Disturbance impacts on carbon uptake in a managed native Eucalyptus forest

CMAR

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Helen A. Cleugh, Vanessa Haverd, Natascha Kljun

14 May 2014

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14 May 2014

Tumbarumba, Bago State Forest

OzFlux

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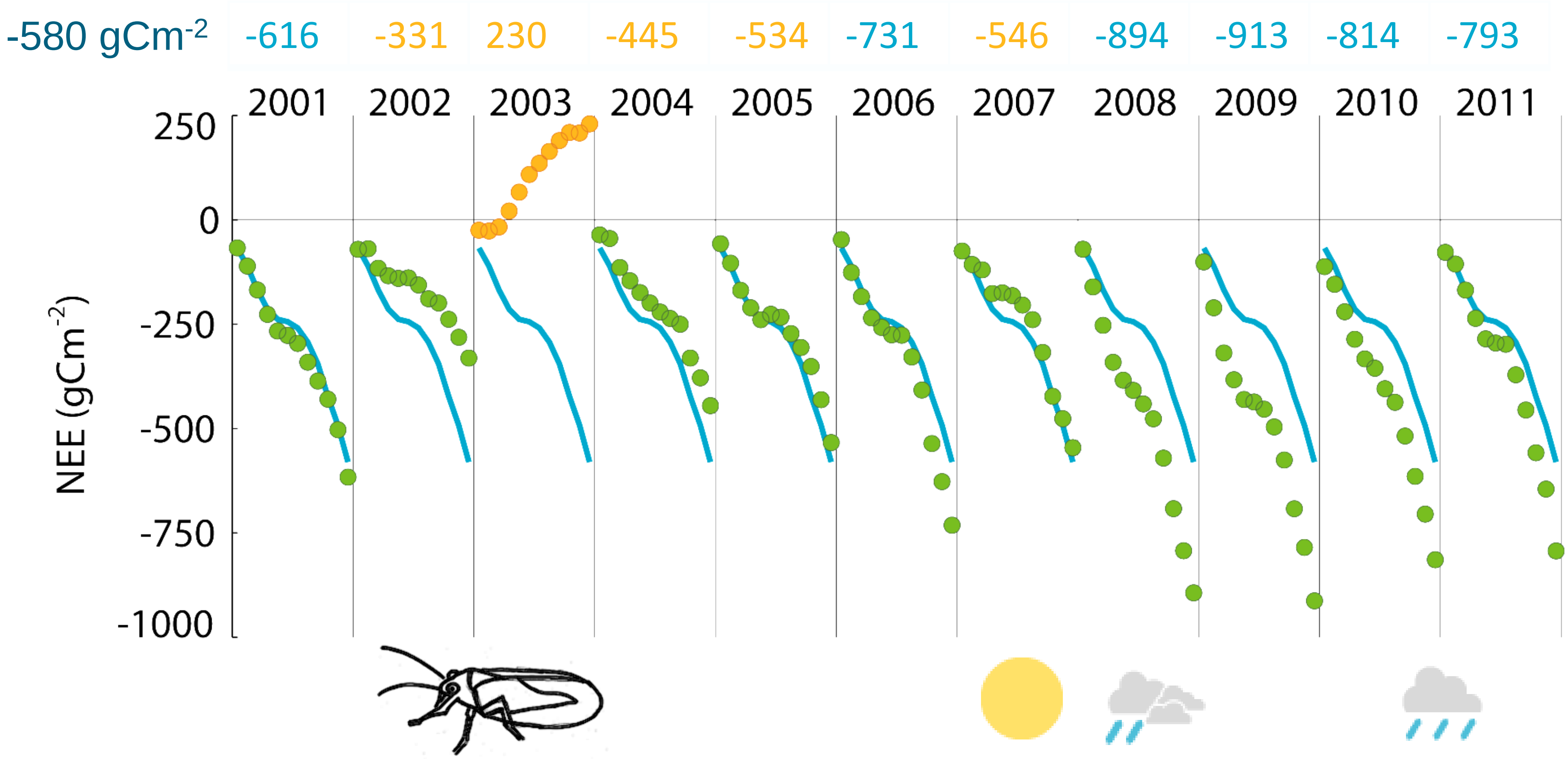
Study Site: Interannual variability of NEE



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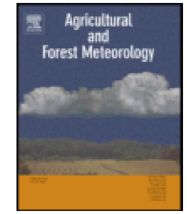

ELSEVIER

CrossMark

Primary and secondary effects of climate variability on net ecosystem carbon exchange in an evergreen *Eucalyptus* forest

Eva van Gorsel[a,*], J.A.J. Berni[b], P. Briggs[a], A. Cabello-Leblic[a], L. Chasmer[c], H.A. Cleugh[a], J. Hacker[d], S. Hantson[e], V. Haverd[a], D. Hughes[a], C. Hopkinson[a], H. Keith[f], N. Kljun[g], R. Leuning[a], M. Yebra[h], S. Zegelin[a]

- Incoming shortwave radiation, spring minimum temperatures and NDVI explain most variance of annual net ecosystem exchange of carbon.

- ...

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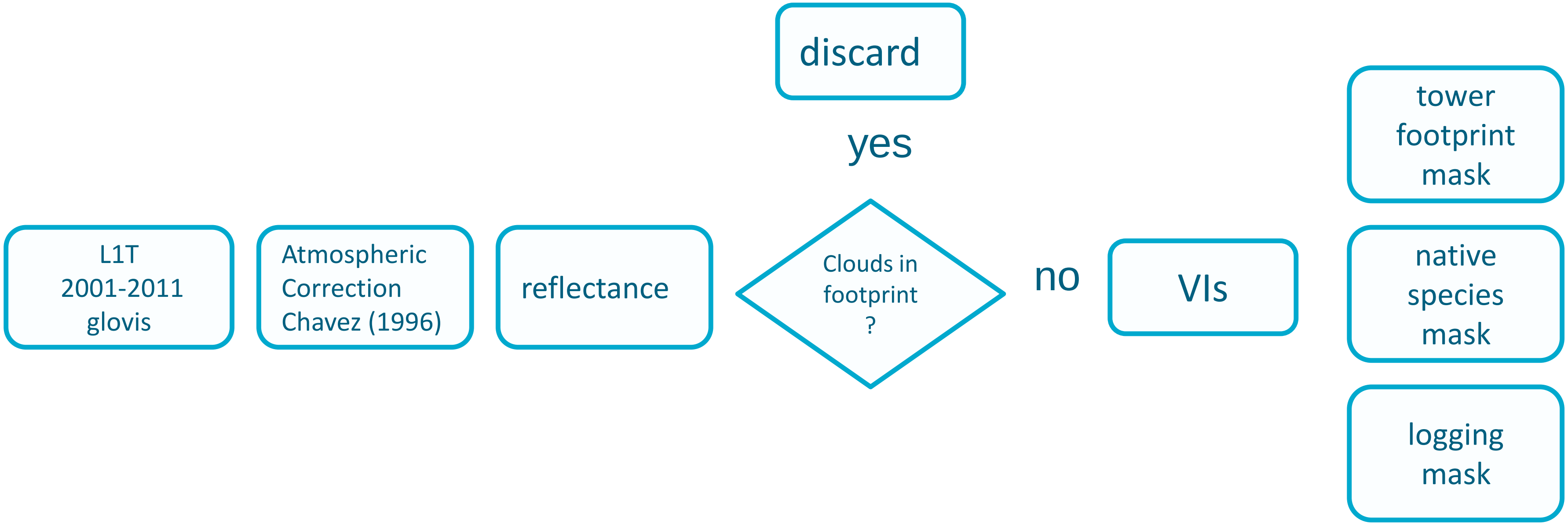
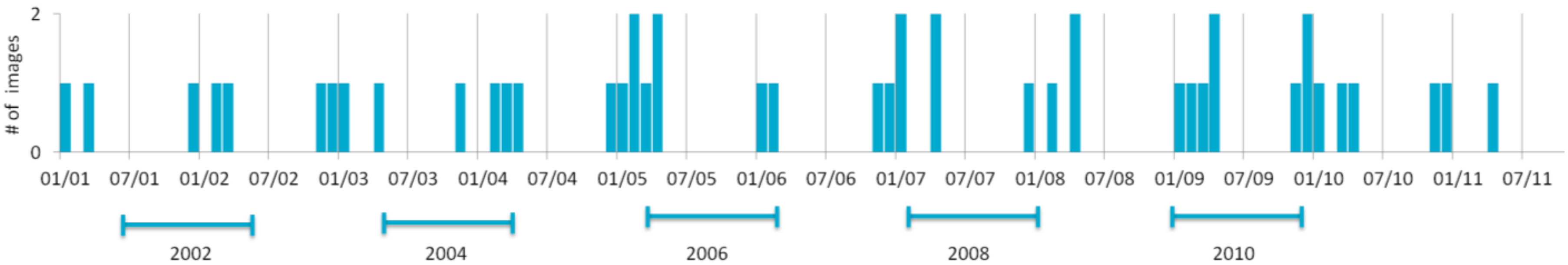
Can vegetation indices derived from Landsat imagery inform on disturbance processes?

