Intensifying post-fire weather extremes and invasion history drive directional diversity loss in a Mediterranean-type crown-fire ecosystem

Jasper Slingsby, Cory Merow, Matt Aiello-Lammens, Stuart Hall, Hayley Kilroy, Ross Turner, Adam M. Wilson, John A. Silander Jr

science & technology
Department: Science and Technology
REPUBLIC OF SOUTH AFRICA

University of Cape Town · iYunivesithi yaseKapa · Universiteit van Kaapstad

Fynbos Forum, PE, July 2016

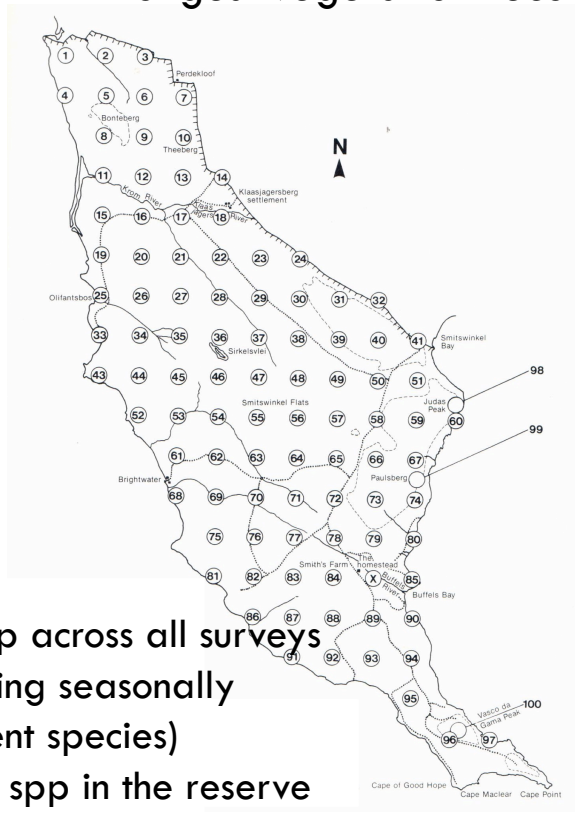
South African NATIONAL PARKS

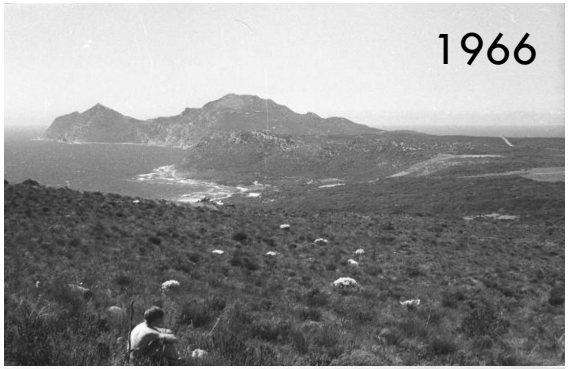
NRF National Research Foundation | SAEON South African Environmental Observation Network

Cape Point Vegetation Surveys

44 years* of change

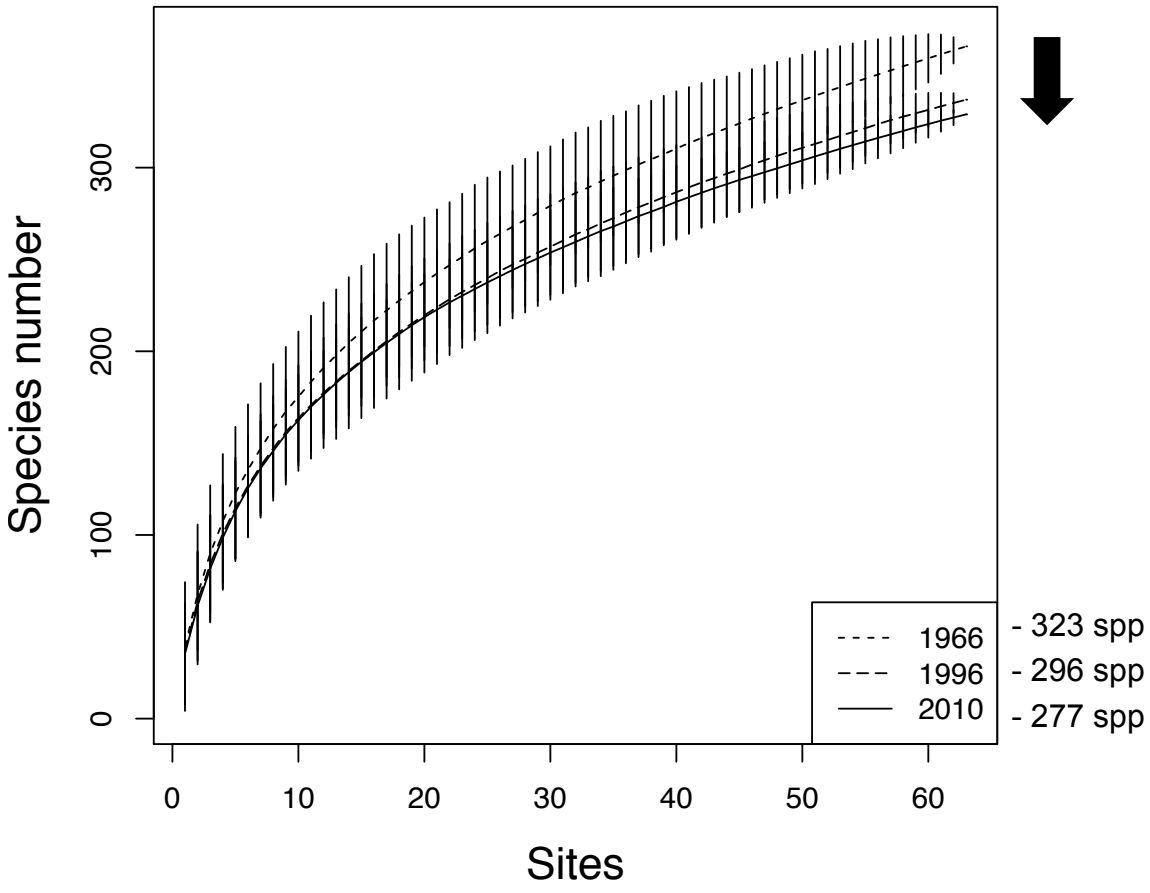
*longest vegetation record in the Fynbos!



