# *Importance of Grasslands and the role they play*

*(… understanding the future of grassland restoration)*

*- by Joan Gibbs*

**Adelaide Plains Grassy Woodland Restoration Forum**

**March 14 - 16, 2012**
**Mawson Lakes, South Australia**

# Acknowledgments


- Kaurna people of the Adelaide plains, who burned their grasslands for land health and game
- Salisbury Council, Brian Pledger & organisers
- Distinguished grassland visitors to SA

- Rural Solutions - *Native Grass Strategy for South Australia, 1 & 2*
- Native Grass Resources Group (NGRG) and Tungkillo Landcare, supporters of our research
- 30 years of students at UniSA, with careers in grasses & seeds

- agrostophiles!

# Dedication – renowned agrostologist

- Agnes Chase (1869 - 1963)
- Smithsonian Institution
- Explained grass structures, simply, for ID
- Made taxonomy accessible to everyone



"Grass made it possible for the human race to abandon his cave life and follow herds.... Grasses have been so successful in the struggle for existence that they have a wider geographic range than any other plant family, and they occupy all parts of the earth." Chase, M. Agnes (1922) *A First Book of Grasses: The Structure of Grasses Explained for Beginners*. (Smithsonian Institution)

# Grasses: Poaceae/Gramineae and…

- 11,000 species; structure of leaf, fibrous roots, florets:
- Major crop plants: rice, wheat, maize, barley
- Stock fodder & materials (bamboo)
- Two major clades: BEP and PACMAD
- Of $C_4$ species, 60% are grasses, …convergent evolution!
- Graminoids (other monocots) & the grassland community

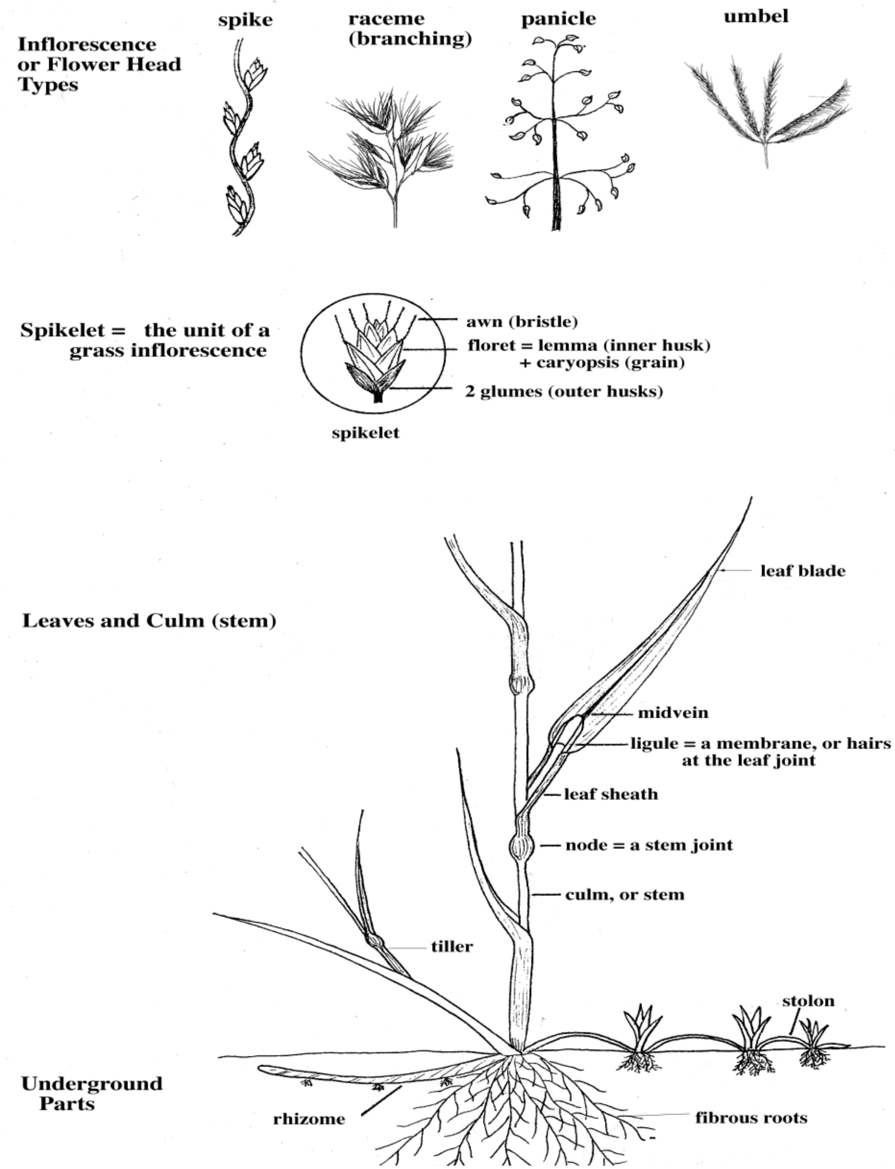
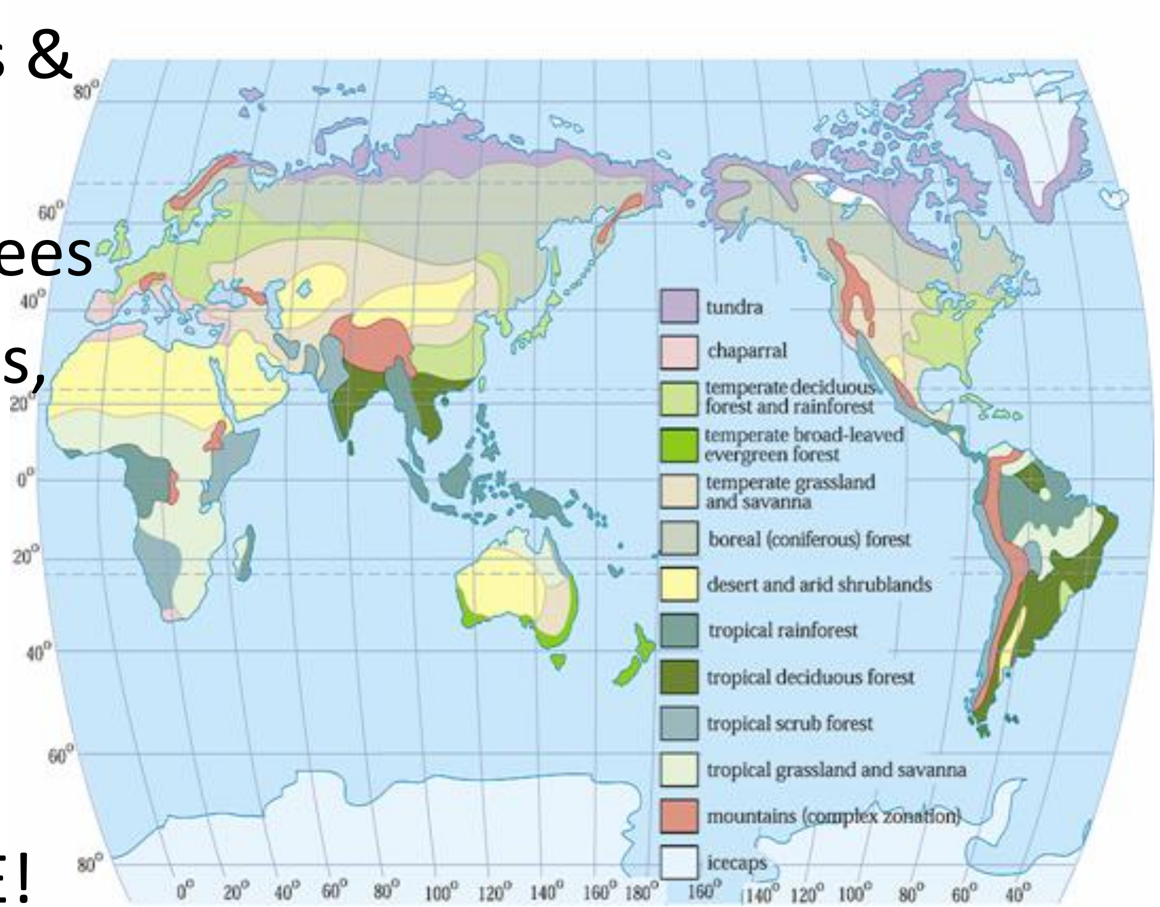


