Cages and poles: Acacia life histories and their implications

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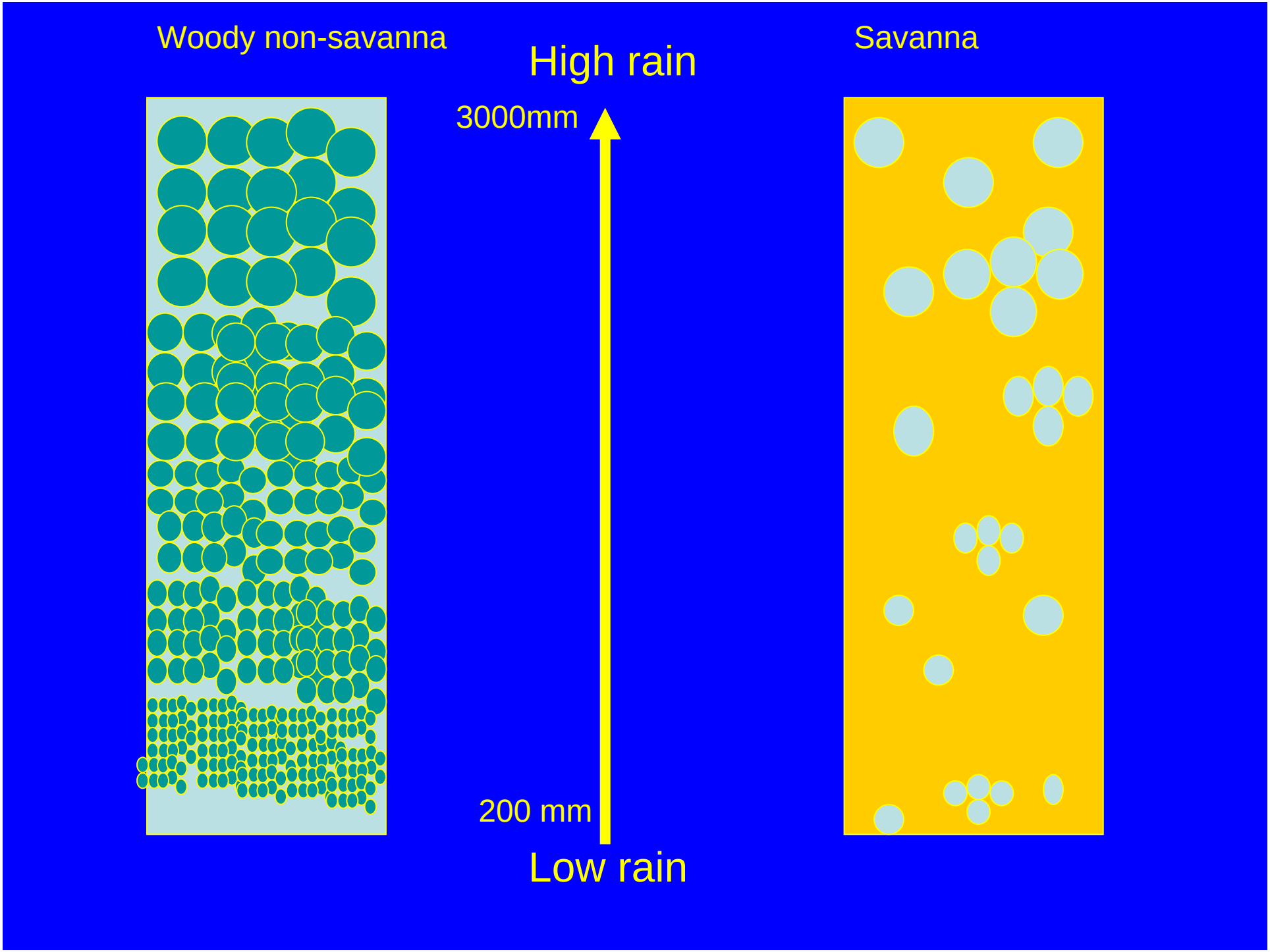
The key question: why so few trees?

- Within savannas
- And between them and alternative biomes


Woody non-savanna
High rain
3000mm
Savanna
200 mm
Low rain

Answers sought:

- Competitive effects of grasses, especially on woody seedlings, saplings
- Effects of grasses on consumers

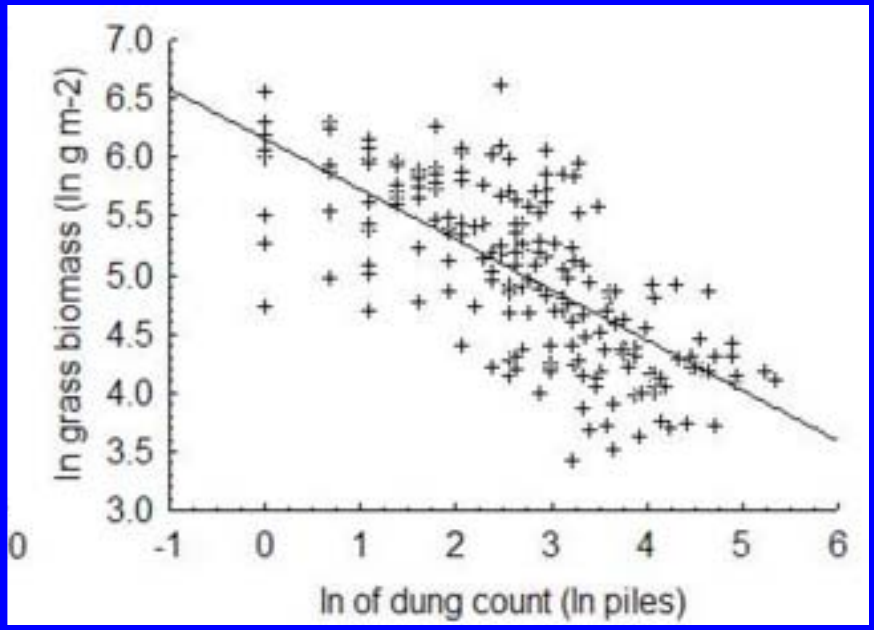
THE distinctive WORLD OF C_4 GRASSES

FREQUENT FIRES, LARGE MAMMAL GRAZERS IN HERDS

Grazers and fire ‘compete’ for food/fuel

Grazers and Fire
are ‘competing’ consumers
of grass

Data ex Hluluwe/Imfolozi
200 plots widely distributed
over the park



More grazing → less grass

Grazers and Fire
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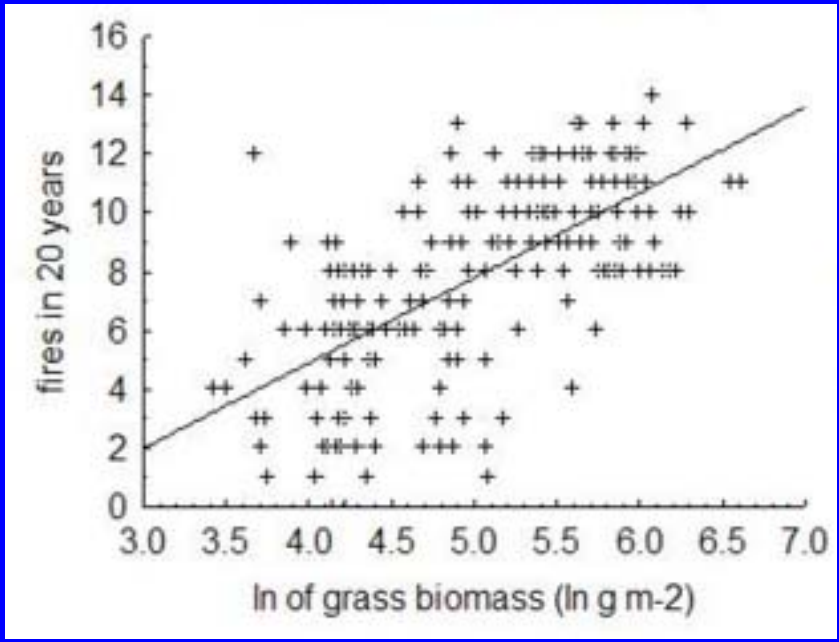
More grass ➔more frequent fires



