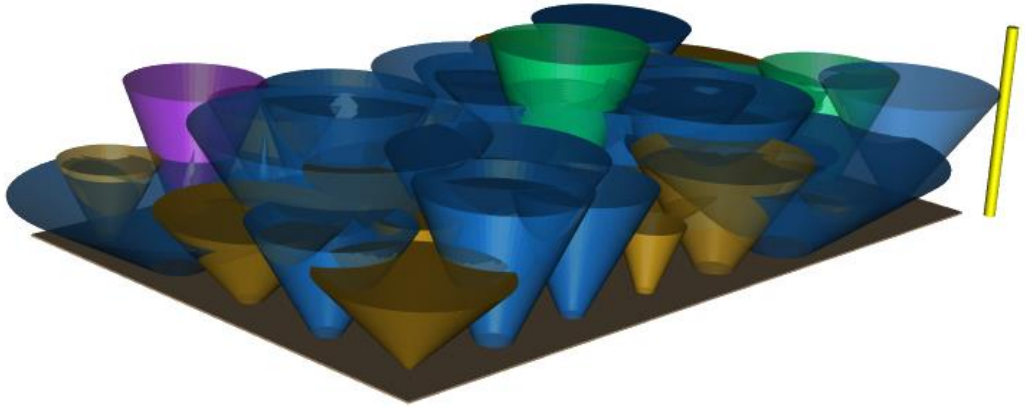
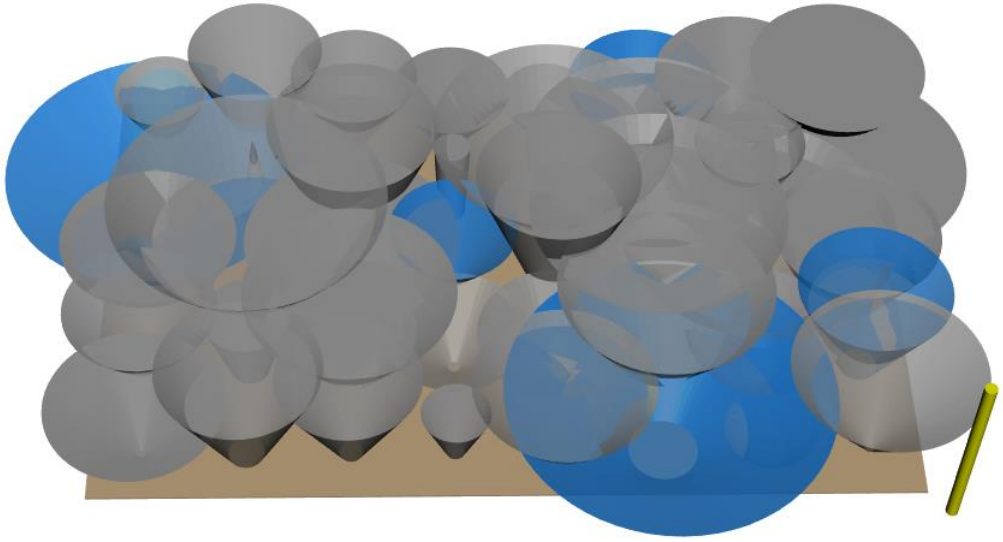
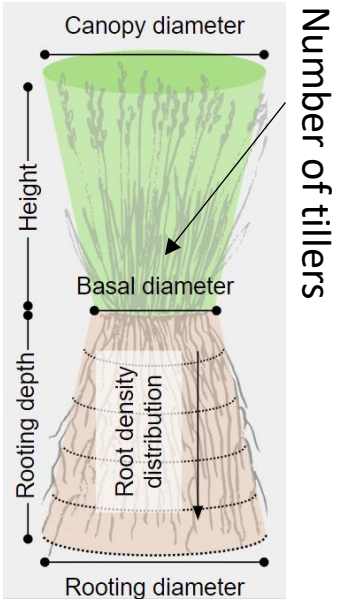
arco_col <- "goldenrod"
heco_col <- "springgreen"
ersu_col <- "purple"
```



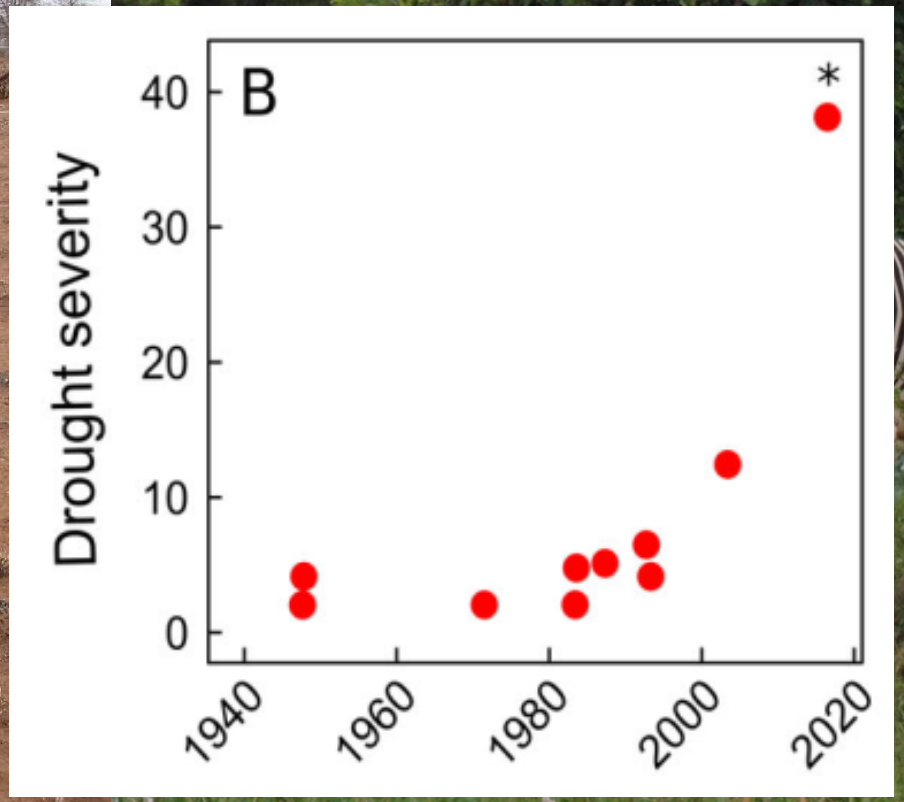
Tagged 5 individual bunch grasses in each plot
Learned a LOT about these individuals (traits)

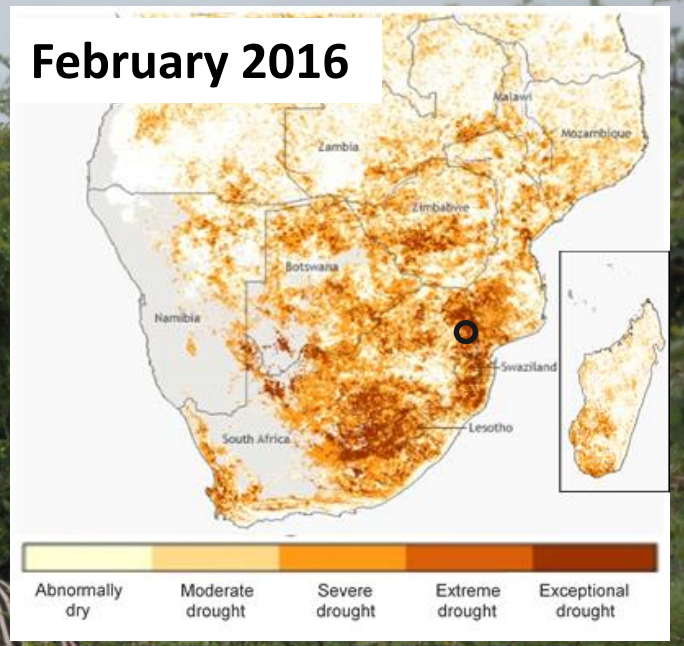
- Specific leaf area
- Veg height
- Flwr height
- Flwr number
- Rooting depth
- Specific root length
- Allometry
- Tiller number
- Root non structural carbohydrates
- Bud number
- Bud location
- Vcmax
- Jmax
- Xylem conduit diamter
- Leaf turgor loss point
- P50
- Max stomatal conductance





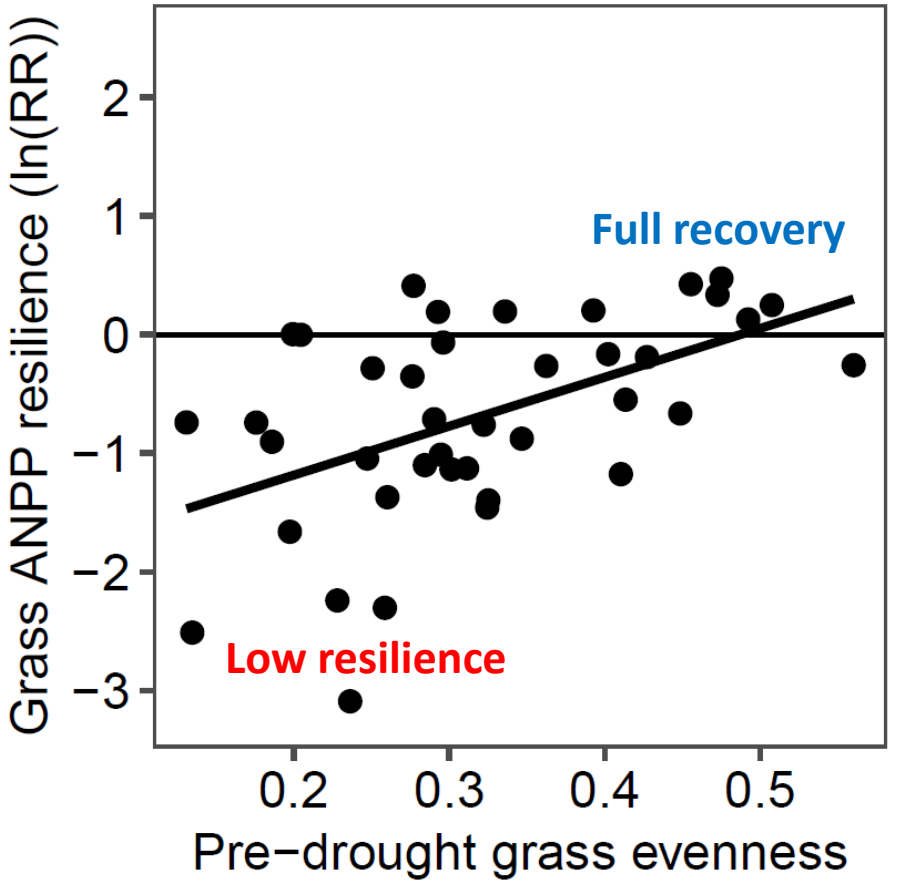
Extreme drought in Kruger National Park





Wilcox et al. 2020

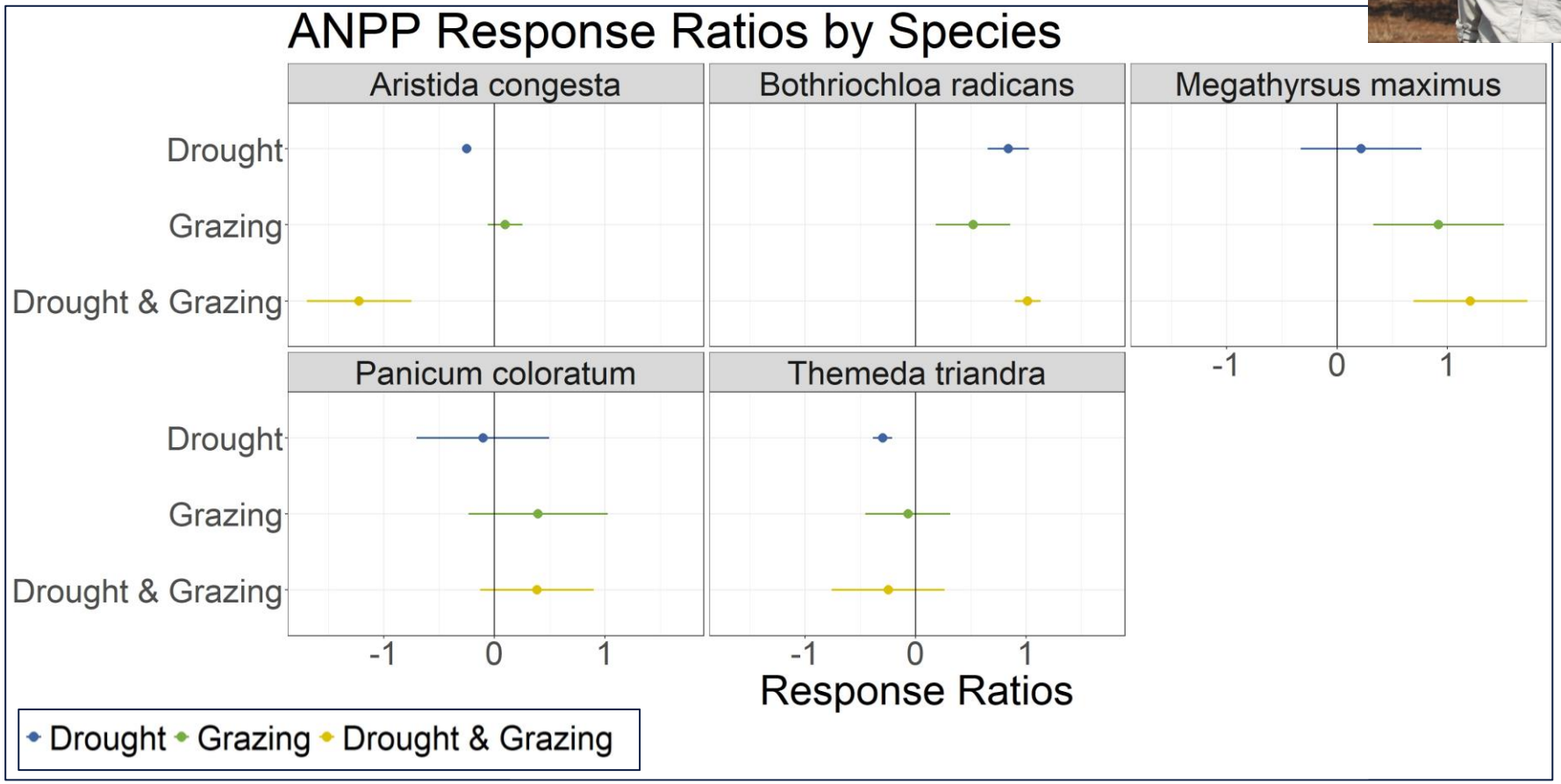
Diversity of plant communities can facilitate resilience



How do compound extreme differ from single extremes?

