# Model Development: Disturbance simulation with the tree-demography model POP

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# Motivation

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- Changes in biomass storage of forest and savanna ecosystems are a major contributor to the global terrestrial C sink ( ~25% anthropogenic C emissions)
- ESMs show divergent biomass turnovers under changing climate
  - Lack of representation of forest dynamics one of the greatest uncertainties in future climate prediction?
- Most DVMs in ESMs have no explicit treatment of demographic processes (recruitment, mortality, competition for resources)
  - Stand-scale individual-based information is neglected
- The Impact of fire on the global Carbon budget / ecosystems

# Goal:

A population model that is

- ecologically defensible (individual/population growth separated)
- deterministic
- computationally efficient
- modular (stand-alone and easy to couple into existing ESMs)

# POP
# Population-Order-Physiology

# POP: Key features

- Driven by annual whole-ecosystem stem biomass increment from CABLE
- Simulates recruitment, allometric growth and mortality of age-size cohorts of trees in stands
  - Stress mortality influenced by declining growth efficiency under crowding and self thinning
  - Frequency based recurrent disturbance mortality, partial and total
- Diagnostic parameters (DBH, Height, etc.) for evaluation
- Delivers C-pool updates / turn-over rates

# POP: Population dynamics

1 pixel ≈ 24 patches (patch representing a stand)

→1 patch = up to 20 kohorts

Each patch:

- Attempt of recruiting for 1 new cohort/year (if sufficient GPP)
- Cohorts with low growth efficiency die
- Has own disturbance history and frequency
- Disturbance Frequencies are randomly generated with an exponential distribution $E(\delta) = f_{dist}$