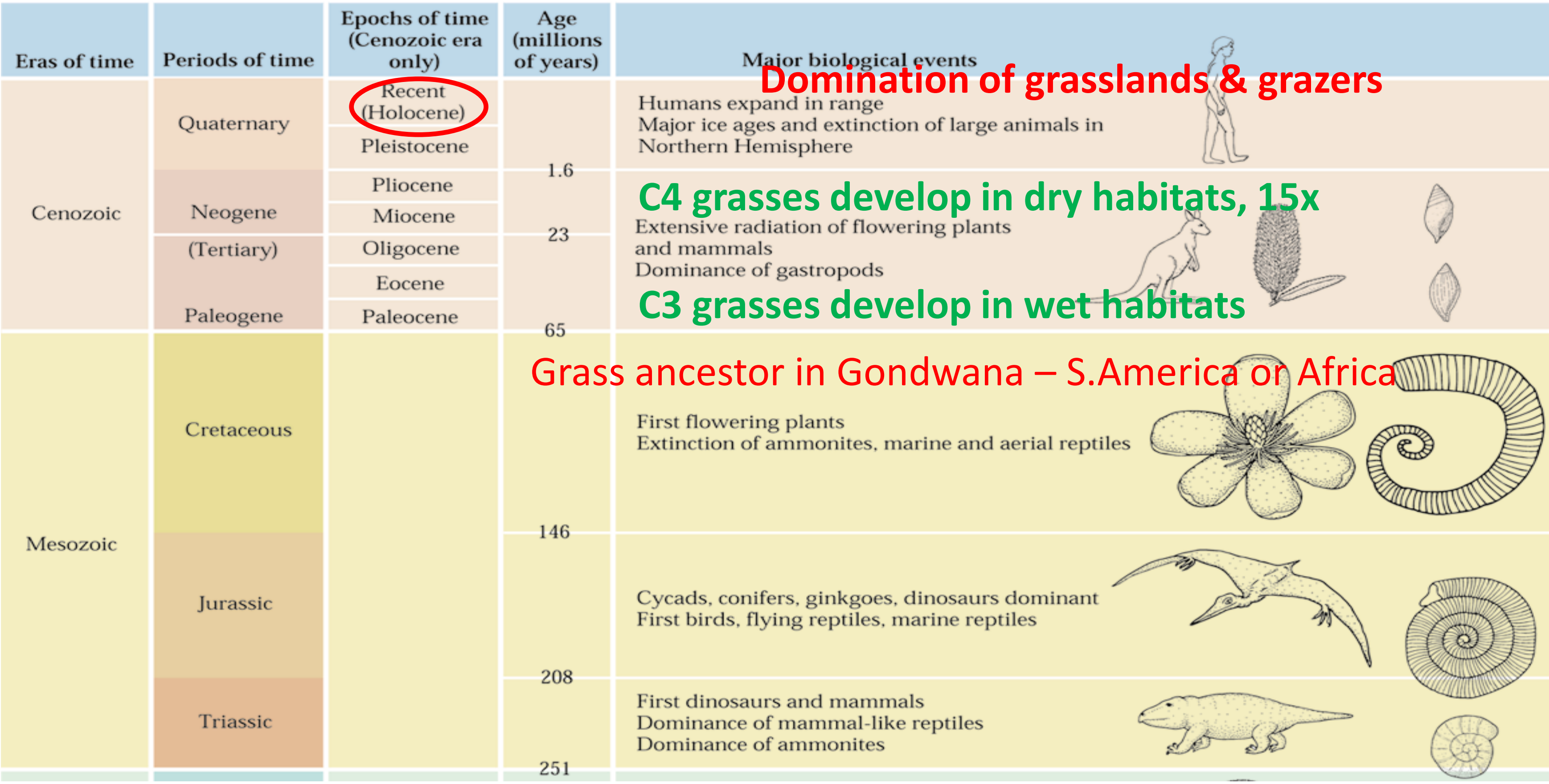
Figure 2. Structure of a grass plant (adapted from Brown, 1986).

# Definition of grasslands

- non-woody grasslands & grassland mosaics
- savannas, scattered trees
- woodlands, shrublands,
- tundra
- Cover 40% of Earth
- 4 major biomes, 35 ecosystem types
- Grasslands DOMINATE!