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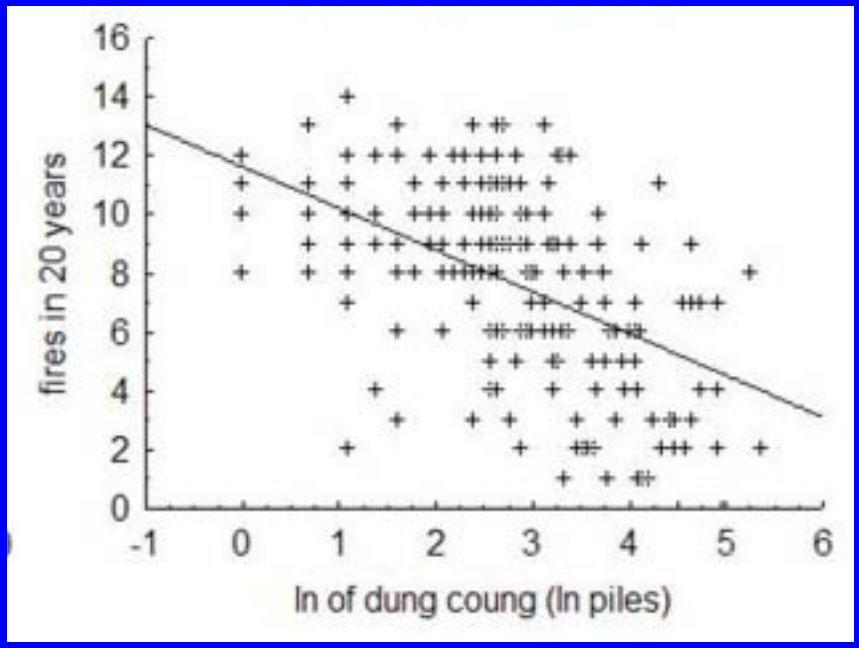


What can trees tell us about fire vs. herbivory as key drivers of tree cover in savannas?

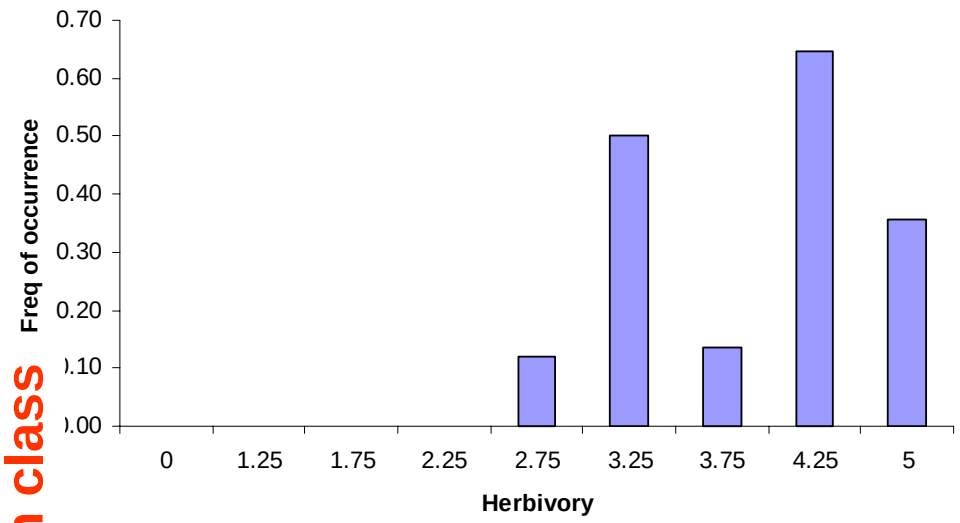
- Acacias
  - Most abundant trees in HiP
  - Highly palatable
  - Structurally defended (well understood cf. chemical defences)
- Sapling stages (demographic bottlenecks)

How do trees differ in in lightly grazed, frequently burnt

Vs heavily grazed seldom burnt communities?

Heavily grazed sparse C4 grass in acacia savanna. Semi-arid 600 mm.

