

CO₂ and fire regime impacts on
vegetation structure:
Potential interactions with land use
and land abandonment

Guy Midgley

SANBI, Cape Town, South Africa

Barney Kgope (SANBI)

Ian Woodward (U Sheffield)

William Bond (UCT)



Land abandonment in S-Africa?

- Urbanisation – movement of younger people to cities
- Land reform – intensive to subsistence agriculture
- Game farming increasing
- Electrification – removes need to source wood for energy provision



Open savanna,
S. Africa, 1955

From pre-industrial
trees have increased
world-wide in savannas



Matched photograph
Same place, 1998

(from Timm Hoffmann,
IPC, UCT)

Sub-Saharan Africa undergoes extensive, frequent biomass burning, leading to a high degree of patchiness in structure, at the landscape scale domestic and wild animal grazing and shifting agriculture add to this mosaic

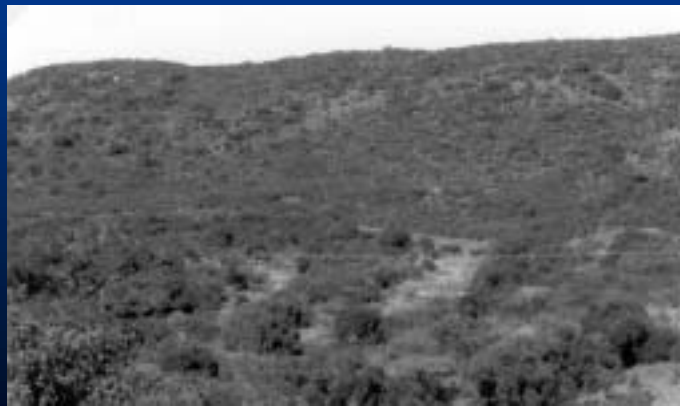
(paraphrased – Privette et al 2004
GCB special issue, Kalahari Transect)

Animals make a difference



?

CO₂



Significant implications for biodiversity

CO₂
climate

Vegetation
structure

Land
use

Fire



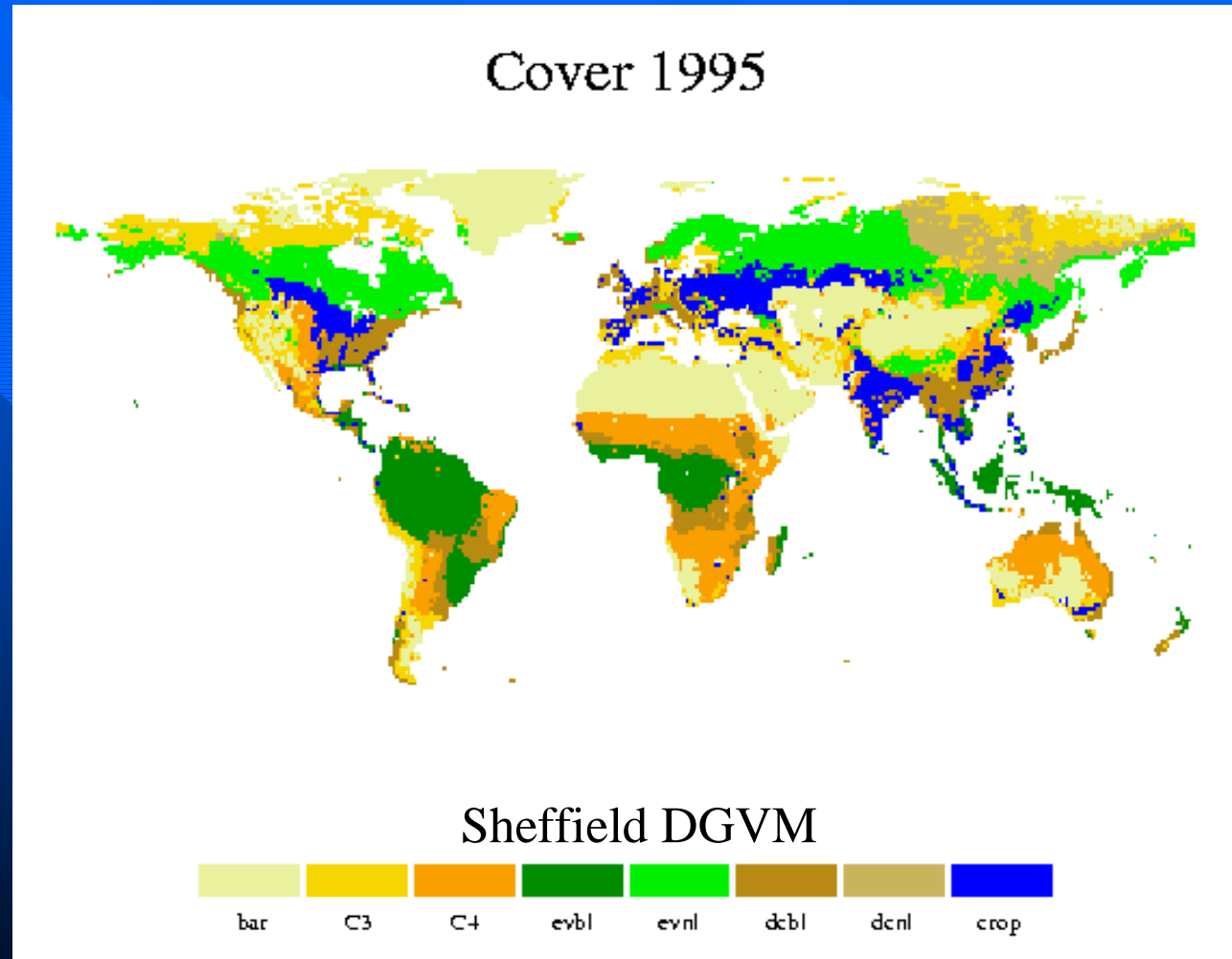
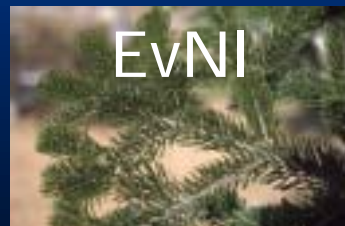
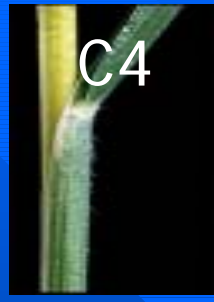
If fire is suppressed, system structure switches



How important is this globally?