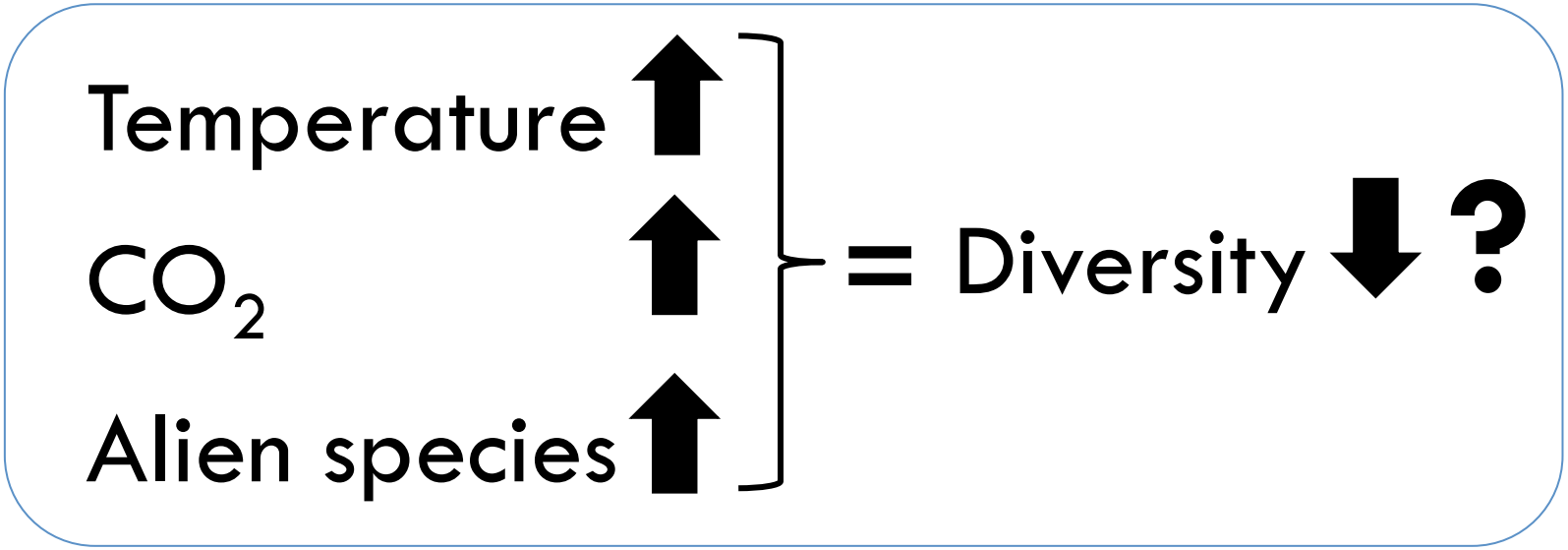


413 spp across all surveys (excluding seasonally apparent species)
~1700 spp in the reserve

Declining Diversity… But Why?



Suspects?

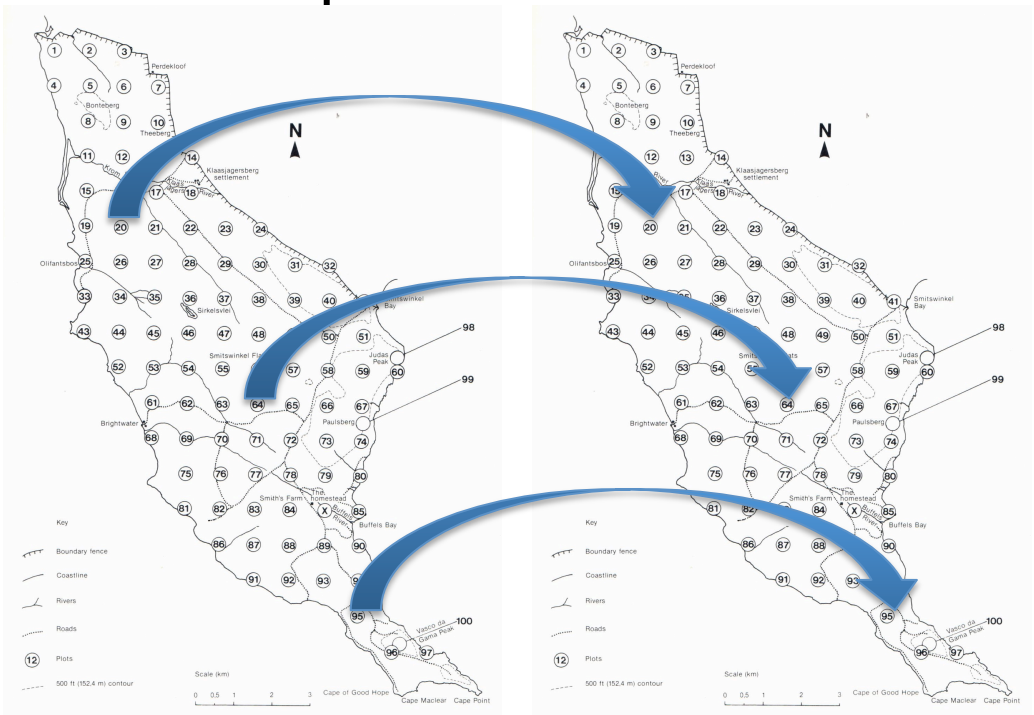


We only have 3 time points…

How do we infer the drivers with no "control"?

Inferring the drivers

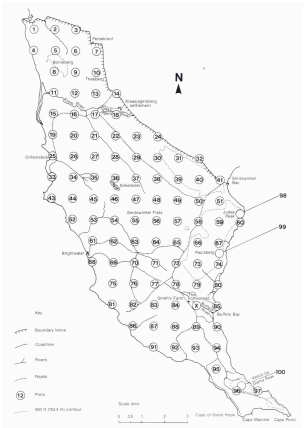
Look at site specific differences!



1966 → Time → 2010

- Change in:
  - Species counts (response)
  - Veld age
  - # of Fires
  - Alien species densities
  - Weather extremes
  - etc

The Model



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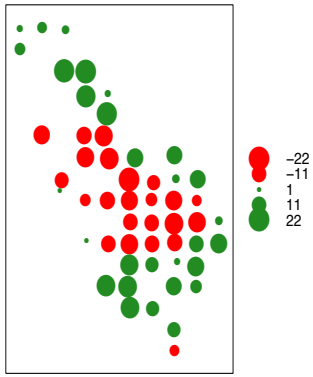

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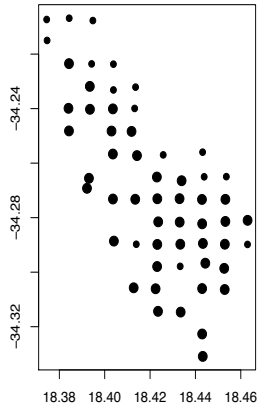

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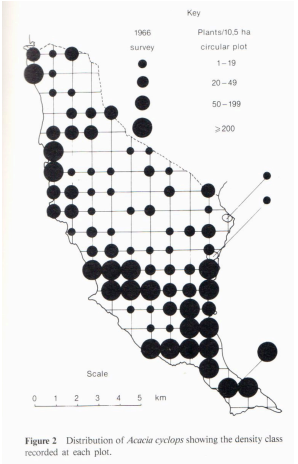


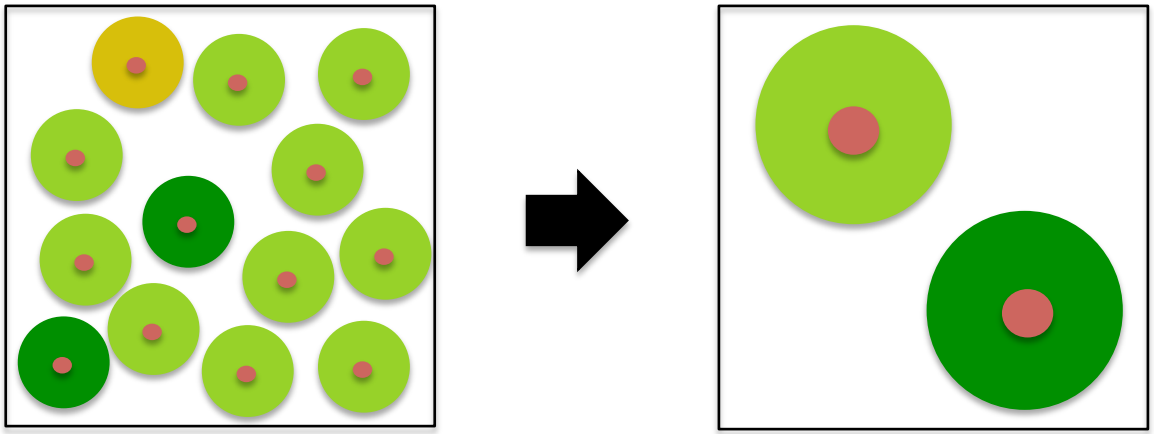
Change in
Total species number
1966-2010