Grazing

Drought



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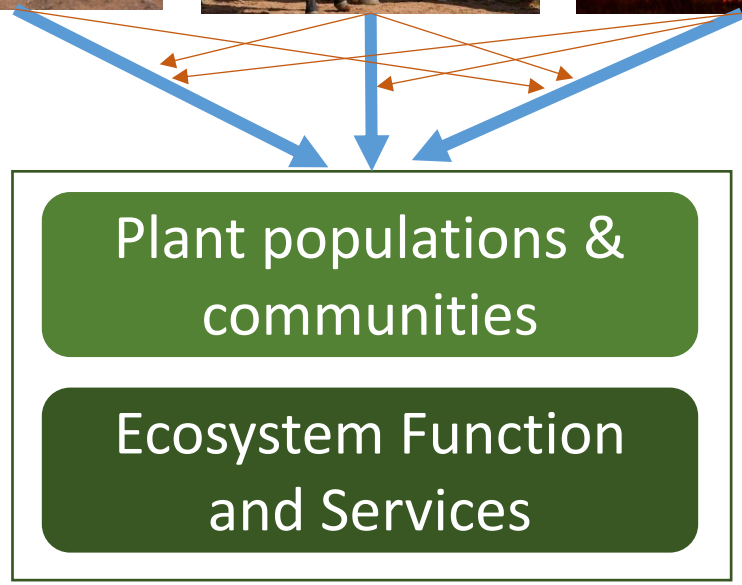
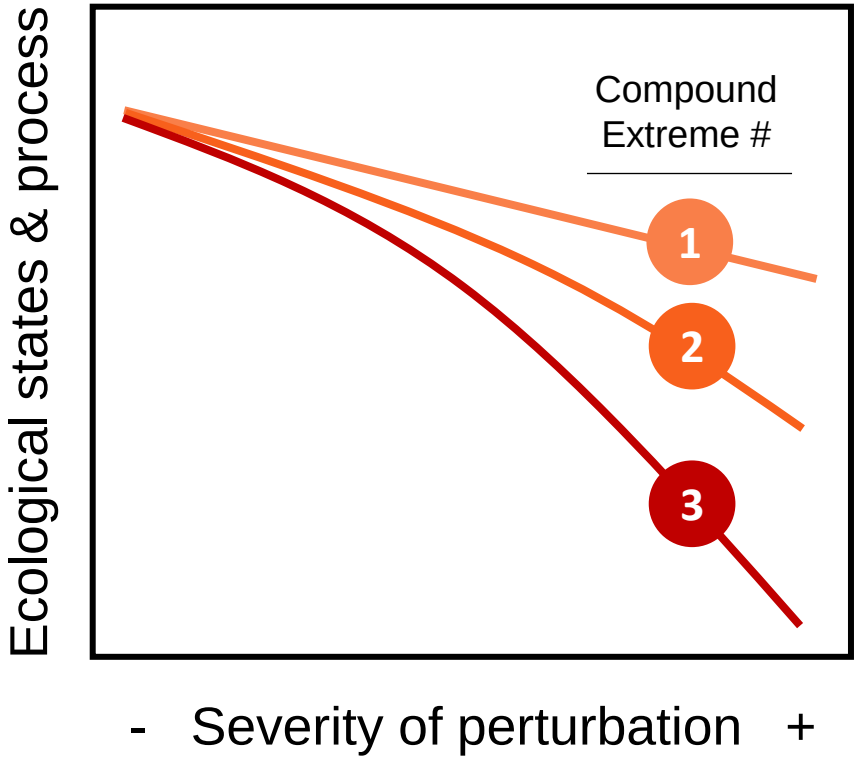




2. How does biodiversity alter responses?

Aristida congesta ssp. barbicollis

3-4
5-6
1-2
7-8

Bothriochloa radicans

17-18
19-20
21-22
23-24

Panicum maximum

Themeda triandra

9-10
11-12
15-16
13-14

Panicum coloratum

25-26
27-28
29-30
31-32

41-42
43-44
45-46
47-48

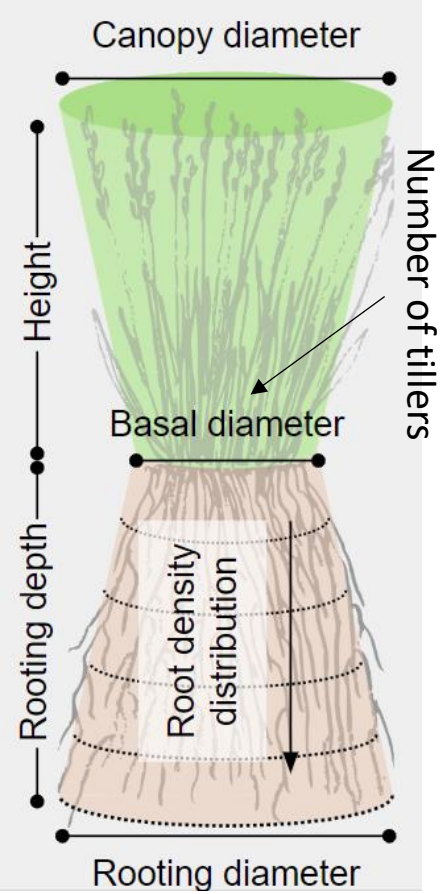
Panicum coloratum

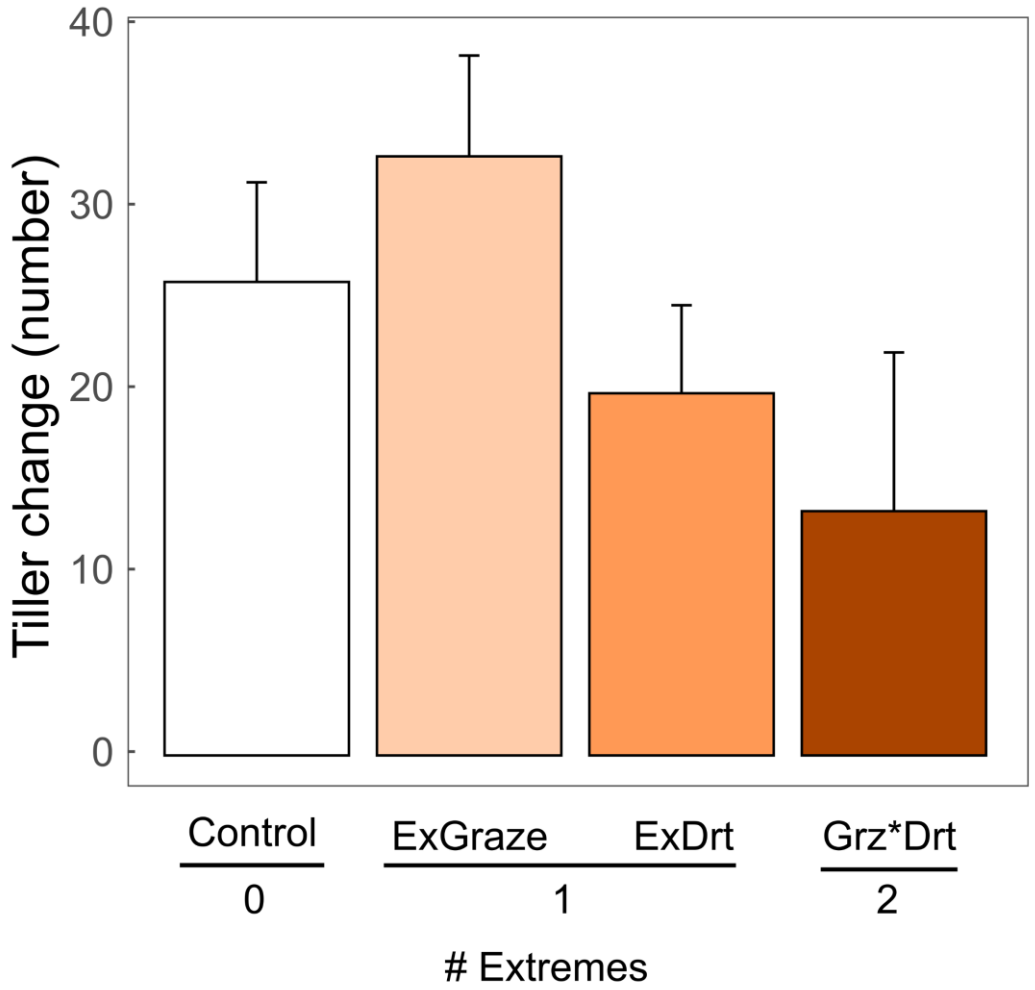
33-34
35-36
39-40
37-38

N

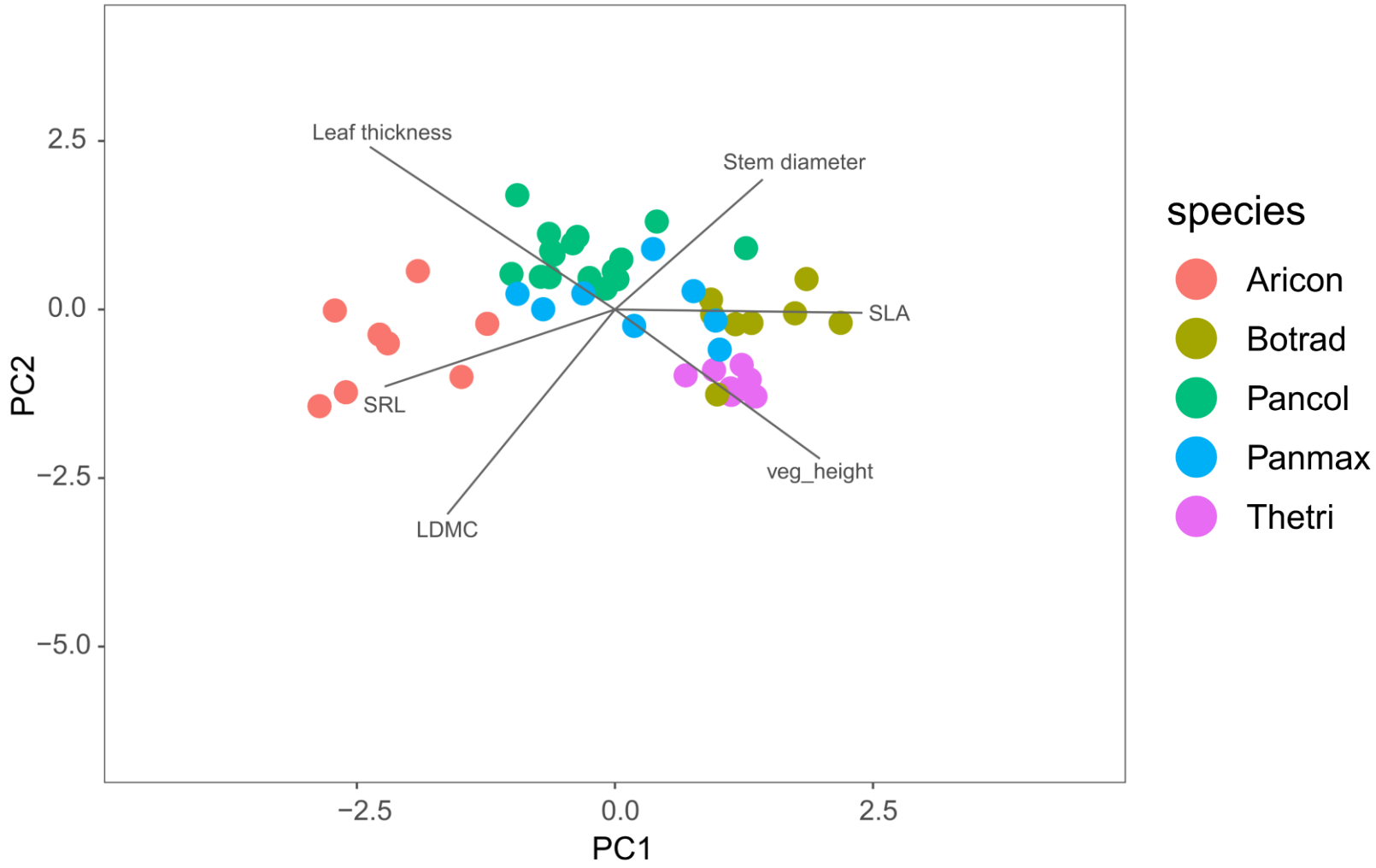
0 50 100 Meters