- extent
- duration / recovery times
- patchiness
- quantification of impact on carbon uptake?

remote sensing data: Landsat 7 ETM+





Quantification:
impact of disturbance on carbon uptake

$$GPP \propto fAPAR_{green} \times PAR_{in} \times LUE$$

$$Chl = LAI \times Chl_{leaf}$$

physiological component

structural component

Quantification:
impact of disturbance on carbon uptake

$$GPP \propto VI \times PAR_{in}$$

$$Chl = LAI \times Chl_{leaf}$$

physiological component

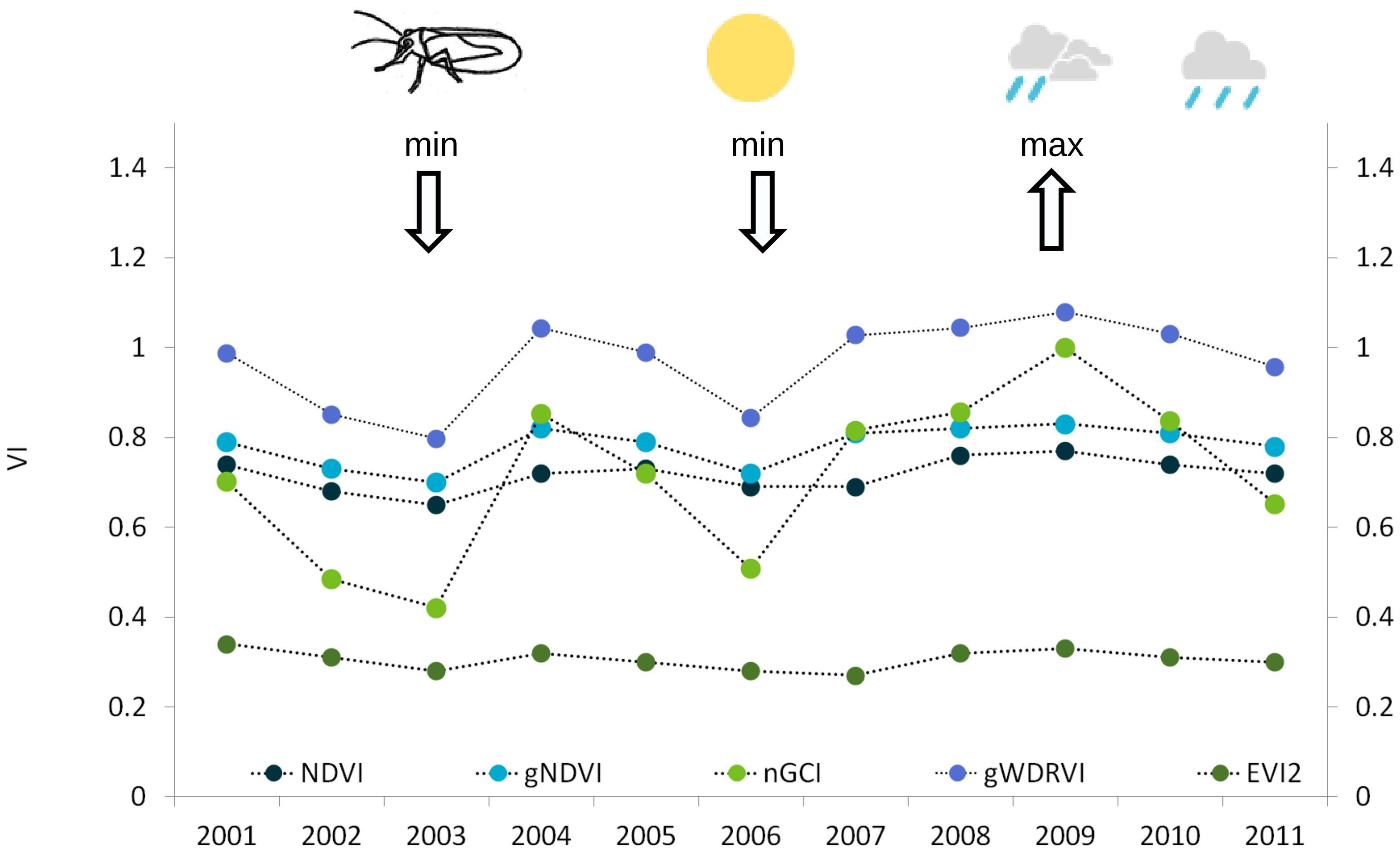
structural component

Vegetation Indices derived from Landsat data

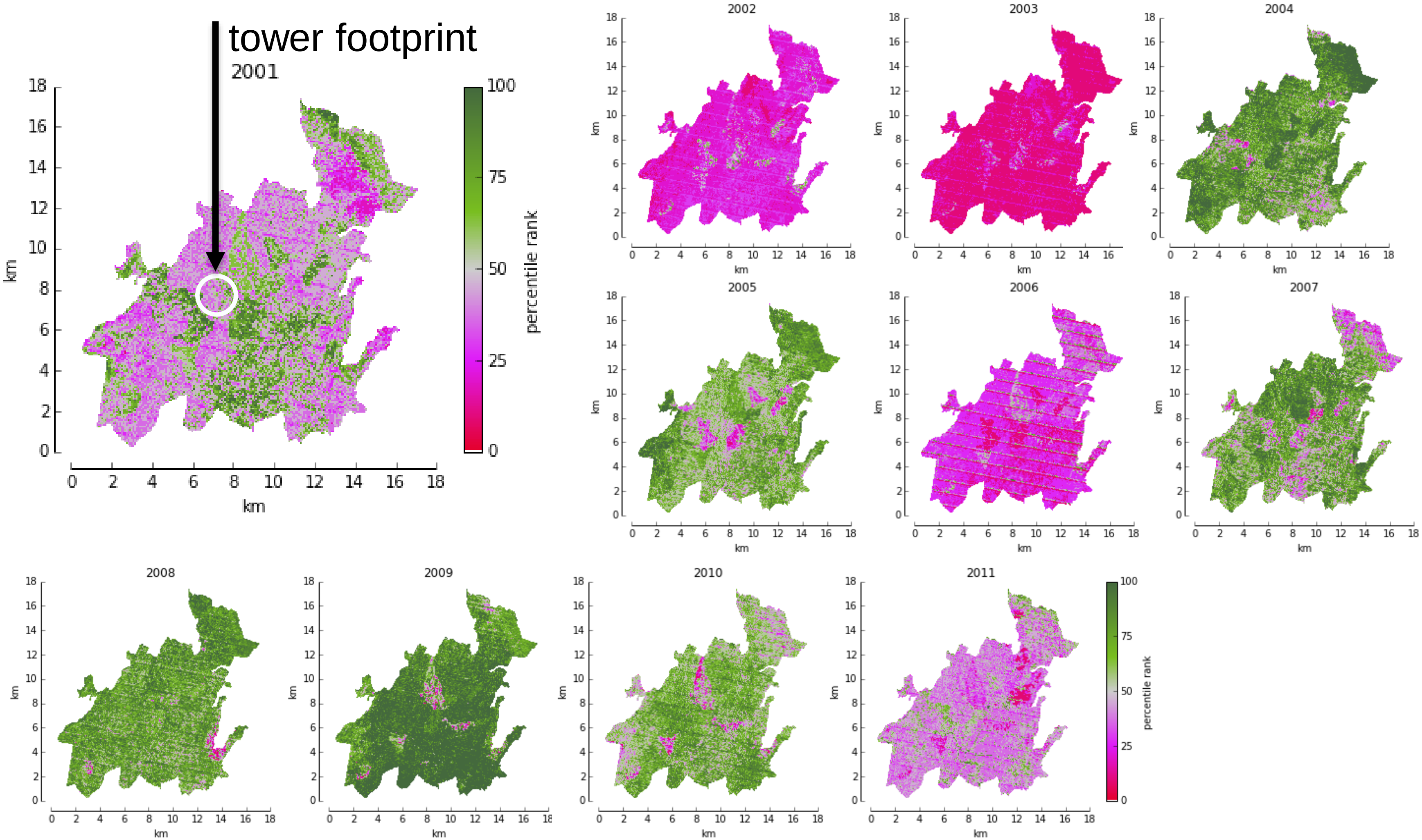
$$GPP \propto VI \times PAR_{in}$$

NDVI	normalised difference vegetation index	$(\rho_{NIR}-\rho_{red})/(\rho_{NIR}+\rho_{red})$
gNDVI	green NDVI	$(\rho_{NIR}-\rho_{green})/(\rho_{NIR}+\rho_{green})$
EVI2	two band enhanced vegetation index	$2.5\times(\rho_{NIR}-\rho_{red})/(\rho_{NIR}+2.4\times\rho_{red}+1)$
GCI	green chlorophyll index	$\rho_{NIR} / \rho_{green}-1$
WDRVI	wide dynamic range VI	$(\alpha\times\rho_{NIR}-\rho_{green})/(\alpha\times\rho_{NIR}+\rho_{green})$ $+(1-\alpha)/(1+\alpha)$

