SPECIAL – The Savanna Patterns of Energy and Carbon Integrated Across the Landscape campaign

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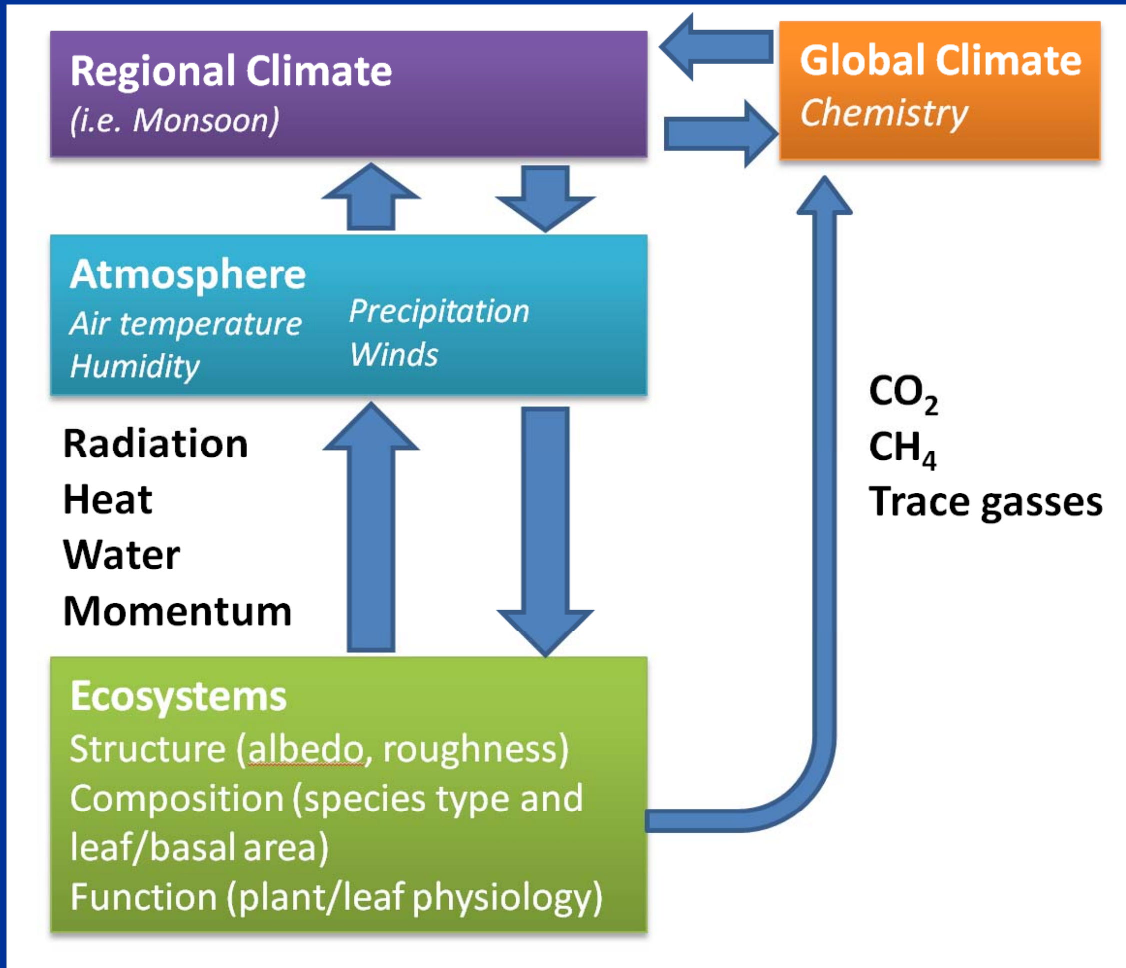
Importance of ecosystems in the earth system

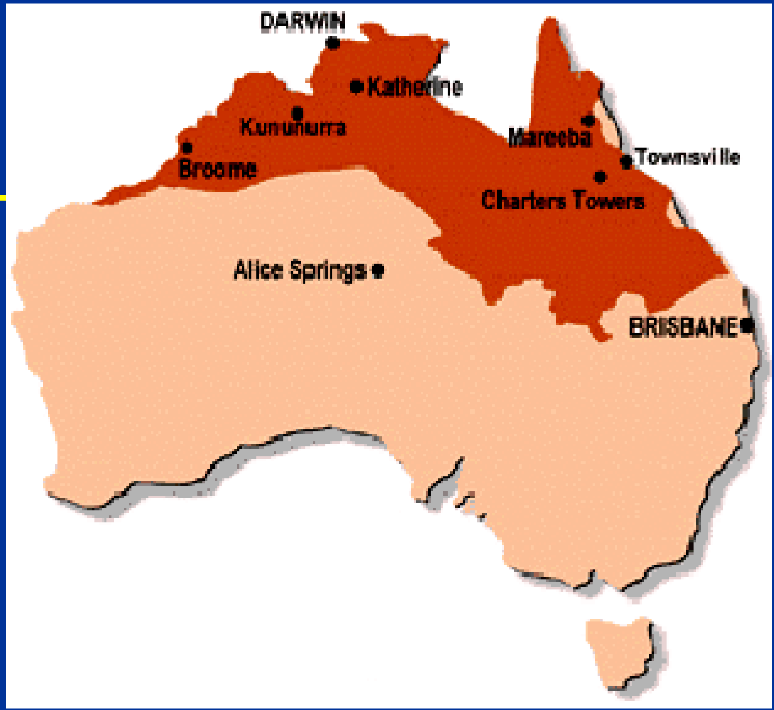
- Local ecosystem surface water and heat balance influences regional climate through **biophysics** (heat, moisture, energy)
- Regional to global coupling
- Coupled to global climate through **biogeochemical** cycles (C, N, P, etc.)
- Changes in climate inherently influence global circulation
- So land surface characteristics and change are important

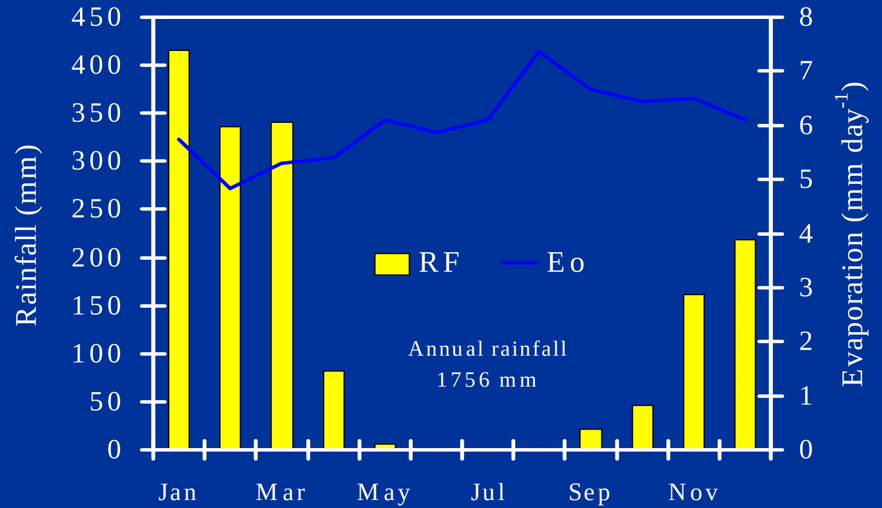


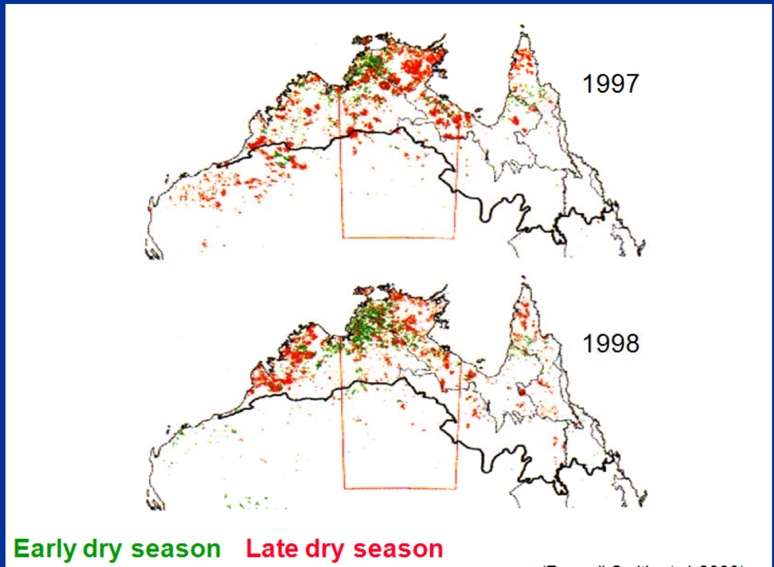
Adopted from Chapin,et al. Science (2000)