# Origins of grasses and grasslands



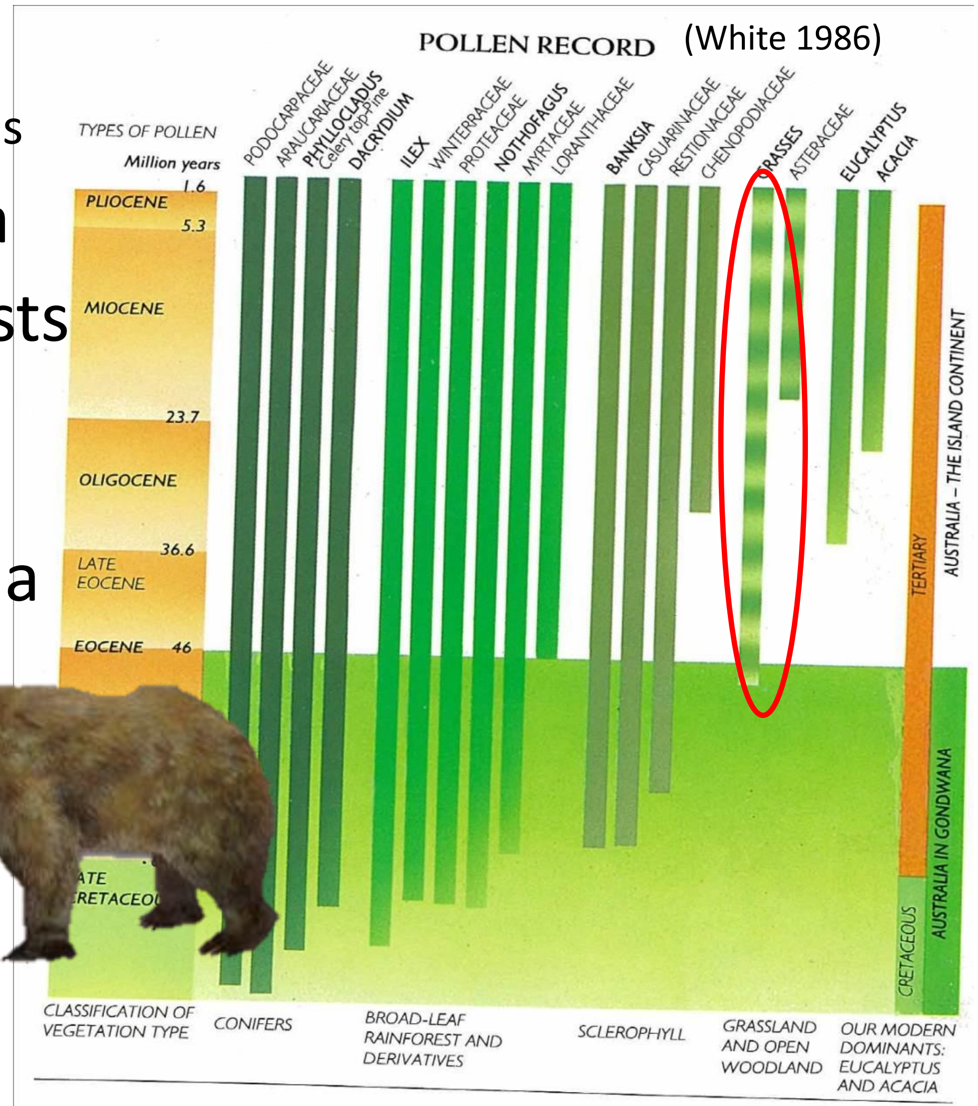
| Eras of time | Periods of time | Epochs of time (Cenozoic era only) | Age (millions of years) | Major biological events |
|---|---|---|---|---|
| Cenozoic | Quaternary | Recent (Holocene) | | Humans expand in range<br>Major ice ages and extinction of large animals in Northern Hemisphere |
| | | Pleistocene | | |
| | Neogene | Pliocene | 1.6 | Extensive radiation of flowering plants and mammals<br>Dominance of gastropods |
| | | Miocene | | |
| | (Tertiary) | Oligocene | 23 | |
| | | Eocene | | |
| | Paleogene | Paleocene | | |
| Mesozoic | Cretaceous | | 65 | First flowering plants<br>Extinction of ammonites, marine and aerial reptiles |
| | Jurassic | | 146 | Cycads, conifers, ginkgoes, dinosaurs dominant<br>First birds, flying reptiles, marine reptiles |
| | Triassic | | 208 | First dinosaurs and mammals<br>Dominance of mammal-like reptiles<br>Dominance of ammonites |
| | | | 251 | |



- Review articles:
  - C. Stromberg 2011. *Evolution of grasses and grassland ecosystems*
  - E. Edwards *et al*. 2010. *The origins of $C_4$ grasslands: .. Ecosystem*

# Origin of grasses in Australia

- First fossil pollen 47 mya
- Phytoliths (silica)- new fossils
- Isolation from Gondwana
- Grasslands replaced forests 40 mya, after G breakup
- Extensive $C_4$ grasslands 12 mya – fossil megafauna at Riversleigh, Qld.
- Domination of $C_4$ grasslands 5 mya - Pliocene



# Fluctuating temperatures & rainfall in Pleistocene form *present-day vegetation: humans favour grass*

- From 1.6 mya
- Trends of drying, fire, instability, fluctuations
- 4 Glacial periods, aridity 100ky = Compositae (daisies)
- Interglacial, warm rain, 10ky = Casuarinaceae, sheoak forests
- Aboriginal burning/ instability - replaced daisies w. grass & sheoaks w. eucalypts
- … OR DO GRASSES FAVOUR HUMANS MANAGING CHANGE?