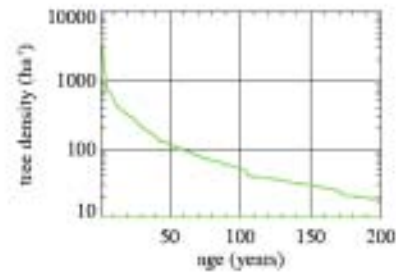
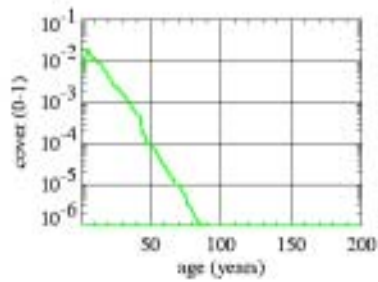
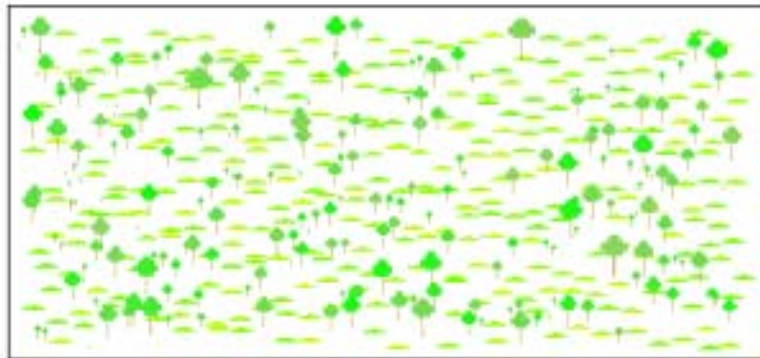
Dynamic Global Vegetation Models (DGVM)