1. Do compound extremes lead to greater population responses?





2. How does trait diversity alter responses to compound extremes?



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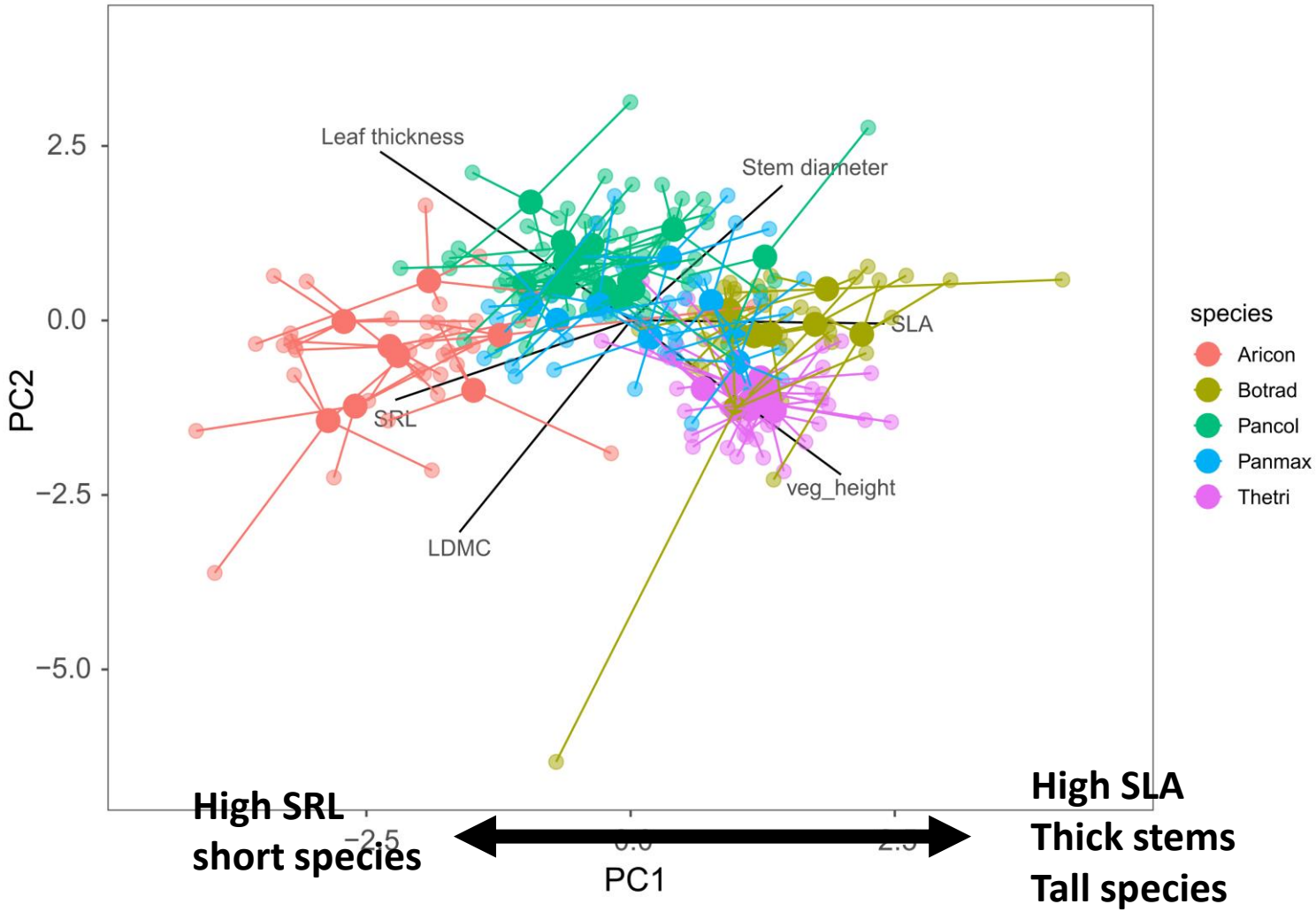

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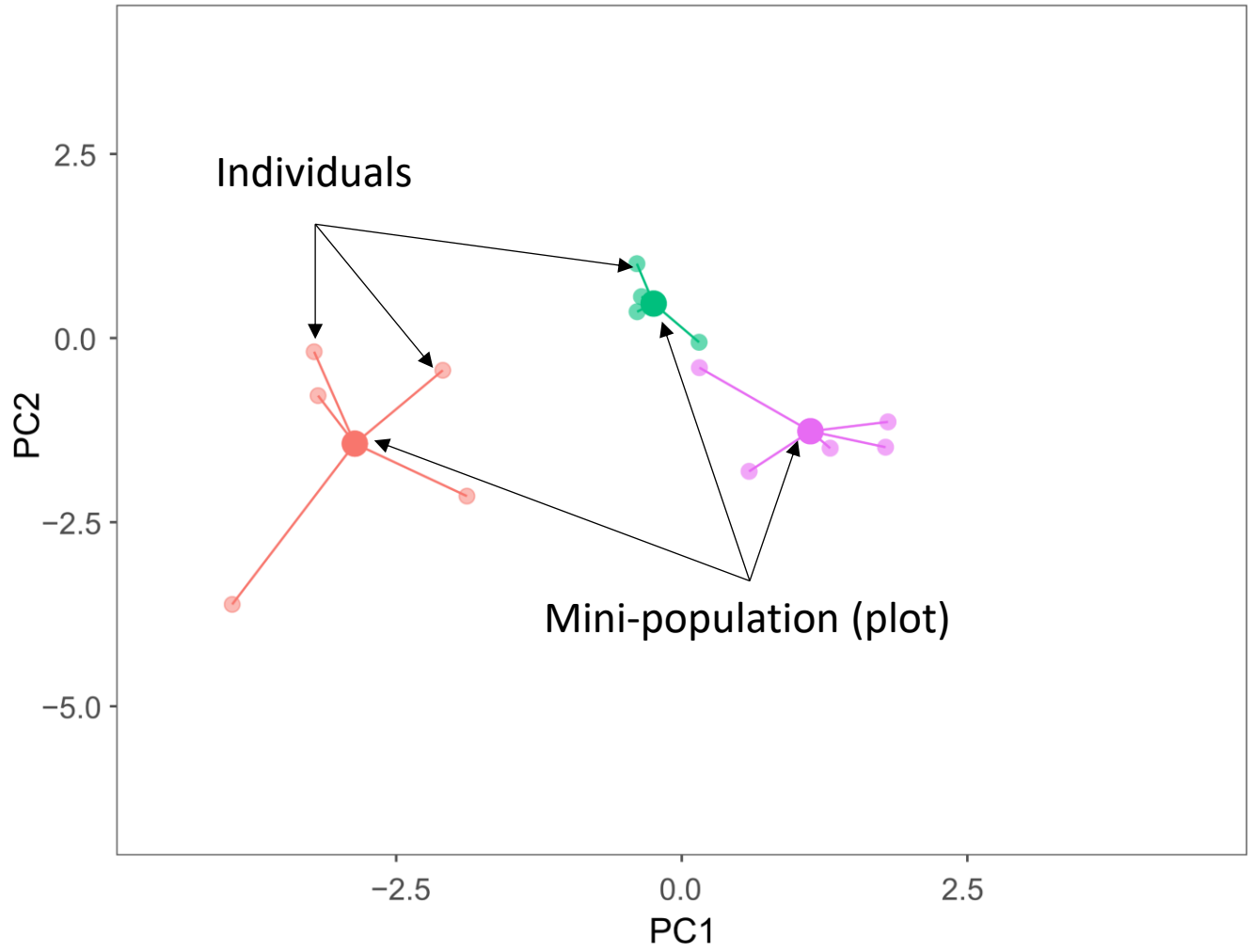

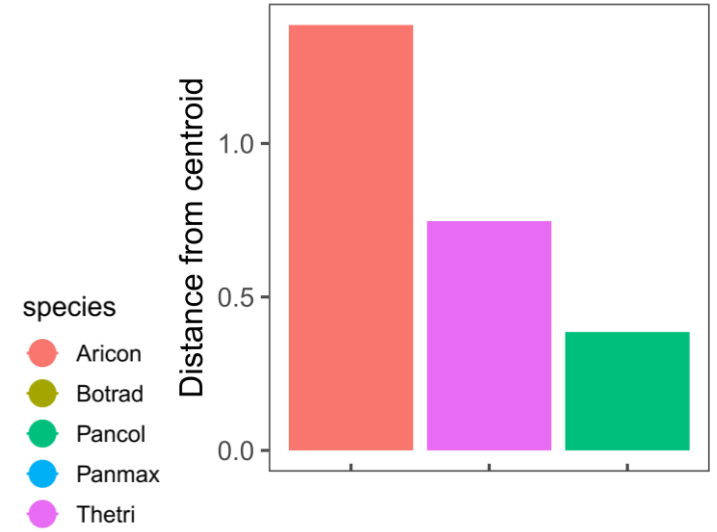

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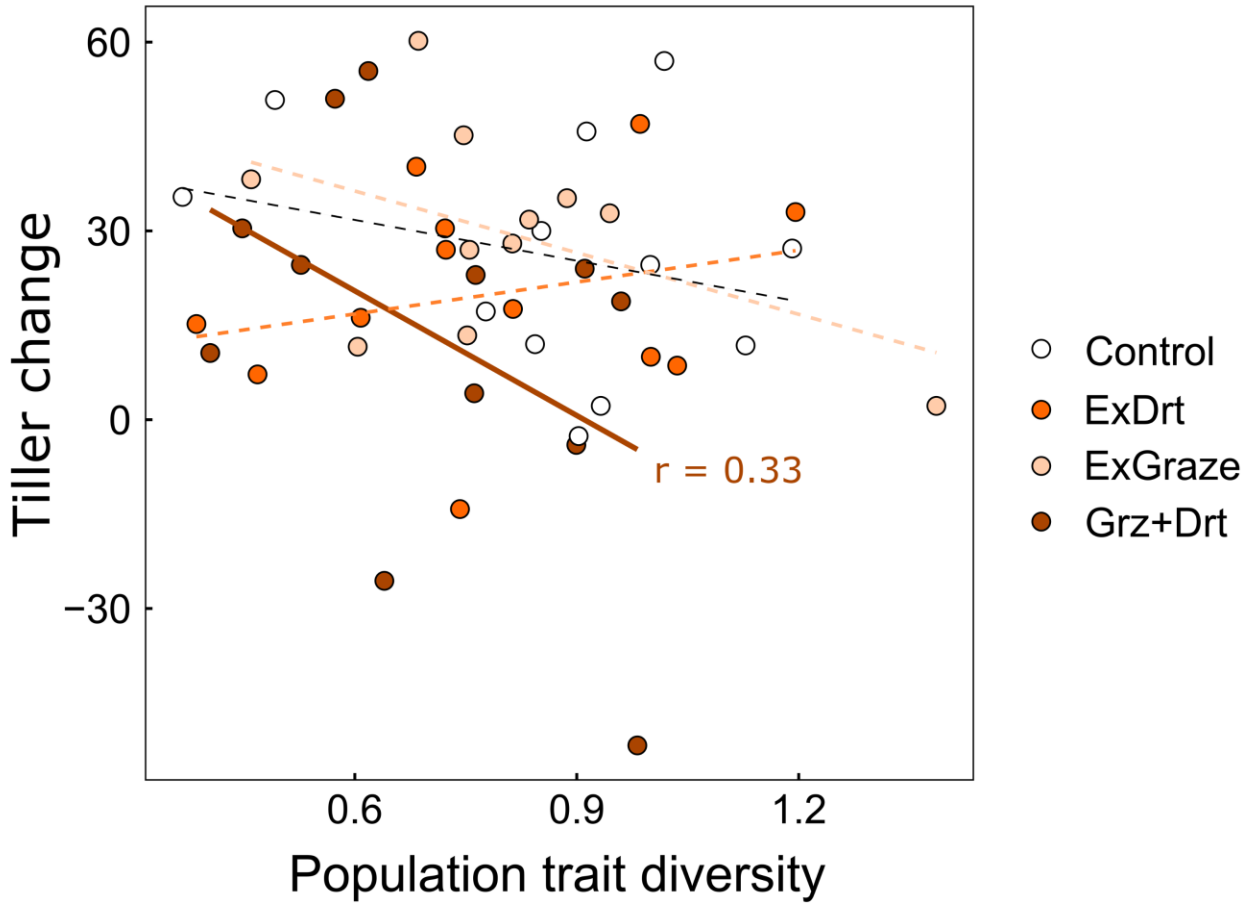

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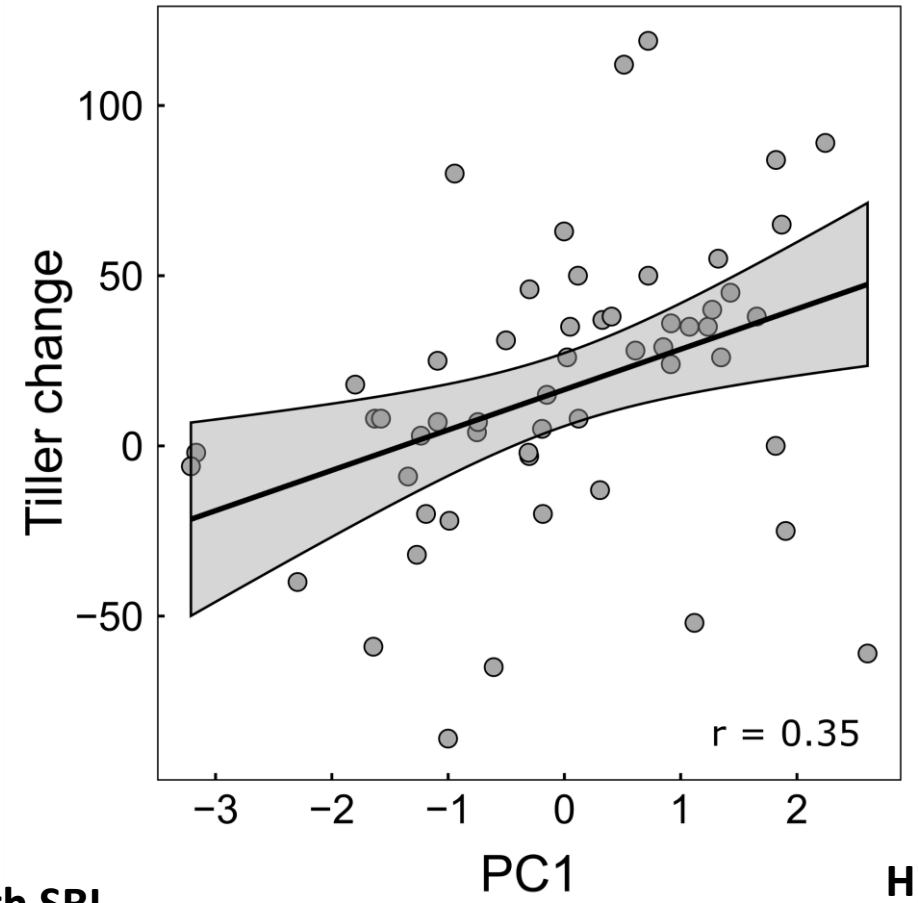


High SRL
short species

High SLA
Thick stems
Tall species

Conclusions

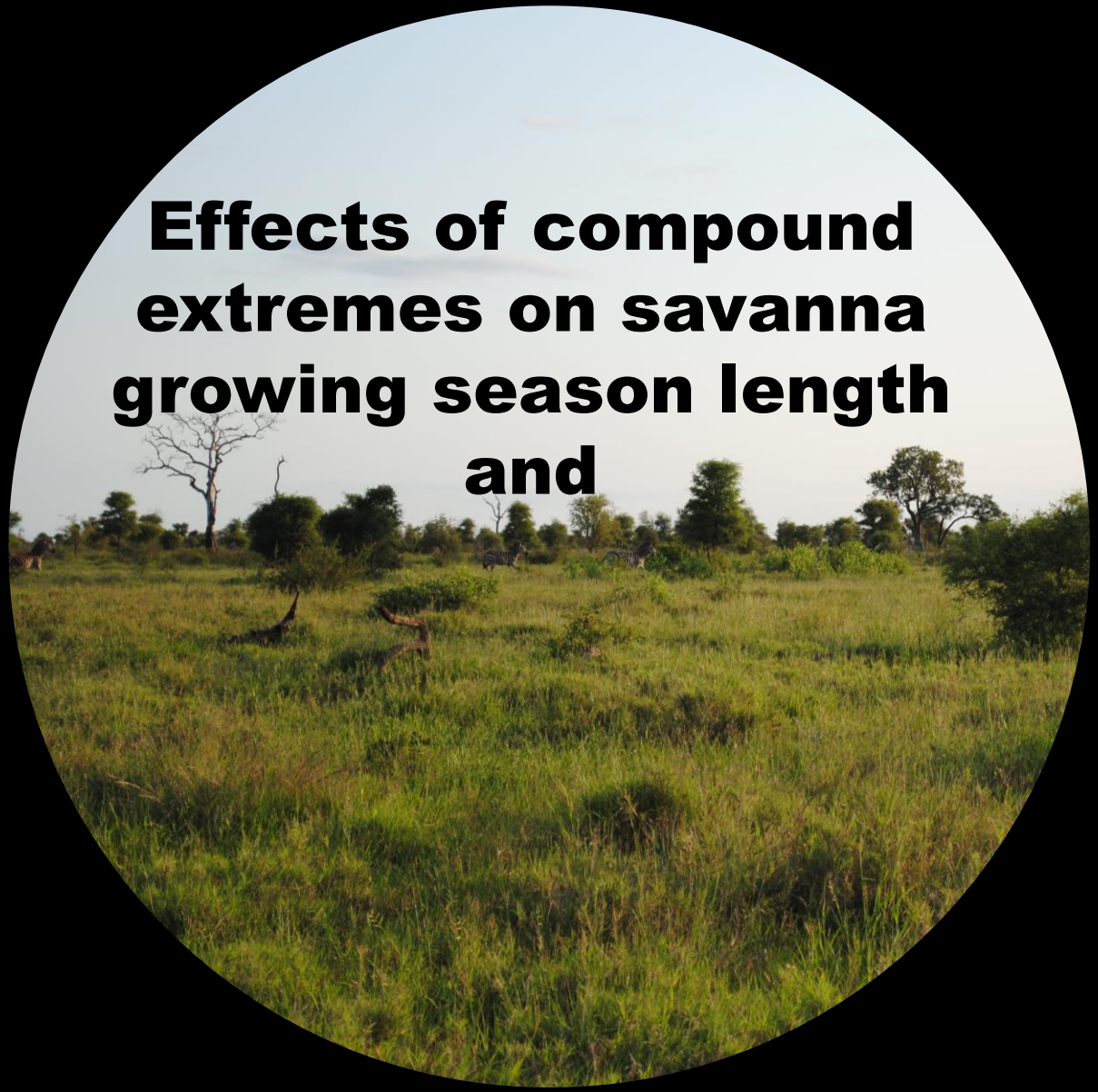
- Compound extremes may have stronger effects than single extremes
- Population diversity did not lead to greater resistance of populations to compound extremes
- However, specific groups of traits correlated to responses to compound extremes
  - Population diversity may be a more important driver of population recovery

Acknowledgements