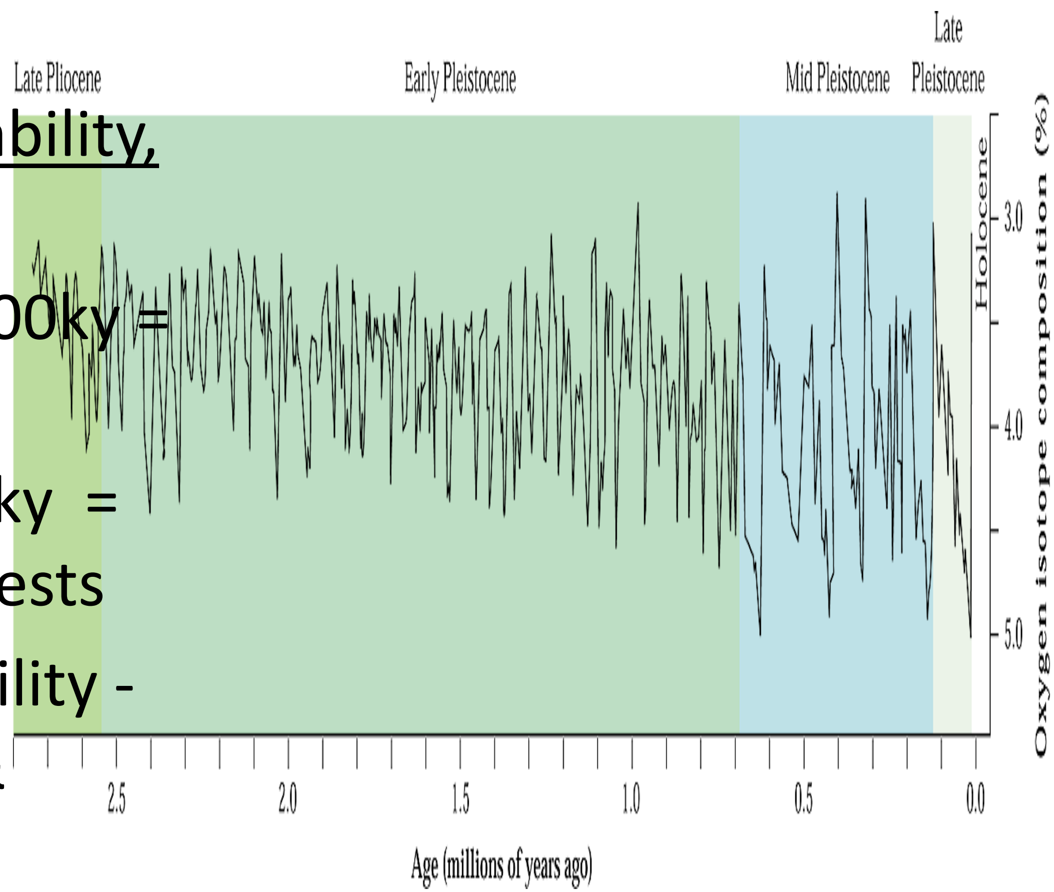
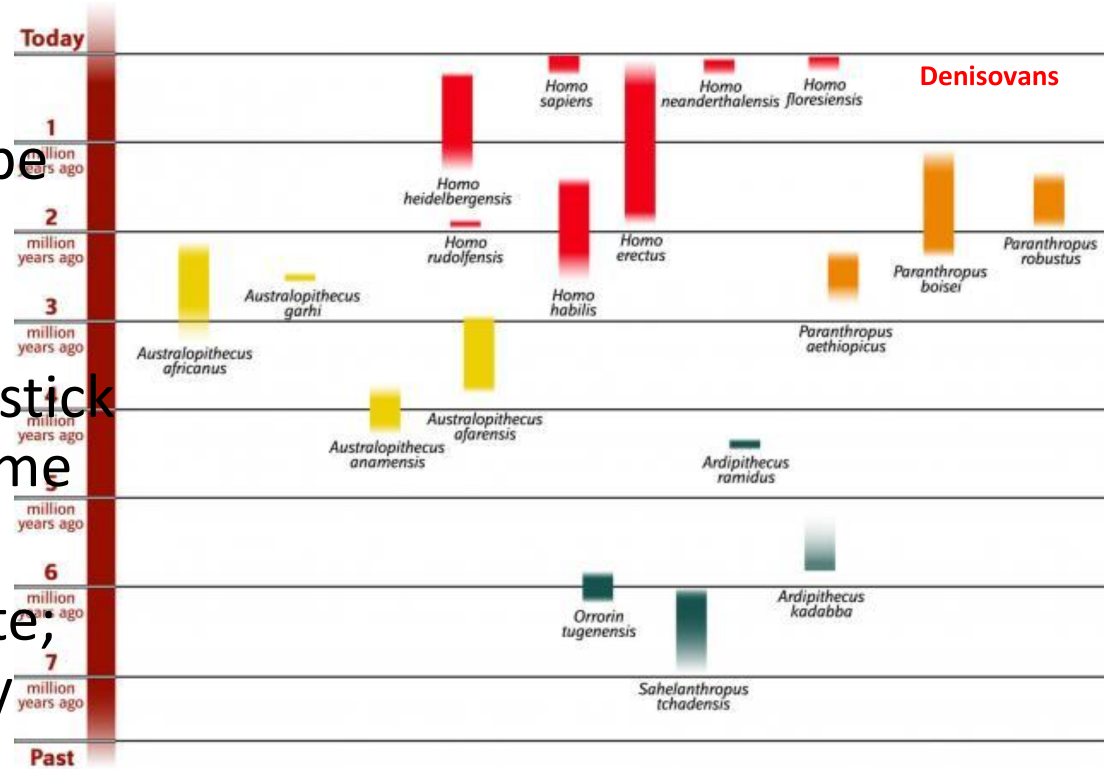



Fig. 41.9 Sediment cores in N. Atlantic; high O-18 in foraminifera shells = icecaps, cold periods. Note fluctuation increases in Pleistocene (hi O is cold/ice; low O is warm)

# Humans evolved as grasslands dominated

- Climate changed forest to grasslands 6 mya, upright ape
- 2 mya first hominids cook vegies; hunted for meat
- .5 mya Neanderthal use firestick farming in grasslands for game (new, Paolo 2010)
- 200,000 ya - unstable climate; extinctions of contemporary *Homo* cousins; rapid drying climate favours *H. sapiens* in grasslands (R. Potts 2011)
- 70,000 ya – 1st migration to Oz?
- 35,000 ya *H. sapiens* displaces Neanderthal in Europe, burning stops (Chauvey Cave, Fr)