Dominant PFTs by vegetation cover

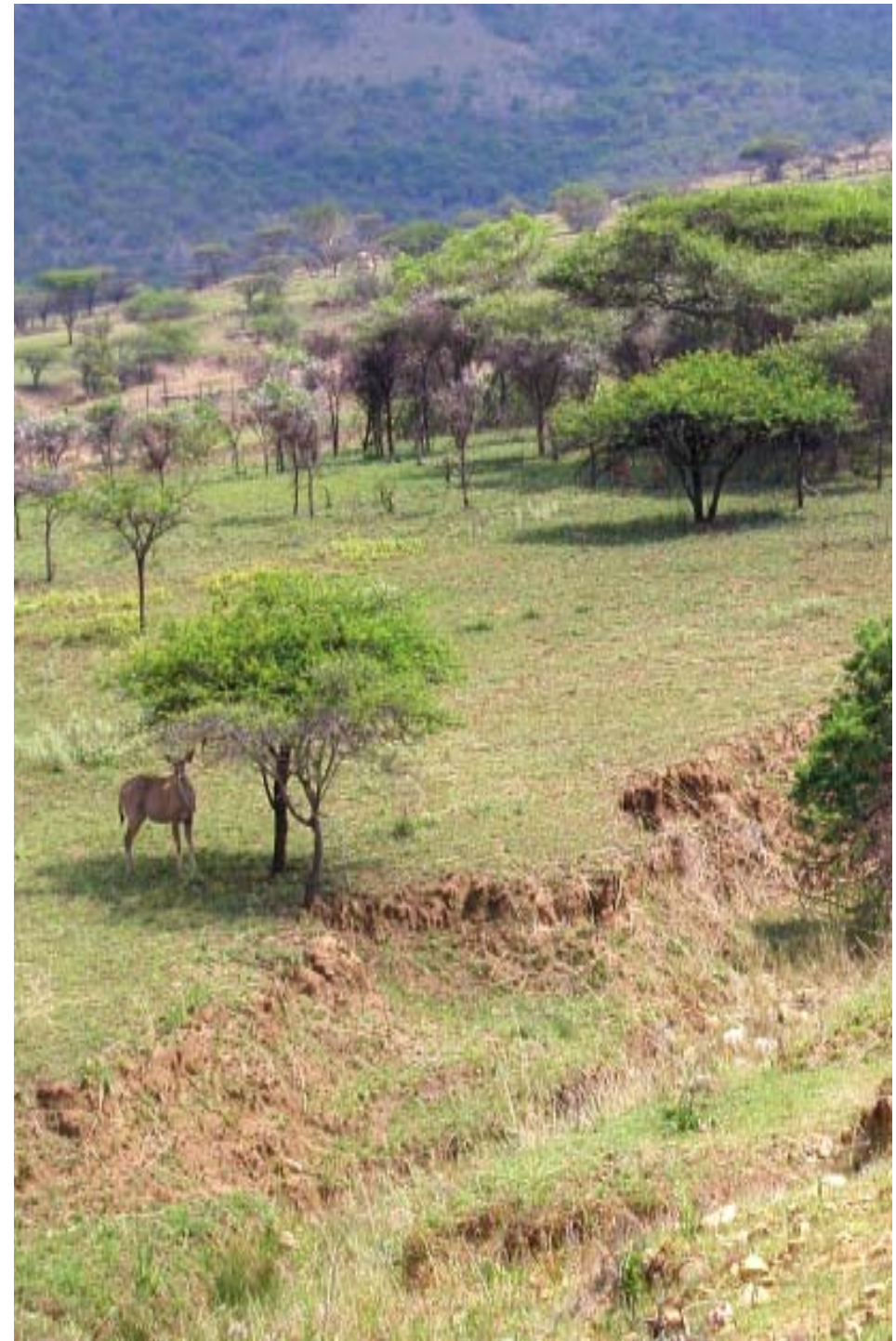


Savanna Southern Africa

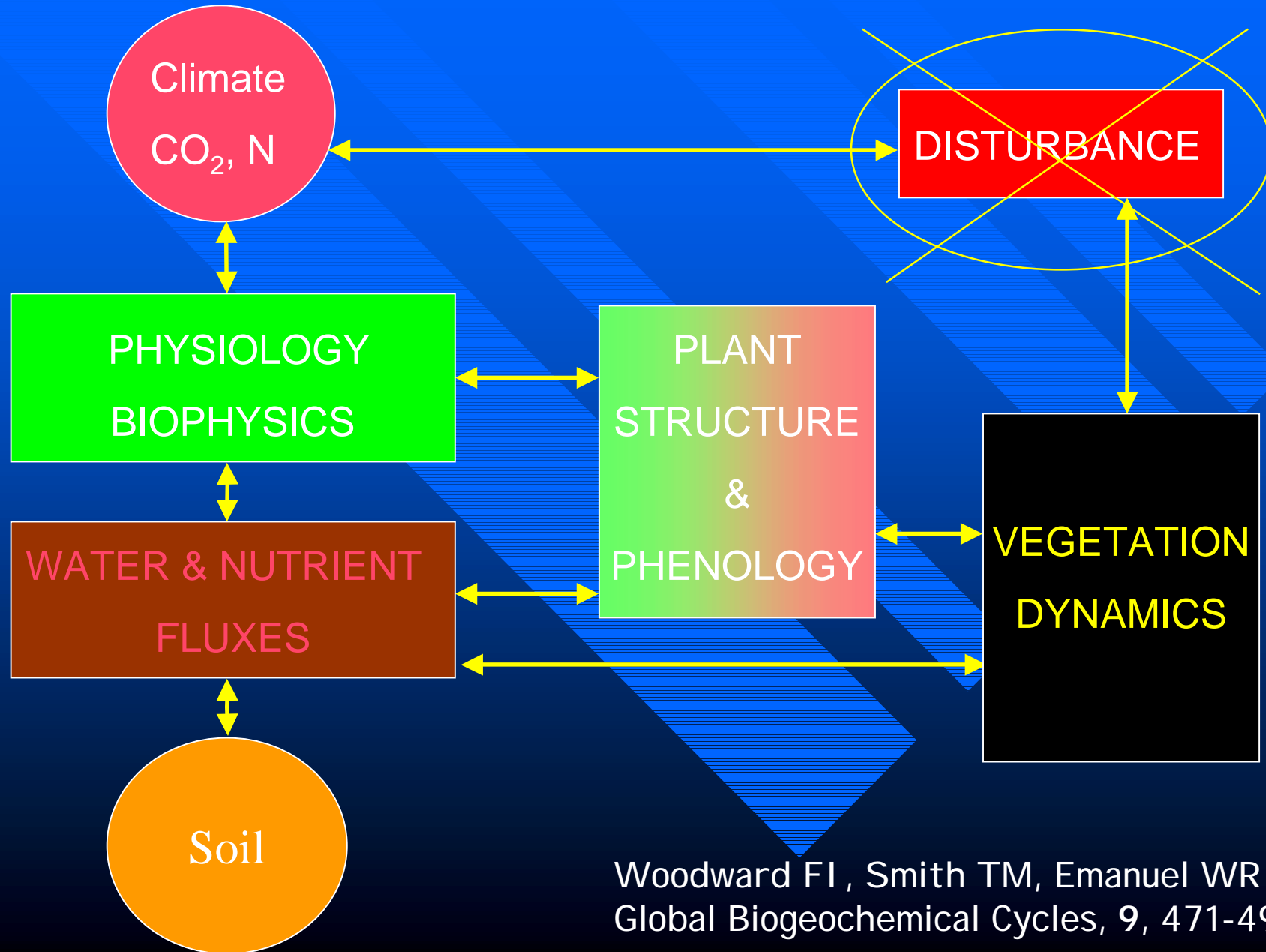
2000 17.500°S 26.250°E
Scale 1000:1 Area = 1.00 ha



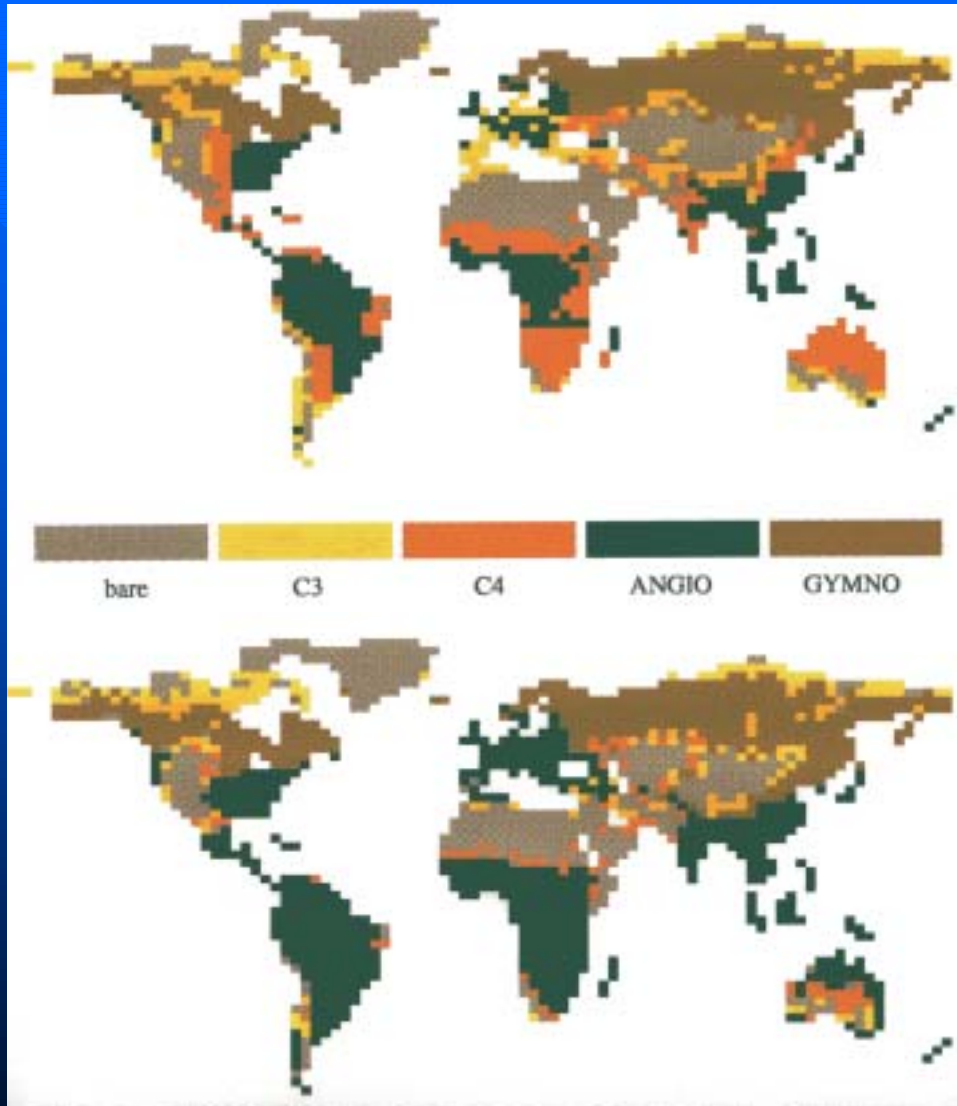
Functional Type	Bare	C3	C4	Evergreen Broad. Needle	Deciduous Broad. Needle
Cover (%)	0	0	76	0	24
Biomass (t ha ⁻¹)	0.0	0.0	3.0	0.0	1.8
Tree density (ha ⁻¹)	0	0	0	0	44
Avg height (m)	0.0	0.0	0.0	0.0	5.8