# POP: Disturbance

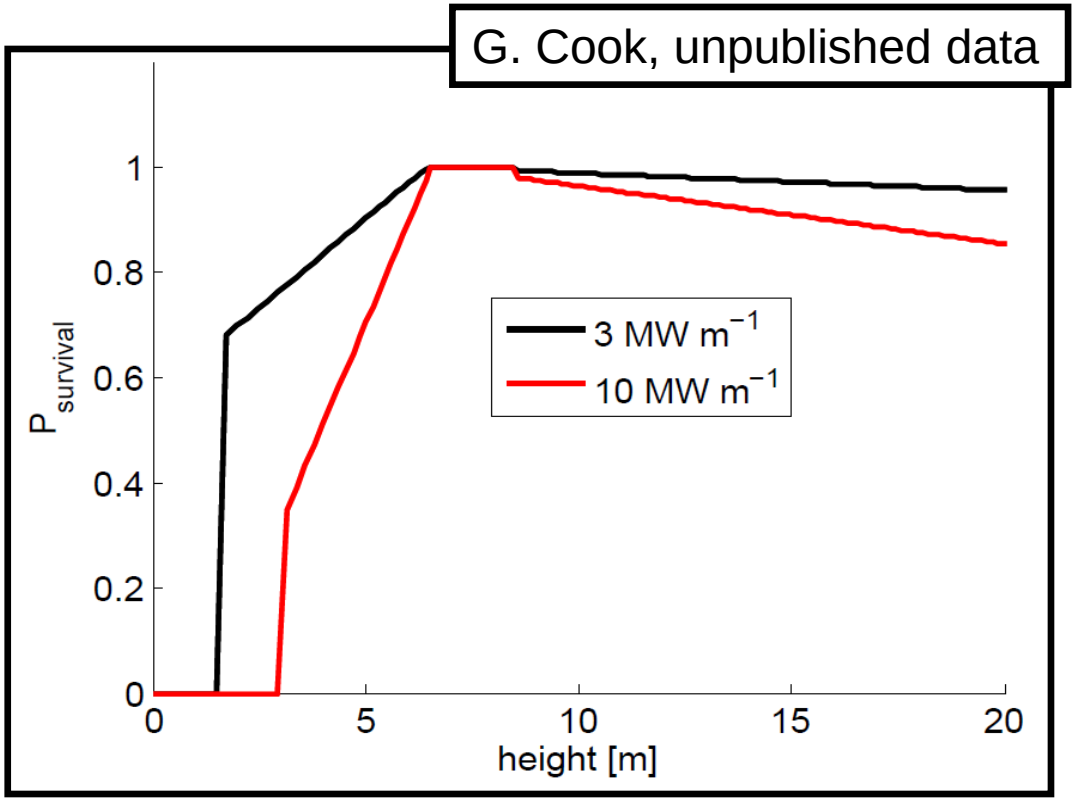
-Compute Fuel Load from biomass

-Determine Fire – Power

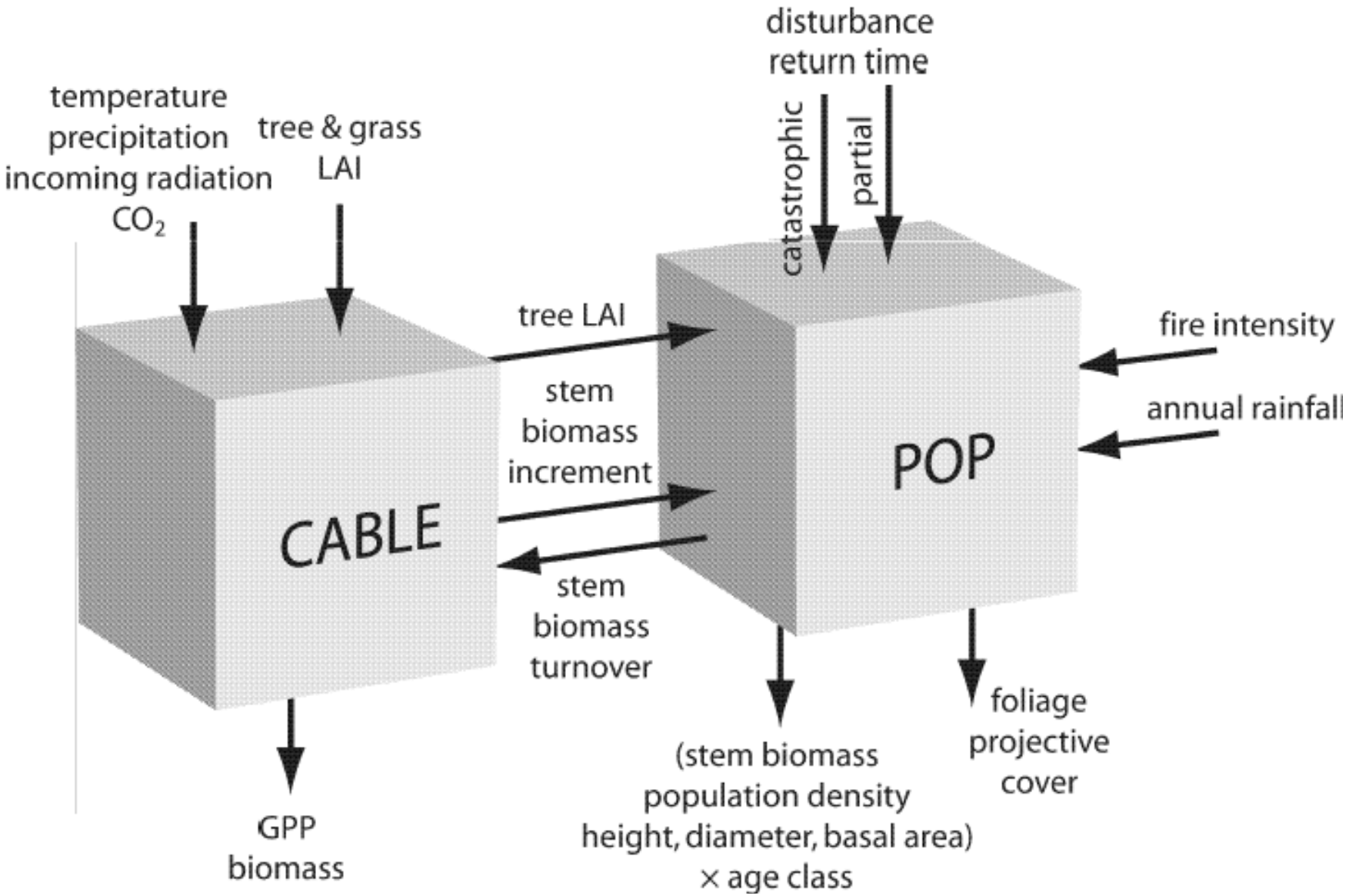
-Compute $P_{survival}$

-Remove killed biomass

-Reset history

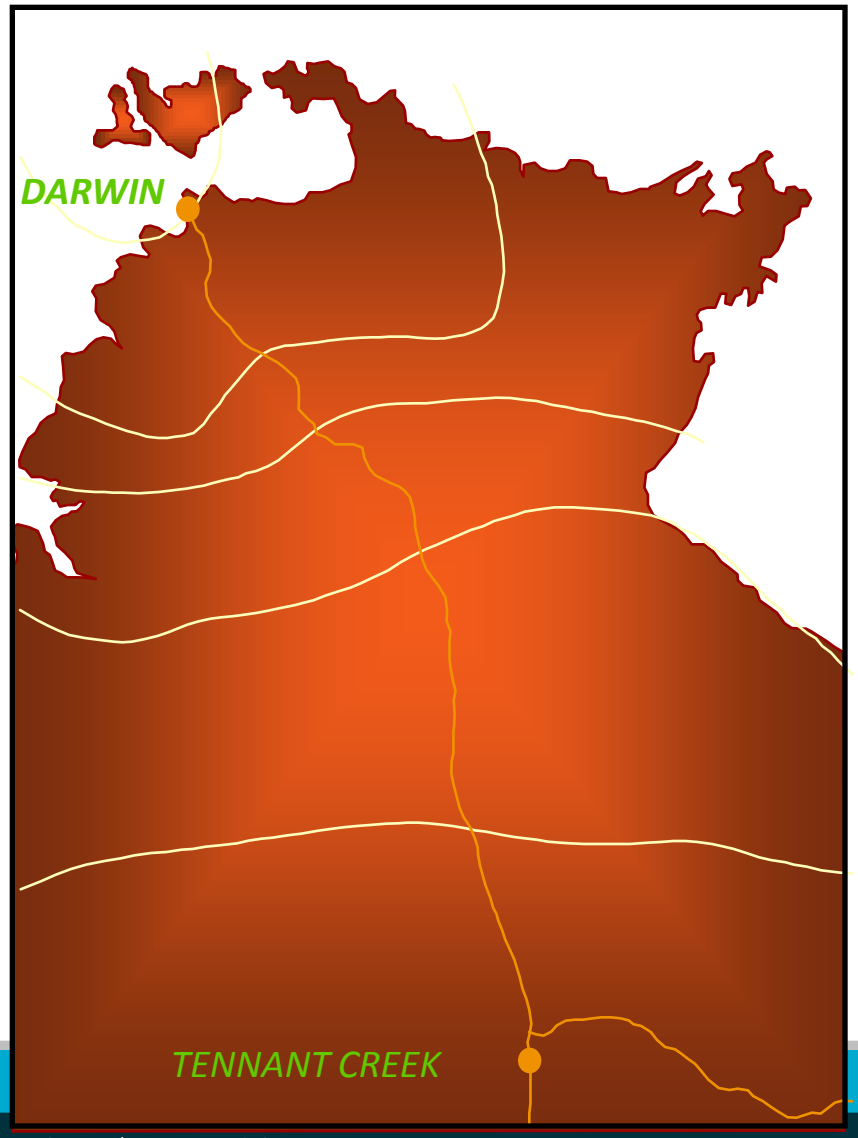


# CABLE - POP Coupling


disturbance
return time
catastrophic
partial
temperature
precipitation
incoming radiation
$CO_2$
tree & grass
LAI
tree LAI
stem
biomass
increment
stem
biomass
turnover
CABLE
POP
fire intensity
annual rainfall
GPP
biomass
(stem biomass
population density
height, diameter, basal area)
× age class
foliage
projective
cover