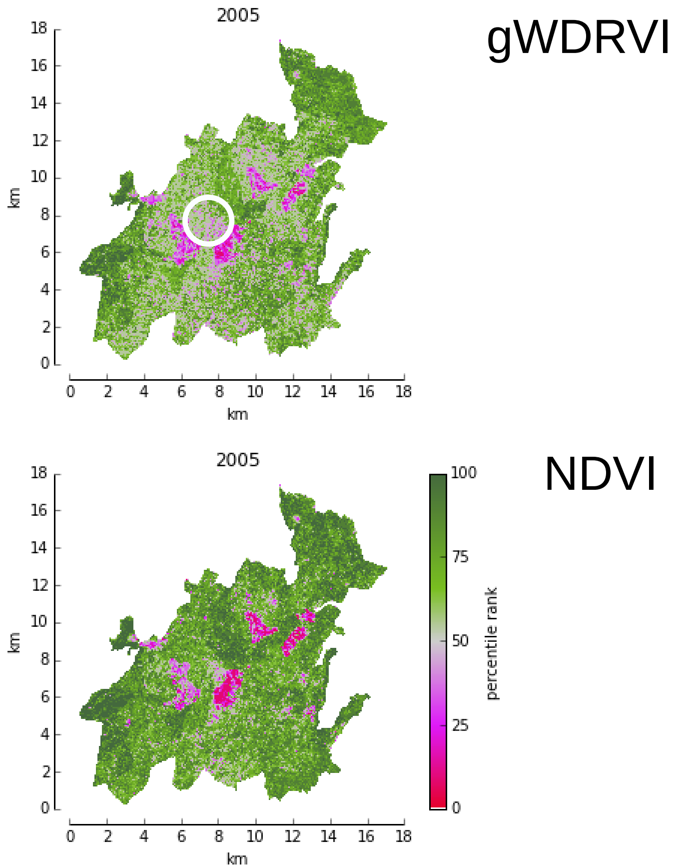
VIs

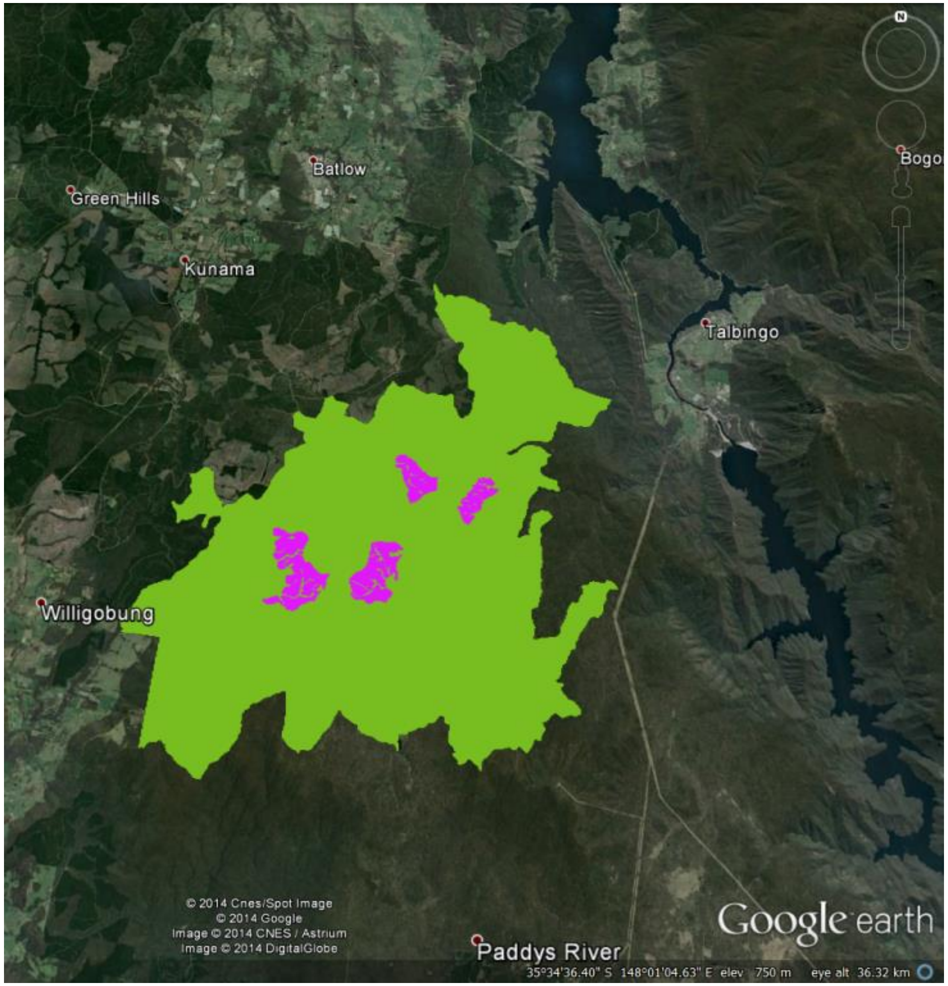

min
min
max
VI
1.4
1.2
1
0.8
0.6
0.4
0.2
0
NDVI
gNDVI
nGCI
gWDRVI
EVI2
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011

Spatial distribution of gWDRVI variation

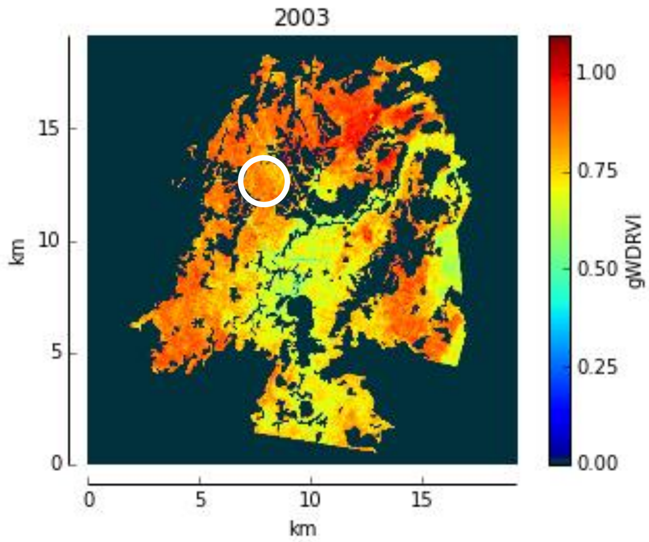


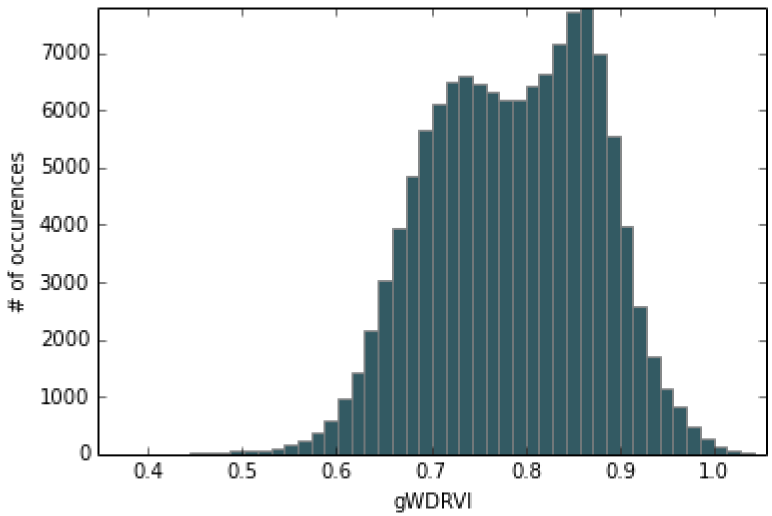
Spatial distribution of VI variation: logging