Sheffield DGVM (Woodward)



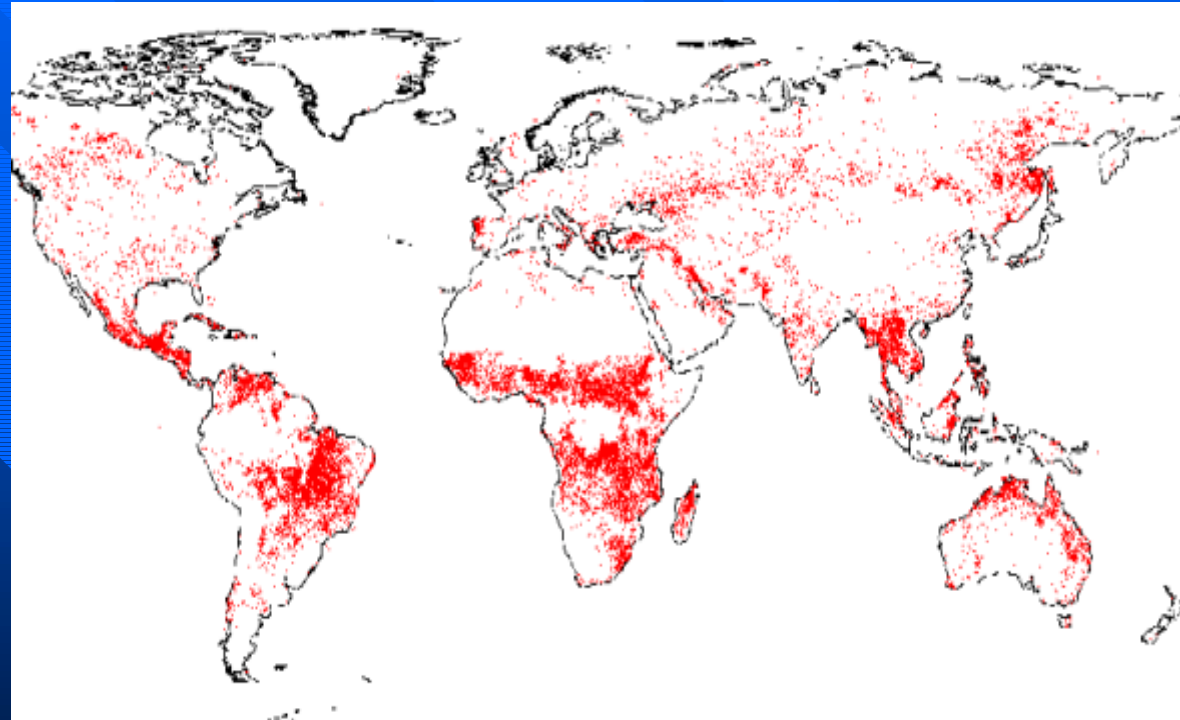
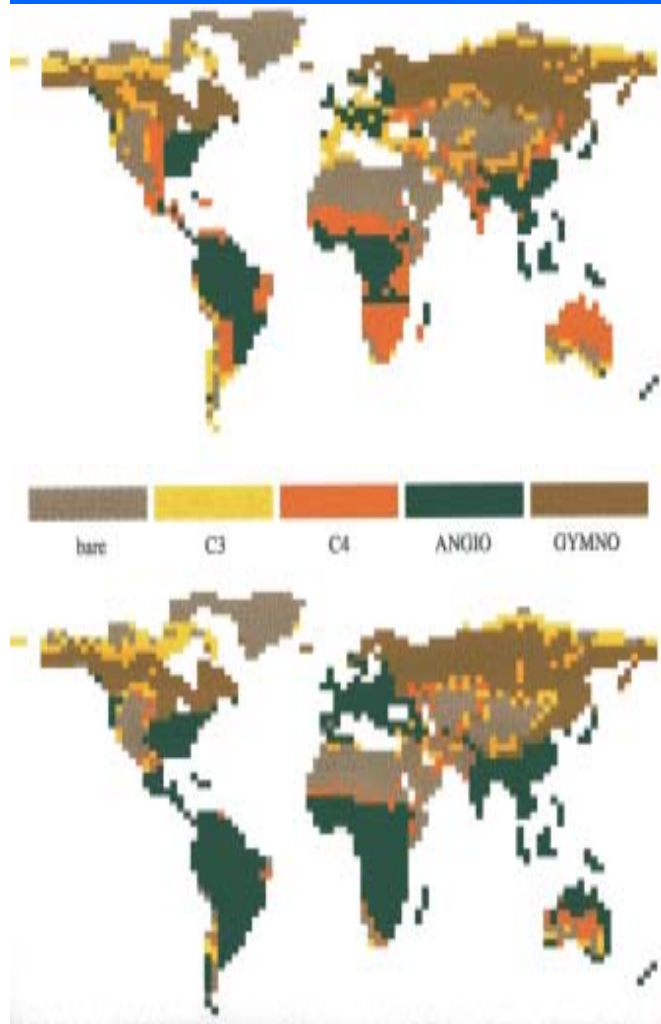
Woodward FI, Smith TM, Emanuel WR (1995)
Global Biogeochemical Cycles, 9, 471-490.



Fire on

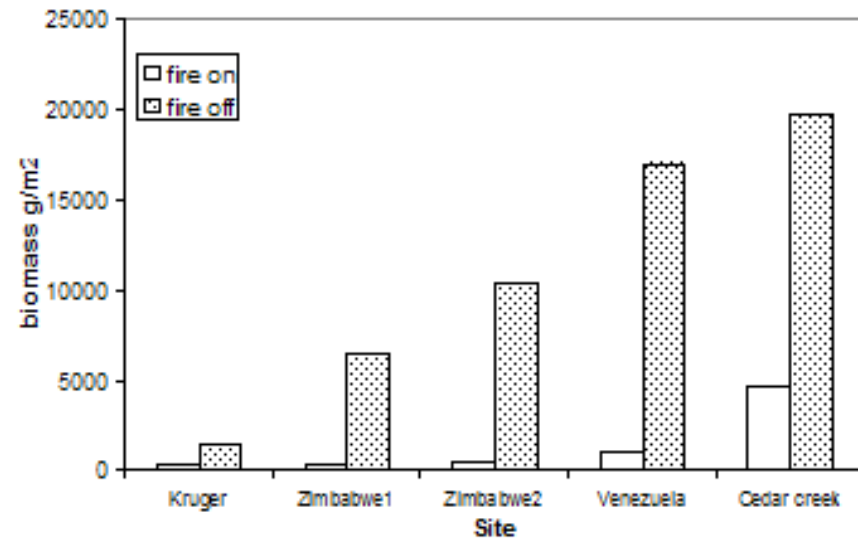
Fire off!