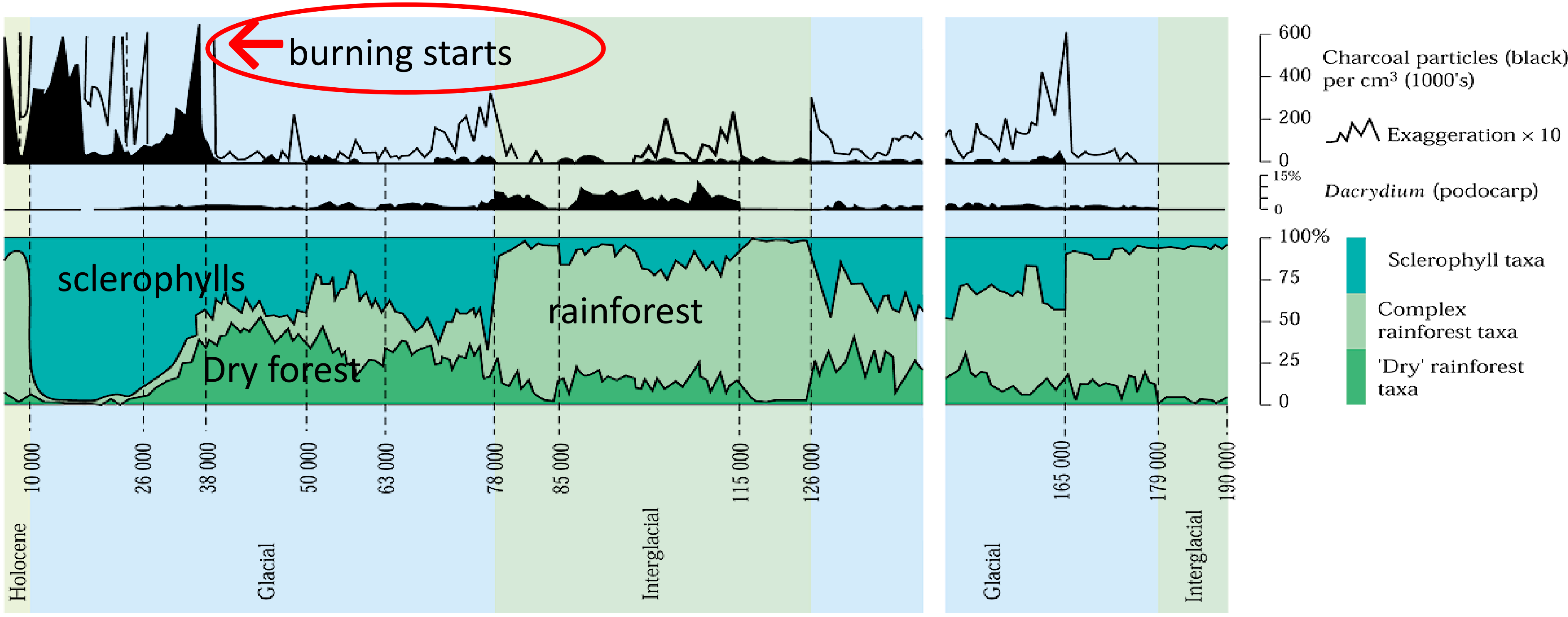

(Smithsonian Institution)

See TV: “Becoming Human” SBS – Episode 3, *Creatures of Climate Change*, [www.sbs.com.au](http://www.sbs.com.au)

Potts, R. 2007. Paleoclimate and human evolution. *Evol. Anthro.* 16:1-3.

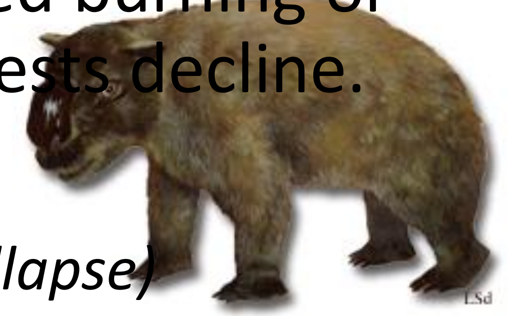
Rasmussen *et al.* 2011. Aboriginal genome. *Science*.

# The last 200,000 years: charcoal & pollen in lake cores show *vegetation changes with fire/climate*




- Evidence of humans burning? Contentious! (Fig 41.10 Knox)
- Proof that vegetation changed with increased burning or with climate change, glacial periods, rainforests decline.
- **Extinction** of megafauna 35-12,000 ya???

(Read: Tim Flannery *Future Eaters*, Jared Diamond *Collapse*)

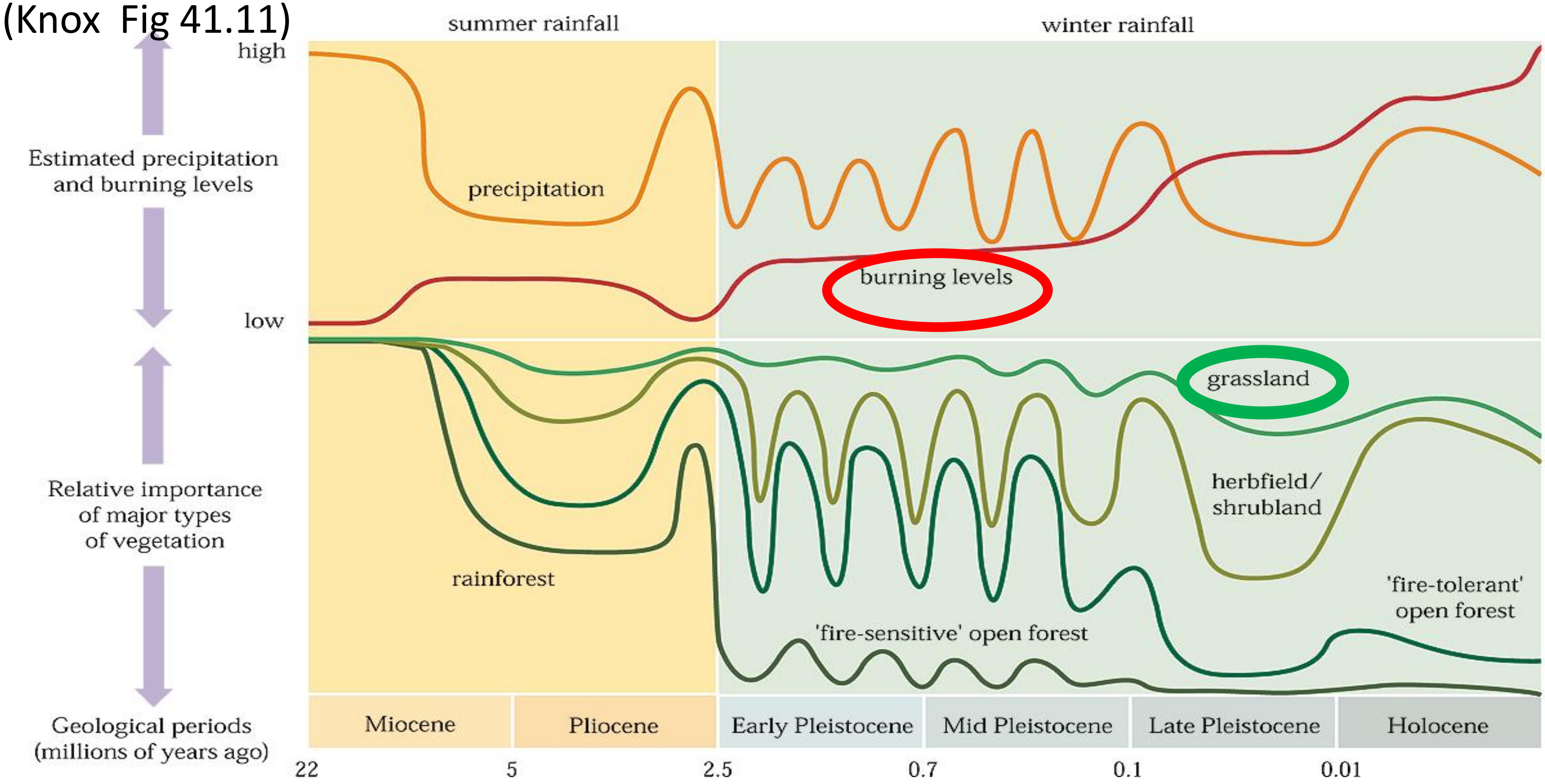


# *Summary: Evolution of ecosystems with climate change and fire (in SE Australia)*

Evidence of precipitation & burning: variable climate = fire-tolerant vegetation replaces rainforest (vs. Flannery "Future Eaters" caused by *Homo*)

$H_a$ CLIMATE INSTABILITY caused increase in fire-prone veg due to increased grasslands?