Fire:
Change in
age since fire,
Count of fires

Extreme
postfire weather:
Consecutive dry days,
Consecutive hot and dry days

Alien species:
Historical densities

Fire – Vegetation age (i.e. since fire)

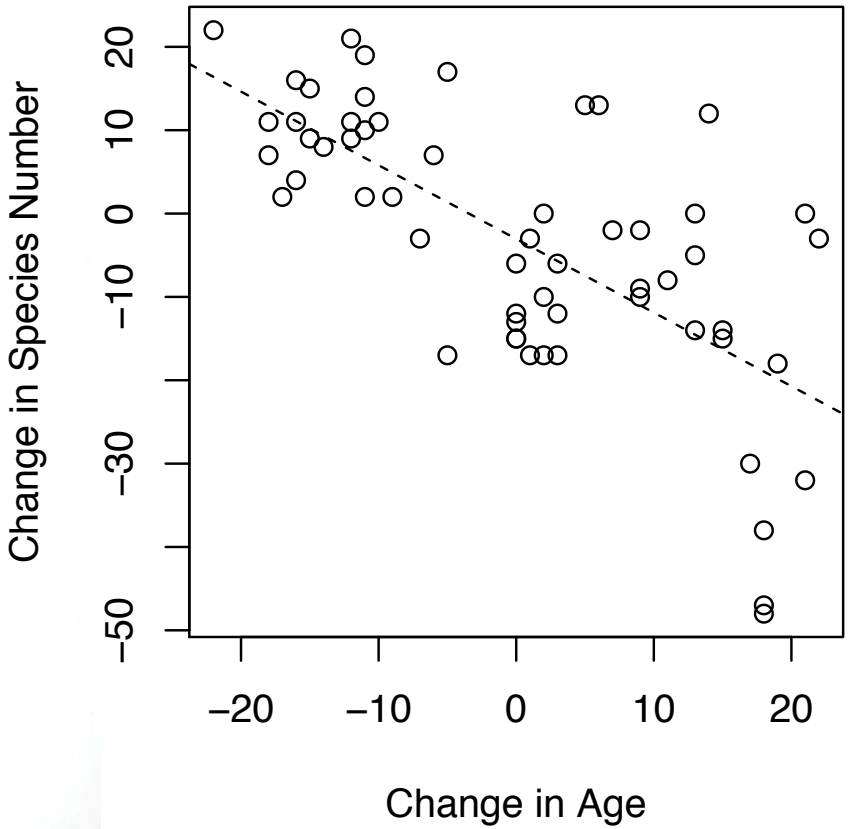


Young

Old

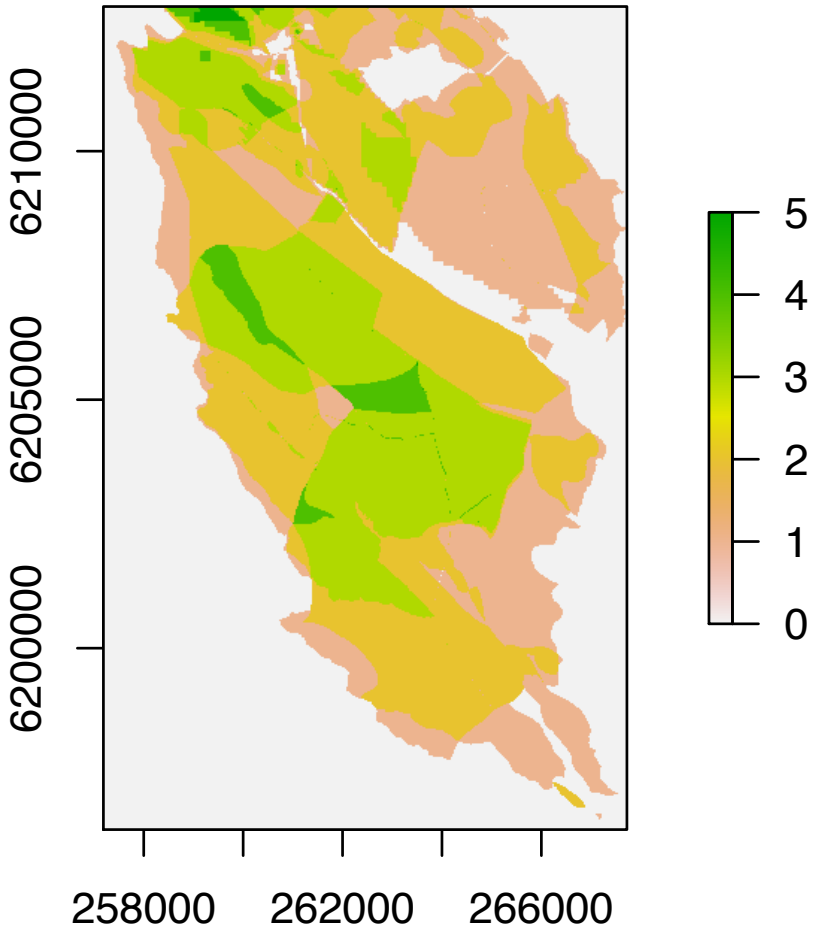
Old plots naturally have fewer species…

Fire – Vegetation age (since fire)