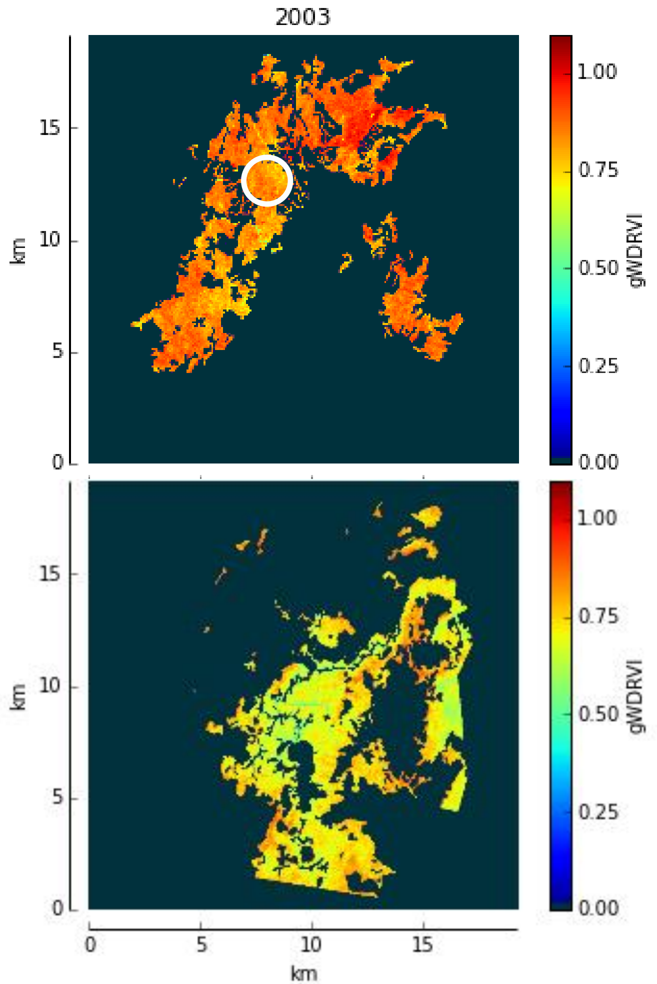


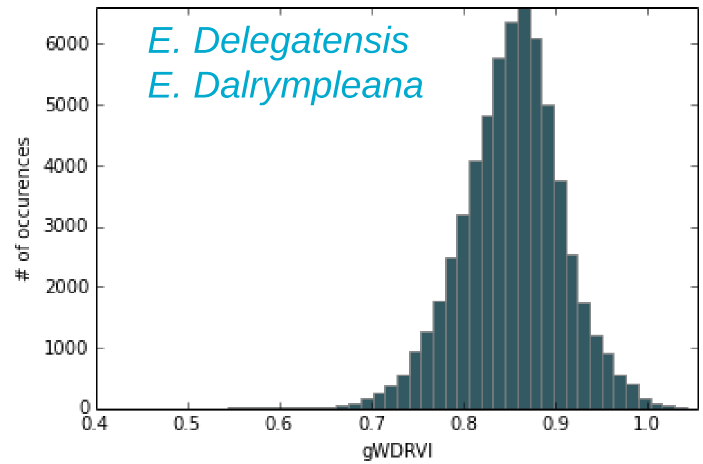
Spatial distribution of gWDRVI variation: insect disturbance

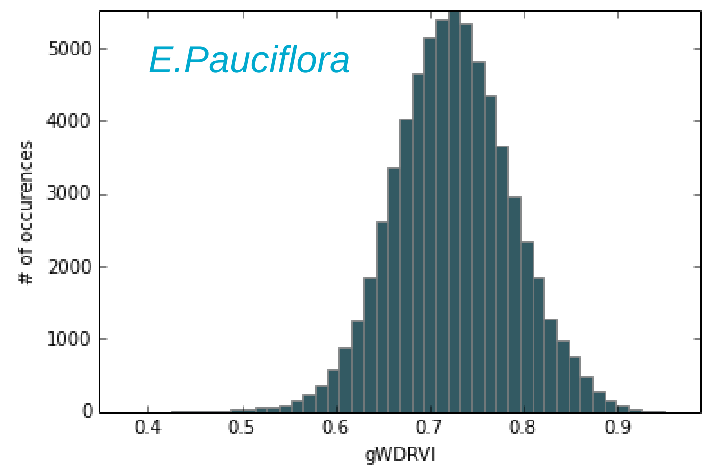




Spatial distribution of gWDRVI variation: insect disturbance

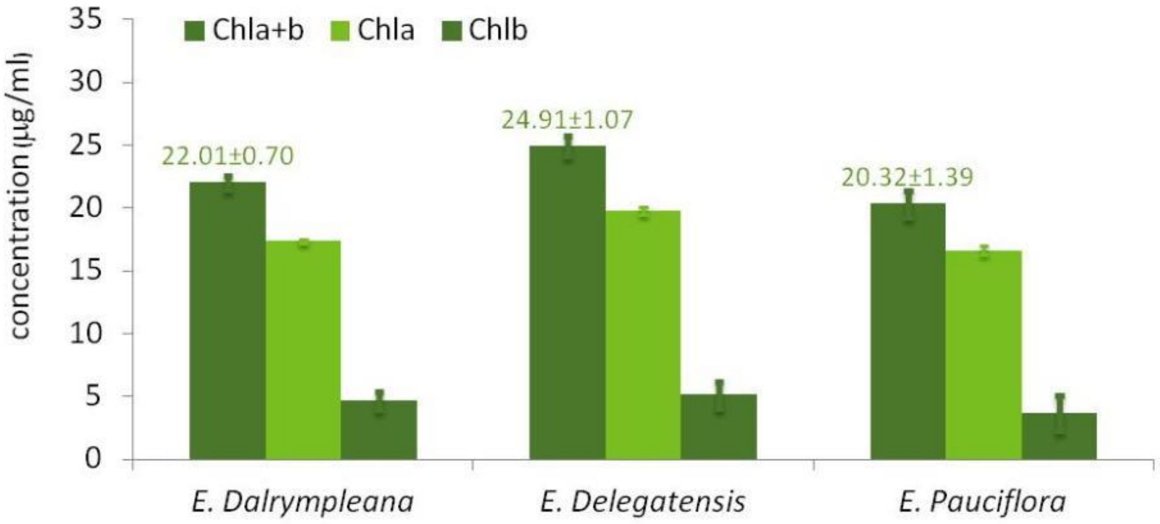






Different Distribution of VI between species: structural or pyhsiological?

$$Chl = LAI \times Chl_{leaf}$$

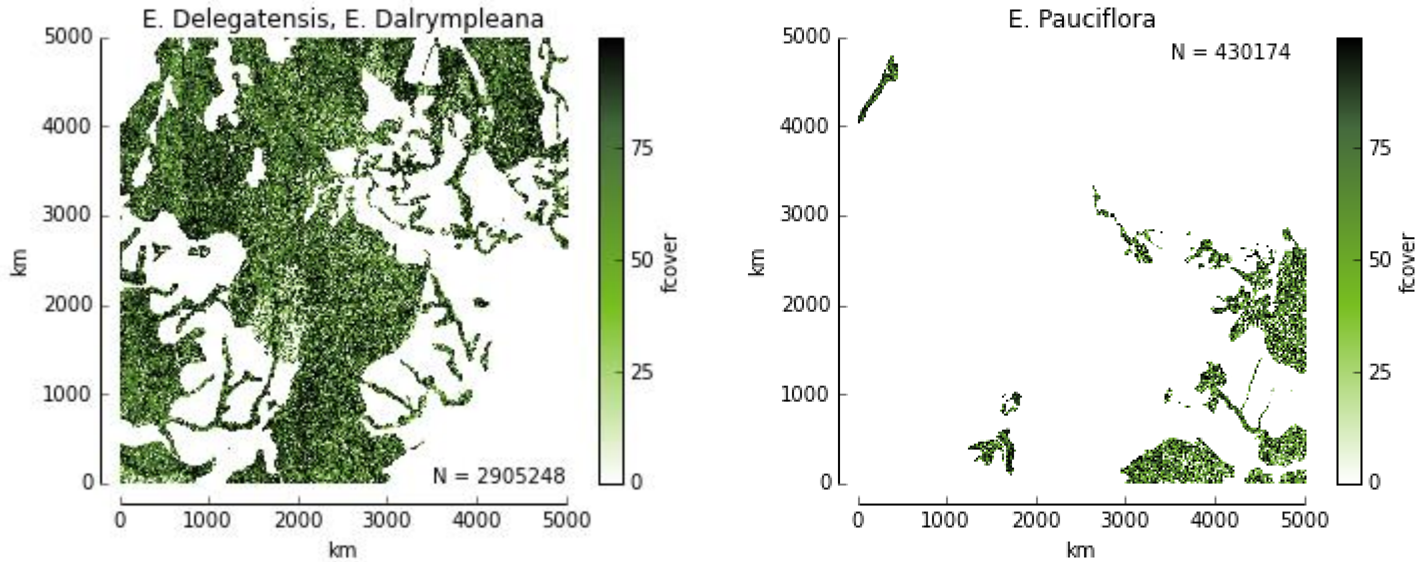


T test:

- the means of the (volume!) Chl_{a+b} concentration does not differ between species

Different Distribution of VI between species: structural or pyhsiological?