Global distribution of fire in 1998
mapped by ATSR-2 World Fire Atlas
(European Space Agency)

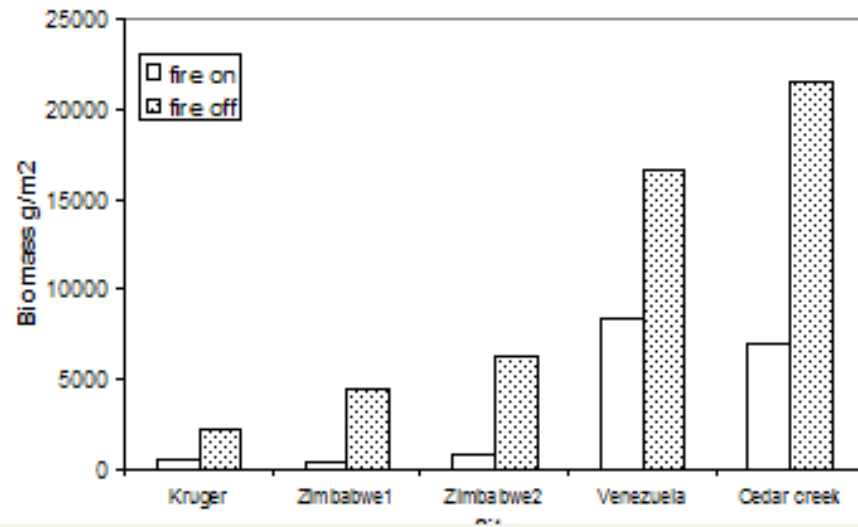


Concept: Fire-dependent ecosystems
Bond et al in press New Phytologist

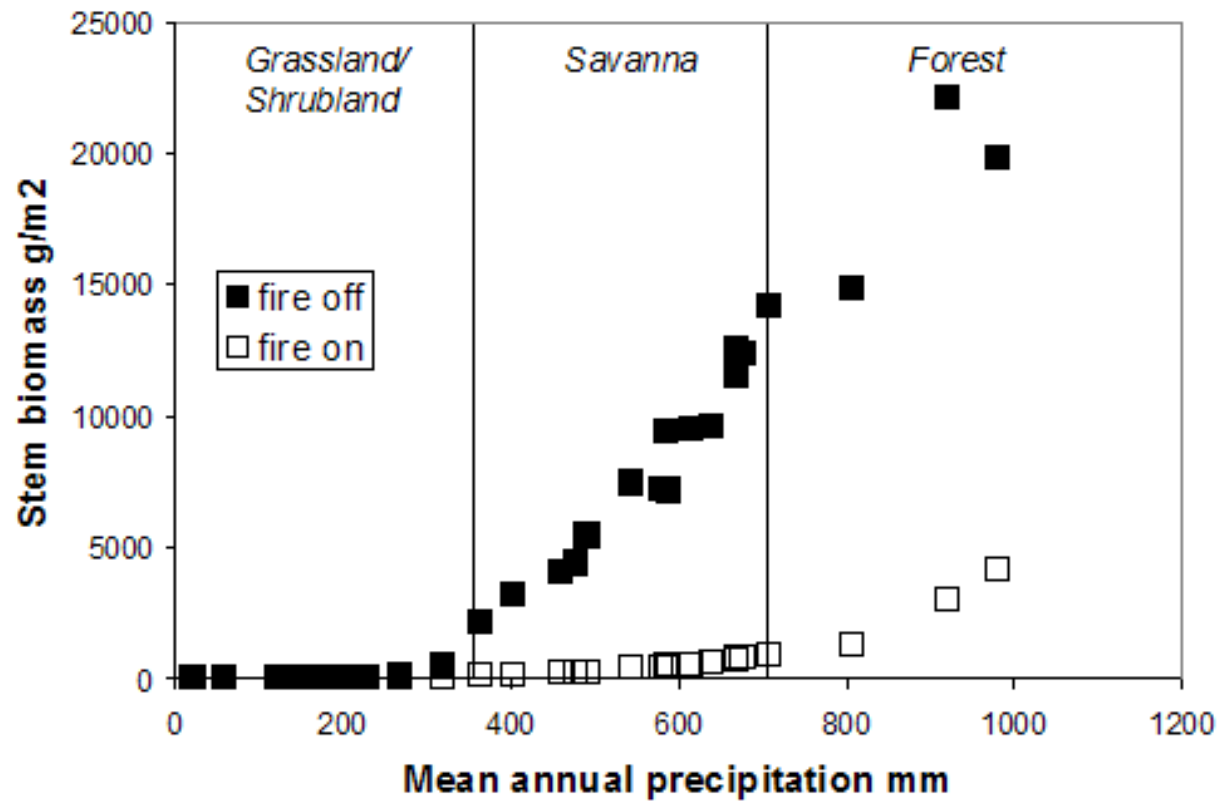
a: measured biomass



b: simulated biomass



South Africa, Lat. 27 S



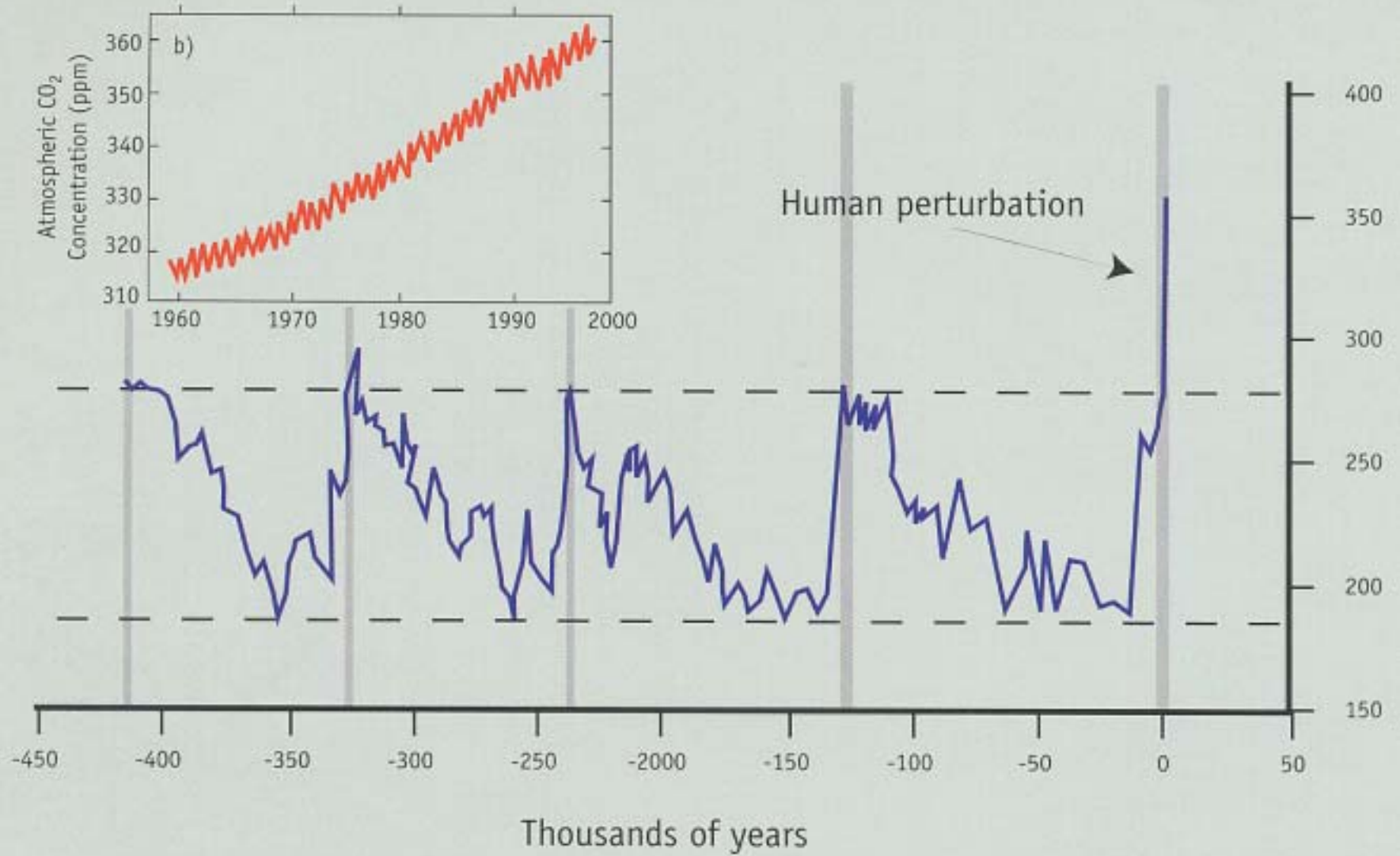
What are the world's FDE's?

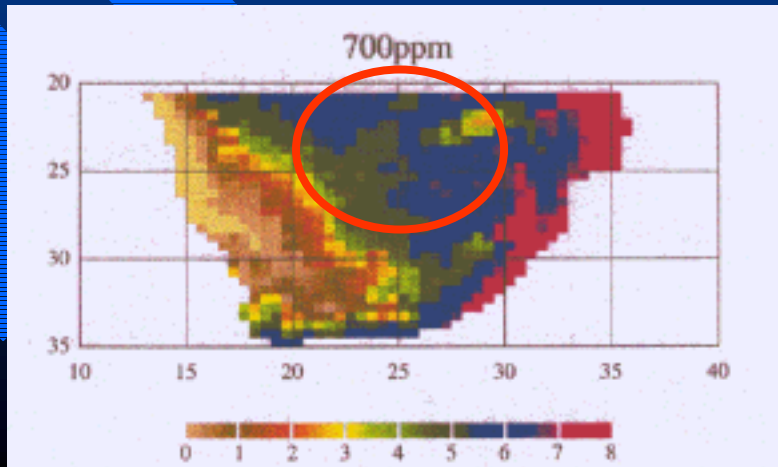
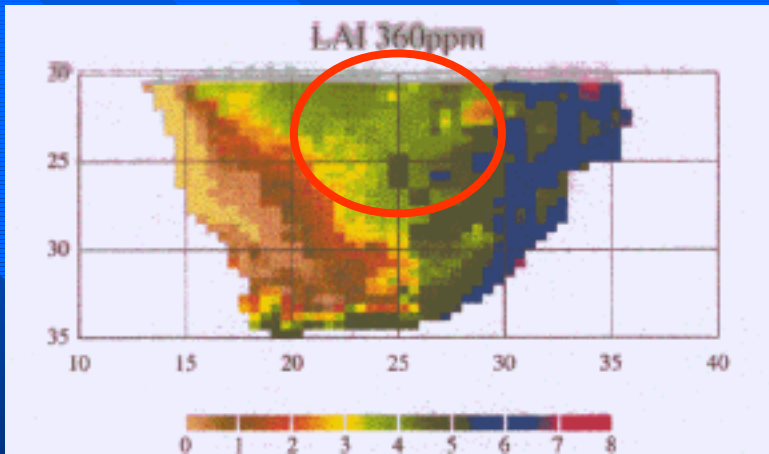
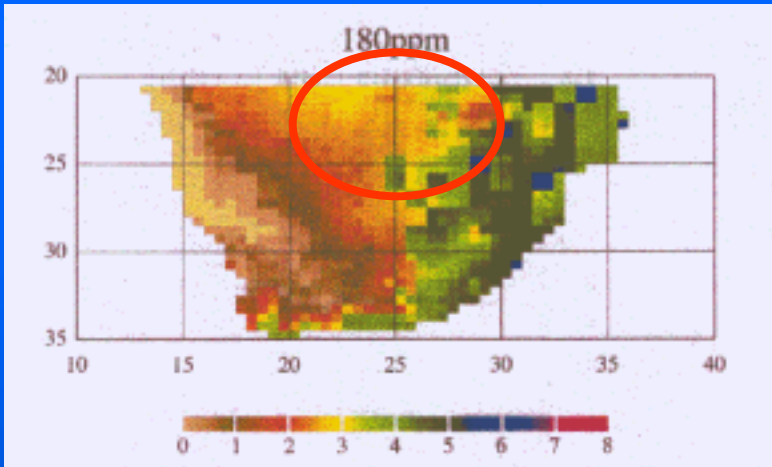
- Most tropical and sub-tropical grasslands and savannas are not at their climate potential and would be replaced by woodlands and forests in a "fire off" world
- Forest cover (80-100% tree cover) would double from 27% of vegetated grid cells to 56% in the absence of burning. More than half of grid cells with C₄ grasses present (>20% cover) would change to closed angiosperm forest in the absence of burning
- Mediterranean shrublands are of much smaller extent but also have the climate potential to be forest, not shrublands
- The third major fire-prone biome, boreal forests, are often dominated by fire-adapted trees with serotinous cones that release seeds only after crown fires, but they do not change structure when fire is suppressed
- Fire is a major force in controlling vegetation switches in many parts of the world