Australian tropical savannas

- Savanna - trees (C3) and grass (C4)
- Open-forest/woodland savanna 25% of Australia, ~2 million km^2
- Mining, Tourism, Pastoralism, Culturally
- Highly seasonal climate in the wet-dry tropics
- Cyclones, grazing and FIRE are disturbances



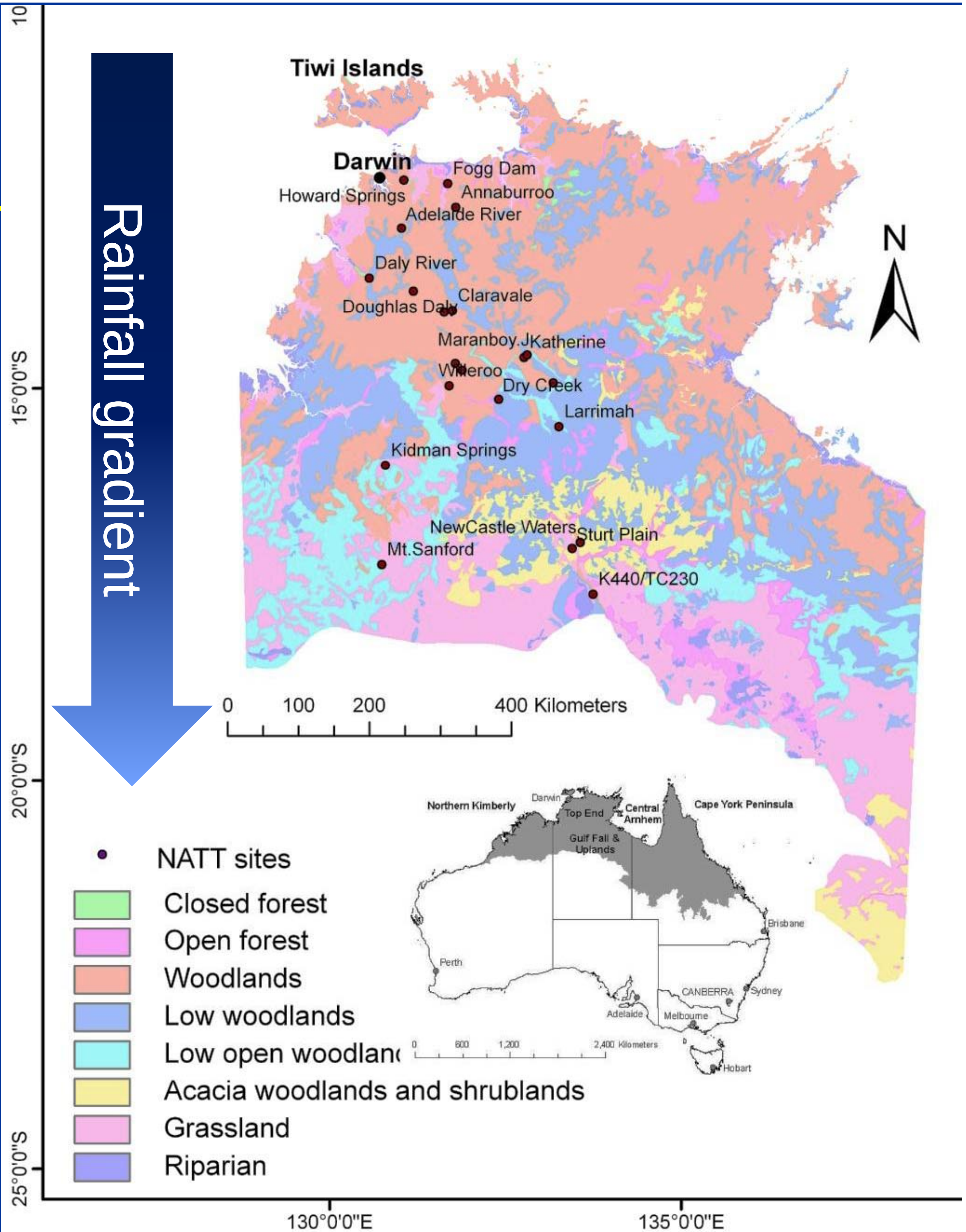




(Russell-Smith *et al.* 2000)

Spatial variability

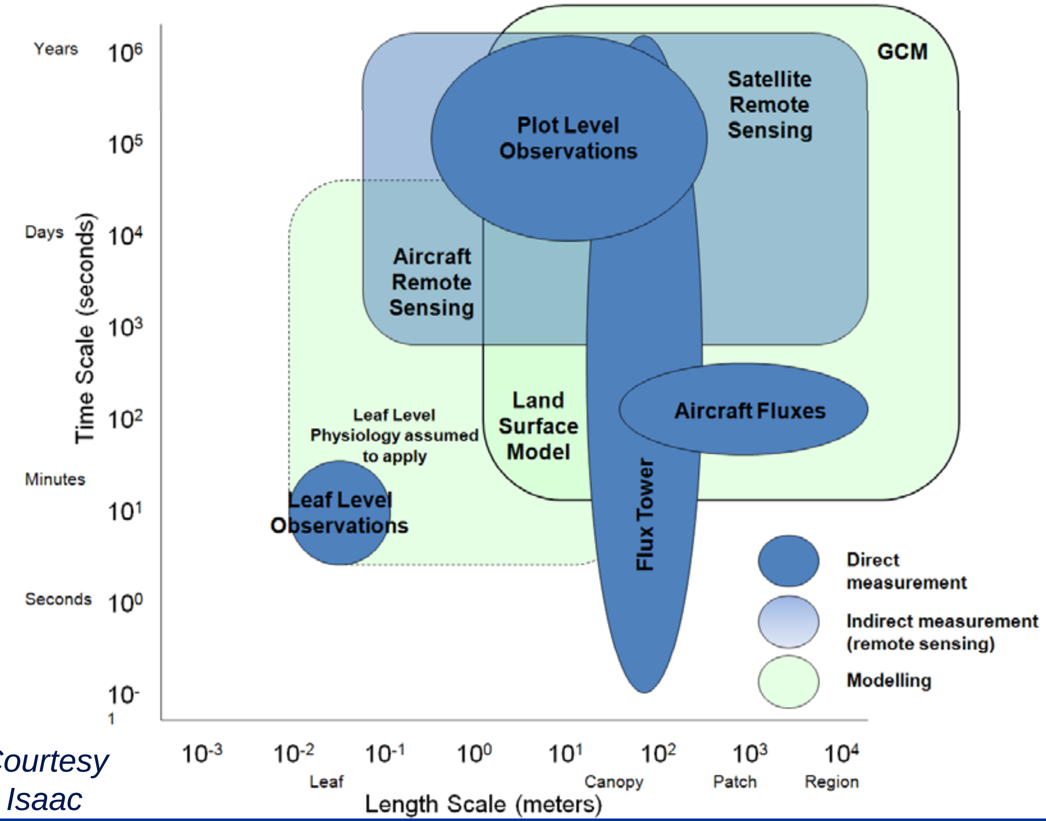
- Strong rainfall gradient
- Savanna region heterogeneous vegetation
- Change in ecosystem characteristics (structure, composition, function)
- Utilise NATT as living laboratory



Savanna Patterns of Energy and Carbon Integrated Across the Landscape (SPECIAL) Campaign

Research question

- What are the patterns and processes driving surface-atmosphere exchanges across the northern Australian savanna landscape?