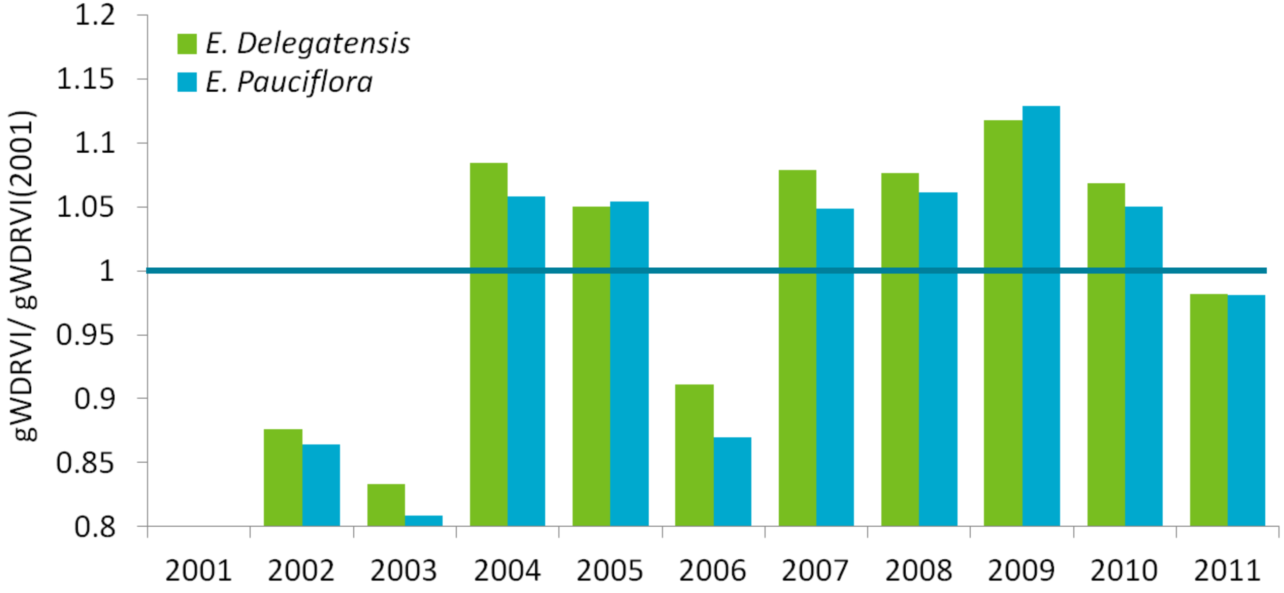
$$Chl = LAI \times Chl_{leaf}$$



T test:

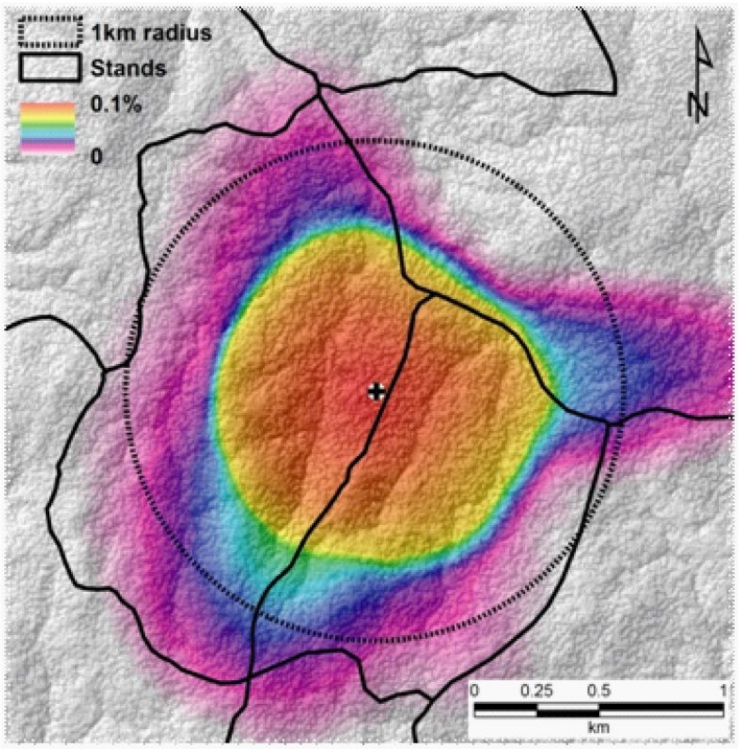
➢ the mean of valid fractional cover (fcover) measurements of E.Pauciflora is significantly smaller than the mean fcover of E.Delegatensis/Dalrympleana

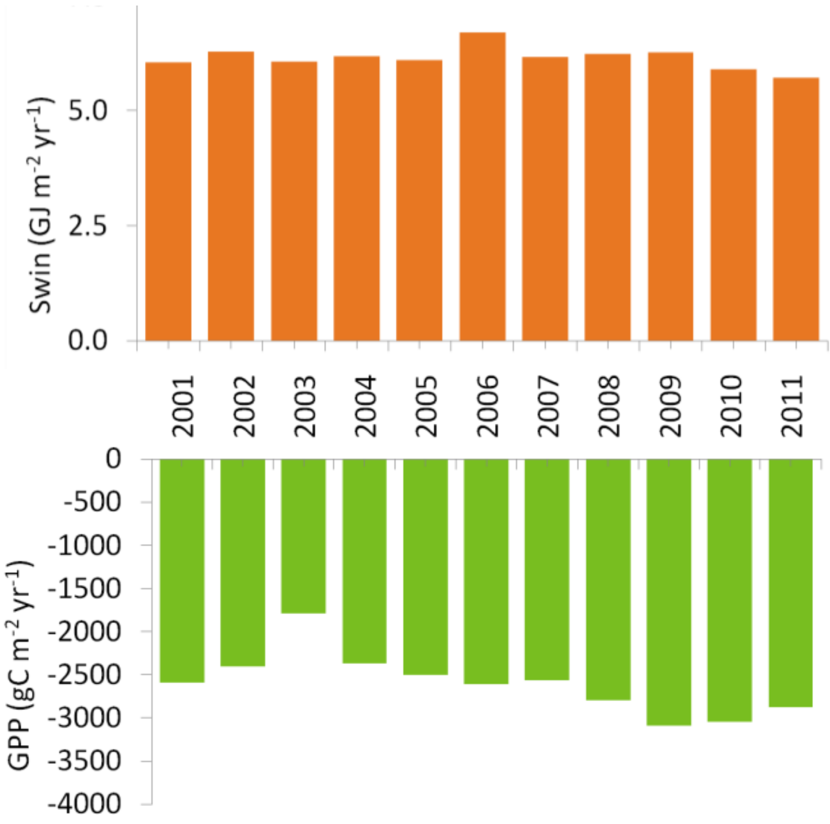
Fraction of VI with respect to 2001: E. Delegatensis and E. Pauciflora



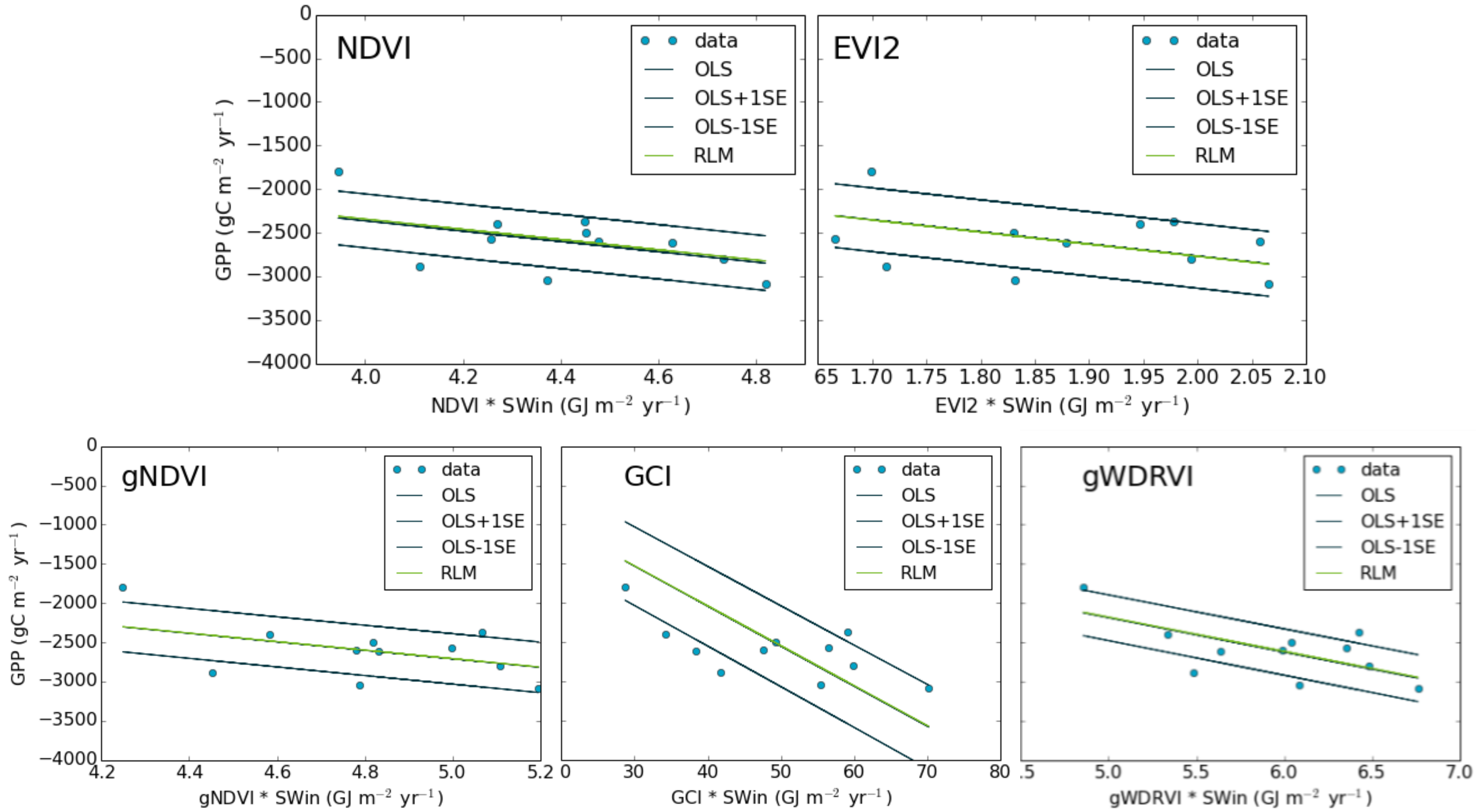
PAR and GPP measurements – flux footprint