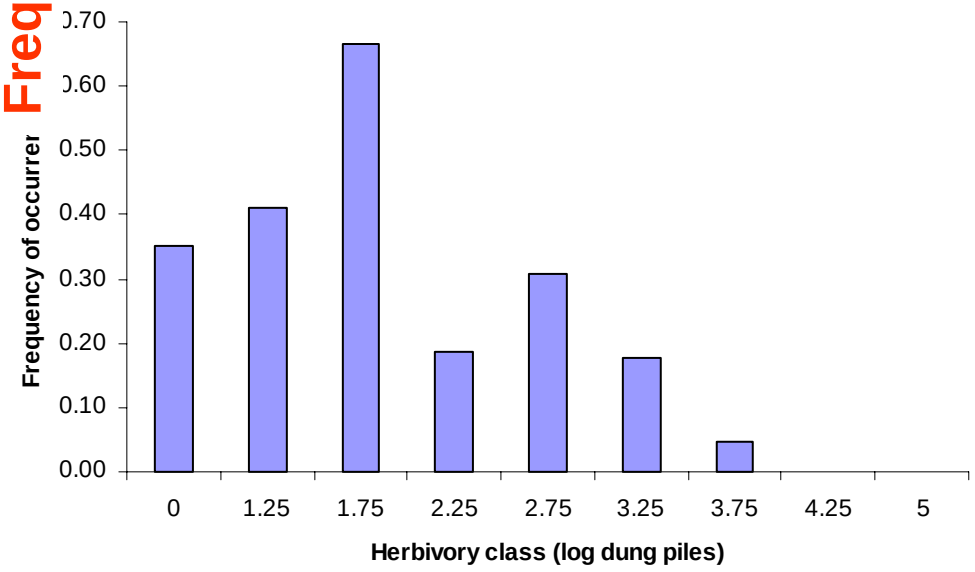
grandicornuta



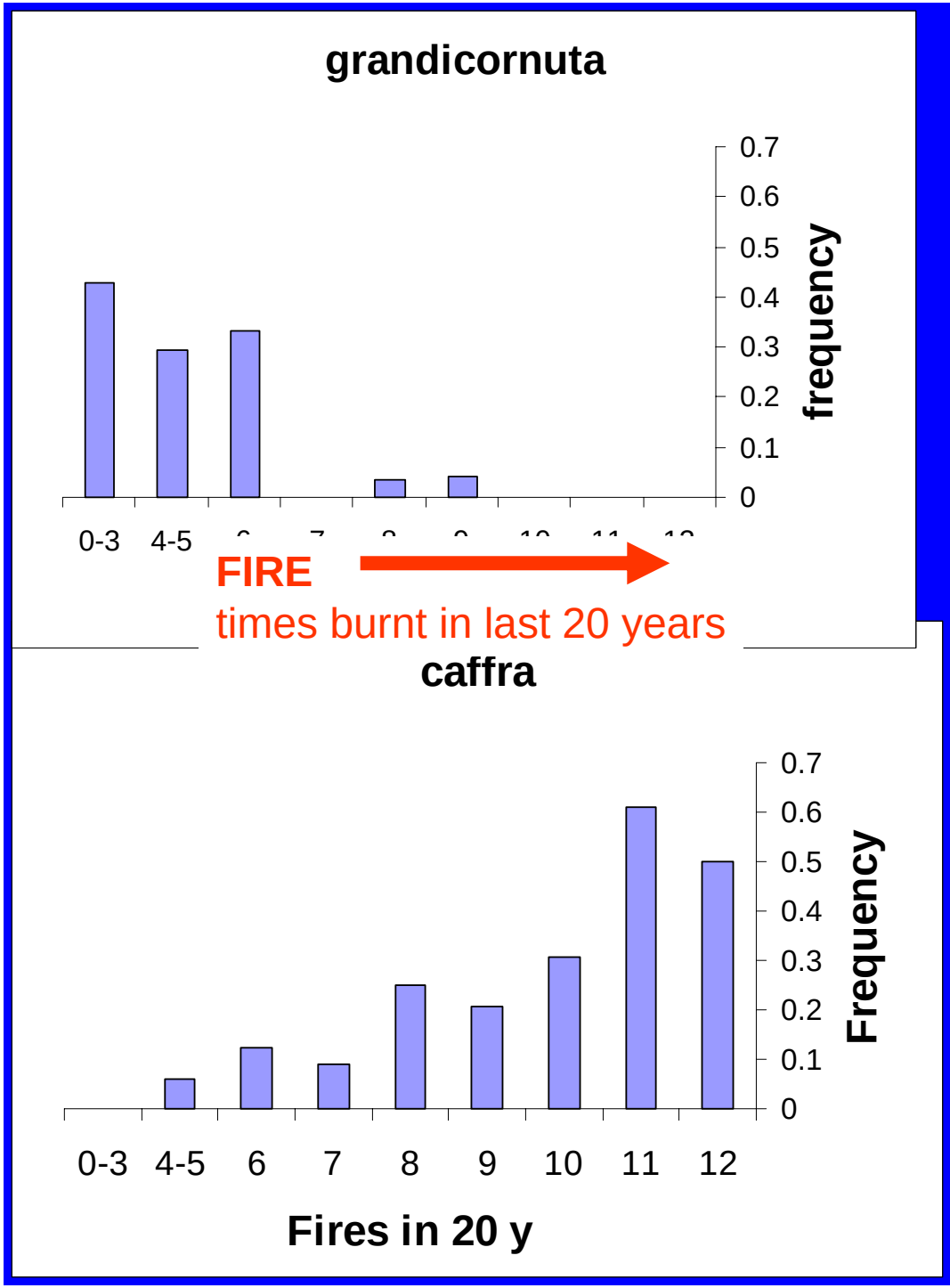
Frequency in class

Herbivory (from dung) →

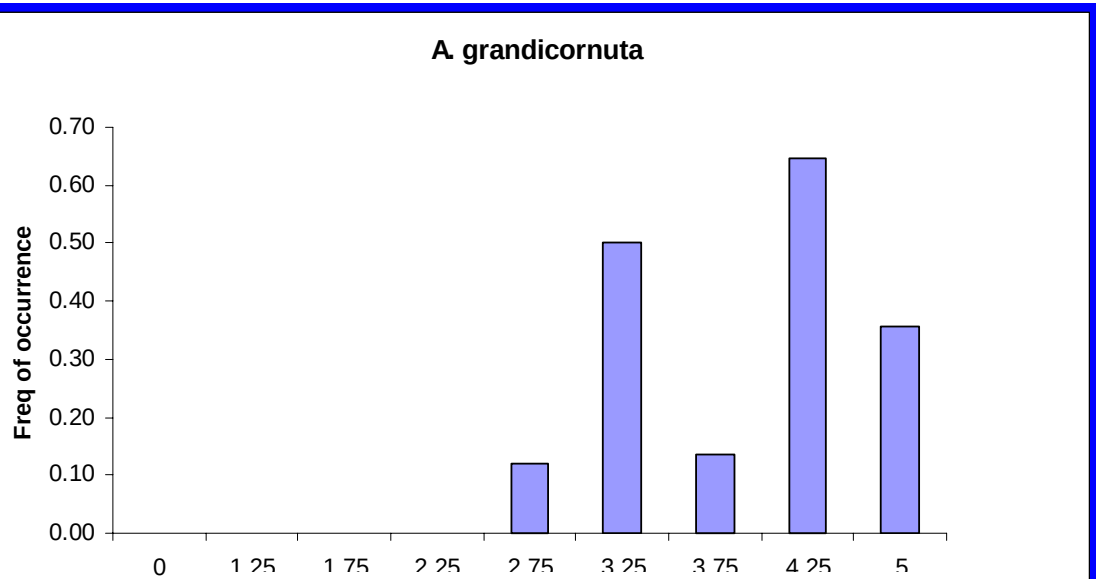
caffra



Acacia species occur at different positions along **HERBIVORY** gradient

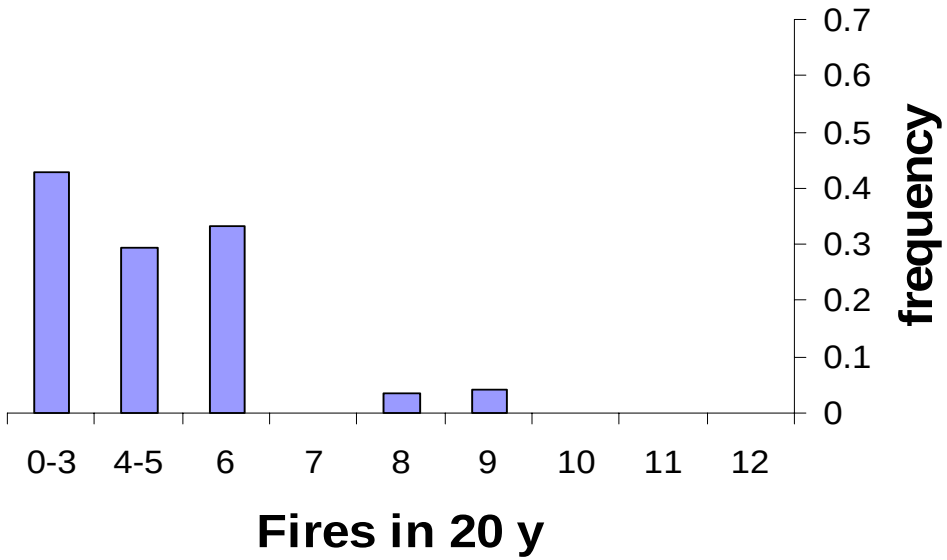


Acacia species occur at different positions along **FIRE** gradient