My lab - Joshua Ajowele, Shelby Williford, Sophia Ronan, Abbi Rodgers, Jenny Hanson, Sheila Cloud

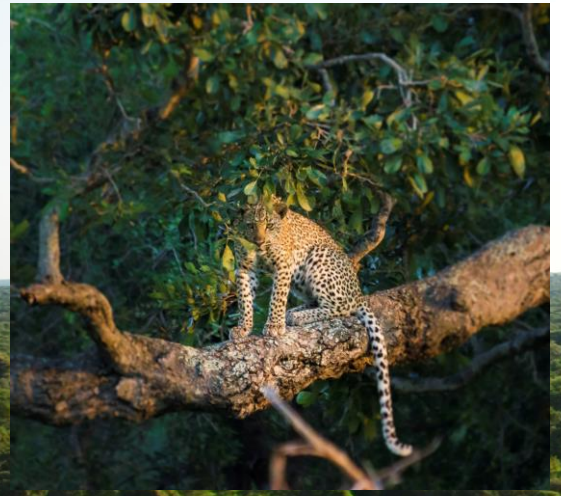
Kruger research - S. Thompson, Tsumbe Dlamini, Mightyman Mashele, Jen Noble, Allison Post, Ashley Carrigy, Abbi Rodgers, Jenny Hanson, Rose Terry, Shelby Williford, Sheila Cloud, Elijah Newark, Nate Lemoine, Mary Schmitt, Kealoha Freidenburg, Alan Knapp, Melinda Smith, Scott Collins, Kevin Kirkman, Kim Komatsu, Tim Ohlert, Oppa Zitha, Elijah Masango, Carter Berry, Sam Mathieu, Mac Gissup, Kathryn Bloodworth

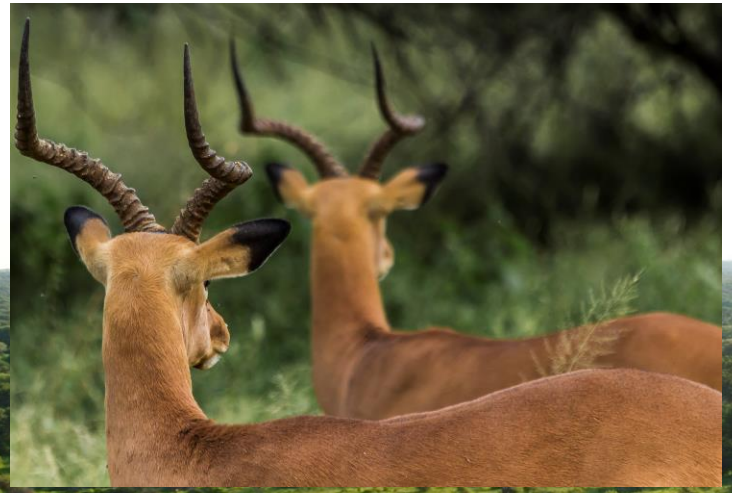
Questions

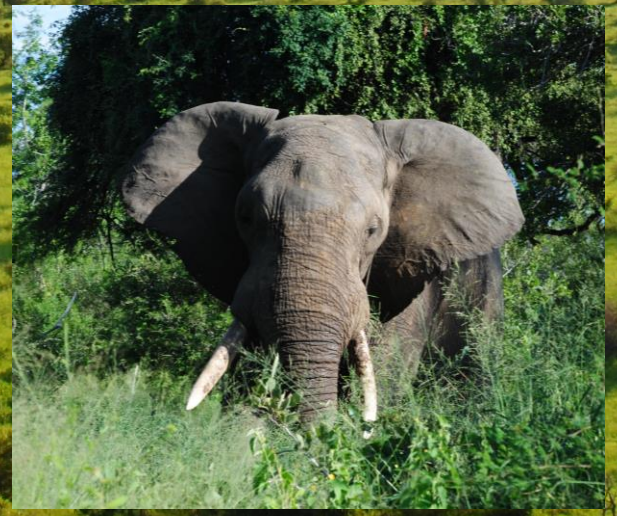

Effects of compound extremes on savanna growing season length and

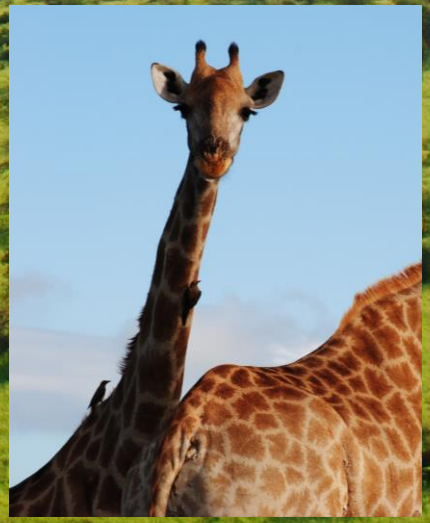

Experimentally simulating compound extremes

Effects of compound extremes on savanna growing season length



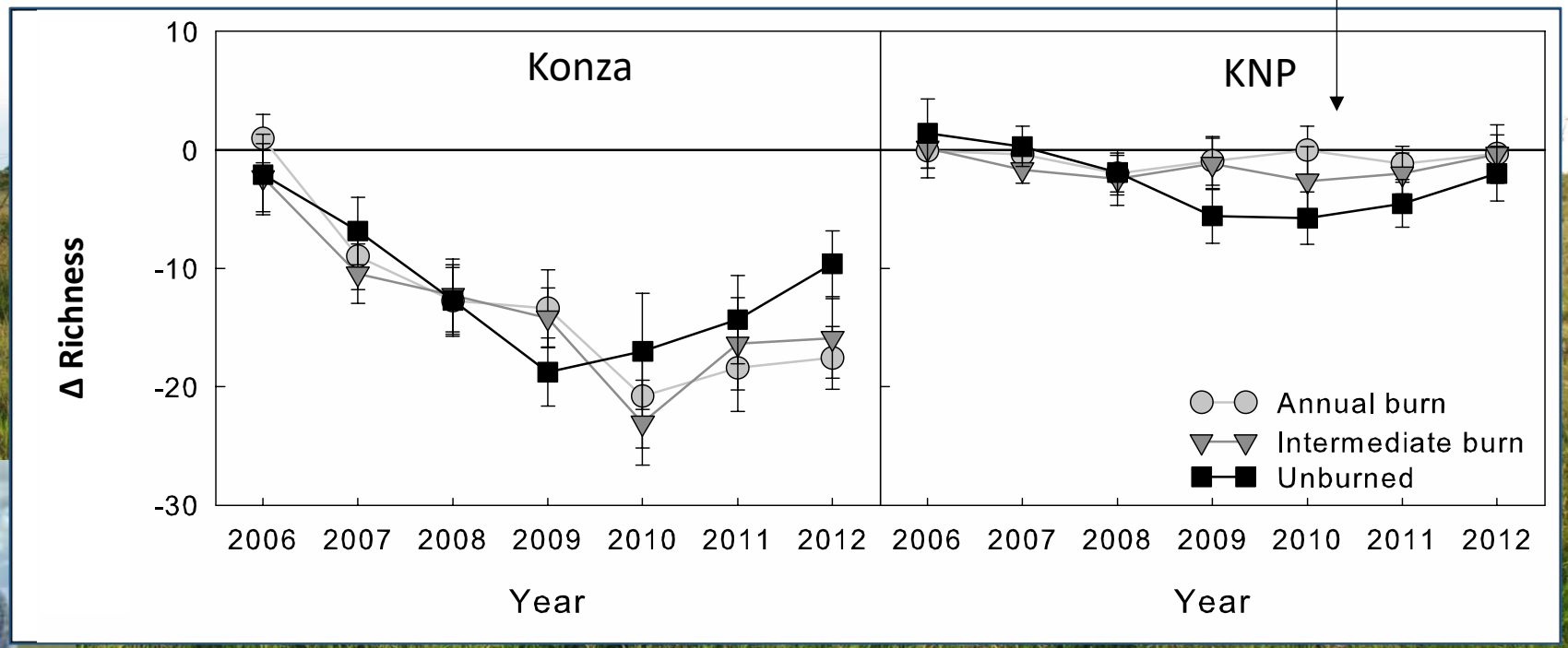




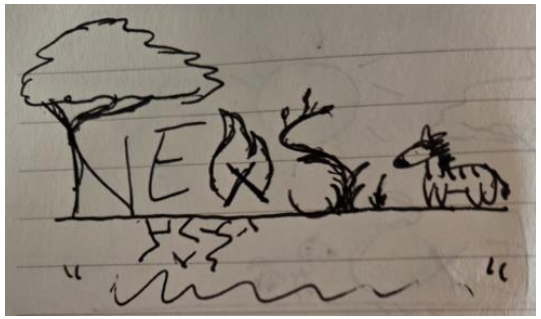


Resistant to ecological perturbations

Low sensitivity to herbivory



Koerner et al. 2014