$$GPP \propto VI \times PAR_{in}$$





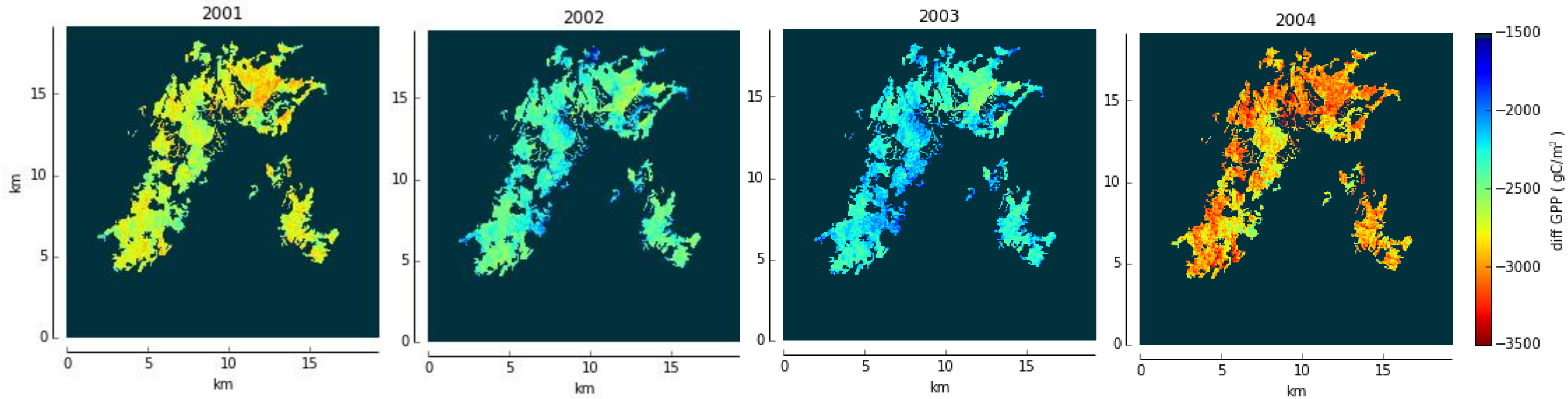
$$GPP \propto VI \times PAR_{in}$$

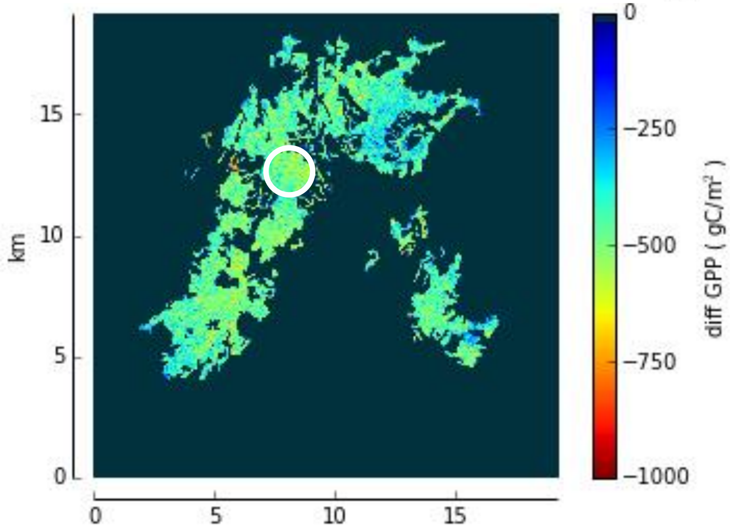


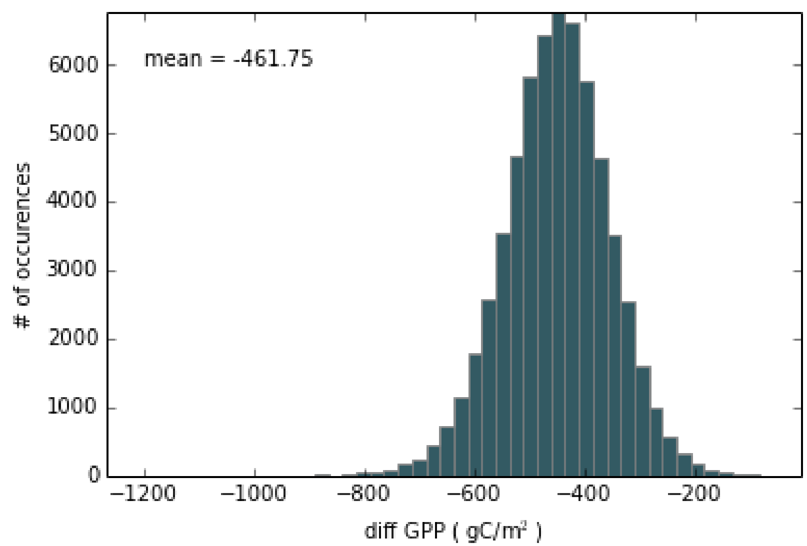
VI ranking

	RLM coeff	std err	95% CI	OLS coeff	std err	95% CI	NRMSD	CV(RMSD)
NDVI	-585.9	22.6	[-630.1, -541.7]	-591.1	20.3	[-636.4, -545.8]	0.219	-0.110
gNDVI	-541.5	21.3	[-583.3, -499.6]	-542.2	19.2	[-585.1, -499.5]	0.226	-0.112
EVI2	-1385.6	61.4	[-1505.8, -1265.4]	-1383.5	56.4	[-1509.3, -1257.8]	0.256	-0.129
GCI	-50.9	3.6	[-57.9, -43.9]	-51.1	2.9	[-57.6, -44.5]	0.363	-0.181
GWDRVI	-435.8	18.3	[-471.7, -399.8]	-437.4	14.3	[-469.1, -405.6]	0.210	-0.104

Carbon not sequestered due to insect disturbance







Conclusions

Landsat 7 ETM+ data has been used to quantify the impact of disturbance on carbon sequestration of a managed native Eucalyptus forest.

- Successful location of areas where selective logging has taken place
- The data allowed us to determine the
  - extent of the insect attack (whole area)
  - duration of the insect attack (1-2 years)
  - patchiness of attack

- The green wide dynamic range vegetation index splits into two distinct distributions according to dominant species.
  - we did not find that the Chlorophyll concentration of leafs between species differed
  - we did find that the fractional cover between species differed.
  - different species had slightly differently affected by insects (reduction / recovery)