# Evaluation

# Study Site: Northern Australian Tropical Transect

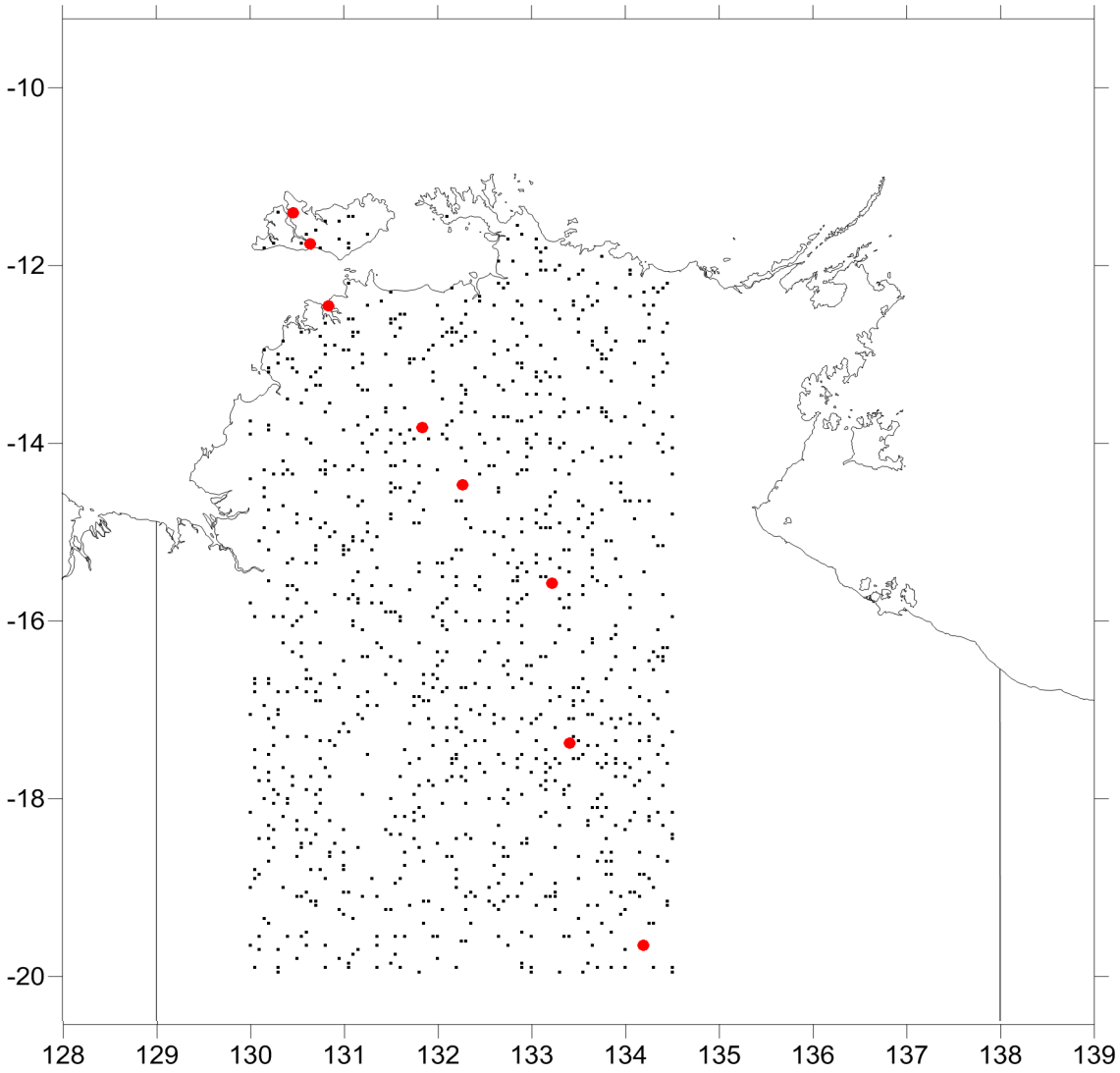



Photos by Adam Liedloff

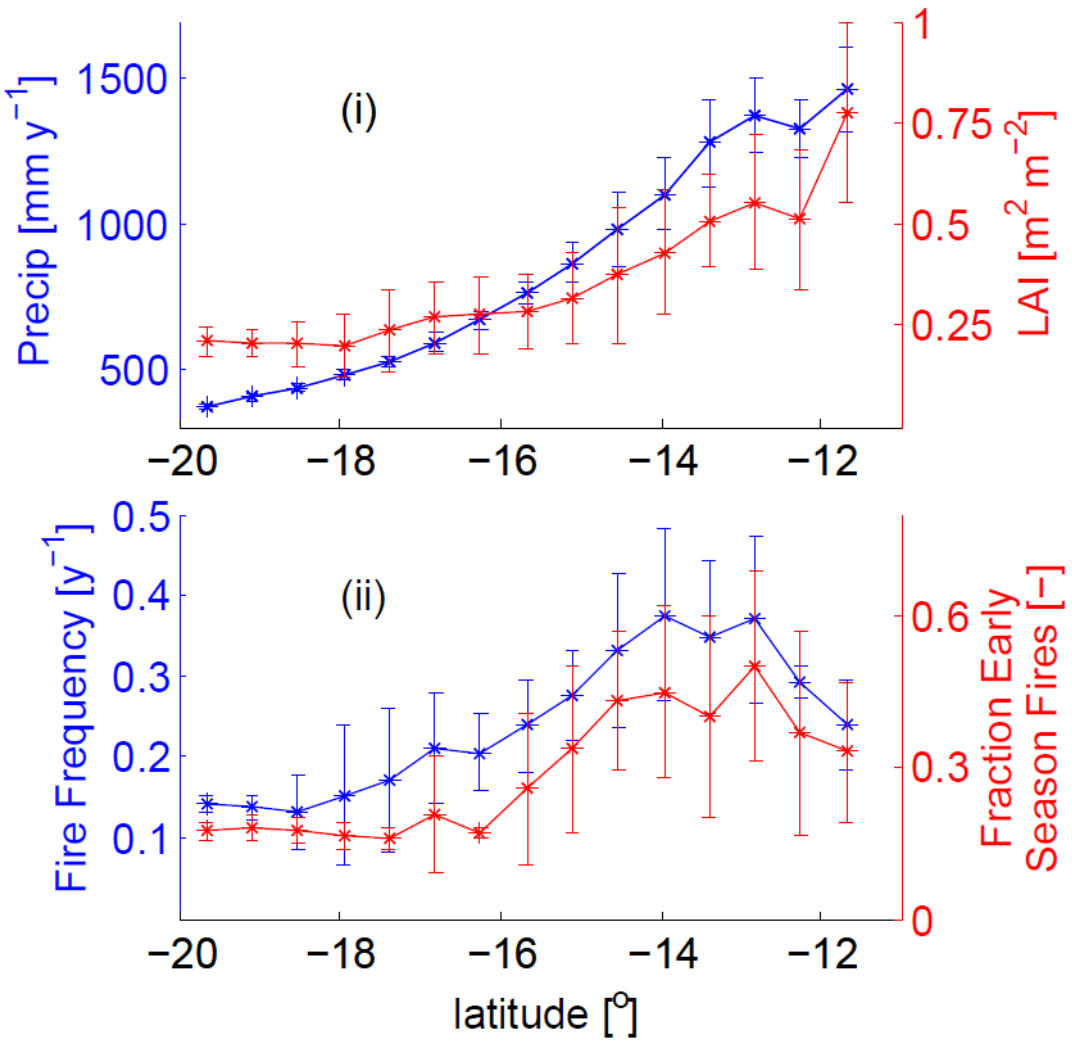
# Sampling the NATT

8 NATT stations

1000 randomly generated pixels for CABLE-POP