HERBIVORY

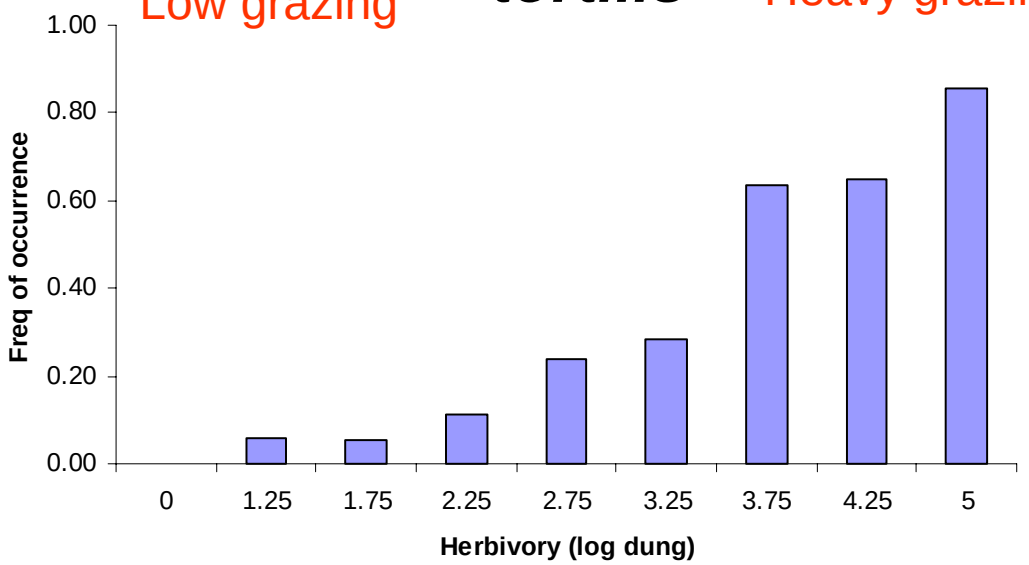
FIRE



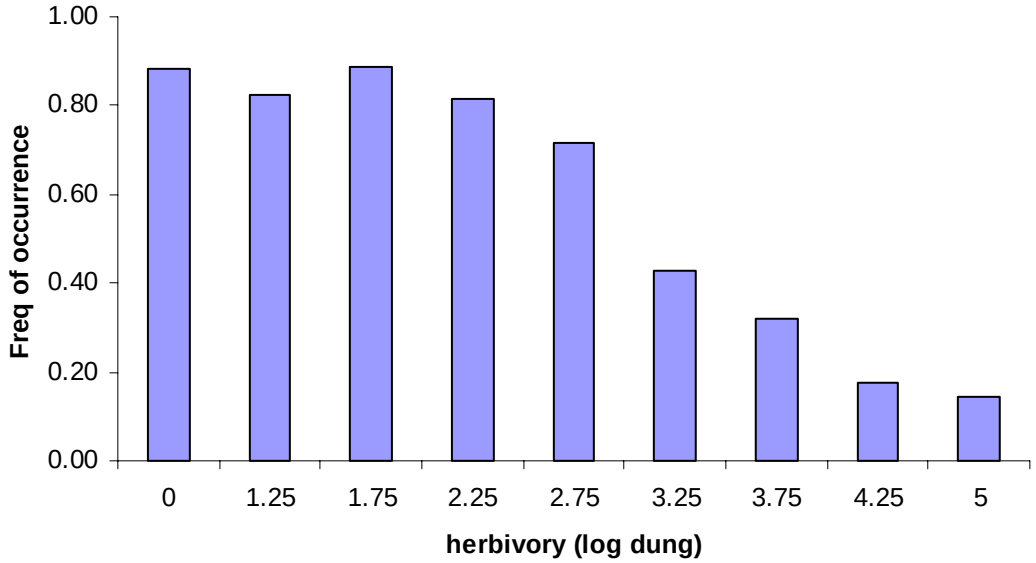
Freq Fire
Low grazing

tortilis

Rare Fire
Heavy grazing

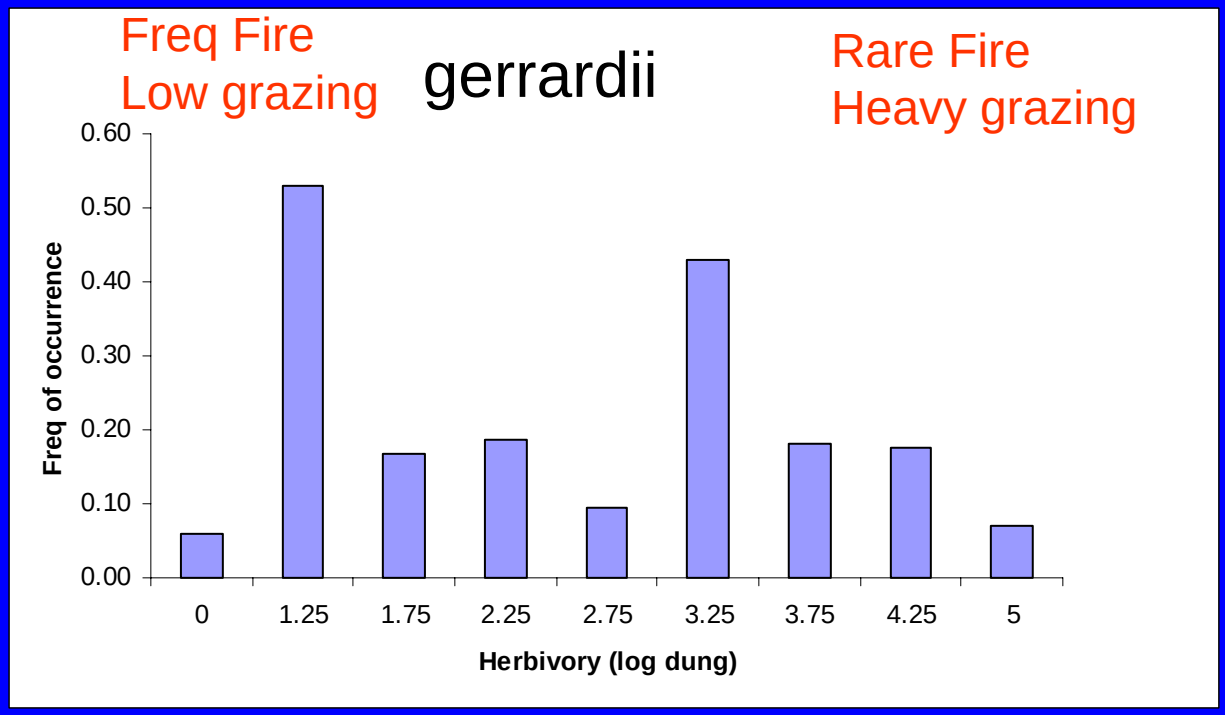


karroo



Acacia species have characteristic Niches along fire/herbivory gradients

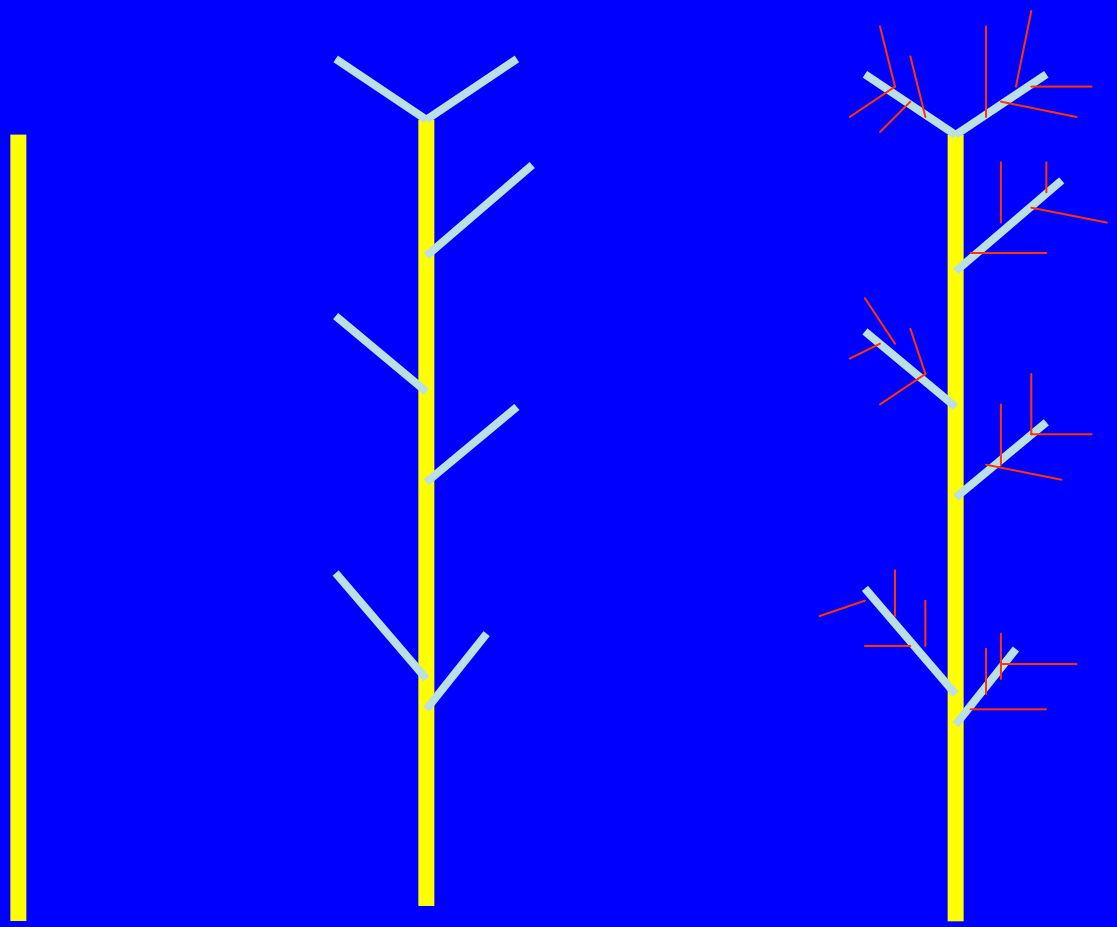