Thank you

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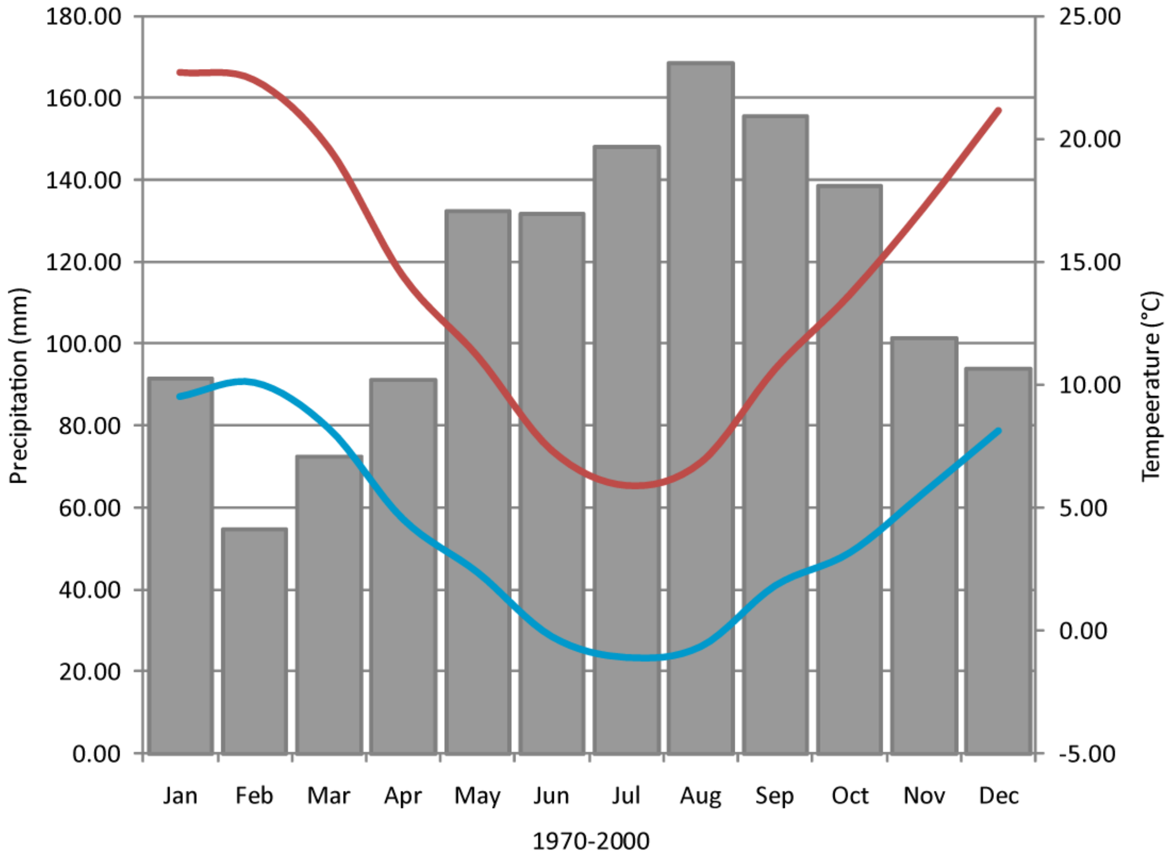
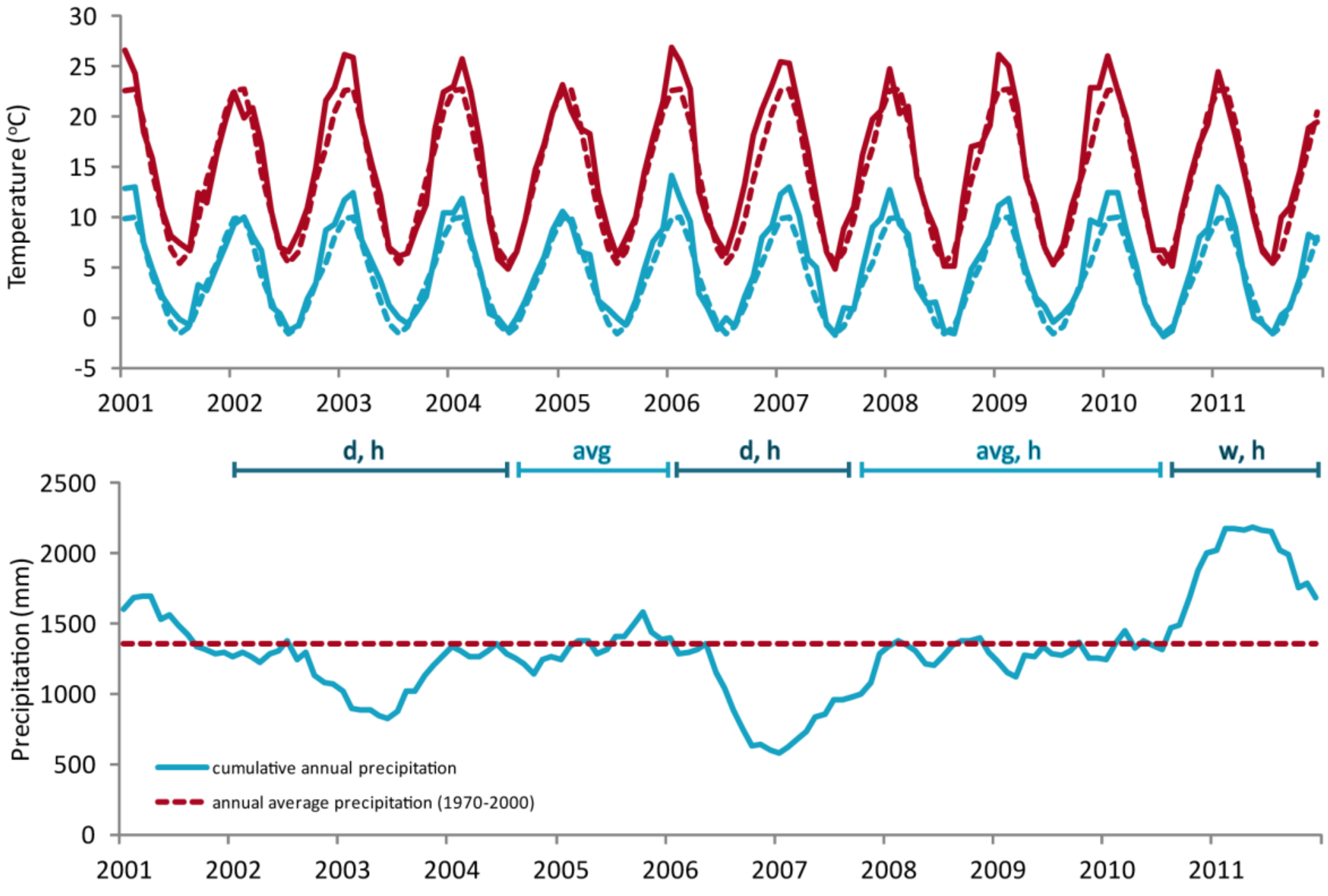
Climate at Bago State Forest (SILO data)

1380 mm

22.7 °C
-1.09 °C



Climate at Bago State Forest (SILO data)



Insect damage 

cool, wet → hot, dry

reduction in natural parasites and predators of Psyllids

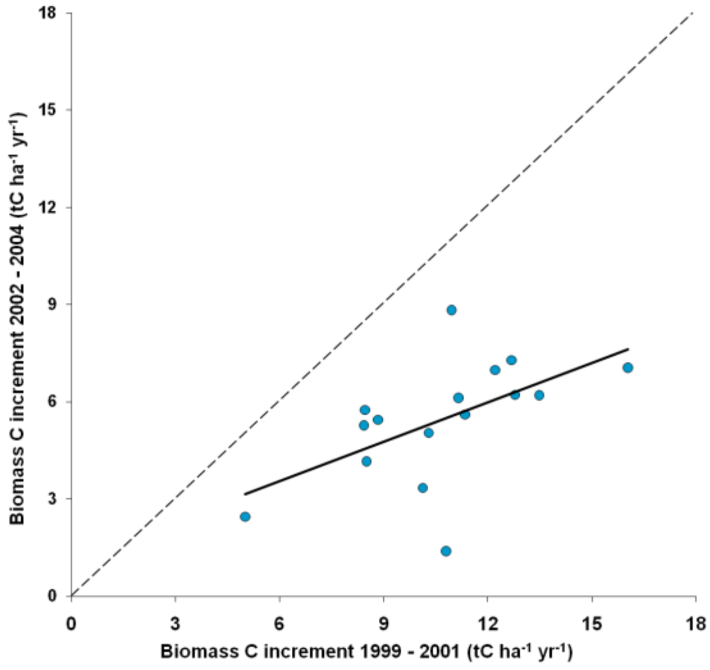
hot, dry

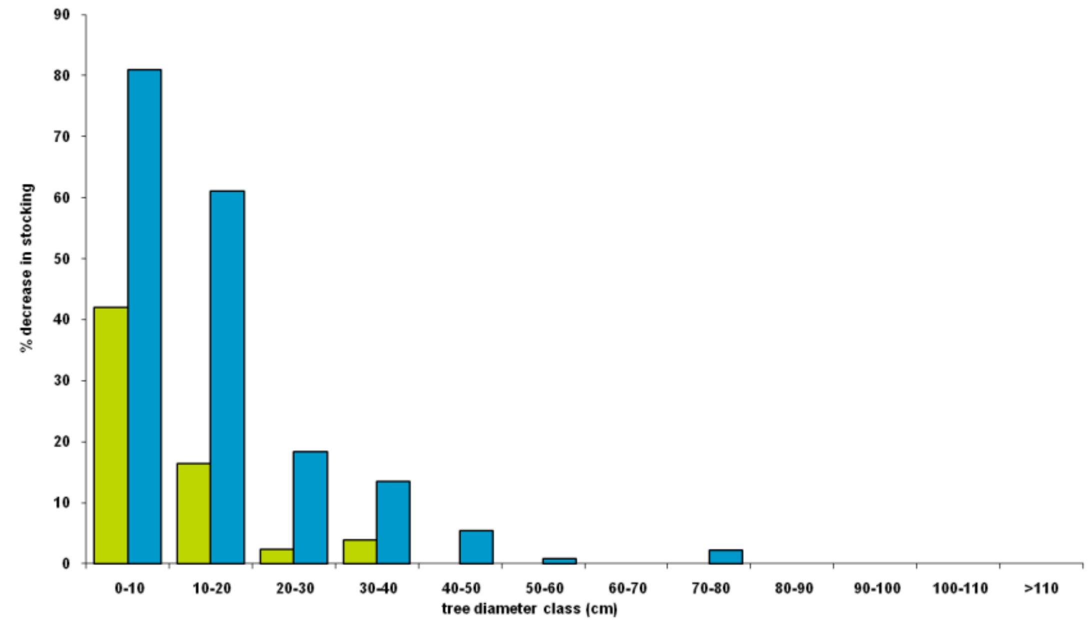
reduction in photosynthetic activity
reduction in biomass increase
decrease in protein synthetic activity (defensive metabolites and enzymes)