# NATT Transect: gradients in rainfall, vegetation cover, fire.



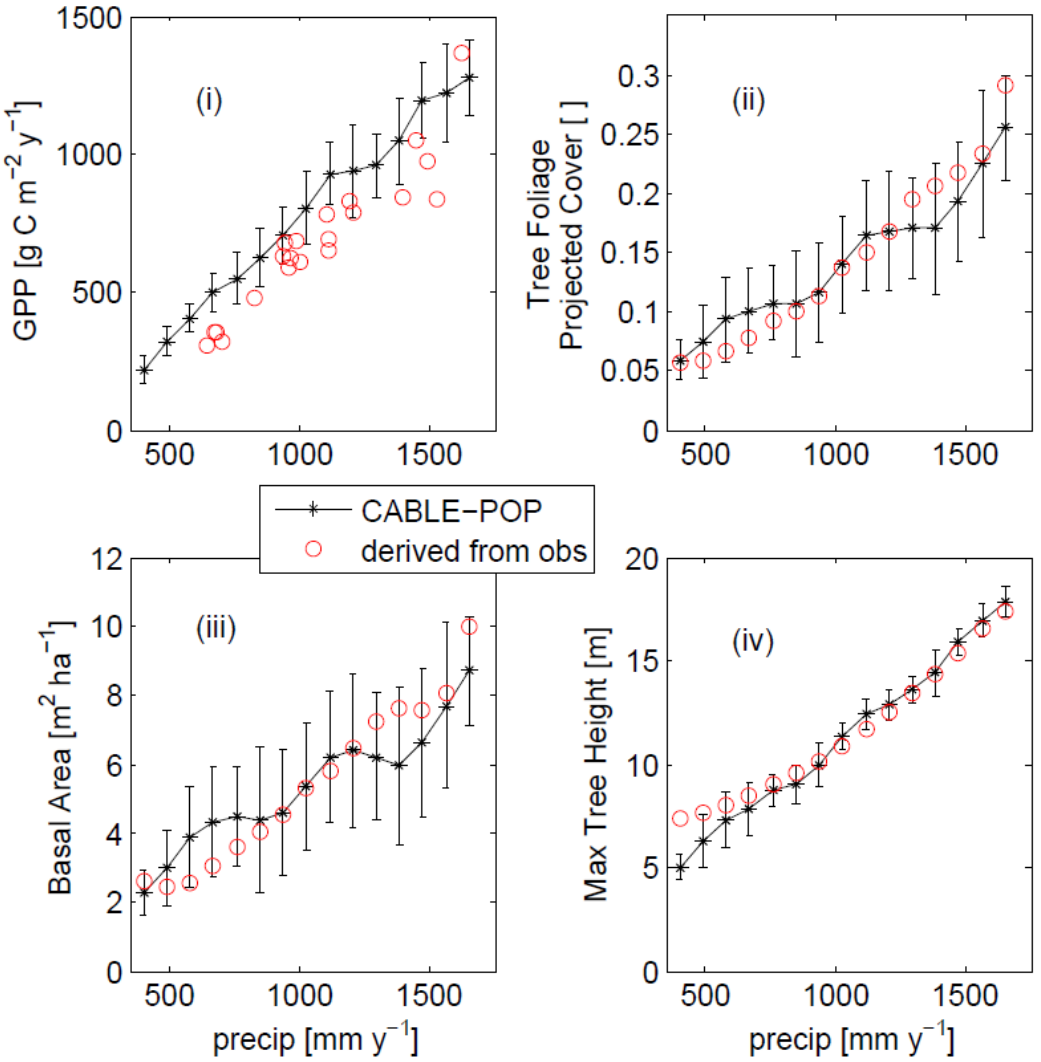

Fire Data: Mick Meyer, pers. comm.

# CABLE-POP vegetation function and structure predictions

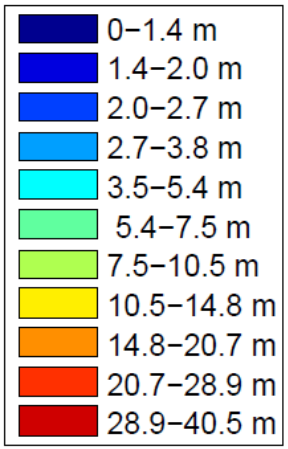
Obs-based estimates

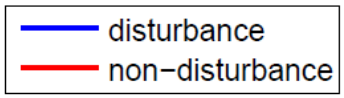

Kanniah, K.D., Beringer, J. and Hutley, L.B., 2011. Environmental controls on the spatial variability of savanna productivity in the Northern Territory, Australia. Agricultural and Forest Meteorology, 151(11): 1429-1439.