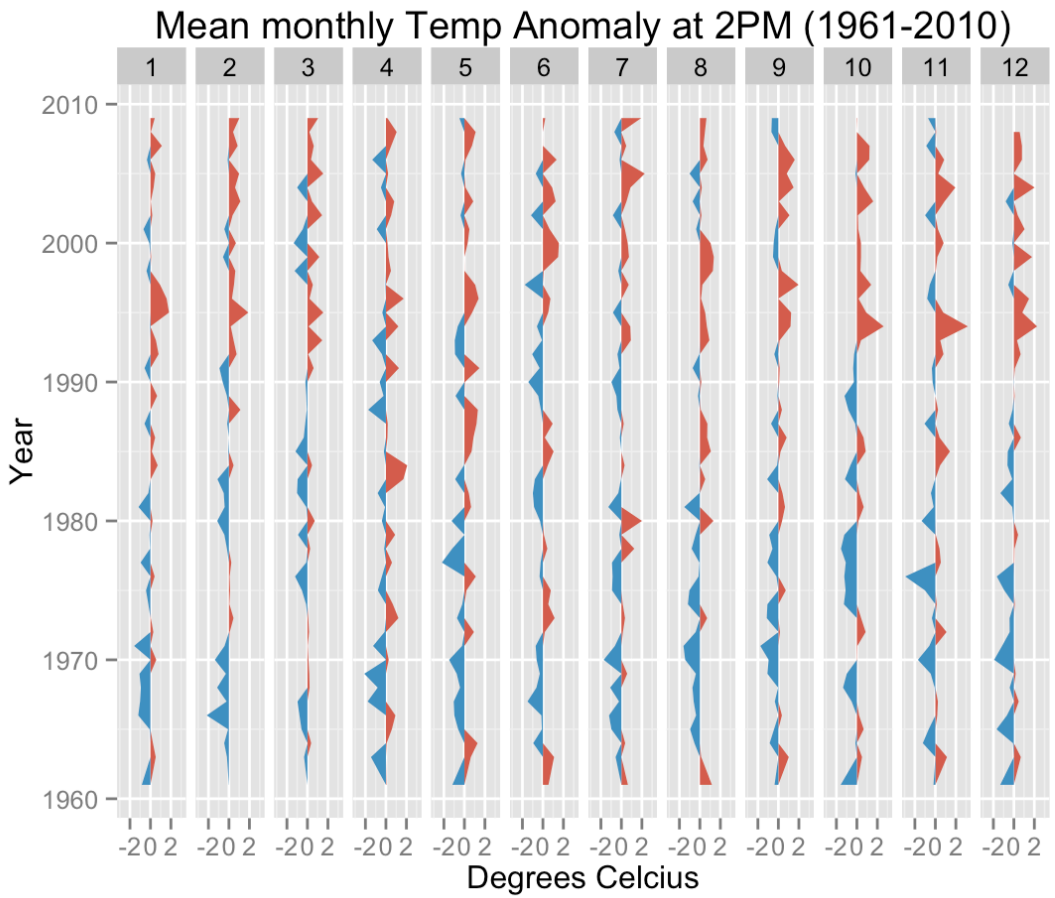


Fire – Too many fires?

Number of fires
1966-2010



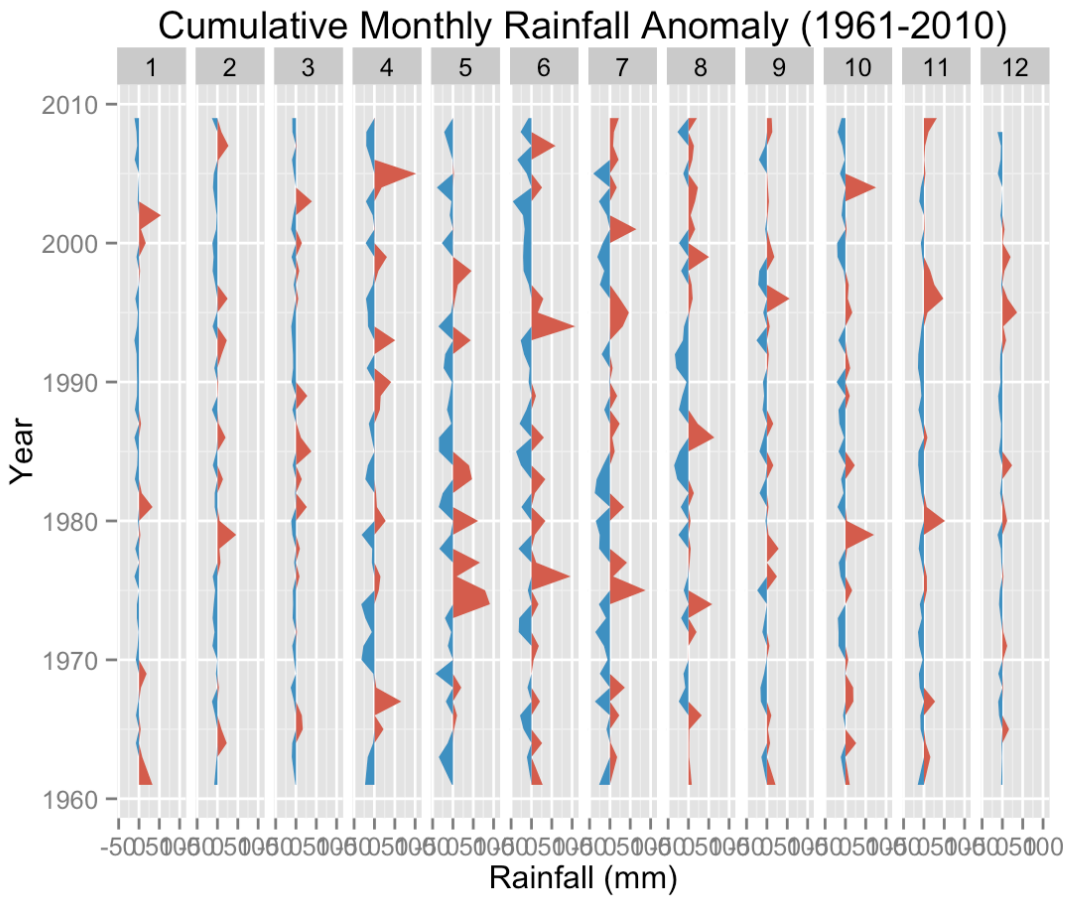
Climate



1.5 degree increase over the 48 year time series

Temperature?

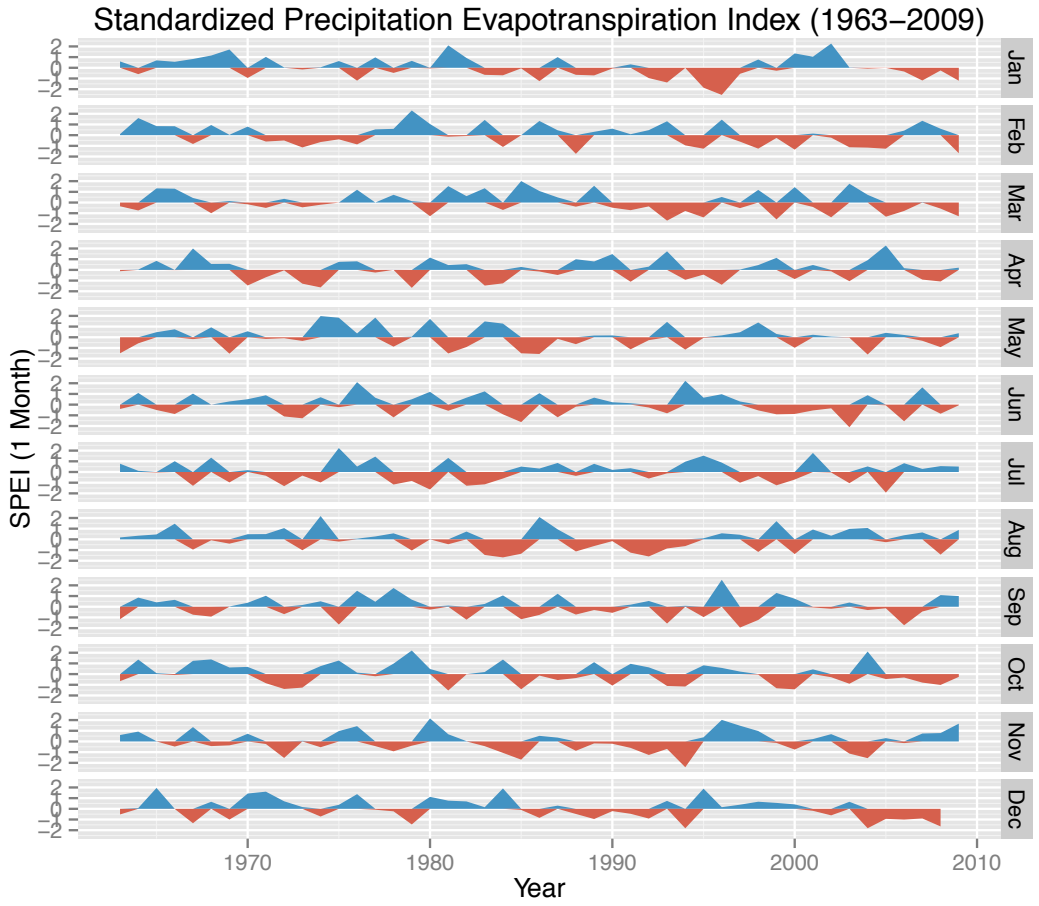
Climate



0.5 mm increase over the 48 years

Rainfall?