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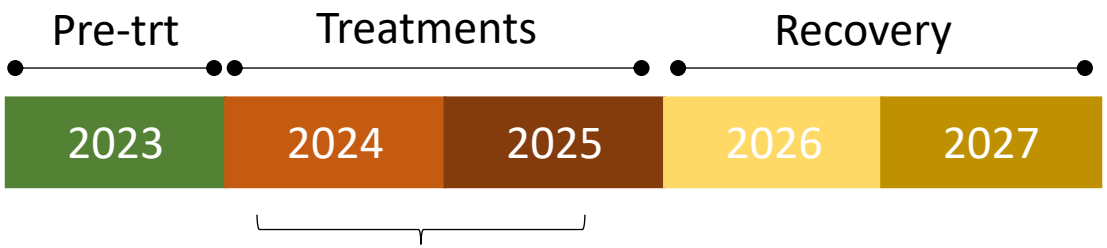
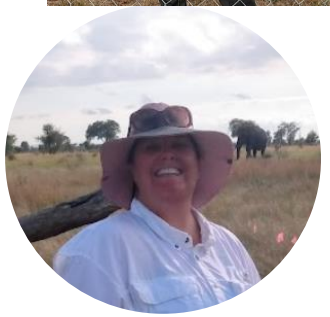


antifying diversity using plant its



Sally Koerner

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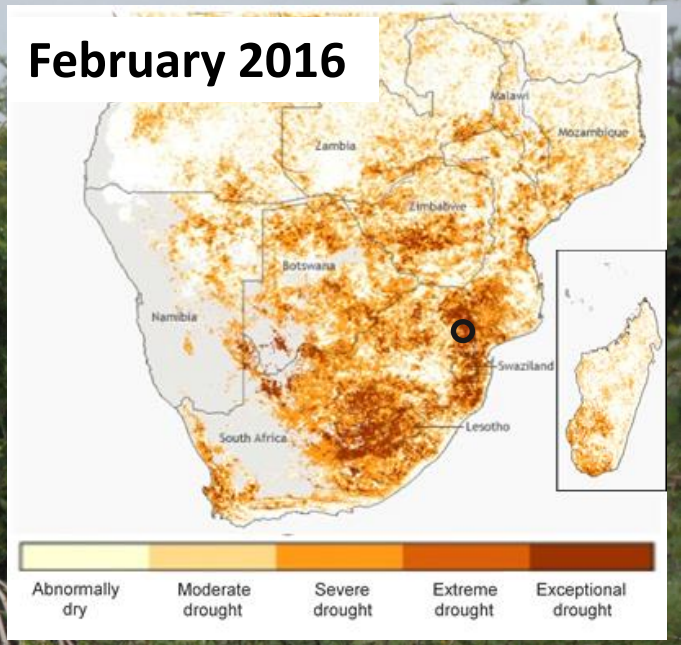
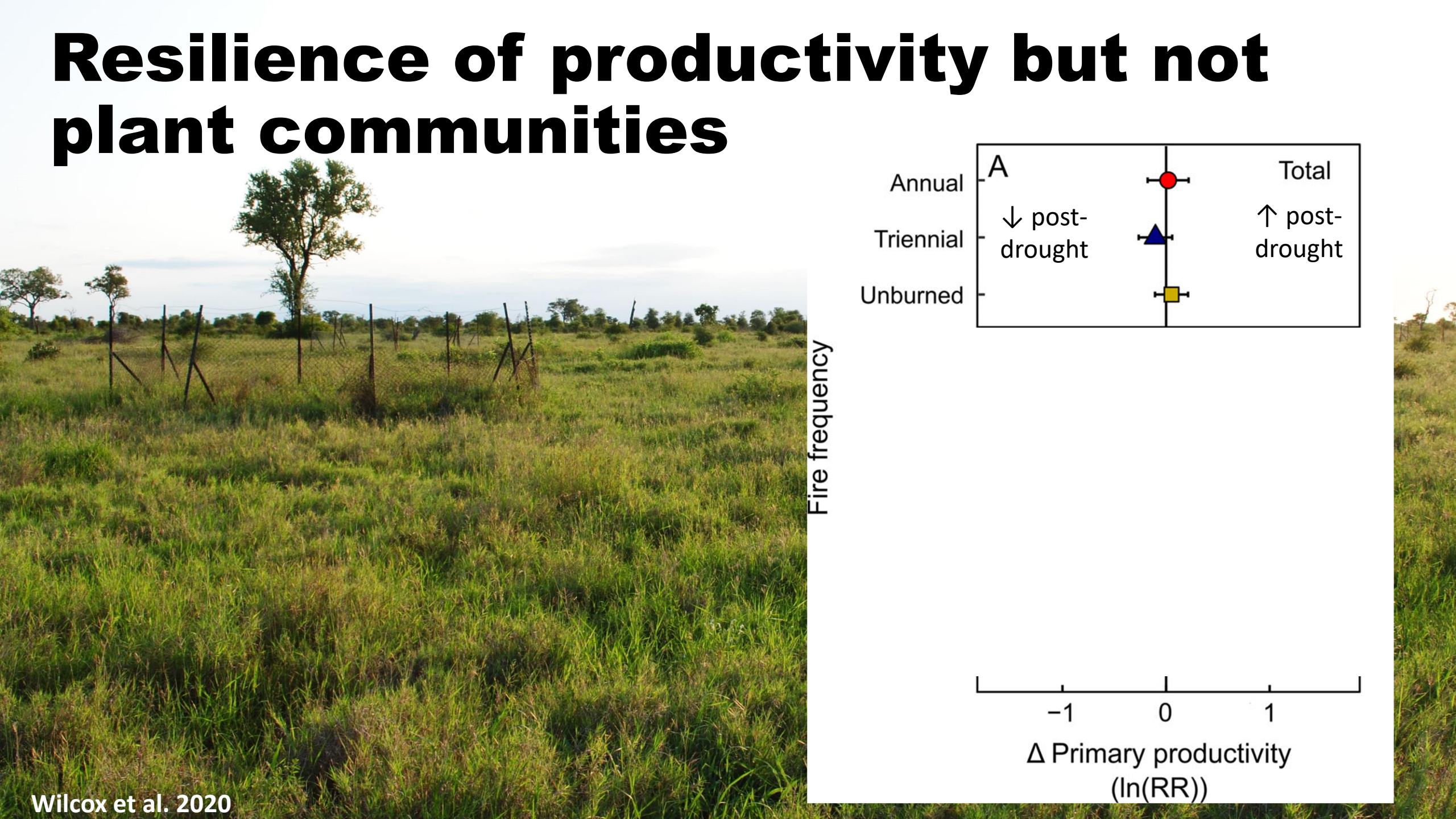
Extreme drought in Kruger National Park



Resilience of productivity but not plant communities



Wilcox et al. 2020

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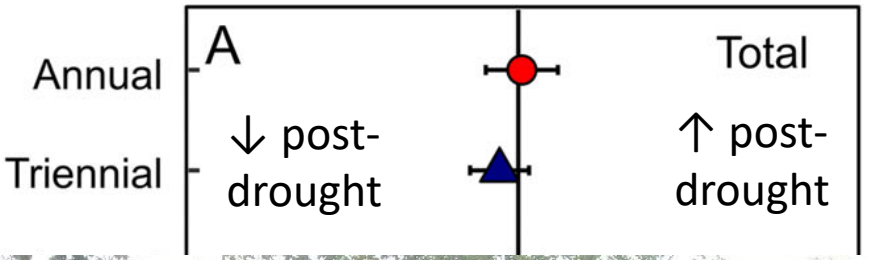
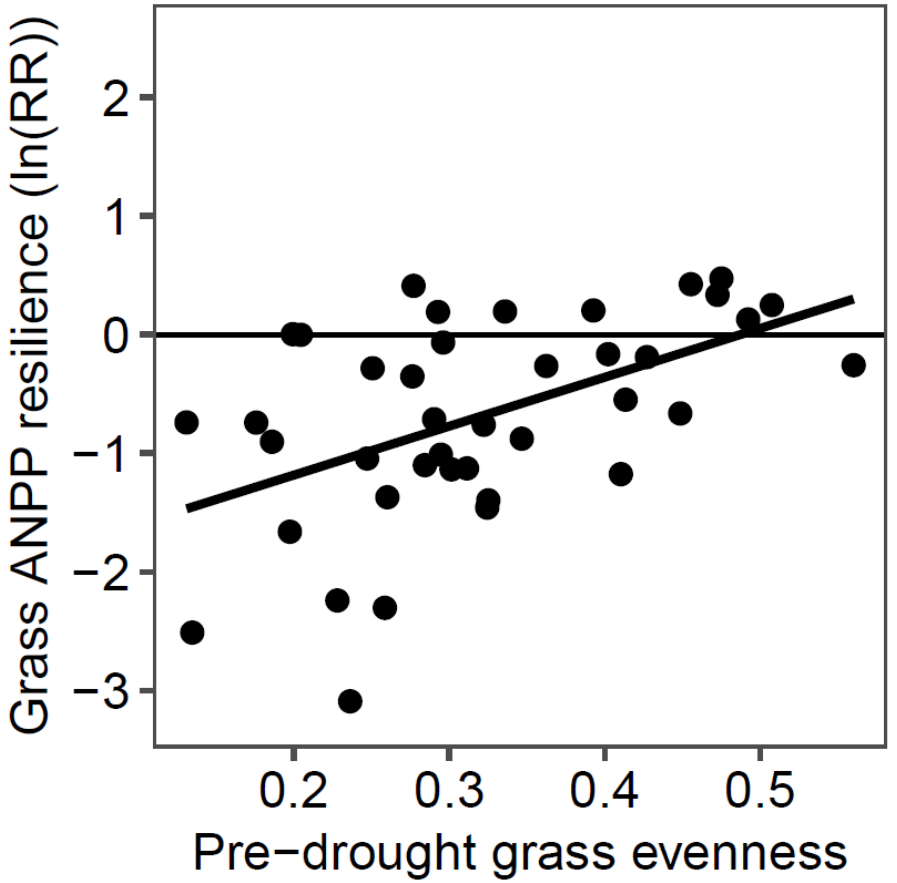


Wilcox et al. 2020

Diversity of grass communities can facilitate resilience

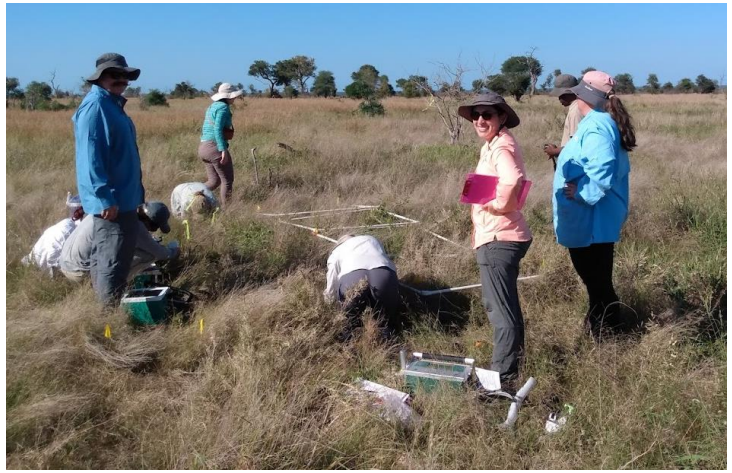


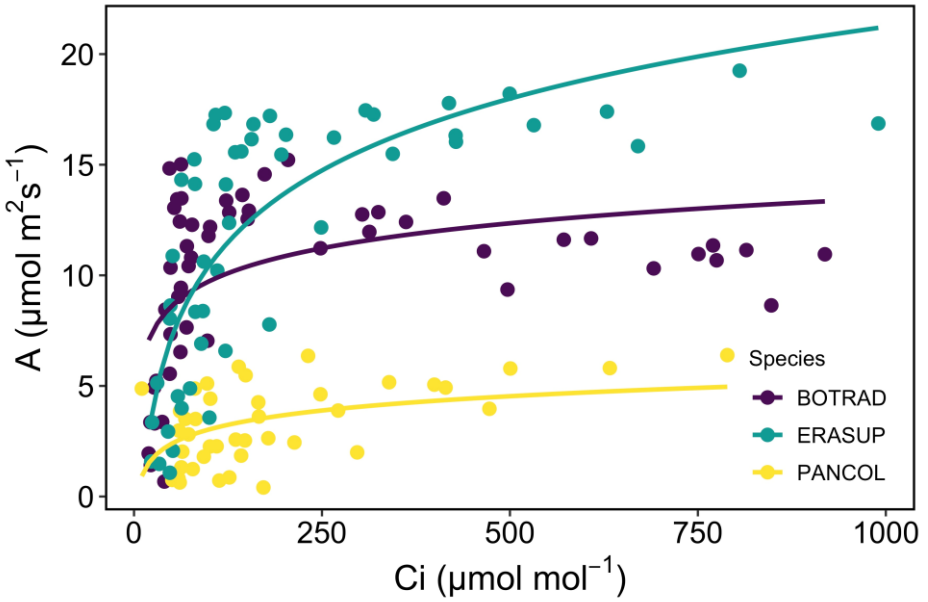
Effects of compound extremes on savanna growing season length

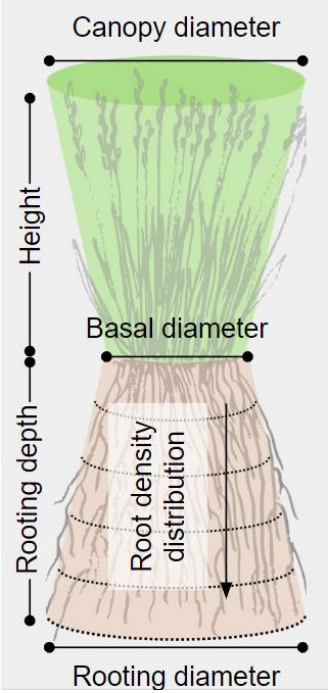
- Drought decreased growing season length 3 years after drought
- Caused by earlier senescence of plants
  - Could be due to increases in annual/weedy plants
- Big implications for wildlife…
  - So, how do we speed up recovery?