(Knox Fig 41.11)



# Cereal crops and origin of money

- 11,000 ya cultivated wild rye (Syria): agriculture, farms
- 9000 ya domesticated wheat (Tigris/Euphrates R)
- 7000 ya maize (Mexico)
- 4000 ya intensive production first city-states (Sumerians) cereal currency
- 1300 BC - first Cu coins (Egypt)
- 500 BC - Roman silver coins had image of Juno Moneta “money”

| | *Timeline of early farming* |
|---|---|
| 9000 BC | Wheat/barley, Fertile Crescent |
| 8000 BC | Potatoes, South America |
| 7500 BC | Goats/sheep, Middle East |
| 7000 BC | Rye, Europe |
| 6000 BC | Chickens, South Asia |
| 3500 BC | Horse, West Asia |
| 3000 BC | Cotton, South America |
| 2700 BC | Corn, North America |


(World Resources Institute 2010)

# Importance of grasslands

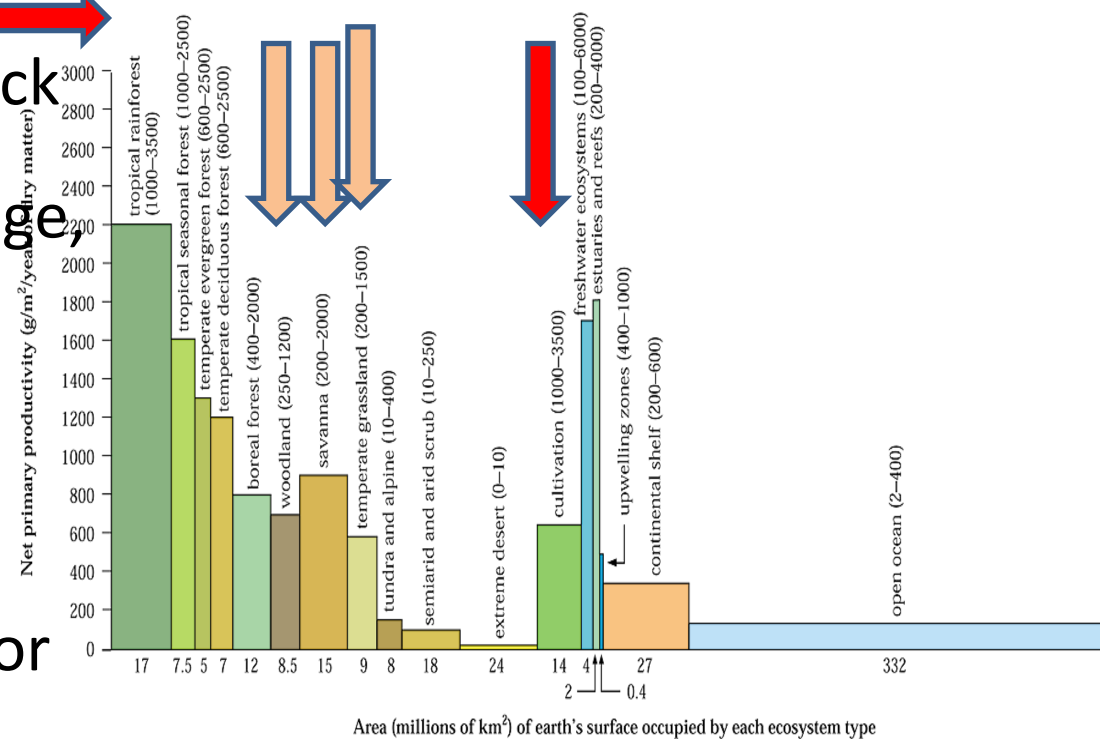
*"Grass is what holds the earth together…"*

- Agnes Chase

# Importance of grasslands (NGRG, Inc)

- Food crops, 700 g/m²/yr
- Goods & Services: livestock production, grassland biodiversity, carbon storage, water infiltration, soil stability, weed/fire management
- $C_4$ savannas = 20% of C fixation (Osborne 2008)
- Conservation of habitat for grassland species
- Tourism and recreation/ parks & gardens
- Basis of world economies

**Global Productivity (g/m²/yr dry matter)**



# The dominance of grasslands

(World Resources Institute 2006)

- Cover 40% of the Earth
- 35 terrestrial ecosystem types, of 136 total
- Australia is in the top five largest grasslands
  - Hummock grasslands (*Triodia*)
  - Tussock grasslands (*Astrebla*, *Austrodanthonia*)
- Human populations highest in dry grasslands (Asia & Africa) – poverty, desertification
- Conversion to crops greatest in temperate region
- Greatest grass productivity in tropical savannas

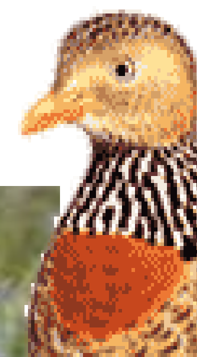
# Grassland associations

Example in SA: *Lachnagrostis limitanea*

- Complex communities
  - Grasses & graminoids
  - Non-grass associates, daisies
  - Grazers, predators, webs
  - Soil microbes
- Strong interconnections
- The most threatened species are found in grasslands
- <1% of original grasslands remain; once 48% of the Adelaide region

- Pygmy blue-tongue

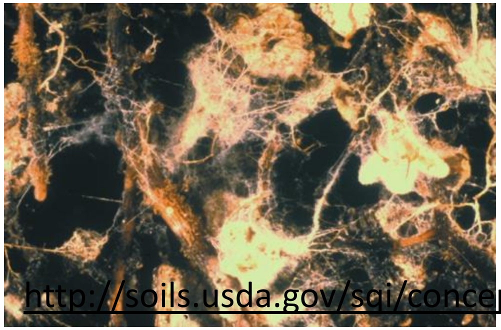
- Plains wanderer



- Blue devils

# Understanding grassland ecosystems


http://1.bp.blogspot.com


http://soils.usda.gov/sqi/concepts/soil_biology

Unseen, controlling life on Earth (90%) (Stamets 2010)