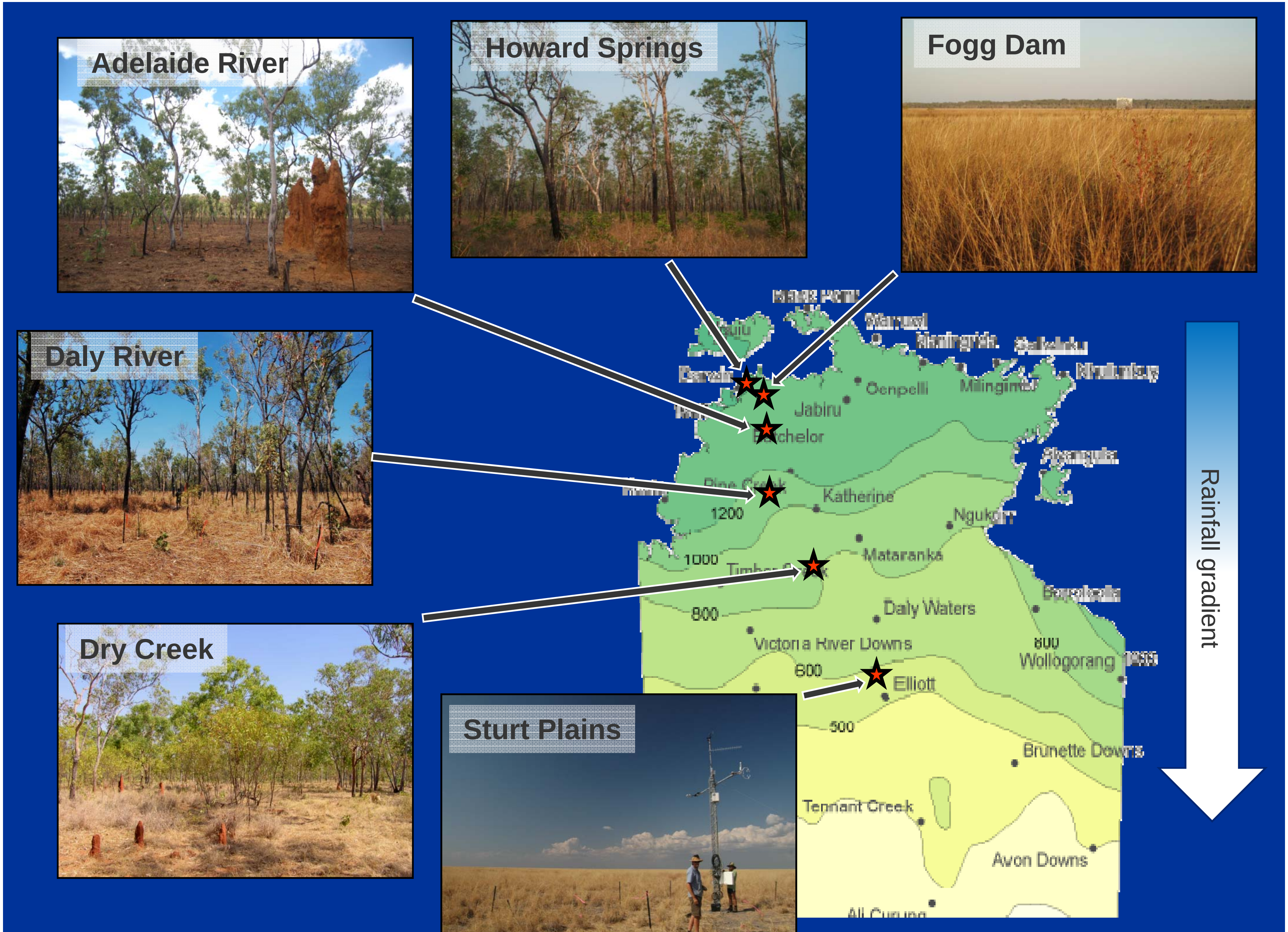


Courtesy Isaac

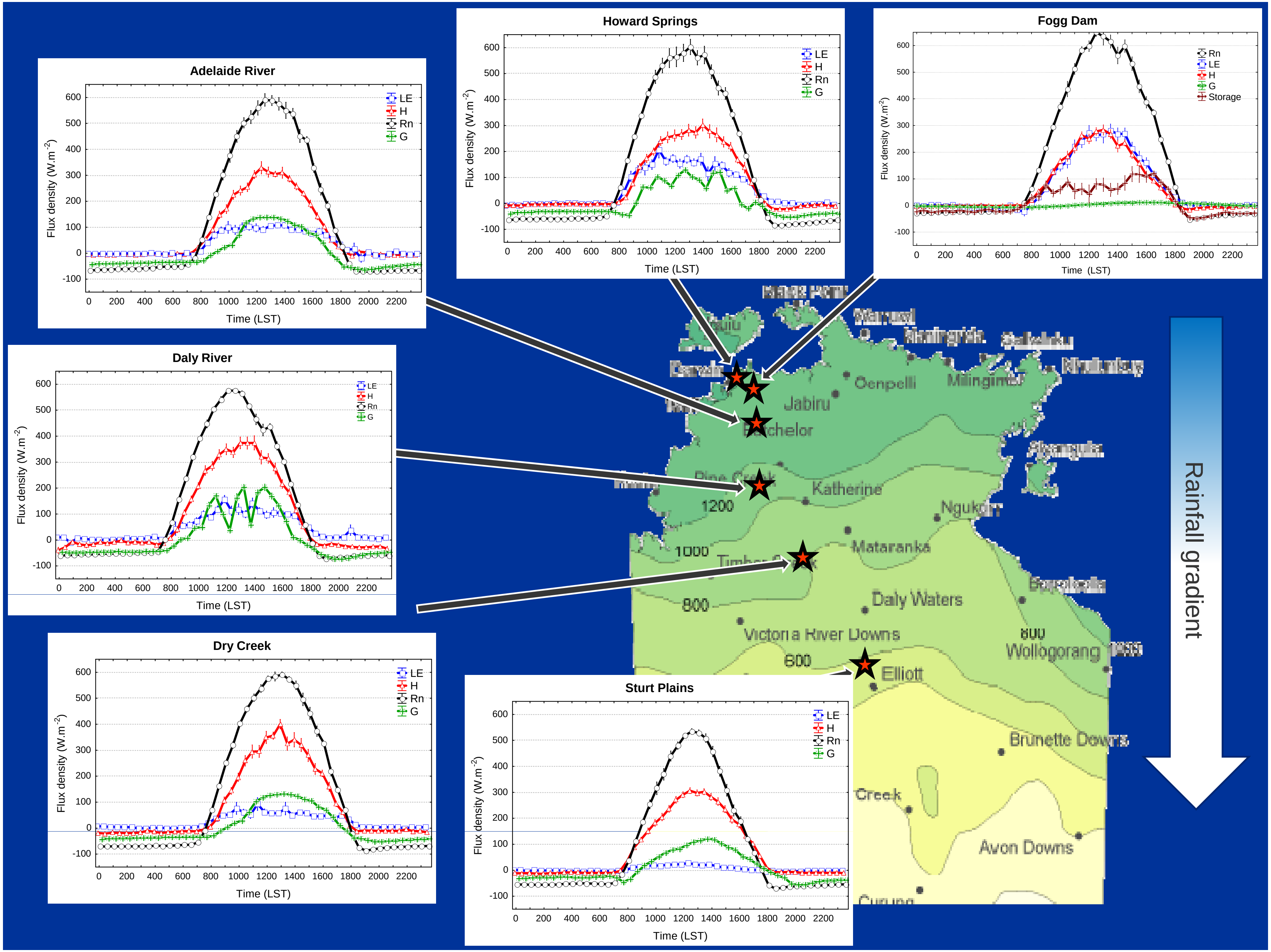
Savanna Patterns of Energy and Carbon Integrated Across the Landscape (SPECIAL) Campaign

Field campaign in dry season 2008. Ongoing...