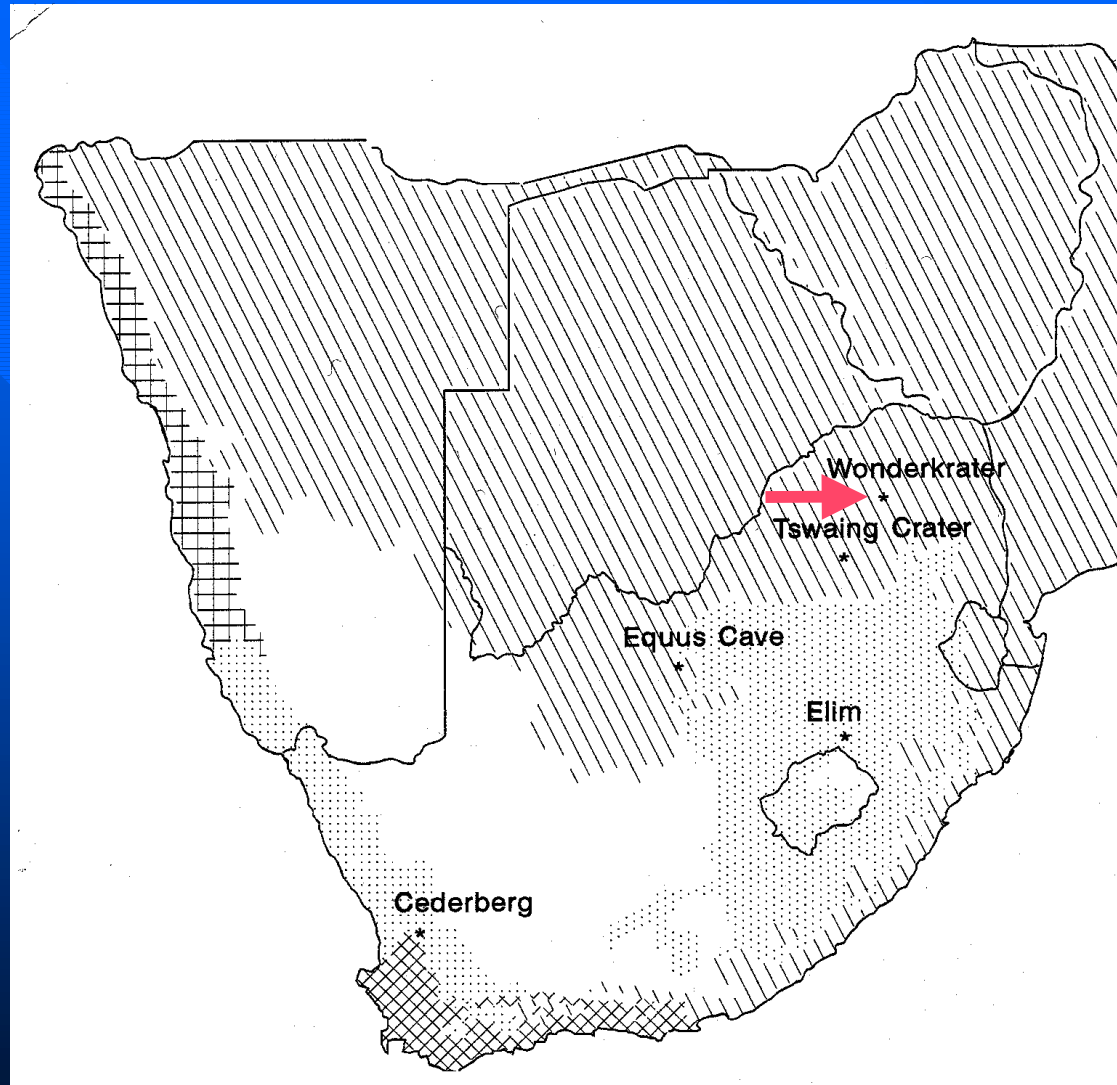
How does CO₂ fit in?



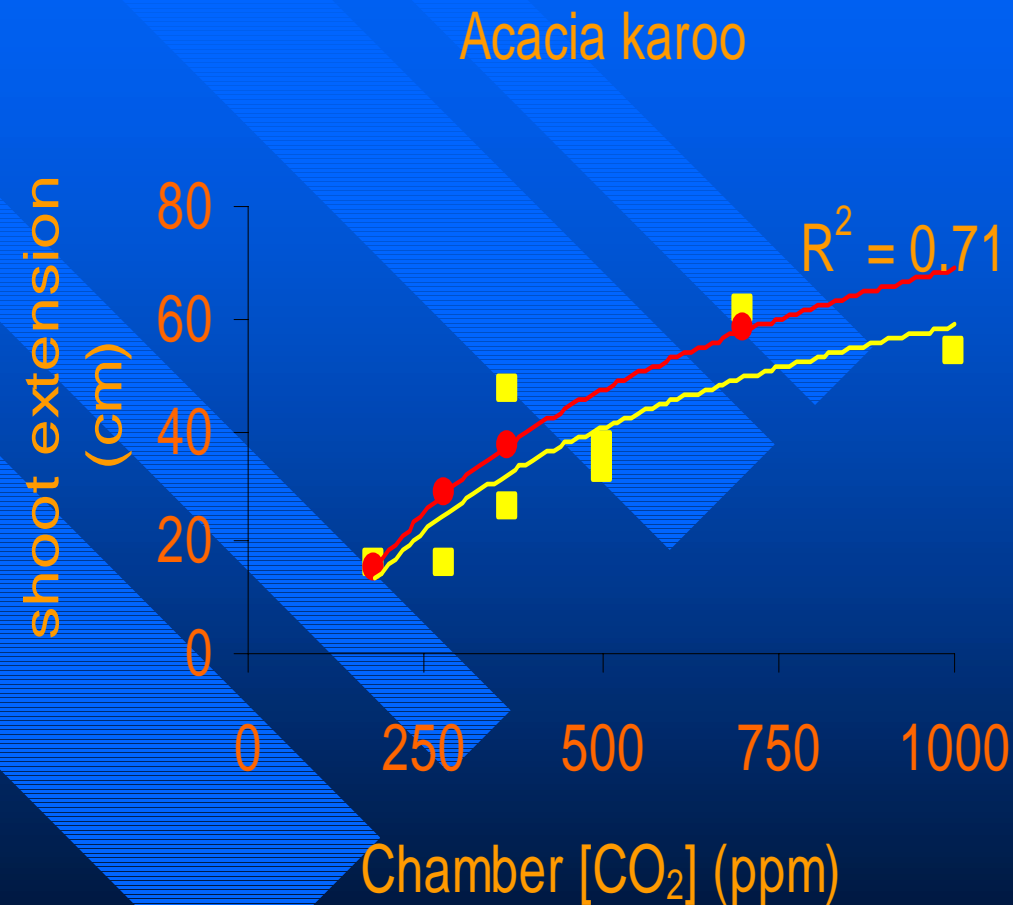
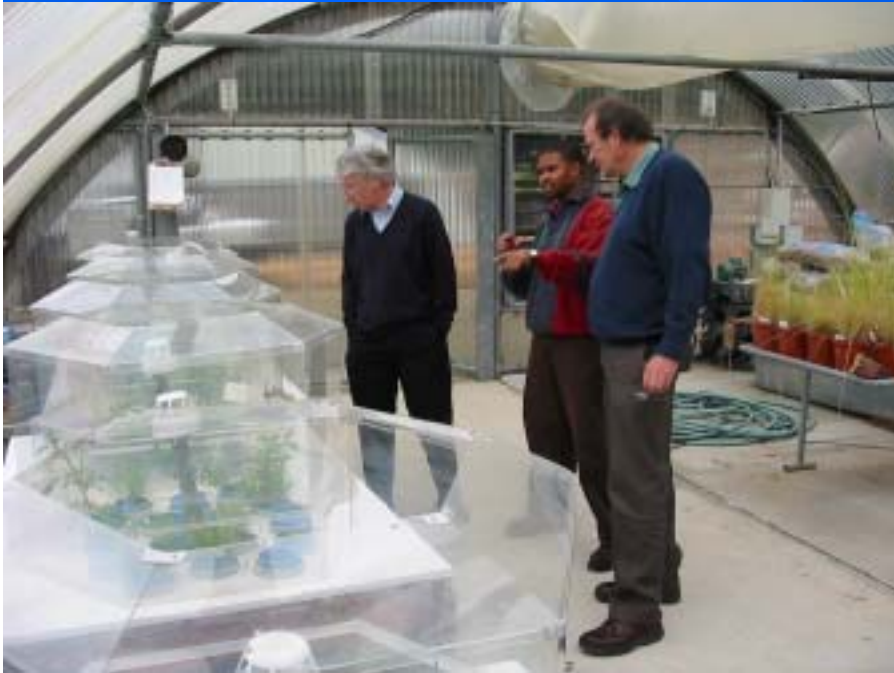
The recent human influence on the carbon cycle