Experimentally simulating compound extremes

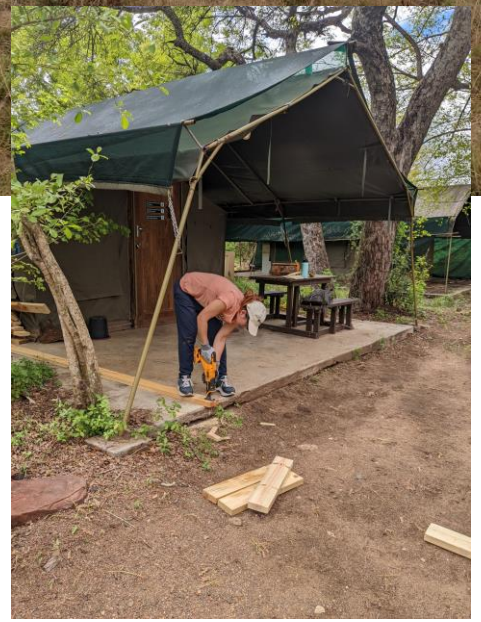
2023: Learning Everything Everywhere All at Once about plants

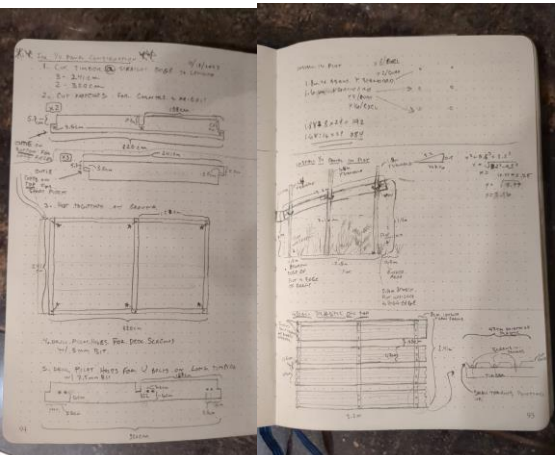






2023 – building the experiment!



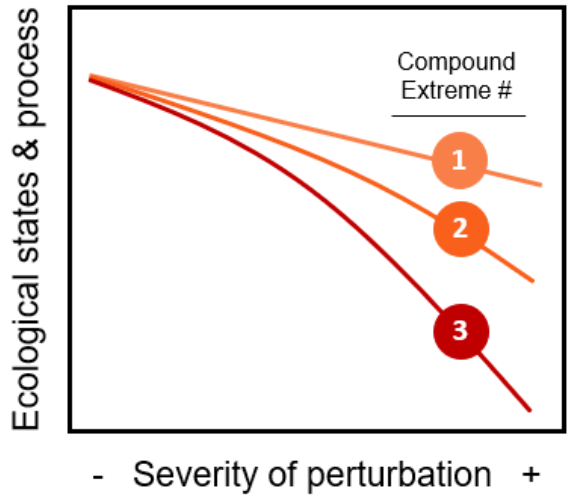


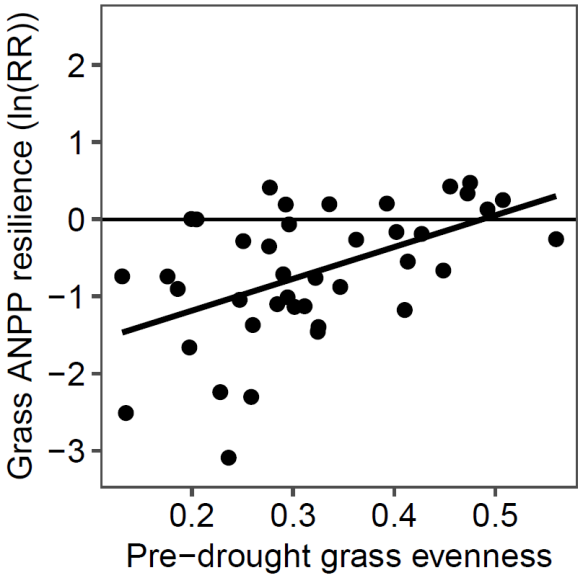
40 hours of driving, 8 hours of field work

Questions

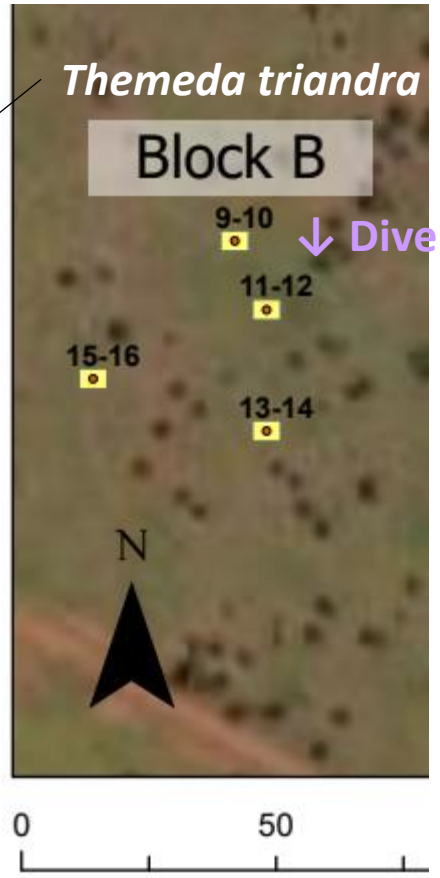
1. Do compound extremes lead to more extreme responses?

2. How does the diversity of species or traits link with responsiveness to compound extremes?

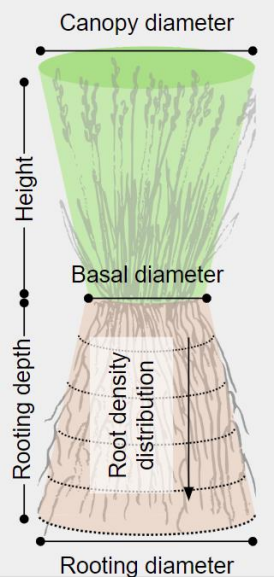


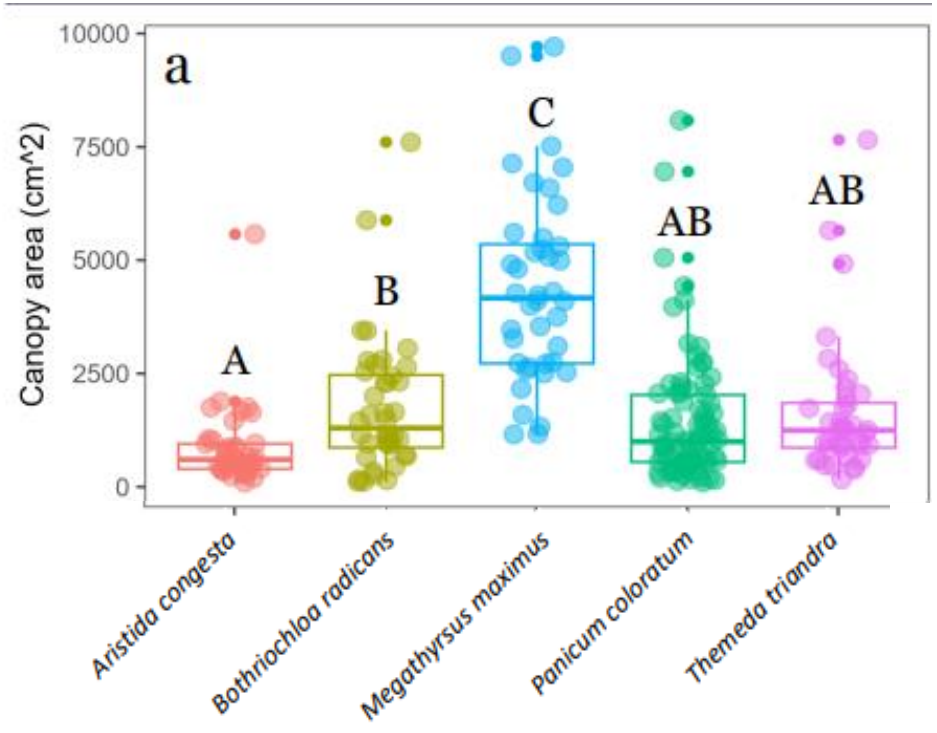