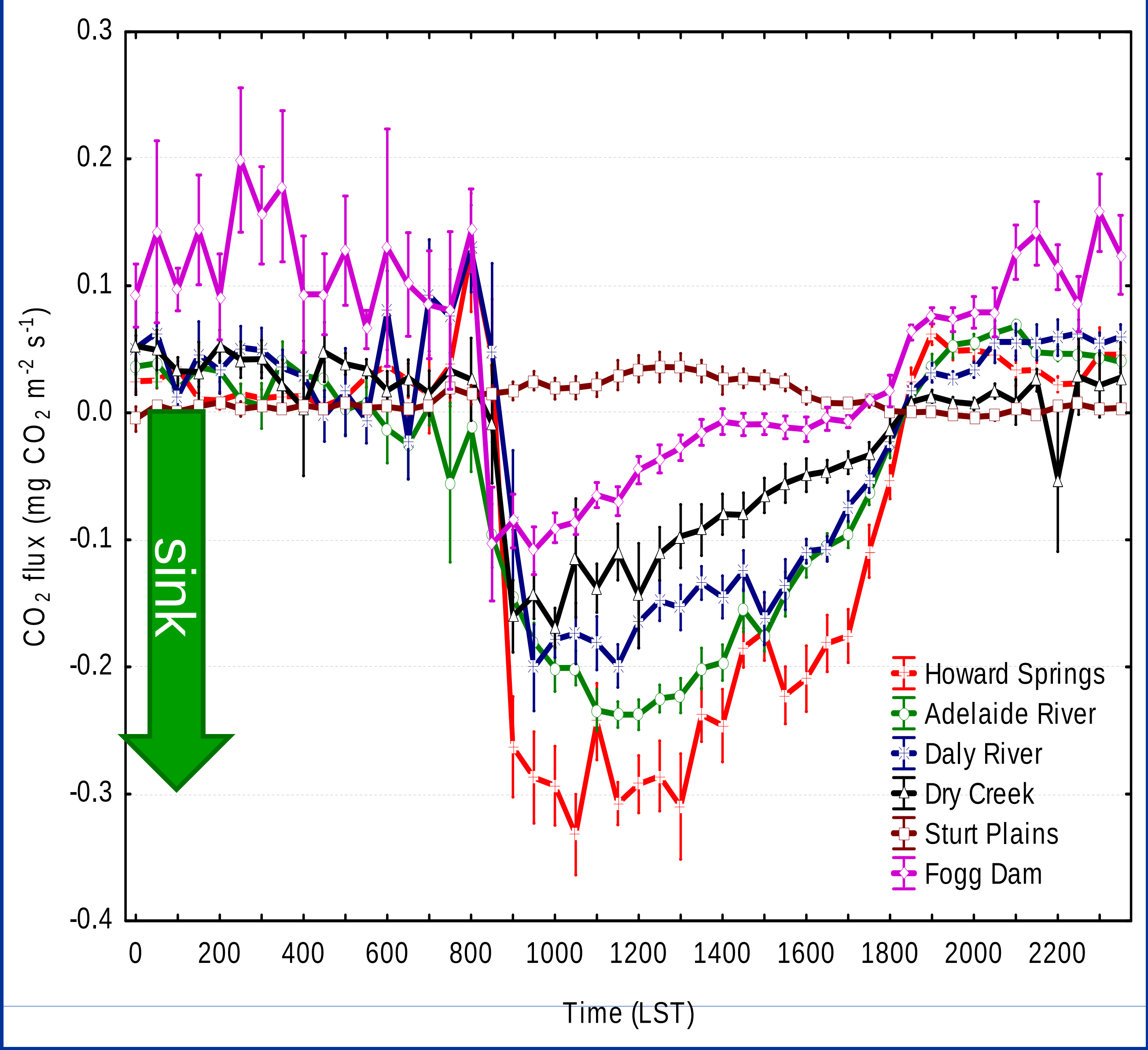
- Ground based
  - Flux towers (6)
  - Structural (DBH, height, species, GPS)
  - Leaf water and leaf morphology
  - Leaf Area Index (LAI2000 and photos)
  - Physiology (Aci and light use curves)
  - Soil water and physical properties
  - Biomass (live, dead, litter)
  - Remote sensing (ASD, CWD, Cover, etc)
- Aircraft
  - Boundary layer
  - Flux transects (transects and grids)
  - RS transects (Lidar, Hyperspectral, PLMR)
- Satellite Remote Sensing
  - LAI, GPP, ET



Beringer et al. (2010)

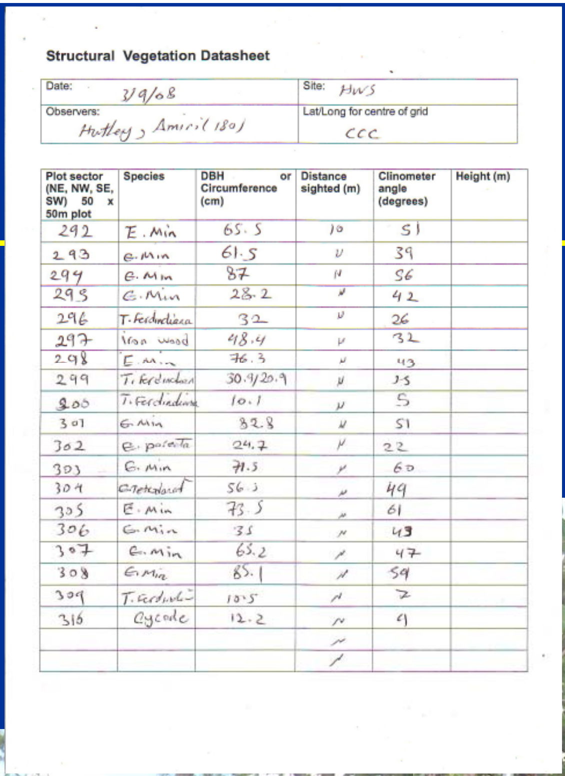

Adelaide River
Flux density (W.m⁻²)
Time (LST)
LE
H
Rn
G
Daly River
Flux density (W.m⁻²)
Time (LST)
LE
H
Rn
G
Dry Creek
Flux density (W.m⁻²)
Time (LST)
LE
H
Rn
G
Howard Springs
Flux density (W.m⁻²)
Time (LST)
LE
H
Rn
G
Fogg Dam
Flux density (W.m⁻²)
Time (LST)
Rn
LE
H
G
Storage
Sturt Plains
Flux density (W.m⁻²)
Time (LST)
LE
H
Rn
G
Oenpelli
Jabiru
Milingimbi
Katherine
Ngukurr
Mataranka
Daly Waters
Victoria River Downs
Wollogorang
Elliott
Brunette Downs
Avon Downs
Creek
1200
1000
800
600
Rainfall gradient

- Less carbon uptake
- Soil moisture and environmental drivers similar
- What drives these differences?



Beringer et al. (2010)