Some species have wide distributions across fire/herbivory gradients



How do woody plants cope with frequent fire vs. intense herbivory?

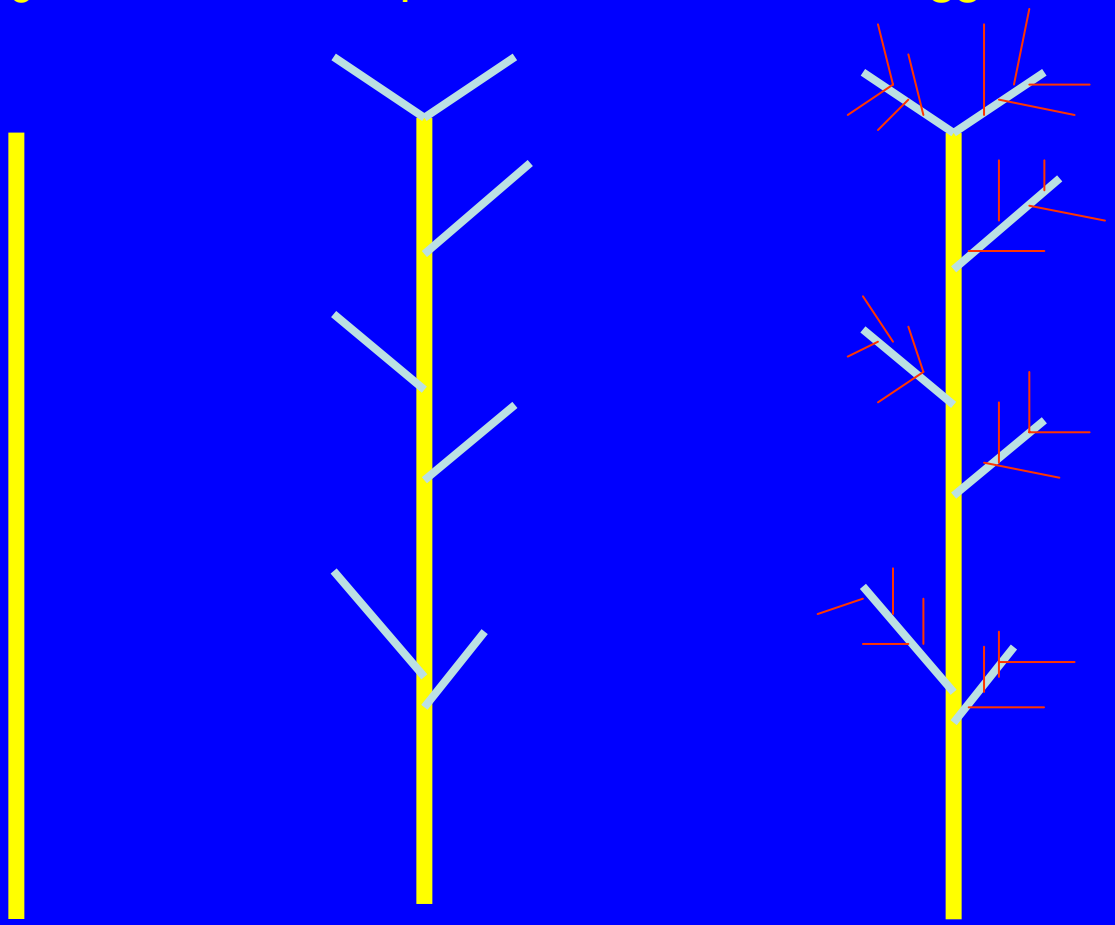
- Above-ground
  - Architectural traits (defence vs. shoot extension) (Archibald and Bond, Oikos 2003)
- Below-ground
  - Starch reserves for sprouting (Hoffmann et al Oecologia 2004)
- Shoot:root ratios