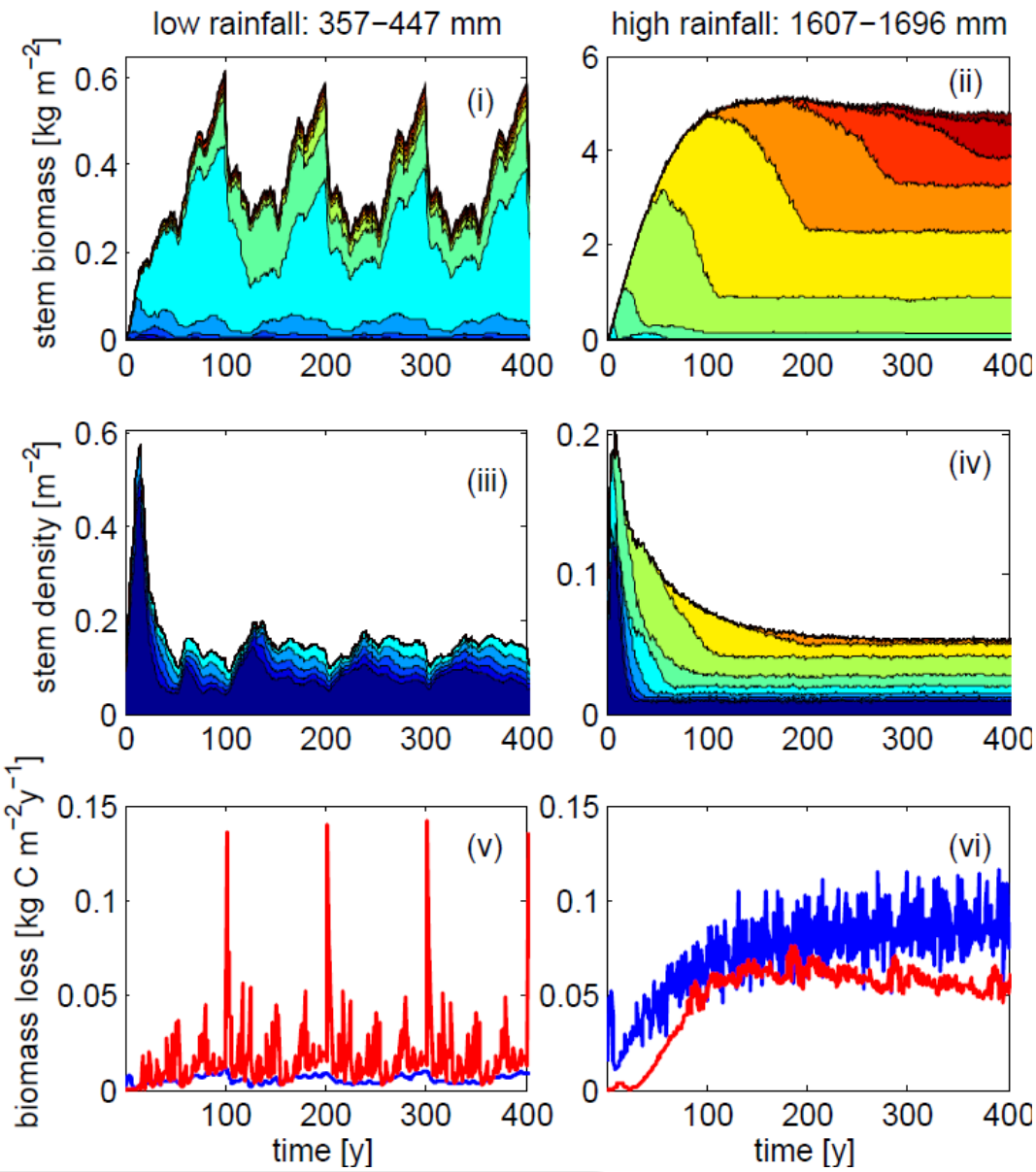
Williams, R.J., Duff, G.A., Bowman, D. and Cook, G.D., 1996. Variation in the composition and structure of tropical savannas as a function of rainfall and soil texture along a large-scale climatic gradient in the Northern Territory, Australia. Journal of Biogeography, 23(6): 747-756.

# CABLE-POP tree population dynamics at low and high rainfall extremes



# Summary and outlook

- POP description just published:

  Haverd, V., B. Smith, G. D. Cook, P. R. Briggs, L. Nieradzik, S. H. Roxburgh, A. Liedloff, C. P. Meyer, and J. G. Canadell (2013), *A stand-alone tree demography and landscape structure module for Earth system models*, Geophys. Res. Lett., 40, 5234–5239, doi:10.1002/grl.50972

- Model will be made available as module via CABLE repository

- Fire model is under construction

- Phenology model is planned

# Thank you very much!

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