Savanna structure and composition

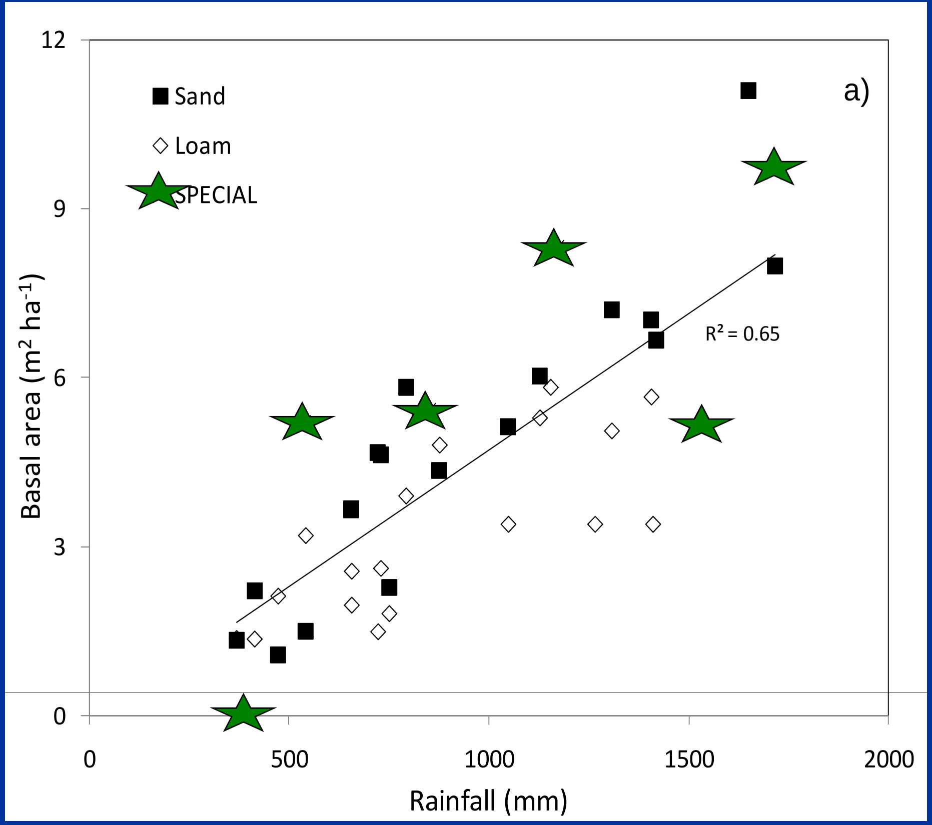


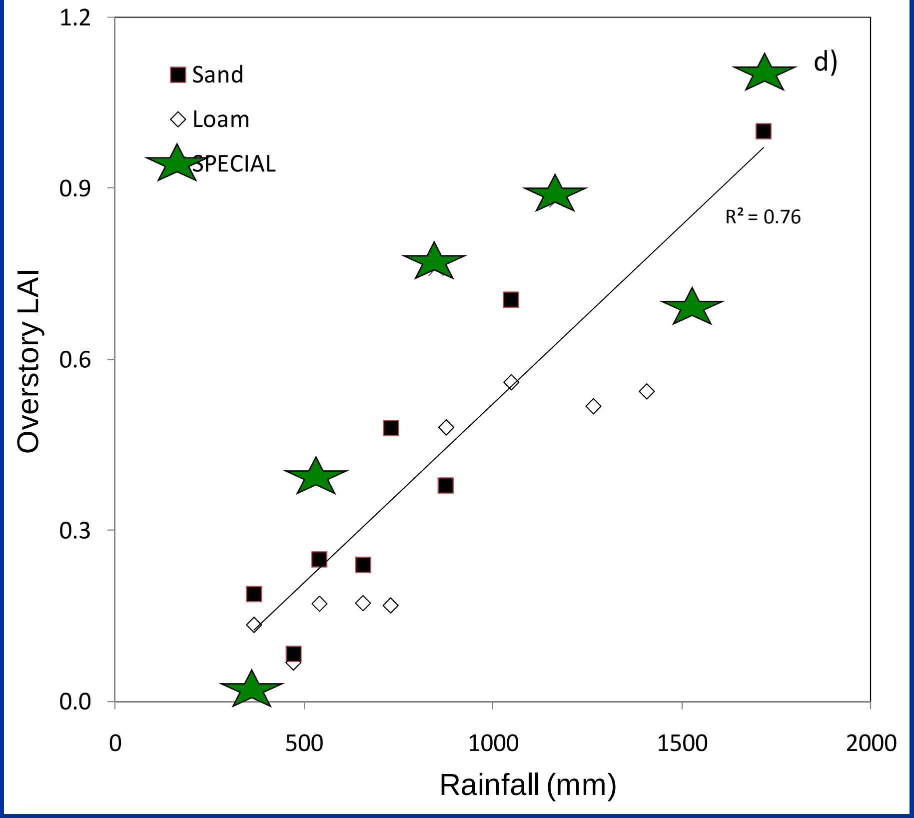
Structural Vegetation Datasheet

Date: 3/9/08	Site: HWS
Observers: Hutley, Amiri (180)	Lat/Long for centre of grid: CCC

Plot sector (NE, NW, SE, SW) 50 x 50m plot	Species	DBH or Circumference (cm)	Distance sighted (m)	Clinometer angle (degrees)	Height (m)
292	E. Min	65.5	10	51	
293	E. Min	61.5	〃	39	
294	E. Min	87	〃	56	
295	E. Min	28.2	〃	42	
296	T. Ferdinandiana	32	〃	26	
297	iron wood	48.4	〃	32	
298	E. Min	76.3	〃	43	
299	T. ferdinandiana	30.9/20.9	〃	25	
300	T. Ferdinandiana	10.1	〃	5	
301	E. Min	82.8	〃	51	
302	E. porrecta	24.7	〃	22	
303	E. Min	71.5	〃	60	
304	E. tetrodonta	56.3	〃	49	
305	E. Min	73.5	〃	61	
306	E. Min	35	〃	43	
307	E. Min	65.2	〃	47	
308	E. Min	85.1	〃	59	
309	T. ferdinandiana	10.5	〃	7	
310	Cycade	12.2	〃	9	
			〃		
			〃		

- Above –ground biomass, stem density, LAI and canopy height declined with rainfall
- Biomass ranged from 35 to 5 t C ha^{-1} along the 1714 to 400 mm rainfall range with LAI ranging from 1.5 to ~0





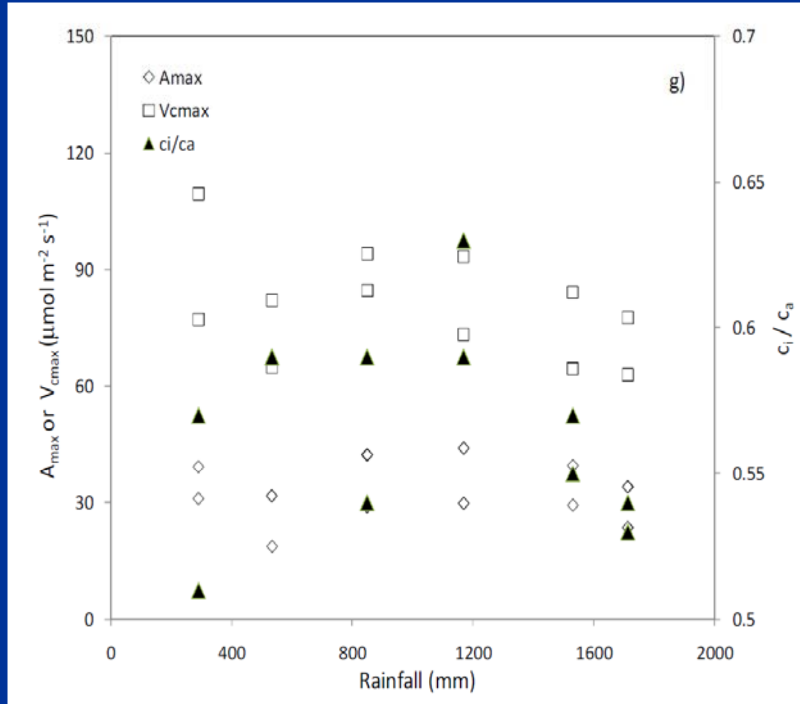
Hutley et al. (2010)