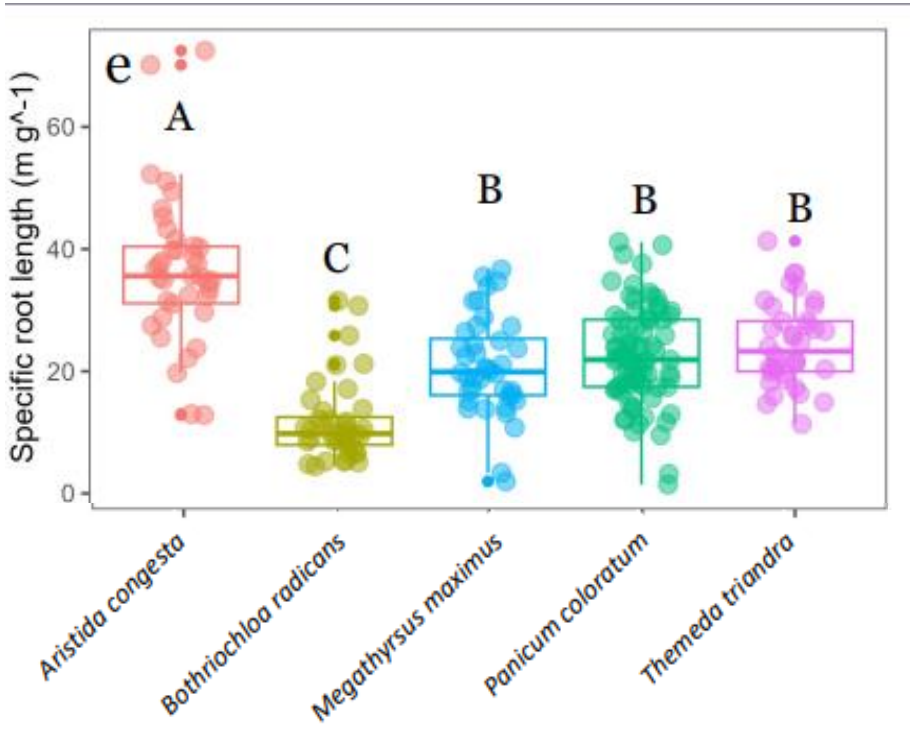
Within each block:
All combinations of Drought, Grazing, and Extreme Fire treatments



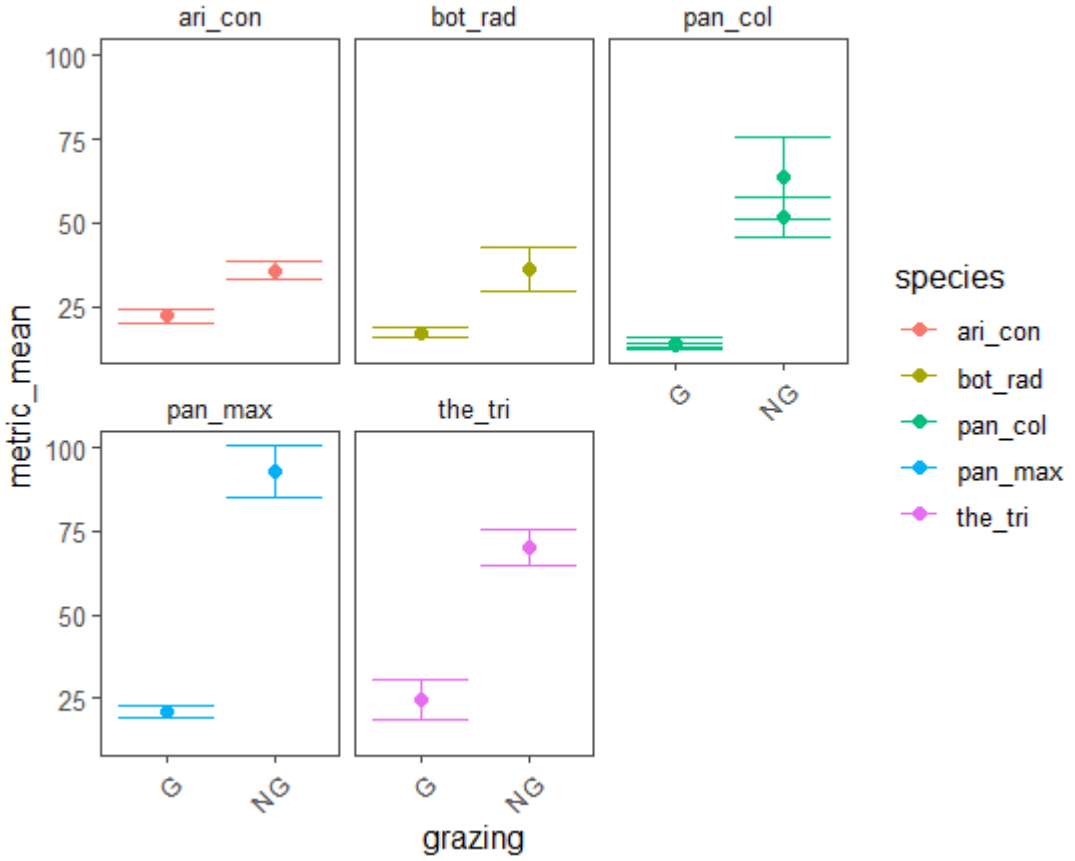
Plant characteristics varied across blocks



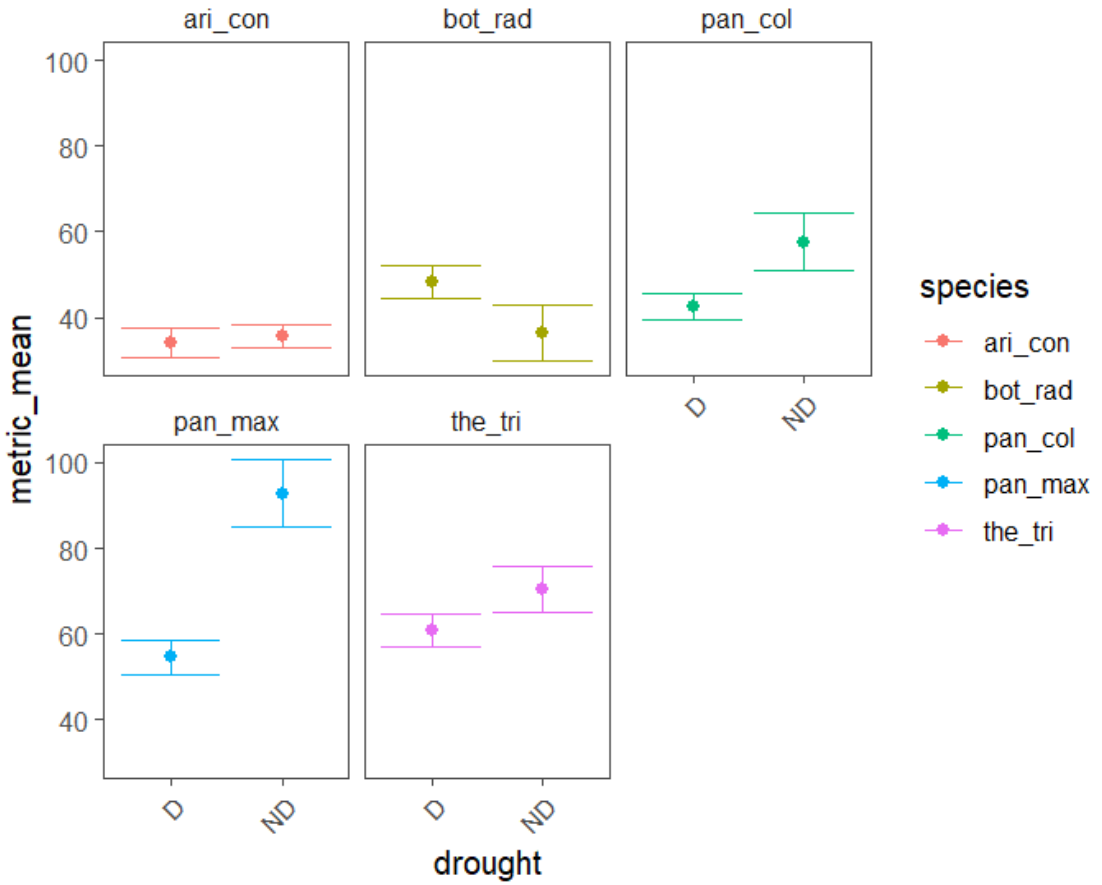




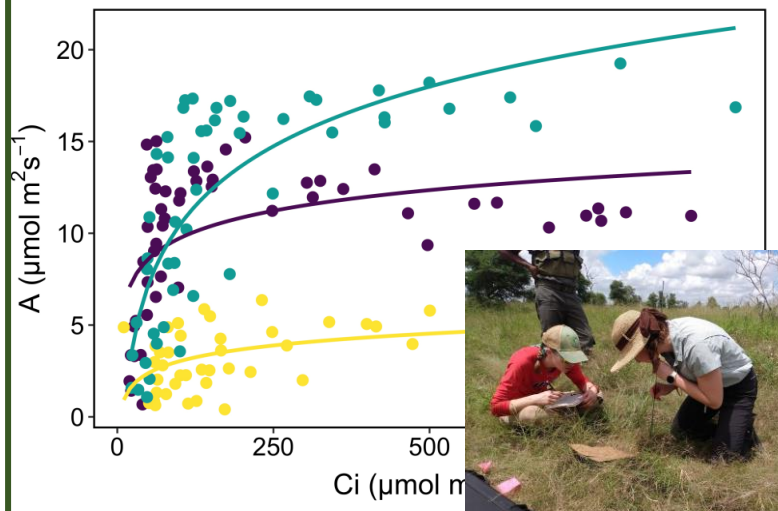
Effects of extreme drought and herbivory

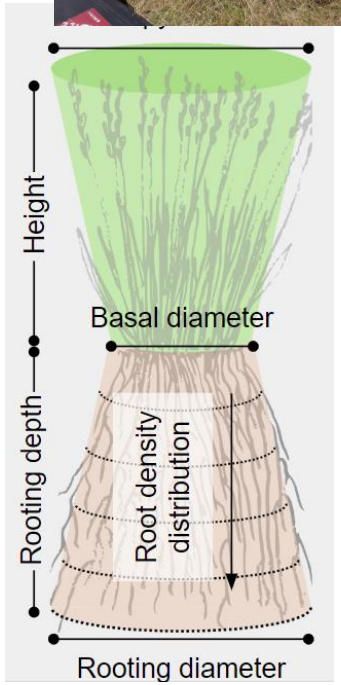


Effects of extreme drought and herbivory



Empirical data



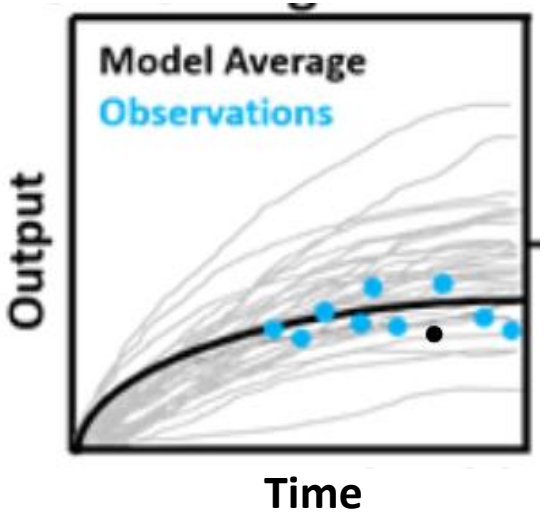


Parameterize models

Light competition

Water and **nutrient** competition

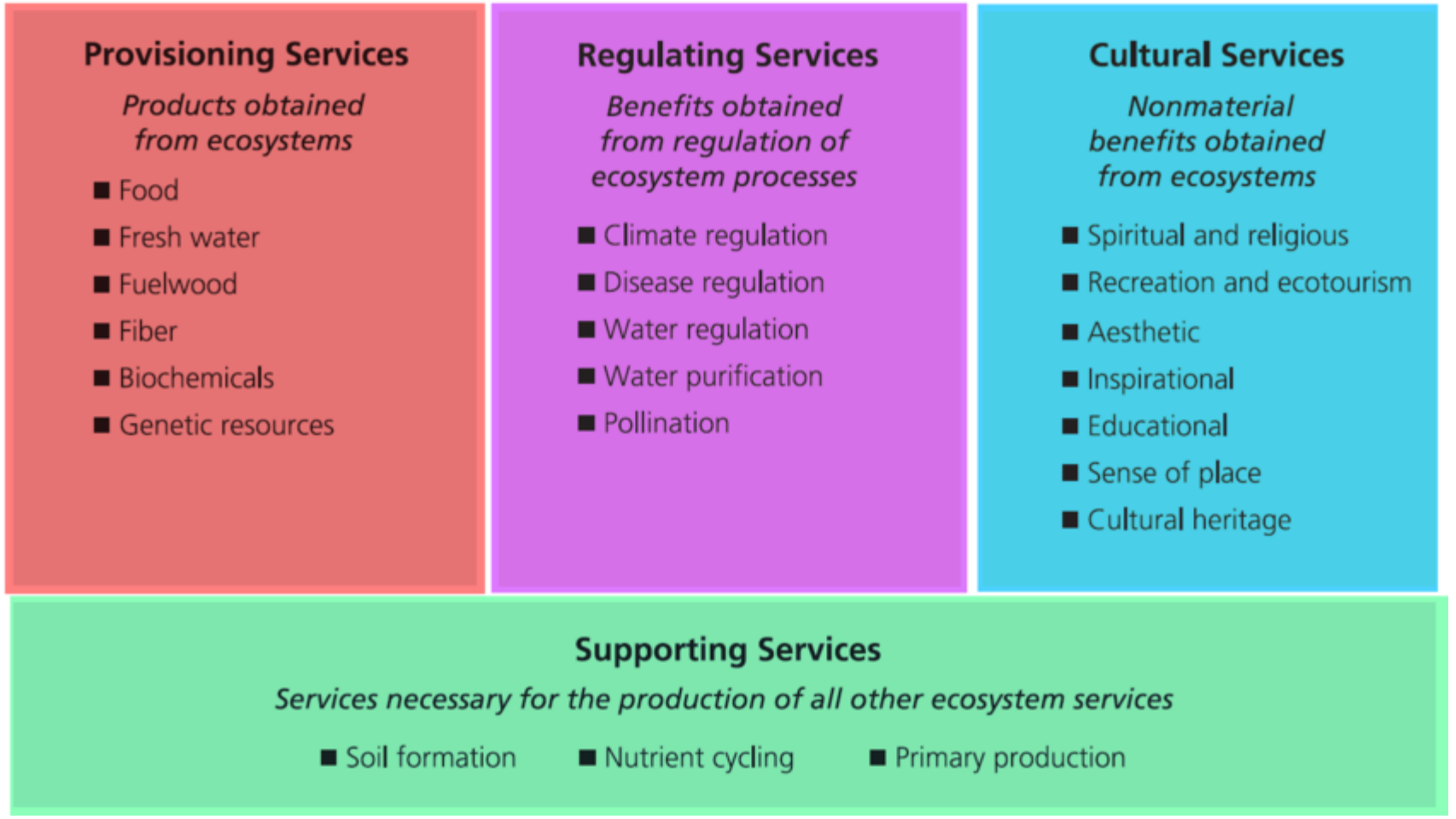
Predictions under future global change scenarios



Thanks for listening!