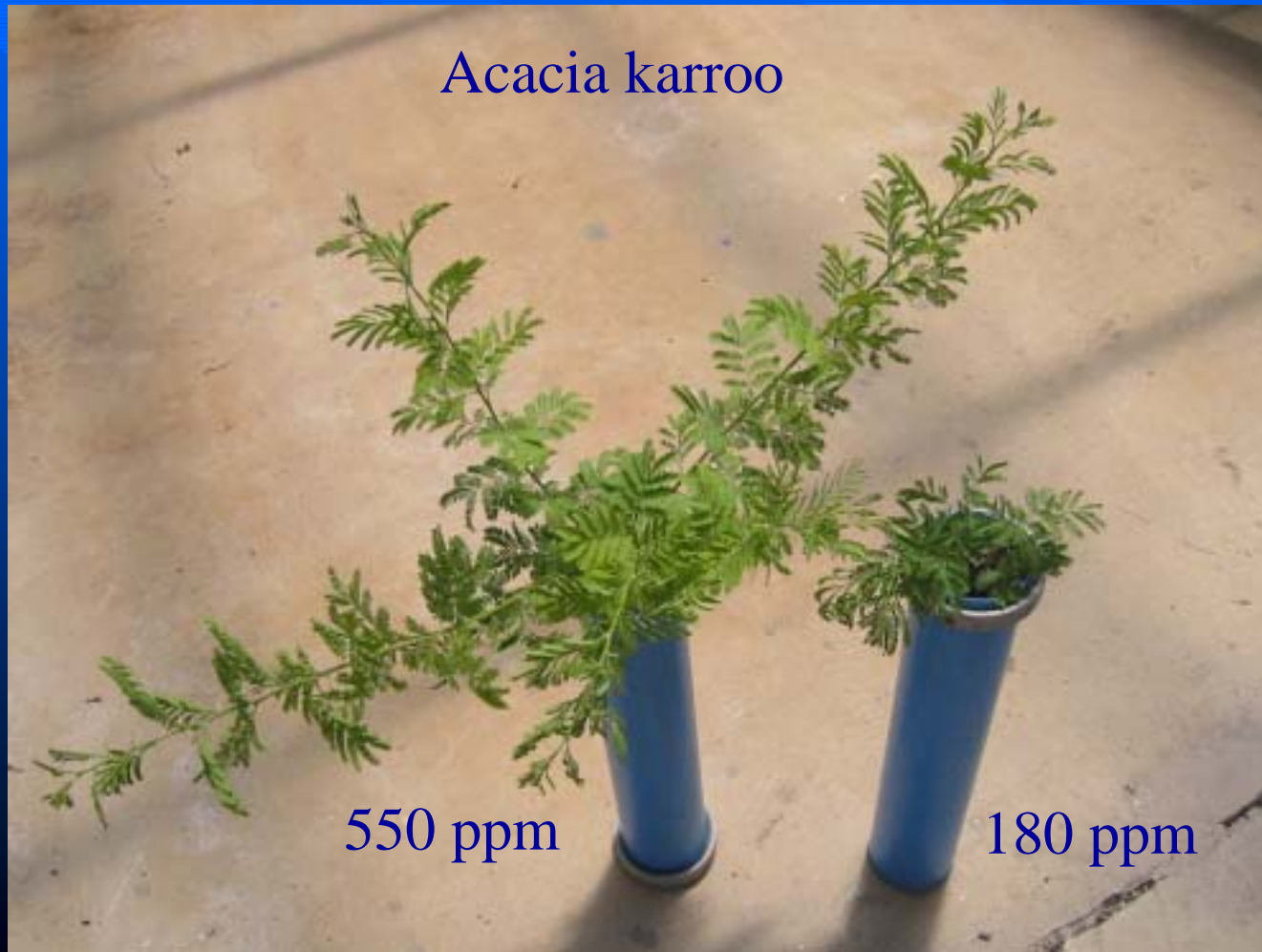




How does CO₂ affect tree growth?



High CO₂ facilitates woody plant colonization?





Elevated CO₂ boosts woody plants

- Greater growth rate
- Greater resilience to injury and disturbance
- Better defence against grazers
- More carbohydrate reserves for reproduction?
- Higher WUE, NUE
- CO₂ increased by >30% since industrial revolution – that is now overlaid on novel land abandonment trends in Europe

CO₂
climate

Vegetation
structure

?

Land
use

↑ Woody plants?

Fire