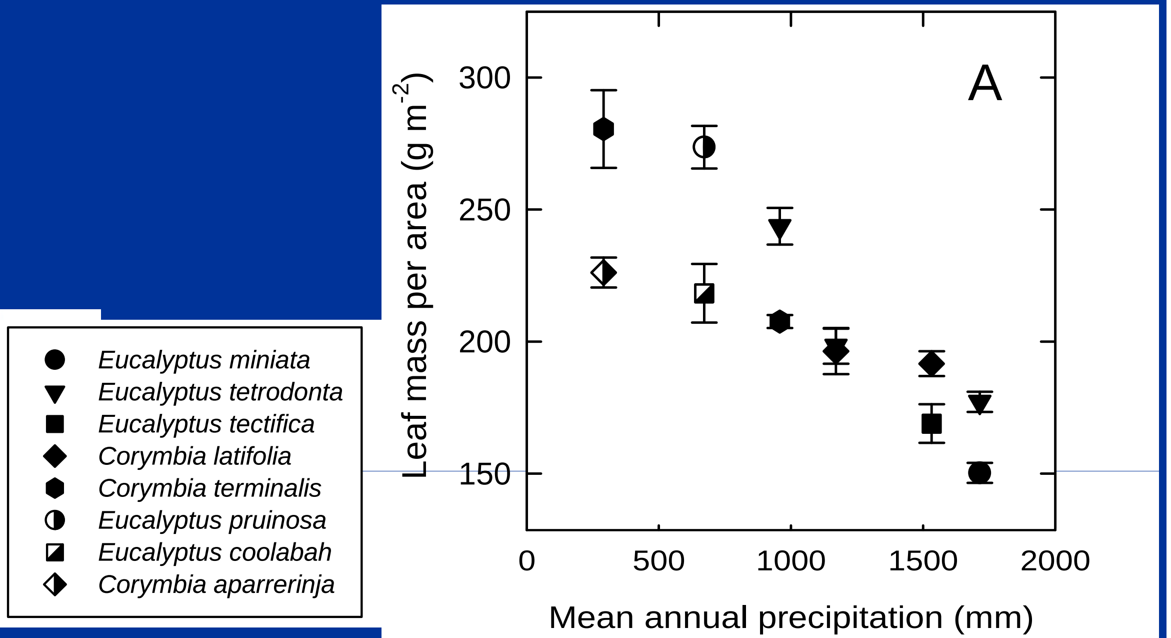
Leaf Level Physiology

A_{ci} and light use curves

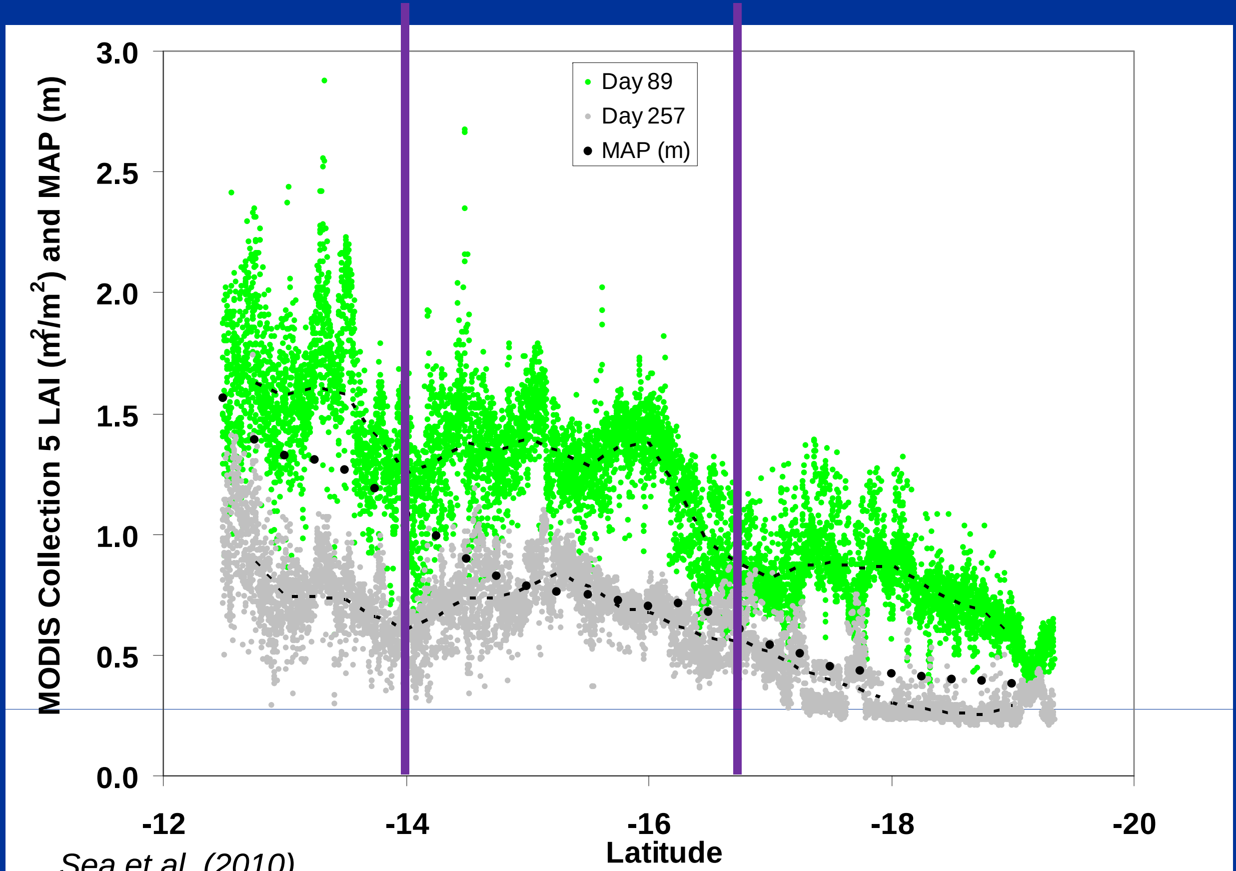
Cernusak et al. (2010)

- Maximum Rubisco carboxylation velocity (V_{cmax}), G_s and C_i/C_a nearly constant
- Leaf mass per area increased strongly along the rainfall gradient
- Variation in ecosystem-level gas exchange not dominated by photosynthetic performance rather changes in LAI along transect.



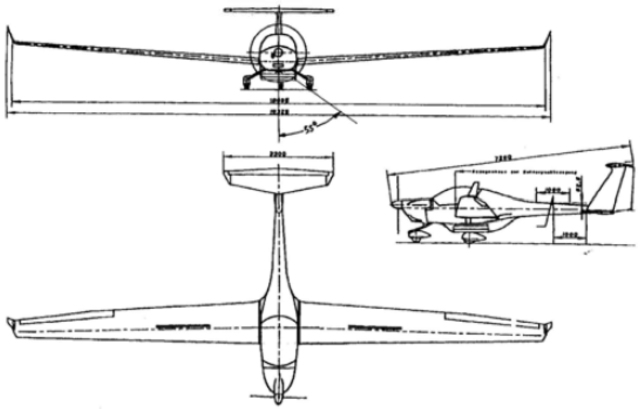


- Satellite remote sensing of Leaf Area Index (LAI) undertaken (MODIS). Agreed very well with ground based hemispherical photos and LAI2000.
- Changes in LAI along transect shows thresholds

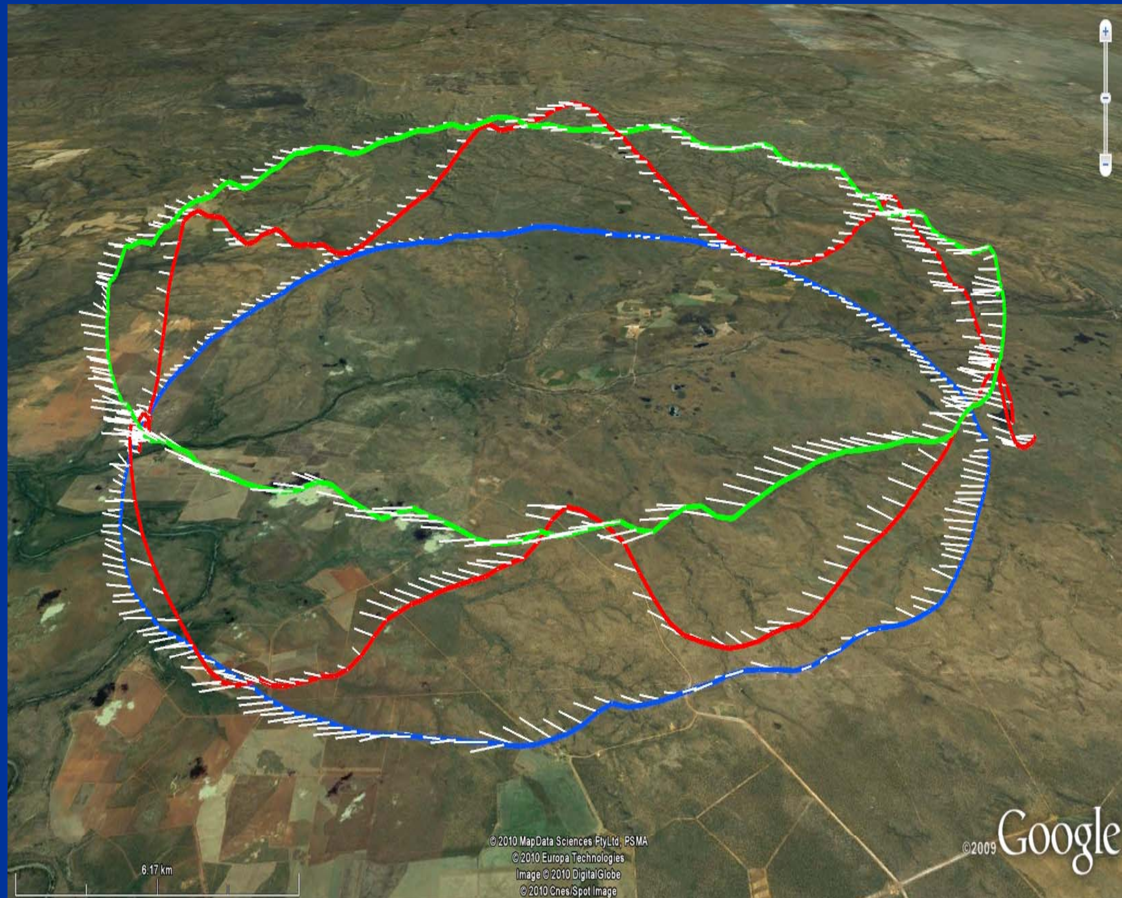


Sea et al. (2010)