Climate

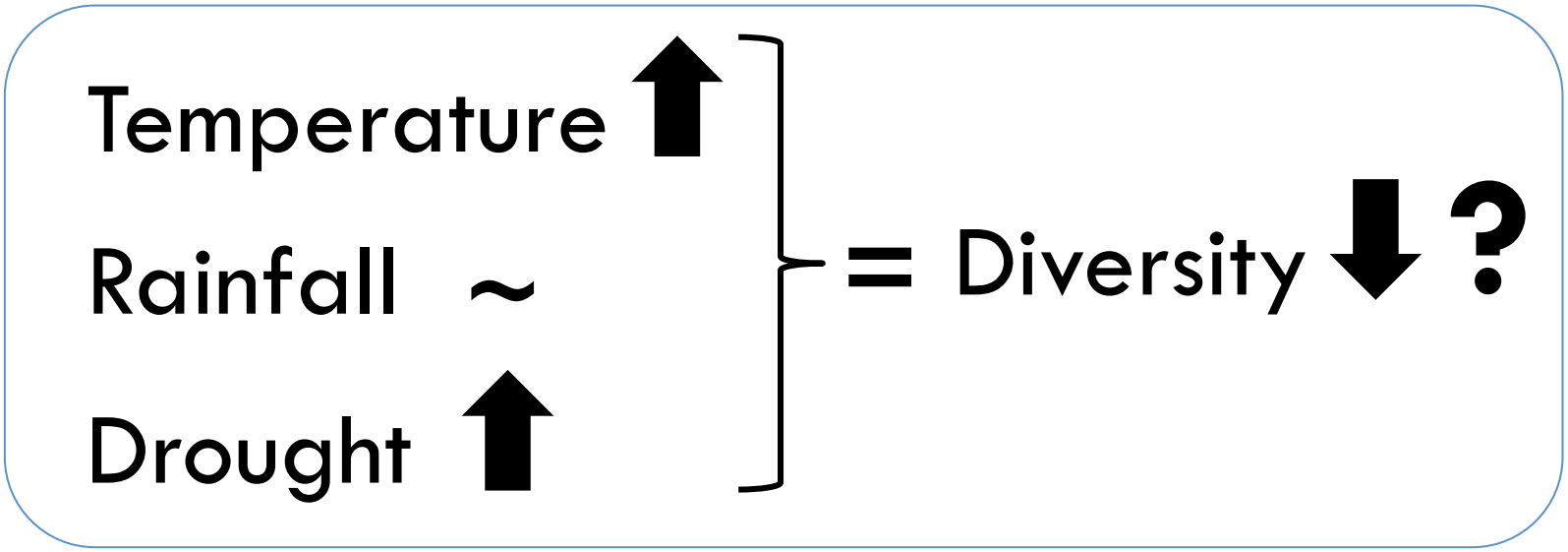


0.4* decline
- i.e. more severe drought

*units of Standard Deviation

Drought Index?

Climate



But all plots have experienced similar weather record?

How can we include it in our model?

Climate

Seed

Seedling

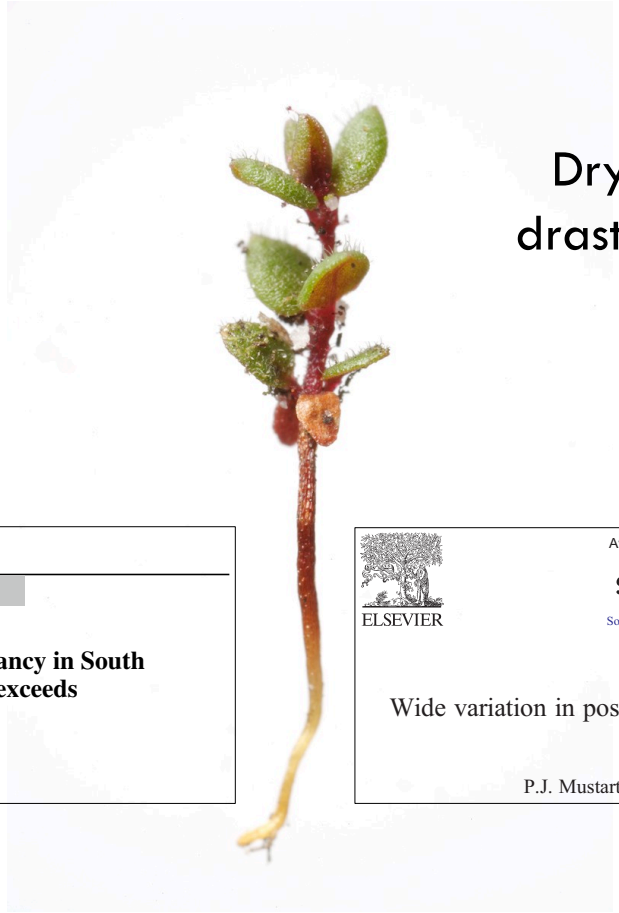
Sprout

Adult

When are plants most vulnerable to extreme weather?

Climate

Higher temperatures (+1.5 or +3°C) suppress seed germination by 30-100%



Drying experiments show drastically reduced seedling survival over 6, 13, 18 or 25 days of drought

Oecologia
DOI 10.1007/s00442-014-3173-6

PHYSIOLOGICAL ECOLOGY - ORIGINAL RESEARCH

Experimental climate warming enforces seed dormancy in South African Proteaceae but seedling drought resilience exceeds summer drought periods

Judith L. Arnolds · Charles F. Musil · Anthony G. Rebelo · Gert H. J. Krüger

Available online at www.sciencedirect.com
SciVerse ScienceDirect
South African Journal of Botany 80 (2012) 110 – 117
SOUTH AFRICAN JOURNAL OF BOTANY
www.elsevier.com/locate/sajb

Wide variation in post-emergence desiccation tolerance of seedlings of fynbos proteoid shrubs

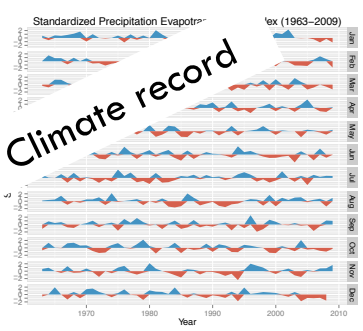
P.J. Mustart [a], A.G. Rebelo [b], J. Juritz [c], R.M. Cowling [a,*]

[Fire *] Climate

- It's the measures of extreme weather in the first summer after fire that we're interested in.

- And because plots burn at different times, these measures of extreme weather vary among plots.