***Five major functional groups:***

- Bacteria
- Fungi
- Nematodes
- Protozoa
- Arthropods


www.gardeningwithmicrobes.com/microbes


http://soils.usda.gov/sqi/concepts/soil_biology


www.uptake.co.nz/resources/soil_biology_primer

# Ecosystem function in grasslands

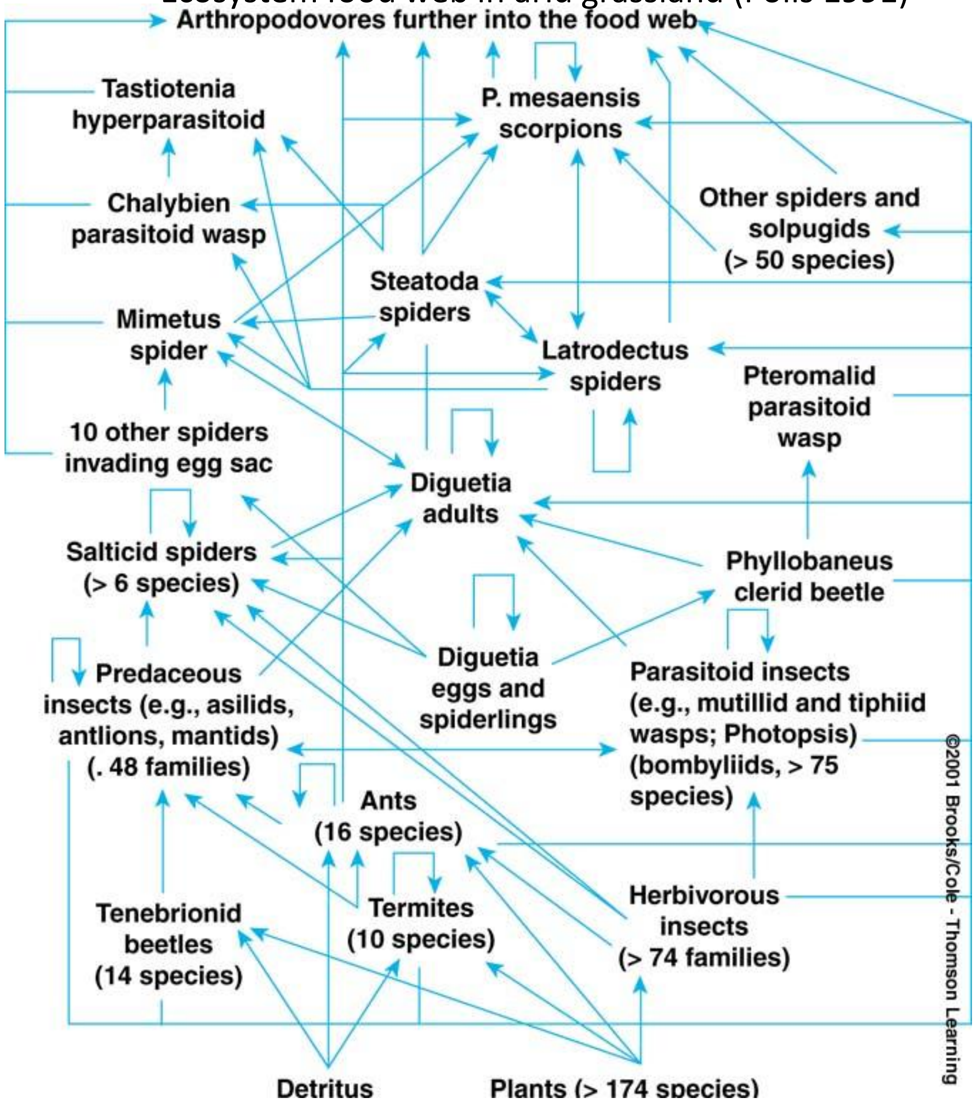
COMPLEXITY = STABILITY

- Decomposition
- Nutrient turnover
- Energy transfer

- Relationships
  - Grazers, predators, decomposers
  - Protector fungi, bacteria
  - Symbiotic fungi

**CONNECTANCE** is greatest in grassland ecosystems; = STABILITY, survive change

Ecosystem food web in arid grassland (Polis 1991)



# Research questions – UniSA, Tungkillo Landcare

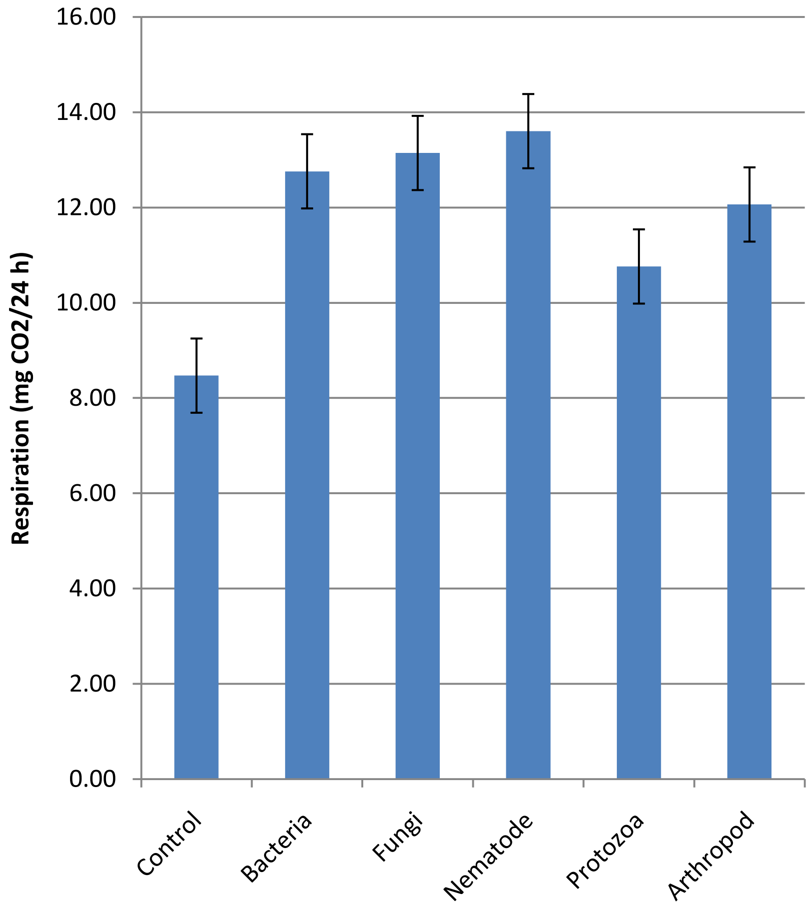
Q1 – Which soil biotic groups are more active?