Shoot architecture



Shoot architecture

N 1^{O}	0	7	7
N 2^{0}	0	7	28
Tot N	0	7	35



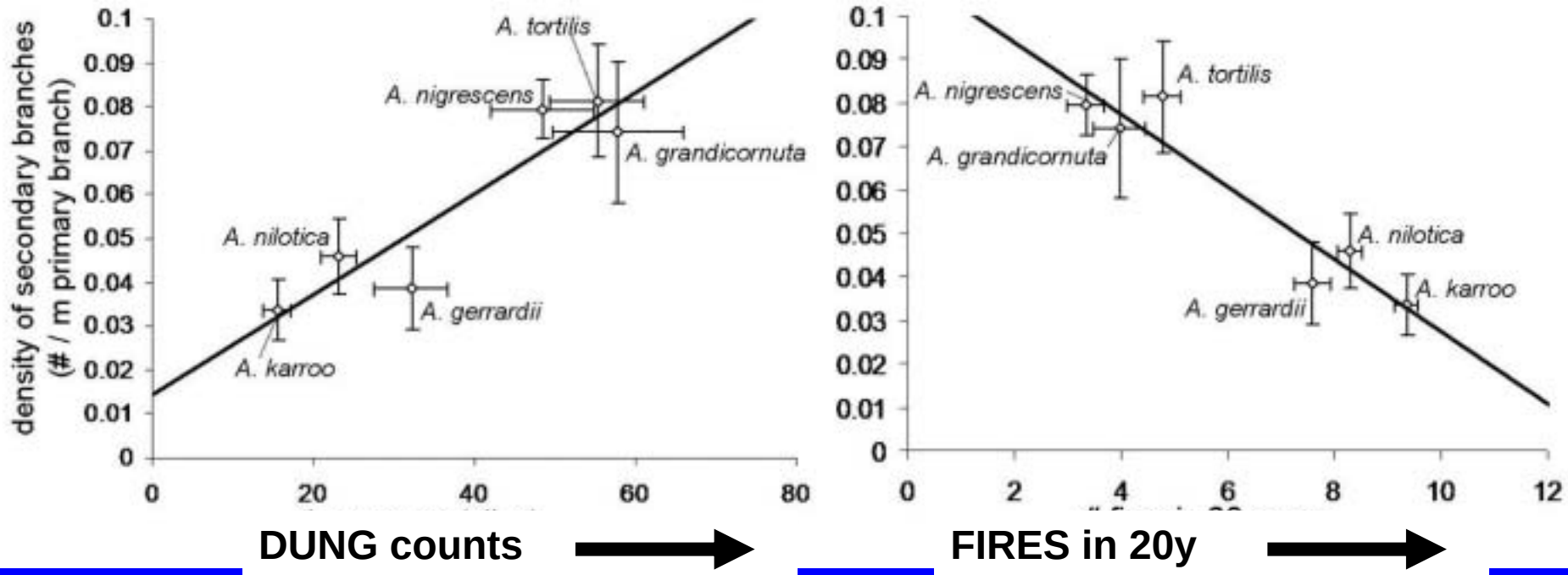


Figure 3.8. Density of 2º branches for Acacia species versus dung count, and fire frequency for plots where the species occurred.
Error bars are standard error of means for each species.

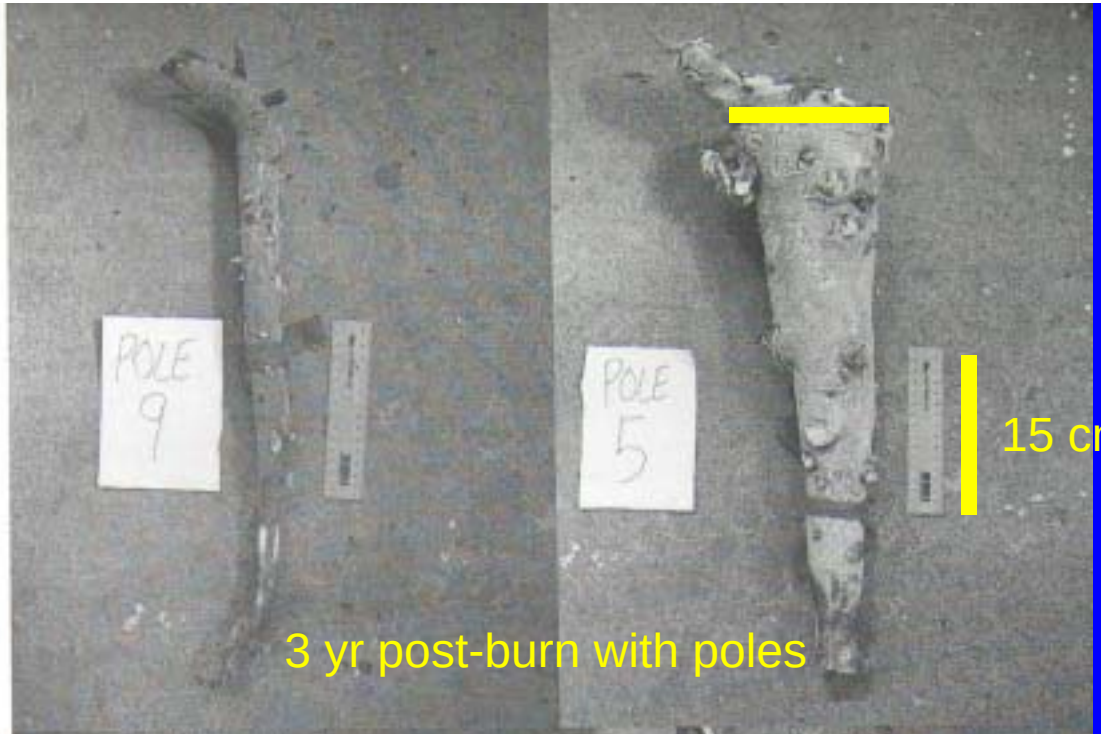
Branchiness decreased with increasing fire frequency (*R2*=0.903, *p*=0.0036)

Branchiness increased increasing herbivory (dung count: *R2*=0.859, *p*=0.0078).

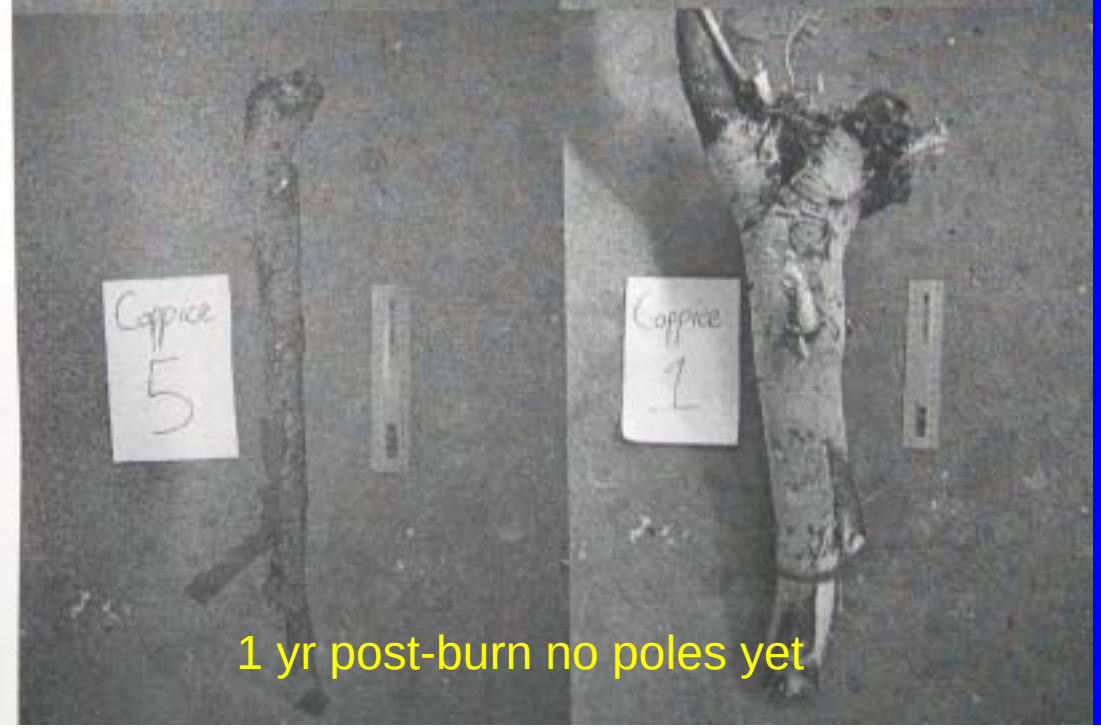
Dense branching, or a 'cage' architecture, confers an advantage in areas with intense herbivory and sparse branching, or a 'pole' architecture, confers an advantage in fire-prone environments.