K_wilcox@uncg.edu

Extreme events impact us through effects on ecosystem services

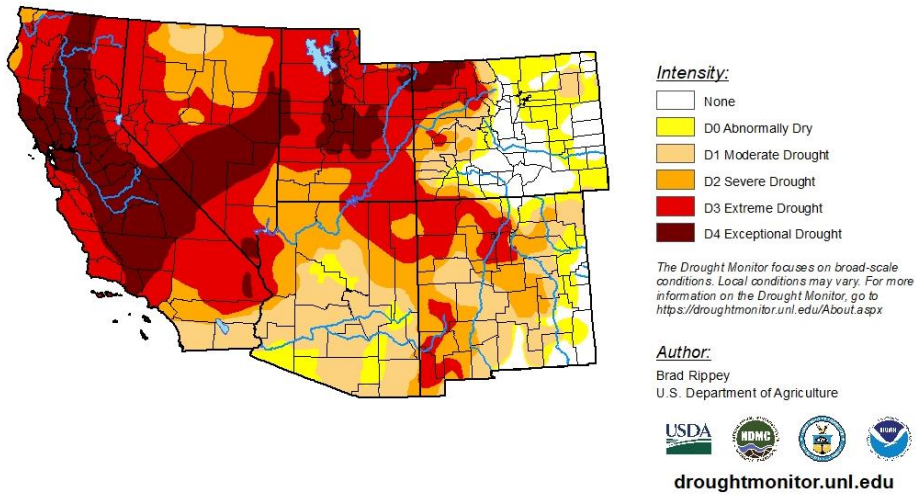


Millennium Ecosystem Assessment

BRIEF COMMUNICATION
https://doi.org/10.1038/s41558-022-01290-z
nature climate change
Check for updates

Rapid intensification of the emerging southwestern North American megadrought in 2020–2021

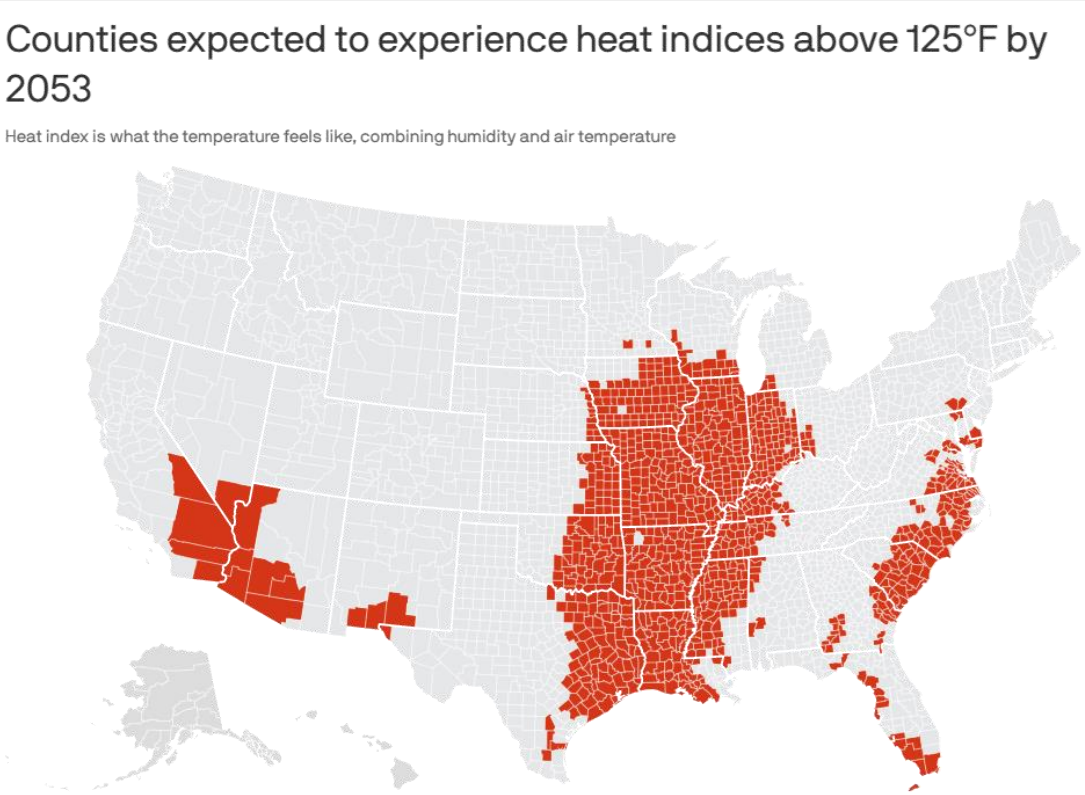
A. Park Williams[1,2]✉, Benjamin I. Cook[2,3] and Jason E. Smerdon[2]



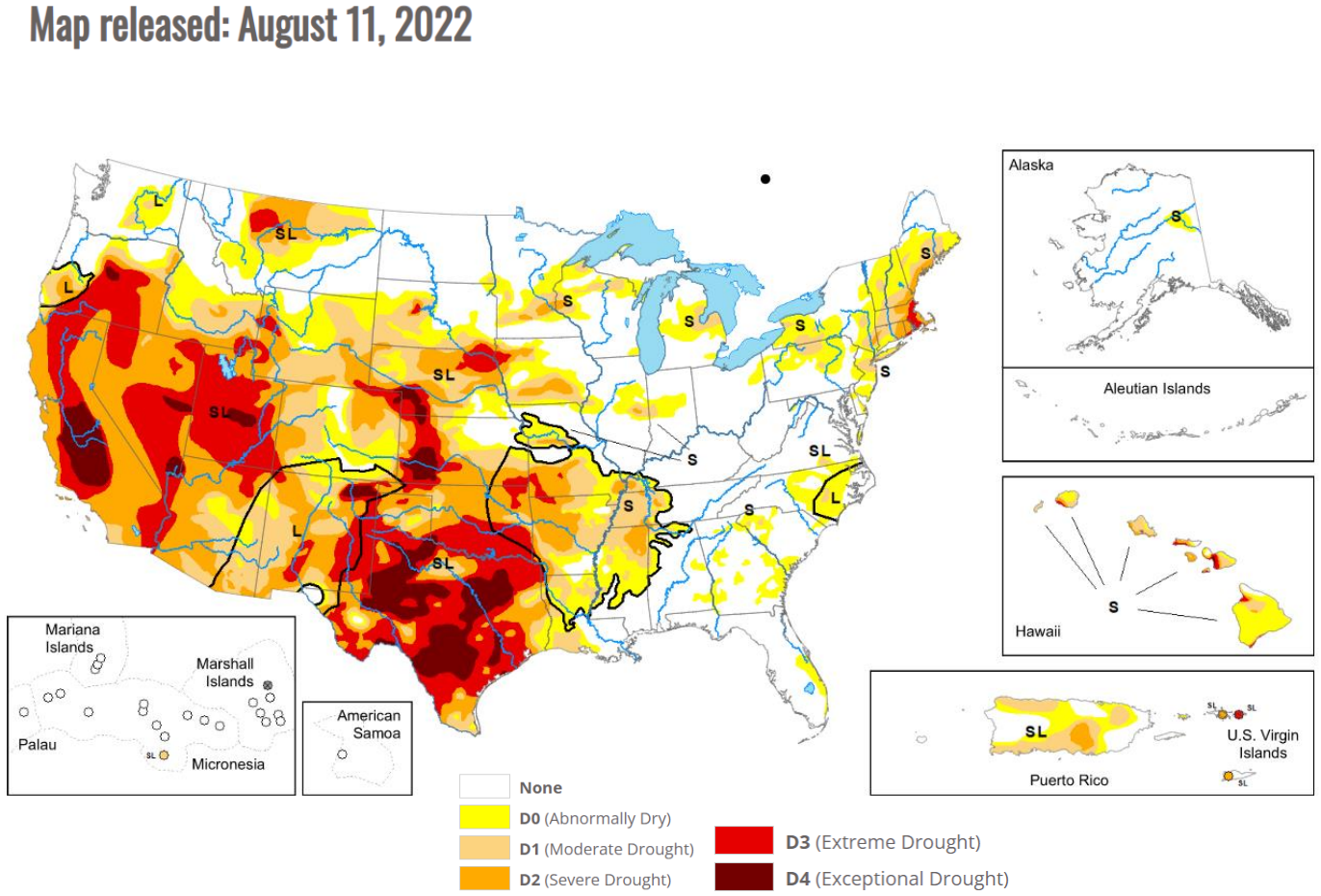
Thousands of acres are underwater in California, and the flood could triple in size this summer

By Bill Weir, CNN Chief Climate Correspondent
Updated 9:47 AM EDT, Sat April 15, 2023

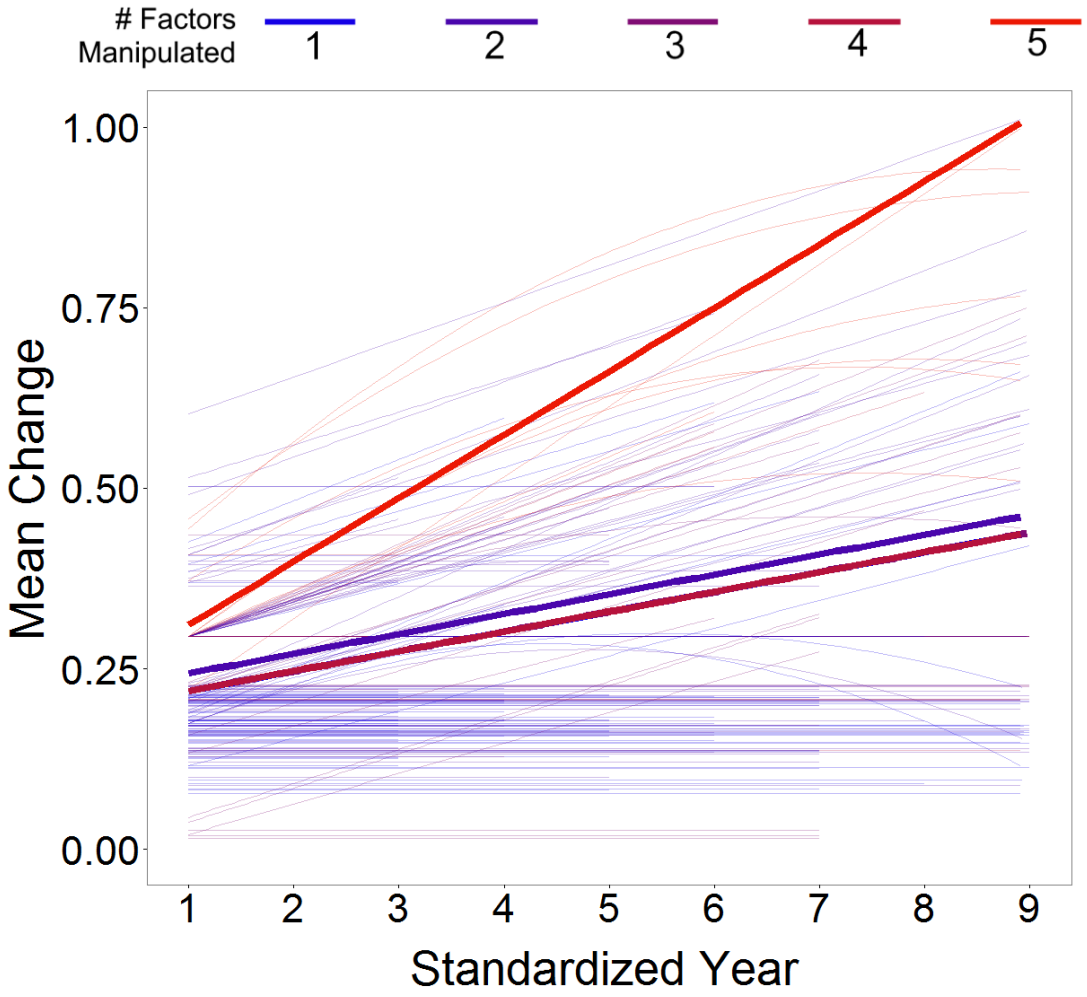
Extreme events are occurring more frequently

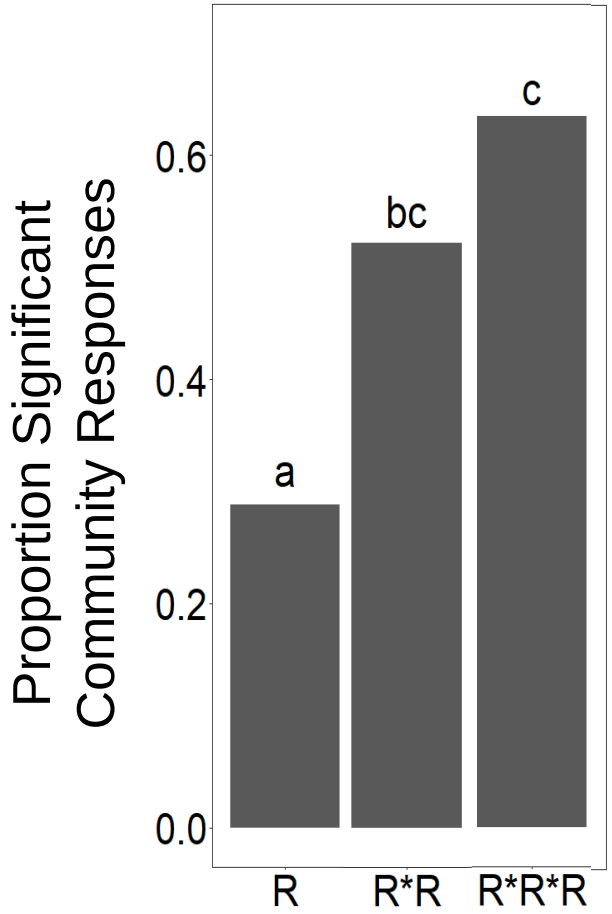


First Street Foundation 2022



Evidence for effects of compound extremes on plant communities





Komatsu et al. 2019 *PNAS*