drought

can trigger mortality in trees that have predisposing factors

Insect damage



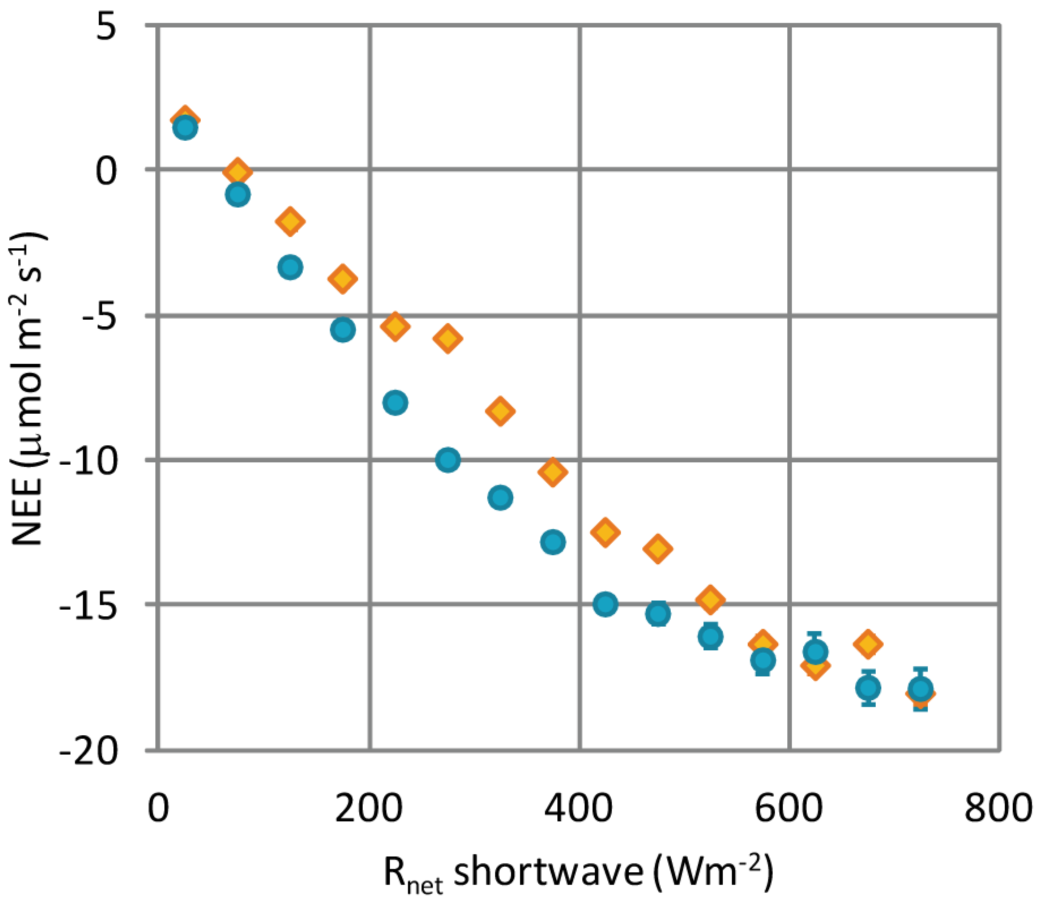


leads to decreased biomass increments

mortality increases and affects larger trees

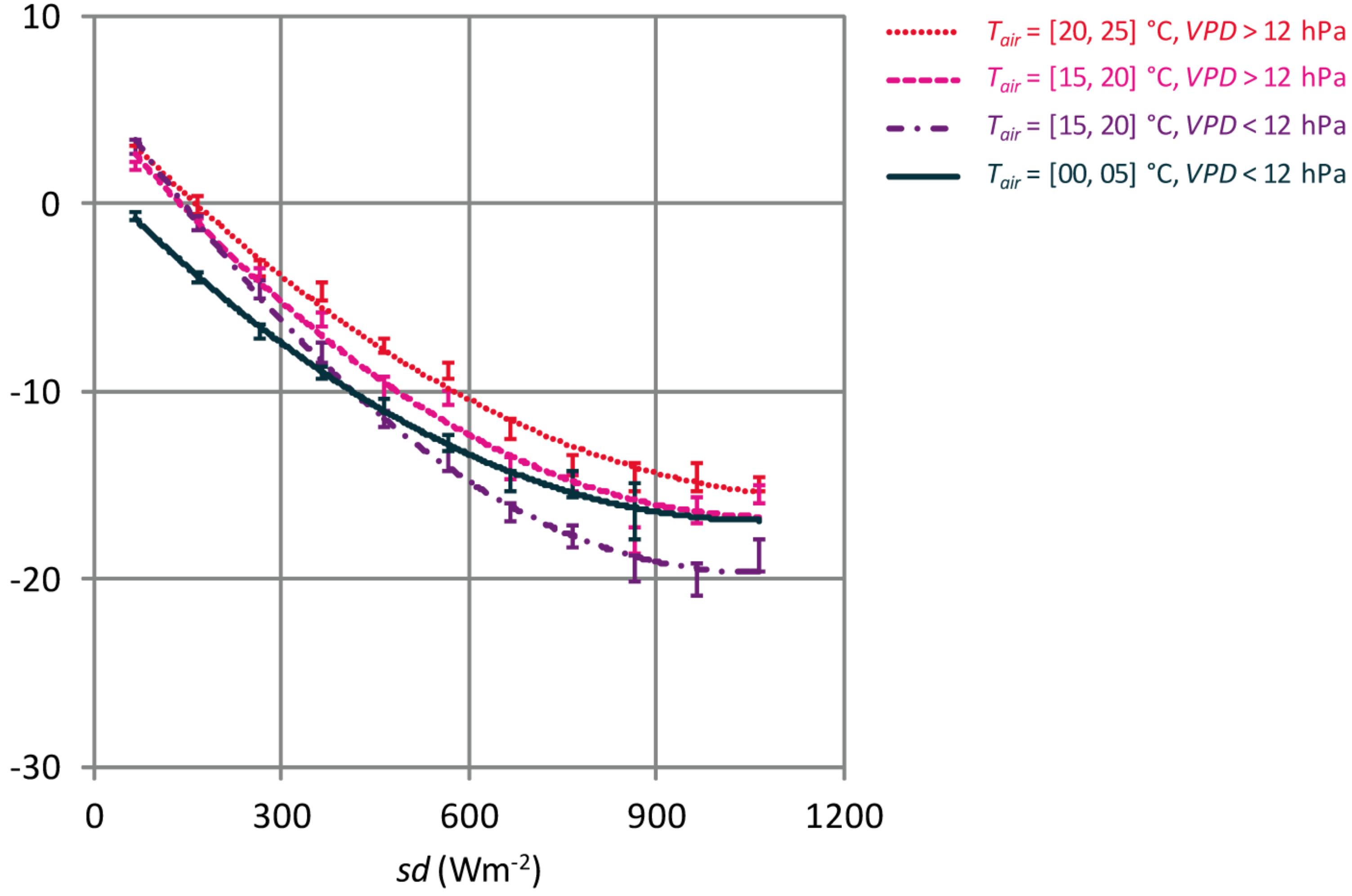
Keith, H., et al. (2011). doi:10.1016/j.agrformet.2011.07.019

Climatological drivers of NEE

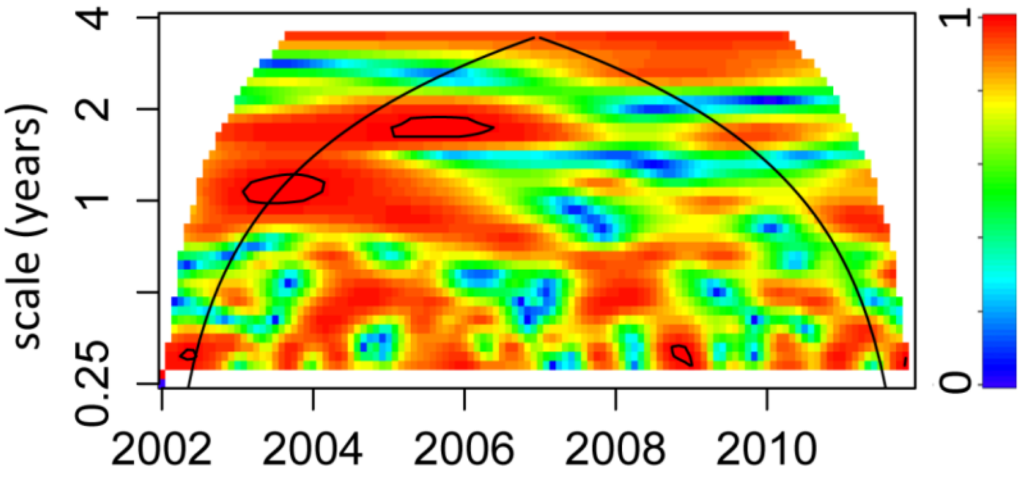


direct radiation
diffuse radiation

modulation through temperature and vpd



Wavelet Coherence
NEE - Precipitation



Wavelet Coherence