[Fire *] Climate



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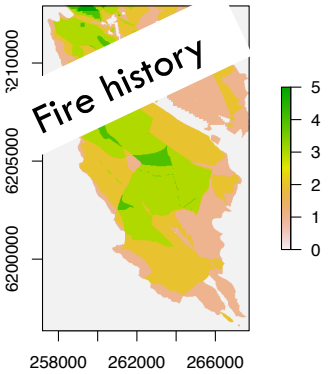
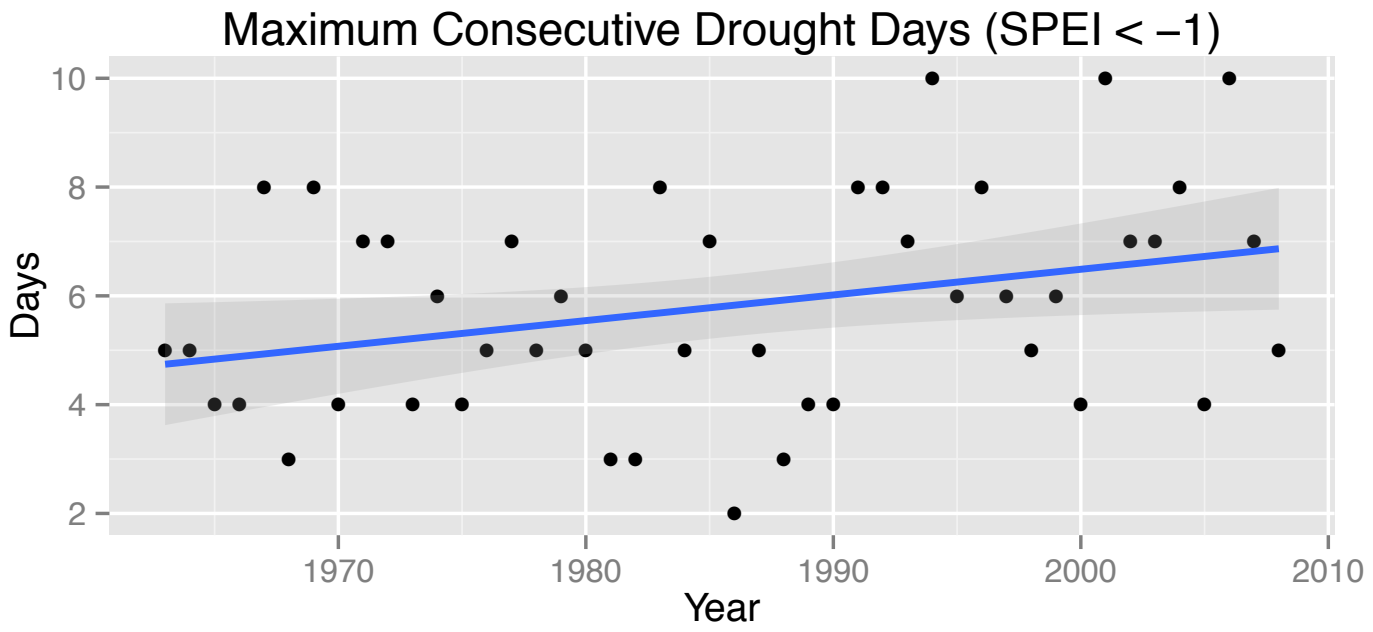


=

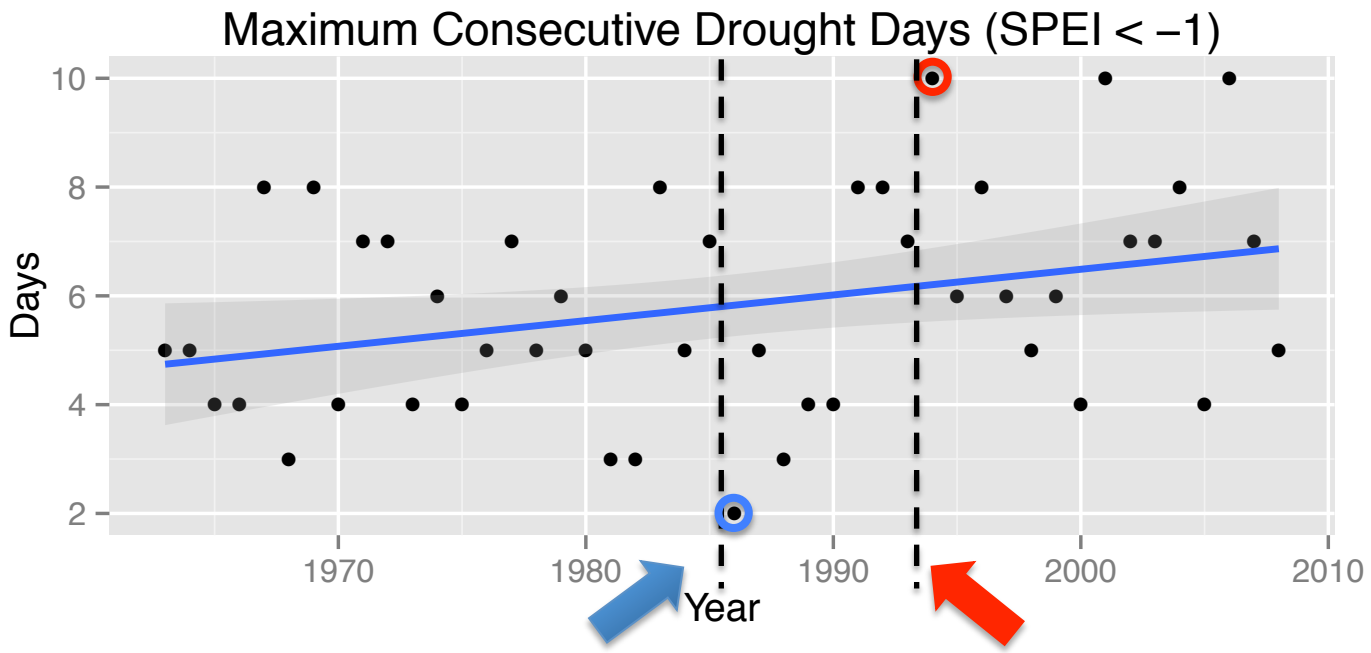
Consecutive Dry Days [<1mm]
Consecutive Hot Days [>95%]
Consecutive Drought Days [SPEI<-1]

<u>in the first summer after fire…</u>
[that vary among plots!]

[Fire *] Climate



[Fire *] Climate



Plot 1 - Benign post-fire summer

Plot 2 - Extreme post-fire summer

Alien species

Invasive alien woody plants in the Cape of Good Hope Nature Reserve. I. Results of a first survey in 1966

H.C. Taylor and Susan A. Macdonald
Botanical Research Unit, Stellenbosch and Bolus Herbarium, University of Cape Town

Invasive alien woody plants in the Cape of Good Hope Nature Reserve. II. Results of a second survey from 1976 to 1980

H.C. Taylor, Susan A. Macdonald and I.A.W. Macdonald
Botanical Research Unit, Stellenbosch, Bolus Herbarium, University of Cape Town and Percy FitzPatrick Institute, University of Cape Town

- Surveys of 200m radius around plots in 1966 and 1976-80
- Intensive clearing occurred in the early 80's, with good follow-up
- Used highest density recorded across both surveys