Aircraft observations



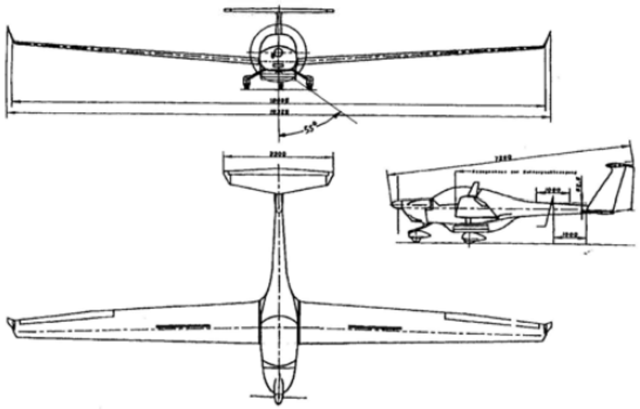
Boundary layer budgets

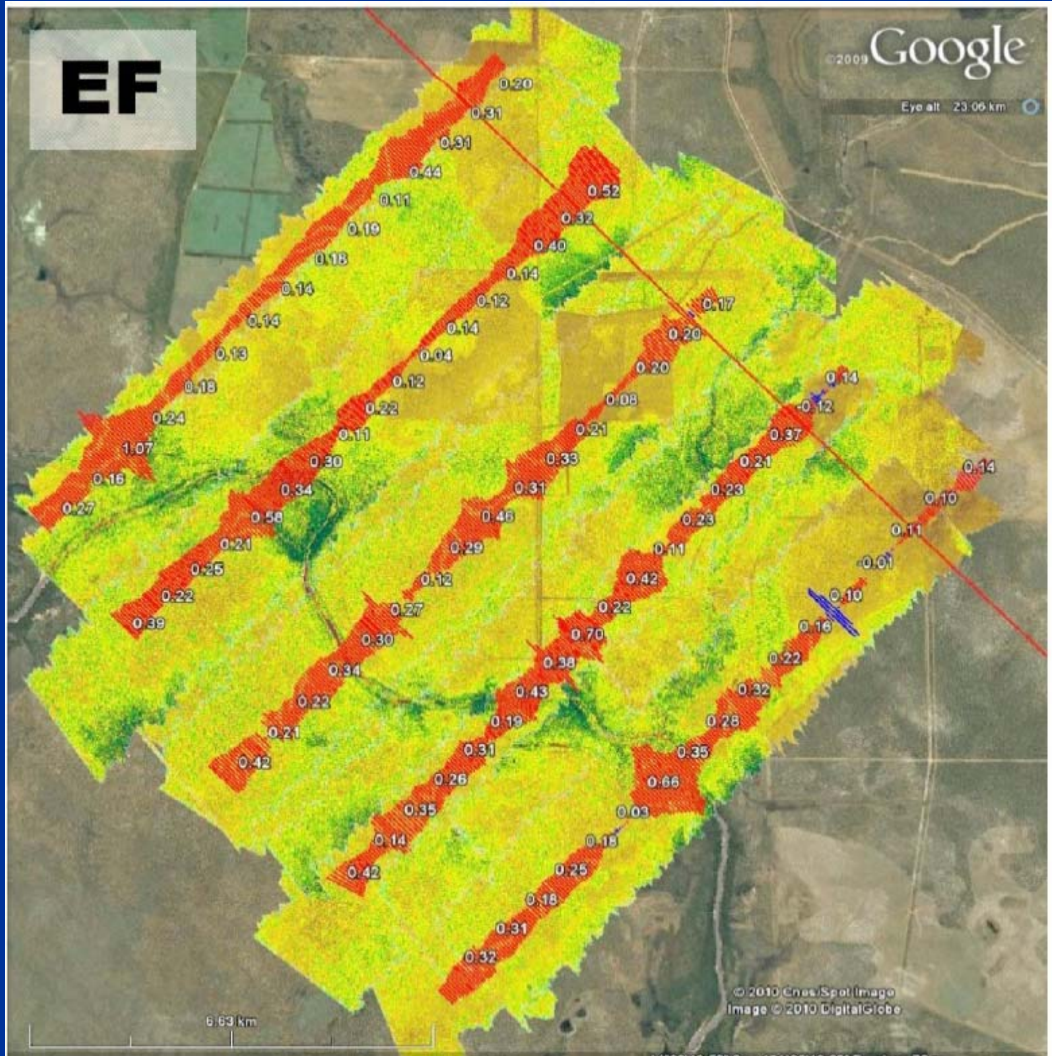


Courtesy Hacker (ARA)

Aircraft observations

Plot grids

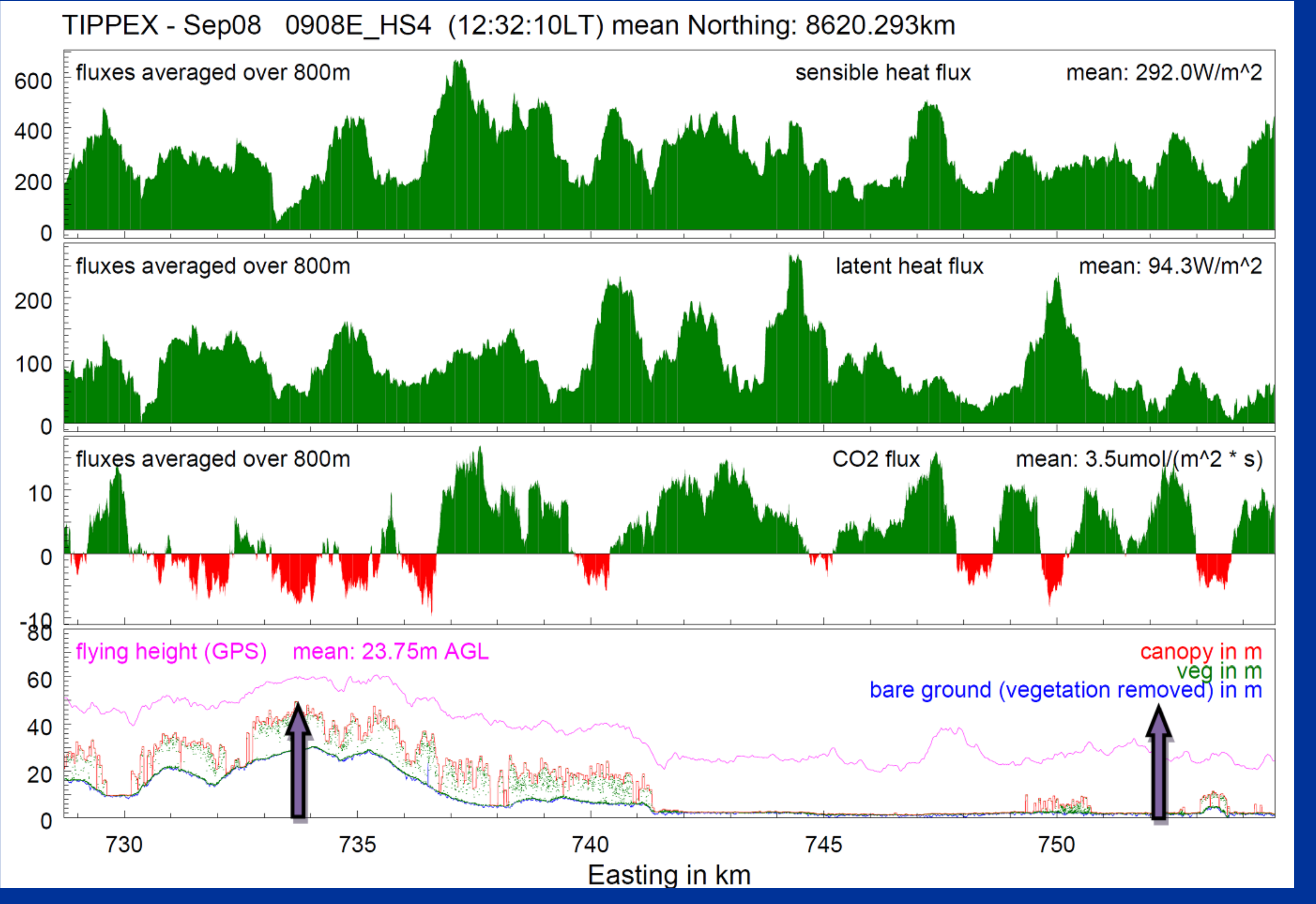




Courtesy Hacker (ARA)