Root attributes of saplings <2m

- Roots excavated to 50 cm
- Roots, shoots weighed
- Root starch concentrations determined



3 yr post-burn with poles



1 yr post-burn no poles yet

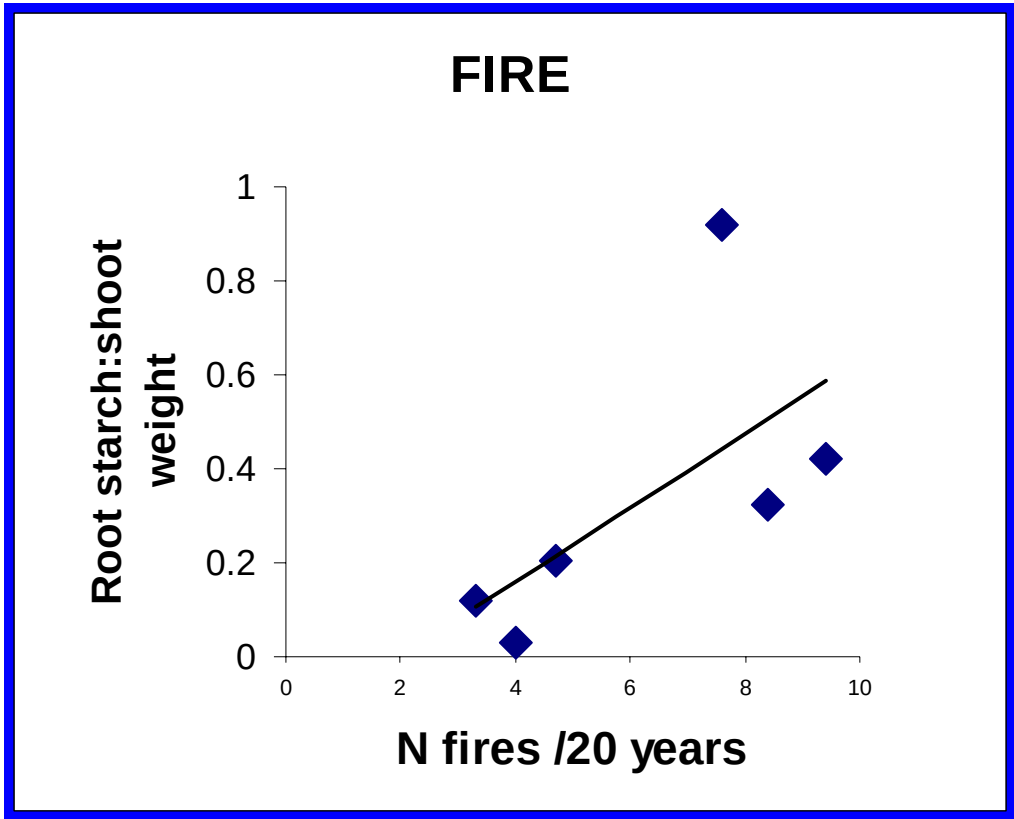
A. karroo tubers

Tubers can get very large

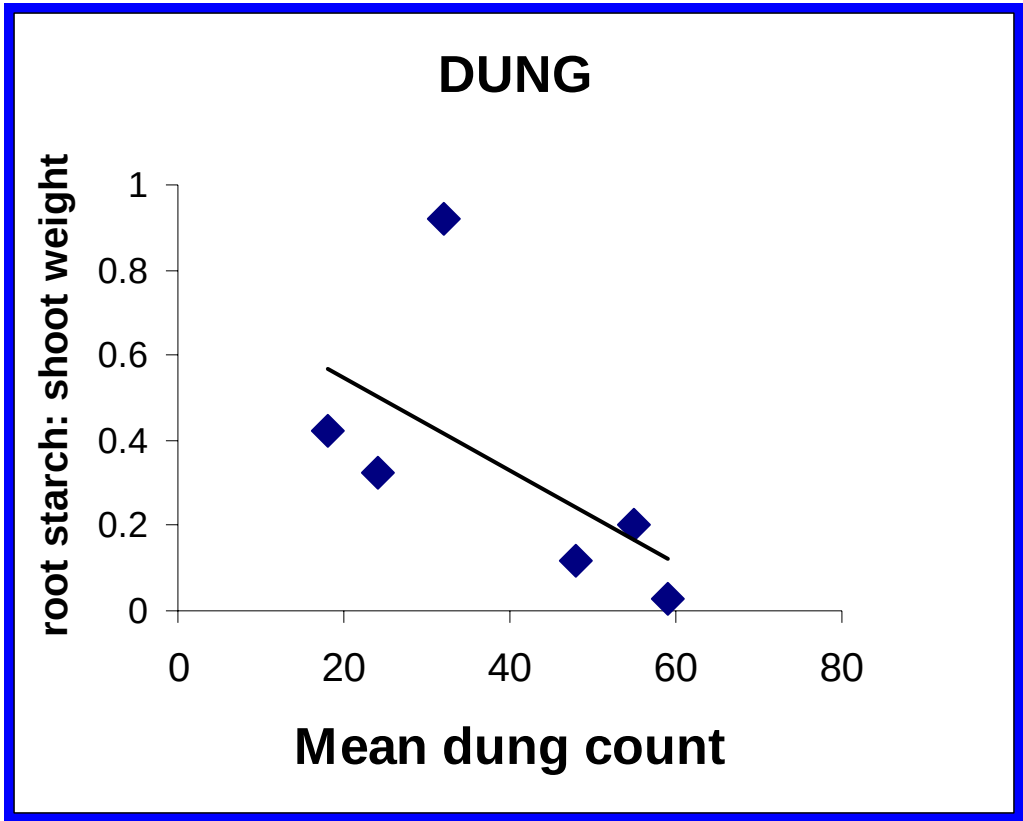
Lignotuber starch:

34.5%+

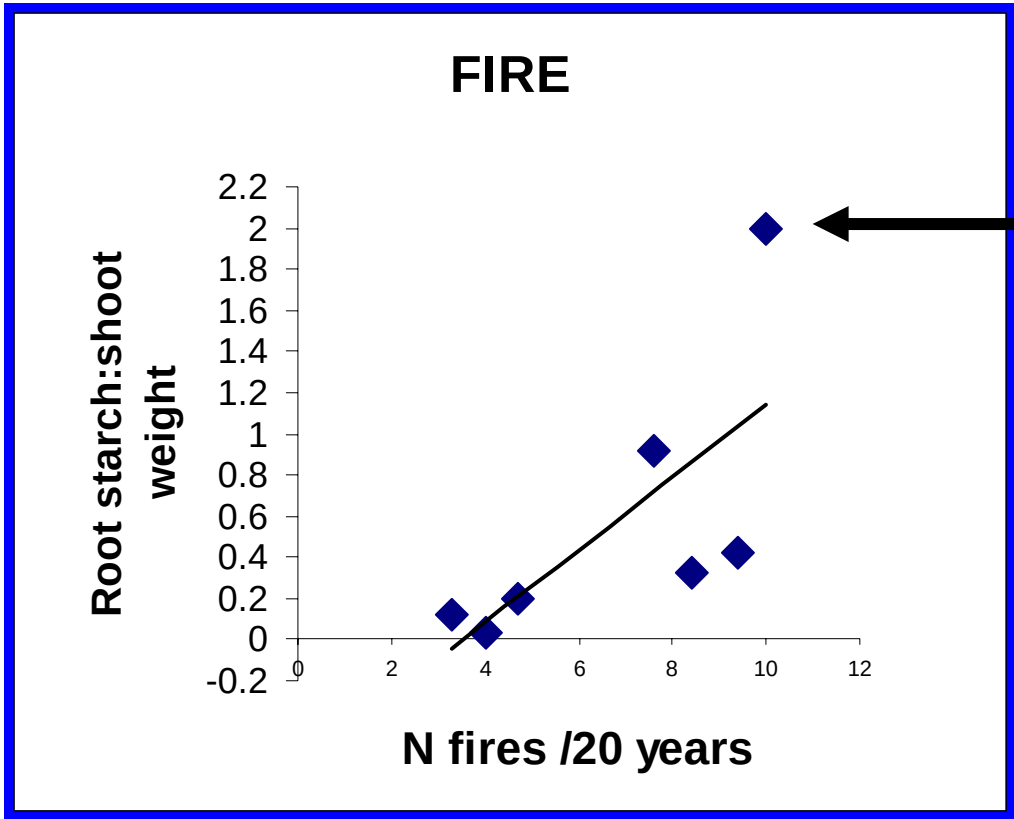
More than 1/3rd of the roots is stored reserves!



Root starch reserves are larger in spp
In frequently burnt savannas



Root starch reserves are lower in species
In heavily grazed savannas



Acacia caffra: a shrub

CAGE Acacias

CAGES

Herbivore tolerant archetype
A. grandicornuta

Highly ramified branches
- Long rigid spines,
- short leaves

Low root: shoot ratio
- No tuber
- Low root starch

Cage habitat

POLES

Fire tolerant archetype
A. karroo (Hluhluwe form)

Sparse branches
- Leaves large,
- longer than spines

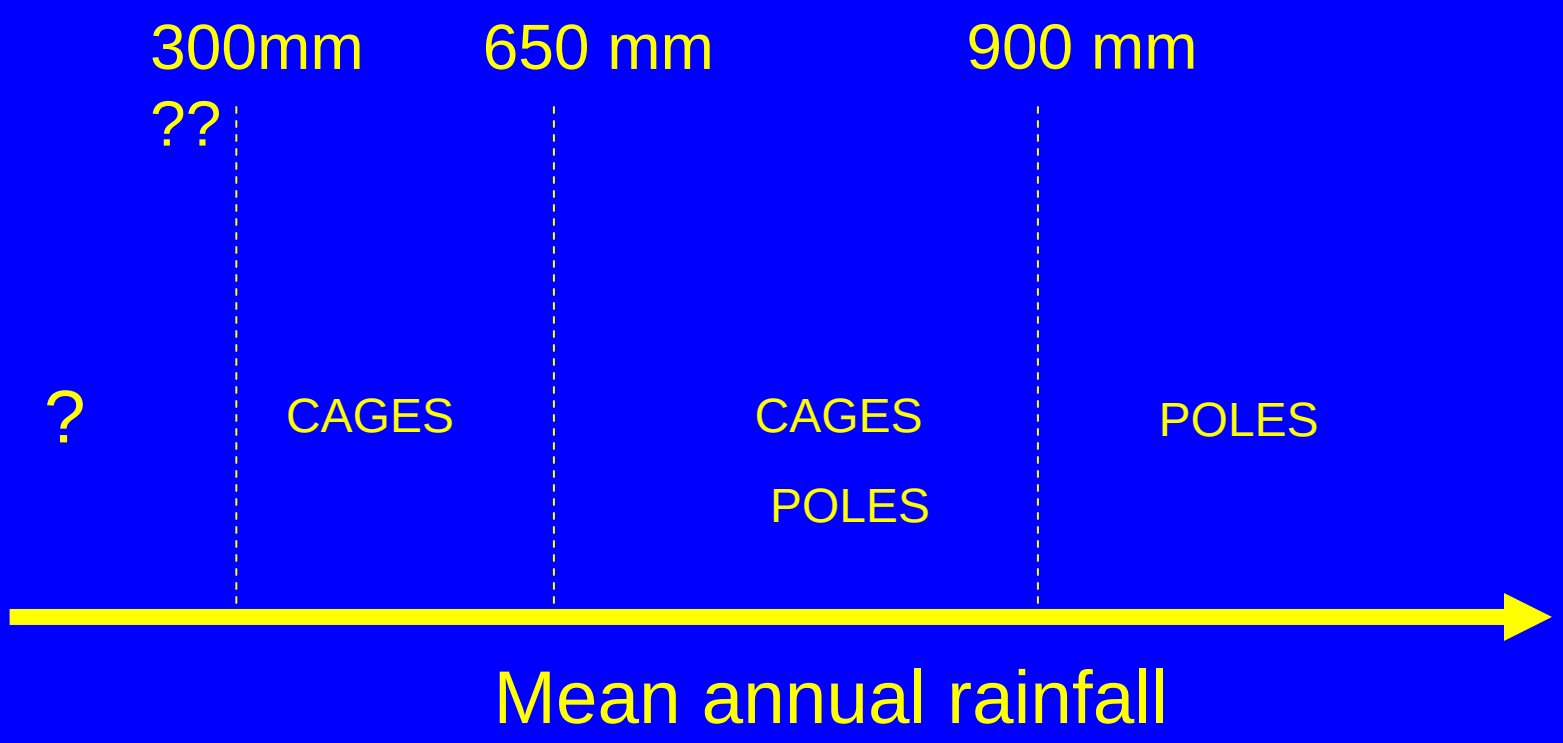
High root: shoot ratio
- Tubers present
- High root starch

Pole habitat

Using Functional traits

- Which consumer where along environmental gradients?
- What are the consequences of changing the dominant type of consumer?
- Where will CO_2 fertilisation have most impact?

Which consumer where?



Modified by soils, landscape position

What are the consequences of changing the dominant type of consumer?

- Look for species shifts in tree vs. sapling layer
  - Adult trees cage: saplings pole
    - Switch from grazer to fire dominated grass sward
    - Caused by heavy culling (Bond et al 2001)?
  - Adult trees pole: saplings cage
    - switch from fire to grazer-dominated grass sward

Where will CO_2 fertilisation have most impact on woody plant increase?

- Two mechanisms proposed
- Indirect effects (Polley 1997)
  - Reduced transpiration causes increased soil moisture favouring woody seedlings
  - Predicts tree increase in **arid** savannas
- Direct effects (Bond, Midgley 2000)
  - Increased growth, carbon storage
  - Most NB for plants with large Carbon sink (POLES)
  - Predicts tree increase in **mesic** savannas

Summary

- Plant functional traits provide predictive framework for ecology
- Traits for fire/herbivore response poorly studied
- Acacia species have different niche positions along gradients of fire/herbivory
- Fire and herbivory select for opposing traits in woody saplings (and shrubs)
  - FIRE: Pole + large root Starch reserves
  - HERBIVORY: Cage – low root reserves
- How general are these traits? Africa, Oz, Sth Am? Europe?

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