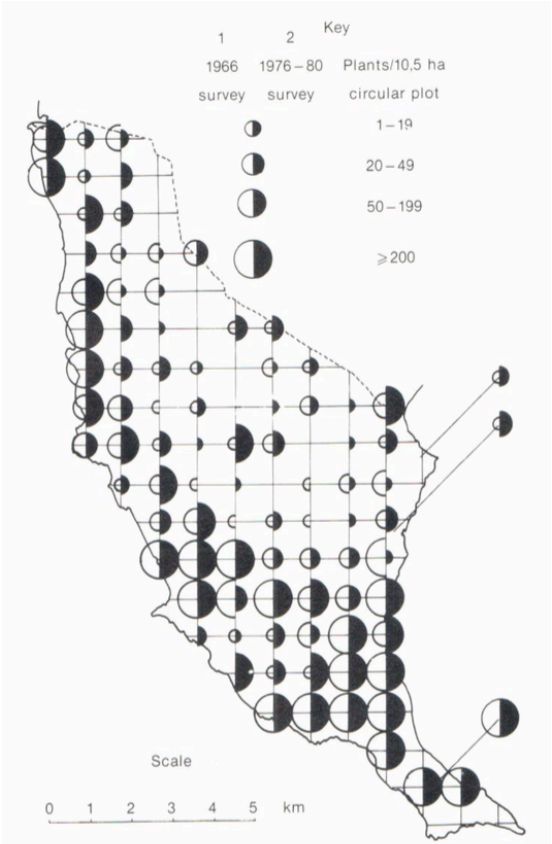
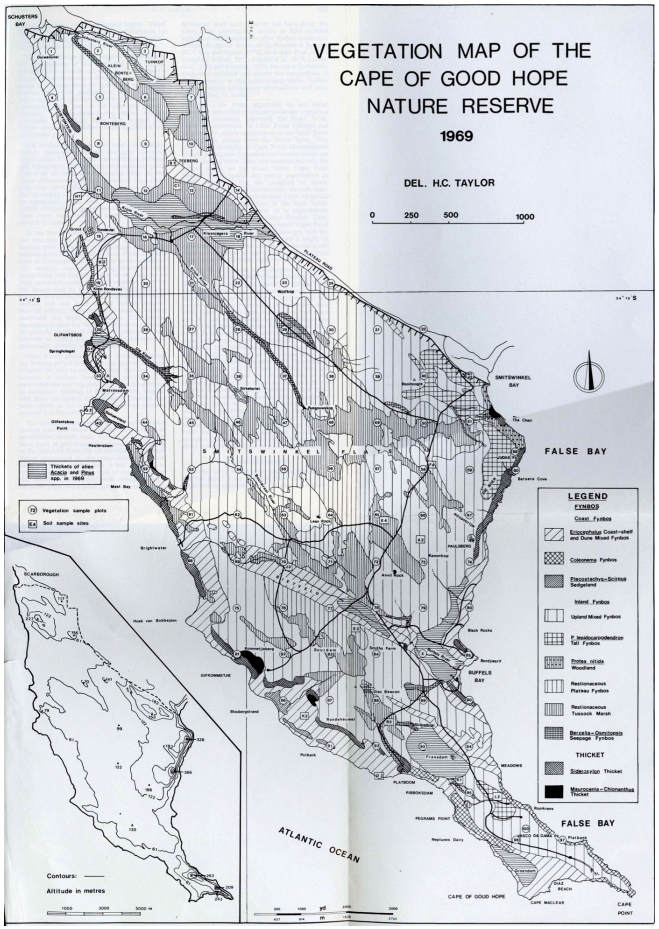


Figure 2 Distribution of *Acacia cyclops* showing the density classes recorded at each plot.

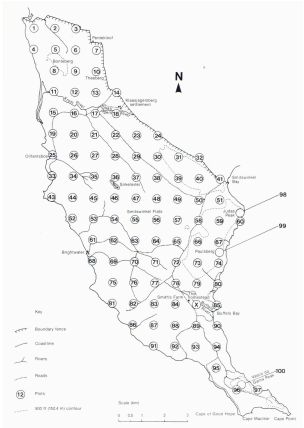
Herbivory?



- Differences in nutrient status of the different veg types and anecdotal evidence of herbivore preferences…

- May also account for other sources of variation…

The Model



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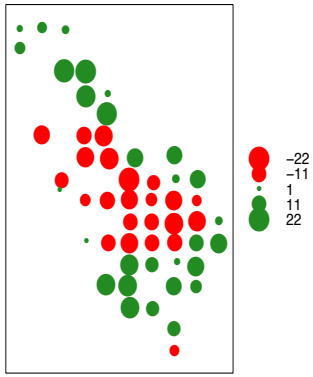

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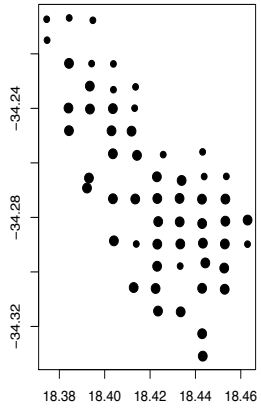

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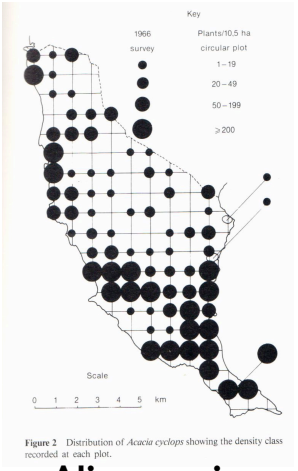

Alien species:
Historical densities

Generalized Linear Model

library(nlme)
library(MCMCglmm)
library(MCMCpack)

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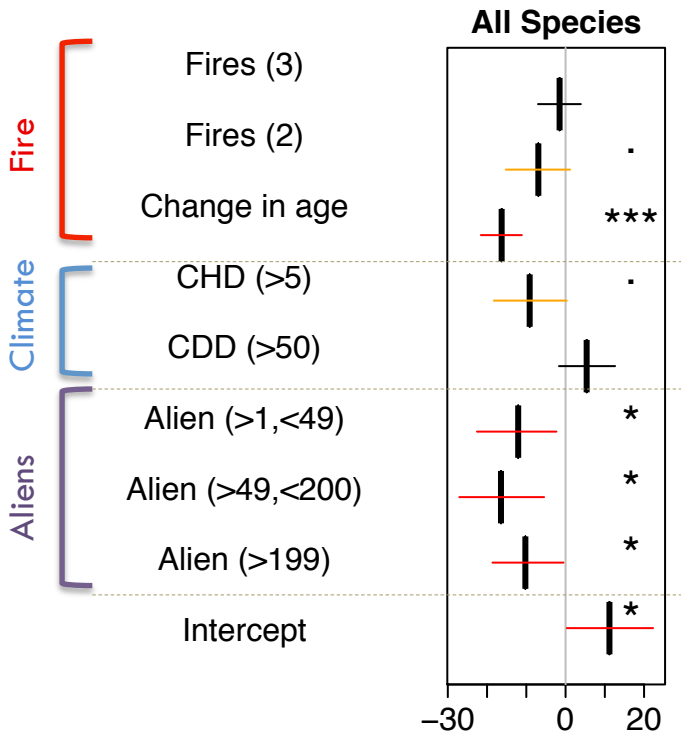
Species counts through time analysis?