Aircraft observations

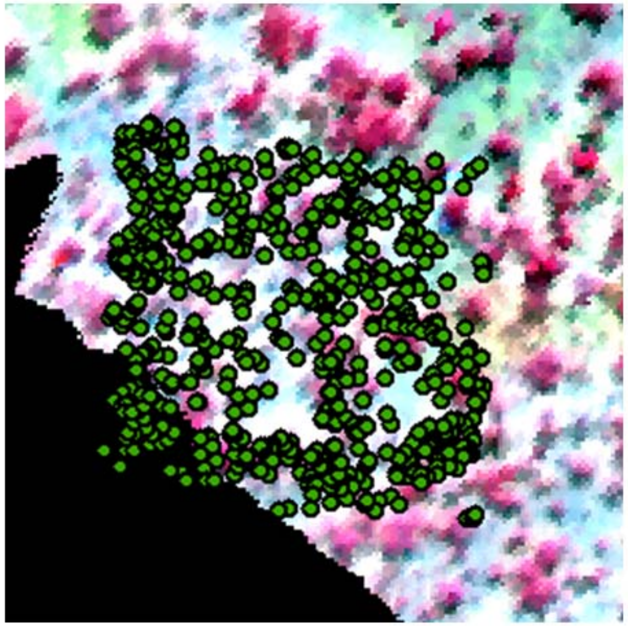
Flux Transects

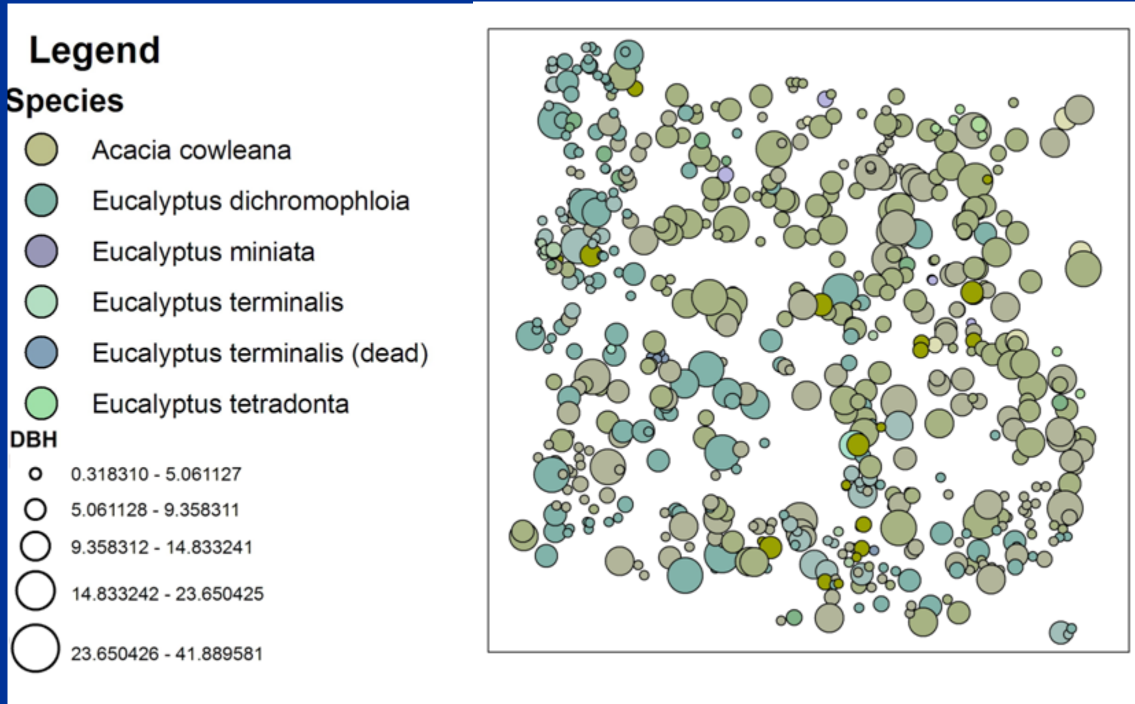


Courtesy Hacker (ARA)

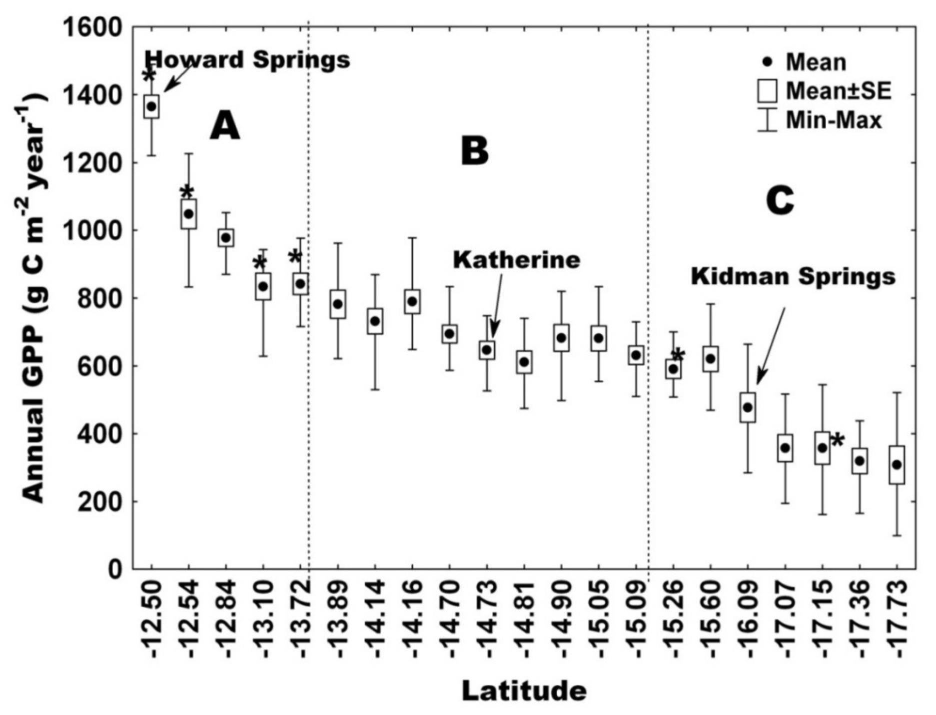
Remote sensing (ASD, CWD, Cover, etc)

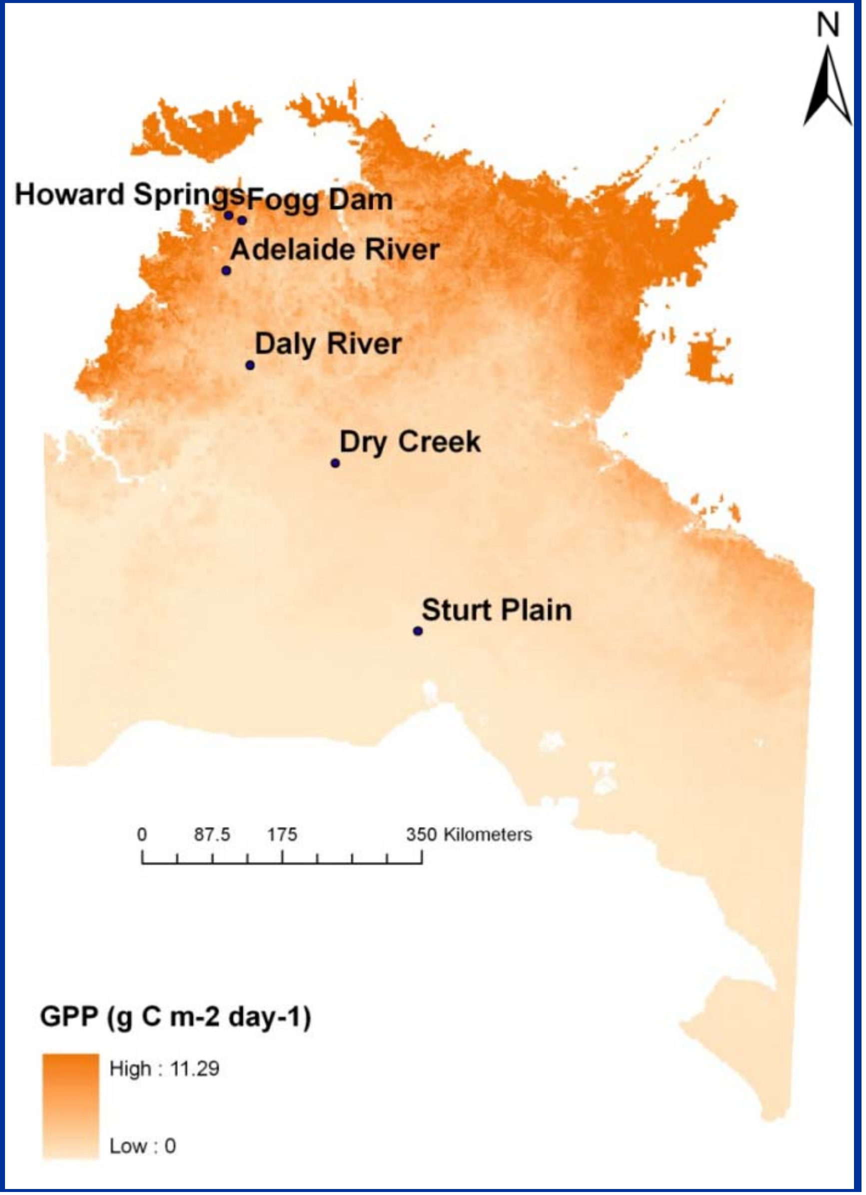
- Spectral library useful for end members
- Hyperspectral (PRI, LUE, NDVI, fluorescence, water content, N, chlorophyll, species classification, etc.).
- Challenge in scaling from leaf to plot (leaf angle, sun angle, obs angle)
- Radiative transfer model needed
- High resolution LiDAR for canopy structure.
- Then plot to landscape (MODIS, Landsat, etc.) ….





Scaling of productivity





Kanniah et al. (2010)

Summary

- Scaling using MODIS performs well due to dependence on LAI. LAI is the expression of resources.
- Processed based LSM are challenged in savannas but optimality based models perform better.
- Exchanges varied substantially across the savanna region. Both in space and time.
- At short time scales the exchanges are modulated by the diurnal cycle of radiation.
- The spatial variability due to 1) meteorological drivers and 2) heterogeneity in the vegetation (structure, composition, function).
- At longer climate time scales the annual precipitation drives vegetation structure and composition, which in turn alters the land surface exchanges.

Acknowledgements

Australian Government
Australian Research Council

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