Q2 – Are weed sites more active than native grass sites?

Q3 – Are C4 grass sites more resilient in drought than C3 grass sites?

Microcosm with alkali trap to measure $CO_2$ ; specific biocides show activity of each biotic group

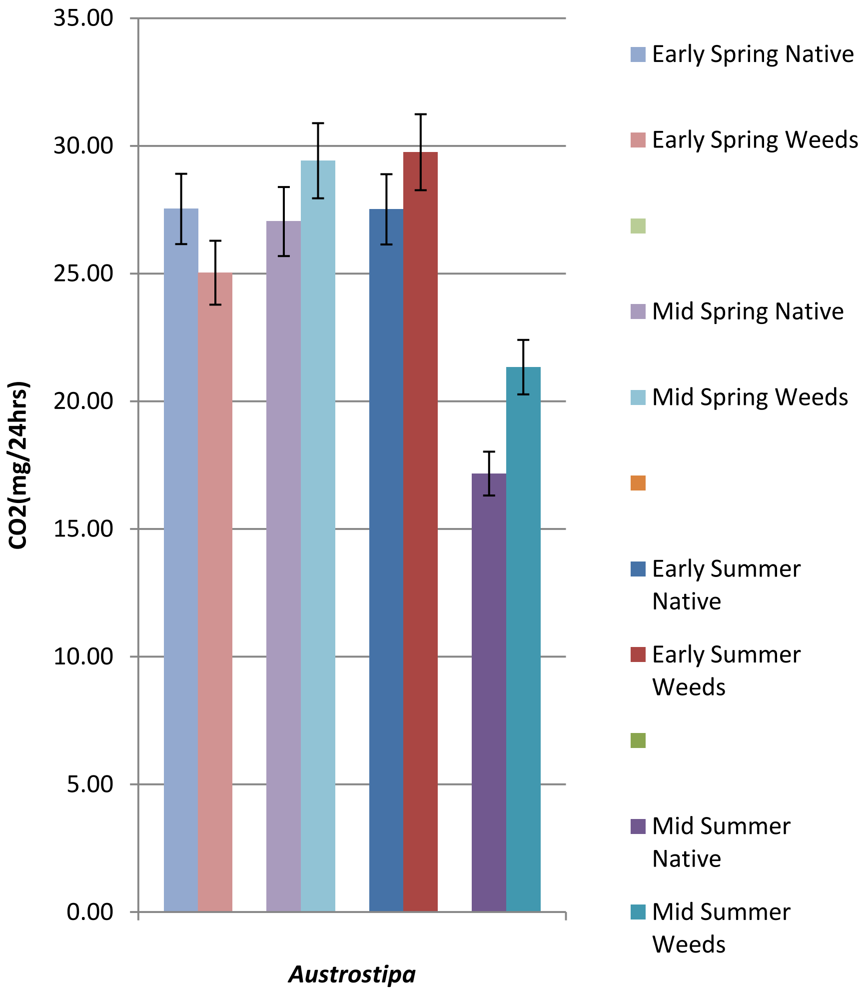
# Q1 – Which soil biotic groups are more active?




- Fungi and bacteria – important decomposers
- Nematodes – graze on grass roots, plant material

Respiration in *Austrostipa* community ($C_3$, cool-season) in optimum season (mid-spring)

# Q2 – Are weed sites more active than native grass sites?




- Weed sites fluctuate more than native grass sites($C_3$)
- Cool-season grass sites are more active than weed sites in spring but less active in summer (drought/heat stress

<u>Q3 – Drought resistance: $C_3$ $C_4$</u>

- Warm-season grass sites ($C_4$) remained active in summer – Microbes tolerate drought in *Themeda* grasslands.

# Conclusions – Tungkillo grassland research

- Applications of research:
  - Seasonal fluctuation of soil organism activity, describes native grass and weedy ecosystems.
  - Dry sites support *Themeda* ($C_4$) grasslands; moister sites support $C_3$ grasslands like *Austrostipa*.

– **Future research:**

- Soil organism taxonomy
- Effects of moisture & temperature on respiration measurement
- Use more sophisticated techniques for $CO_2$ such as PLFA (for biota) or infra-red gas analyser
- Test more species of grasses, other weed sites

# Grasses, Fire and Fungus (NGRG project)


- *Austrodanthonia fulva* growth was significantly greater with biochar (from *Chloris*)
- *Austrodanthonia fulva* growth was significantly greater with protective fungus (*Gliocladium)*
- The combined effect of both fungus and biochar was <u>equal to </u>the effect of either alone, but no greater

  - Research project by Liam Crook, UniSA. 2011

# New research questions

- Introduced species: which are harmful, benign or beneficial to native grasses?
- Does cool burning promote grass growth and beneficial soil organisms?
- Does kangaroo grazing stimulate native grass growth?
- What else?....

# ***Conclusions:*** What are sustainable grassland systems?

- Dominance by grasslands and humans has been the most dramatic and rapid change in Earth's history.
- Evidence: pollen record shows grasses dominated in Pleistocene with humans, grazers, drought & fire.
- Study evolved cultures:
  - Mongolian steppe culture
  - Value of herbivores
  - Grazing systems
  - Lifestyle vs. money
- Grass & fire connection
  - Many endangered species = lack of fire regime?
- Firestick farming (400,000 y)
  - Low-temperature burning for biochar & fungi
- **Prioritise grassland species/ecosystems with *fire regime dependence*!**

# Grassland restoration ideas

- Data & research needed!
- IUCN has 250 Centres of Plant Diversity CPD (50% have grasslands)
- Field-based research groups, ILTER network
- Biodiversity Reserves (CSIRO)
- Register of restoration plots, like Salisbury Council's grassland production sites
- Community research groups (non-institutional)
- Biodiversity enterprise and food from Nature w. people
- Food security with biodiversity?

READINGS:


- "Habitat Restoration Planning Guide for NRM" 2010. www.environment.sa.gov.au
- "The SER International Primer on Ecological Restoration" 2004. www.ser.org
- "A Sustainable Planet through Solutions for its People" 2010. www.wri.org
- Henson PM 2003. *What holds the Earth together*. J. History of Biology **36**:437-460.
- Glover JD, Cox CM, and Reganold JP 2007. Future Farming: A Return to Roots? *Scientific American* 297: 66–73.

# Discussion?

- First conference on Ecological Restoration – Perth, 27 November 2012
- Submissions open now!
- Contact: Jason.Stevens@bgpa.wa.gov.au

- **SOCIETY FOR ECOLOGICAL RESTORATION AUSTRALASIA**
- INAUGURAL CONFERENCE ON ECOLOGICAL RESTORATION