Results: Change in Species Number



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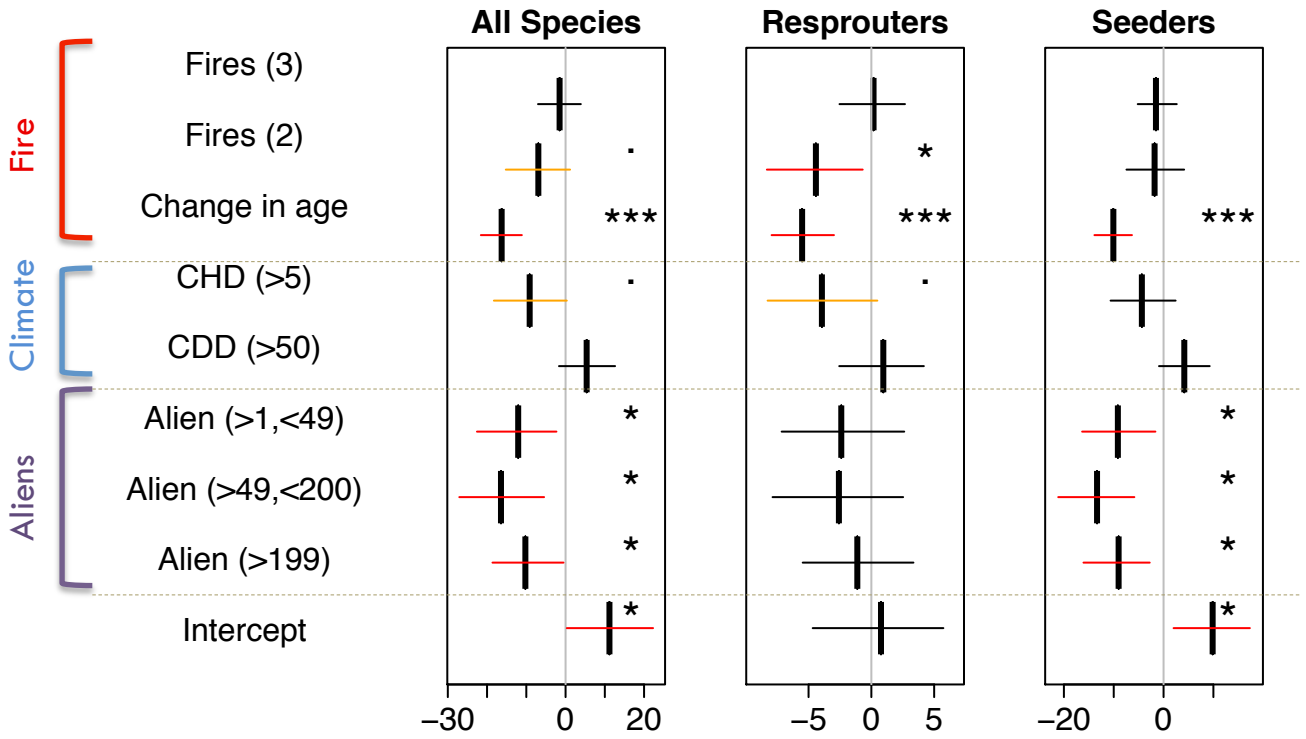

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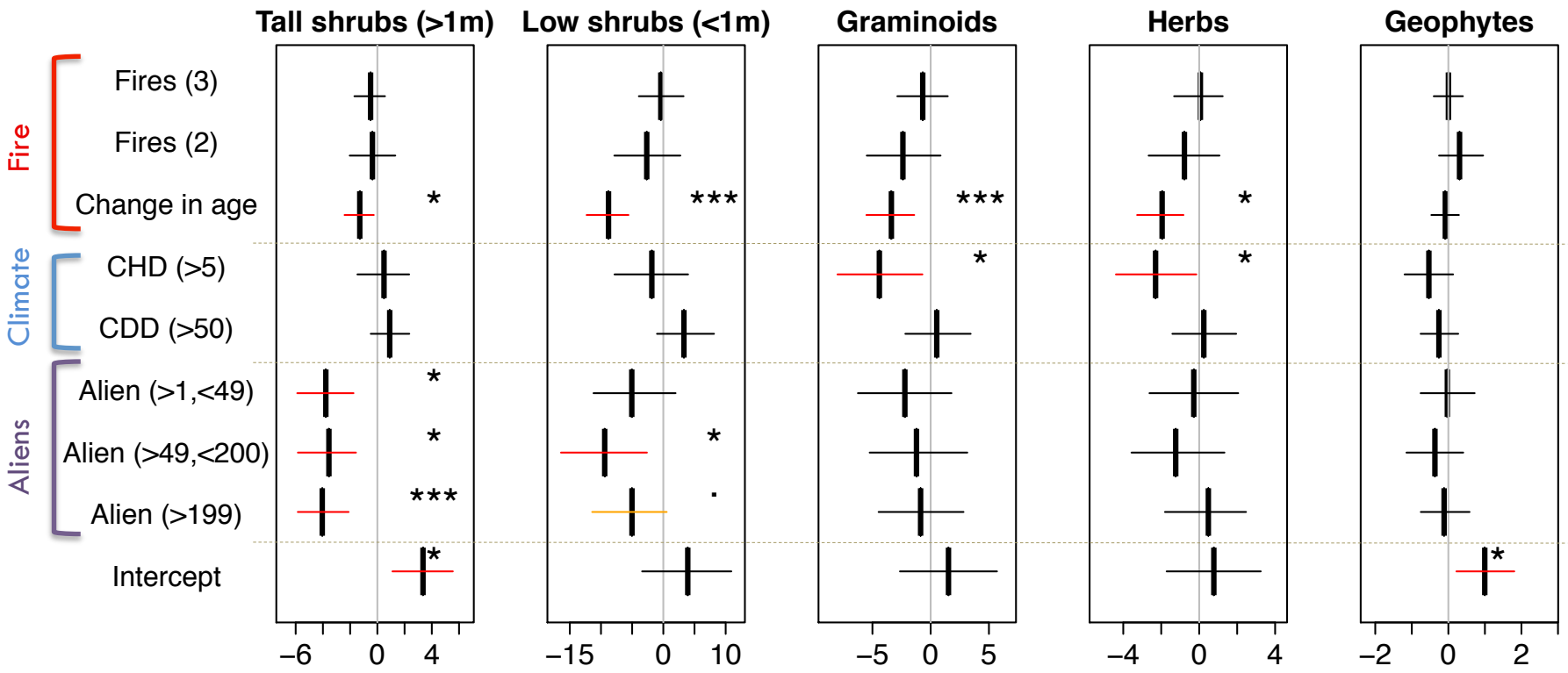

Conclusions

- Clear legacy impact of historical (pre-1990) woody alien species invasion (esp *Acacia cyclops*).
  - Seeder species and shrubs most severely impacted

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  - Sprouter species, graminoids and herbs most effected
  - This interaction between fire and climate change is of great concern in crown-fire ecosystems like more Mediterranean-Type Ecosystems
- One has to consider multiple drivers of change when exploring patterns in long-term observation datasets.
- One has to account for differences in post-fire vegetation age (or numbers of individuals) when comparing diversity in Fynbos sites through time.

Implications for management and research

- For rare species, we could consider retaining patches/ populations of mature individuals in case of recruitment failure/summer mortality
  - BUT!!! Pathogens may be a problem…

- Bet hedging strategies like being able to skip a fire interval (~seed dormancy) may be a key trait conveying resilience in the short term?
    - Anecdotal evidence, but needs further attention…

- We need to know what's happening to species other than the Proteaceae…

Acknowledgements

- South African National Parks (SANParks)
- Sean Privett, Richard Cowling, Timm Hoffman, Nicky Allsopp, SANParks Honorary Rangers
- The late Hugh Taylor
- Funders: NSF (USA), NRF (RSA)
- Many others…

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