Ecosystem Services Based Adaptation to Climate Change: Why and How?

Photo credit @ Alamgir
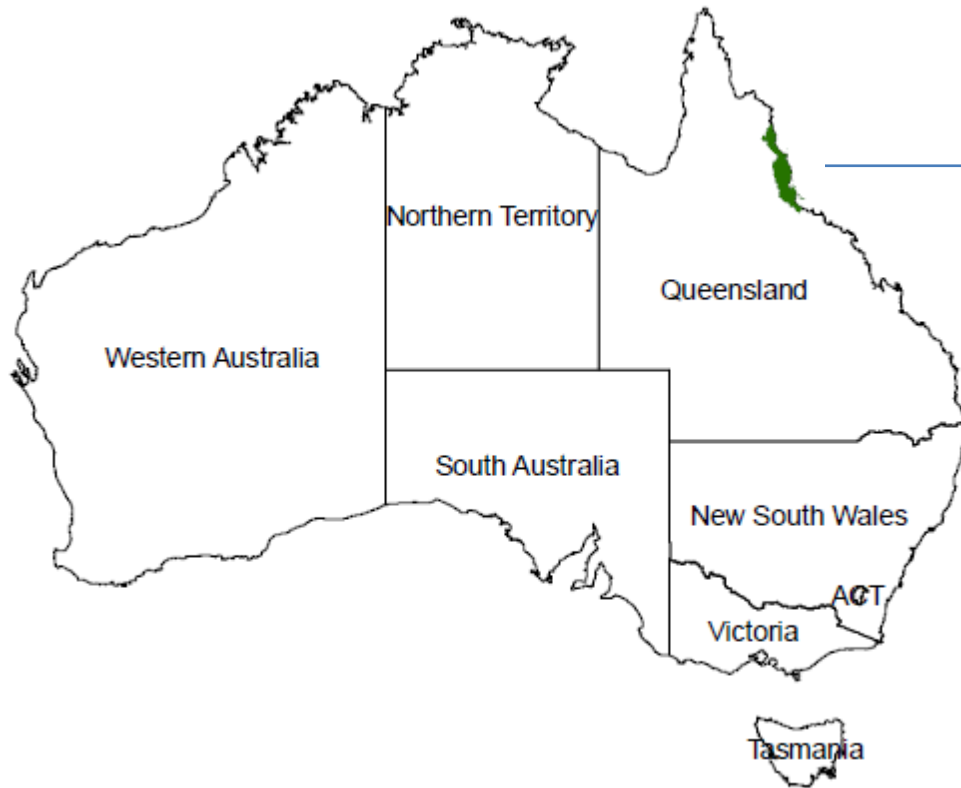
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Wet Tropics Bioregion

- ➤ One of 85 bioregions in Australia.
- ➤ It covers two million hectares (approx.)
- ➤ 894,420 ha (45%) of Wet Tropics bioregion was inscribed on the World Heritage list in December 1988
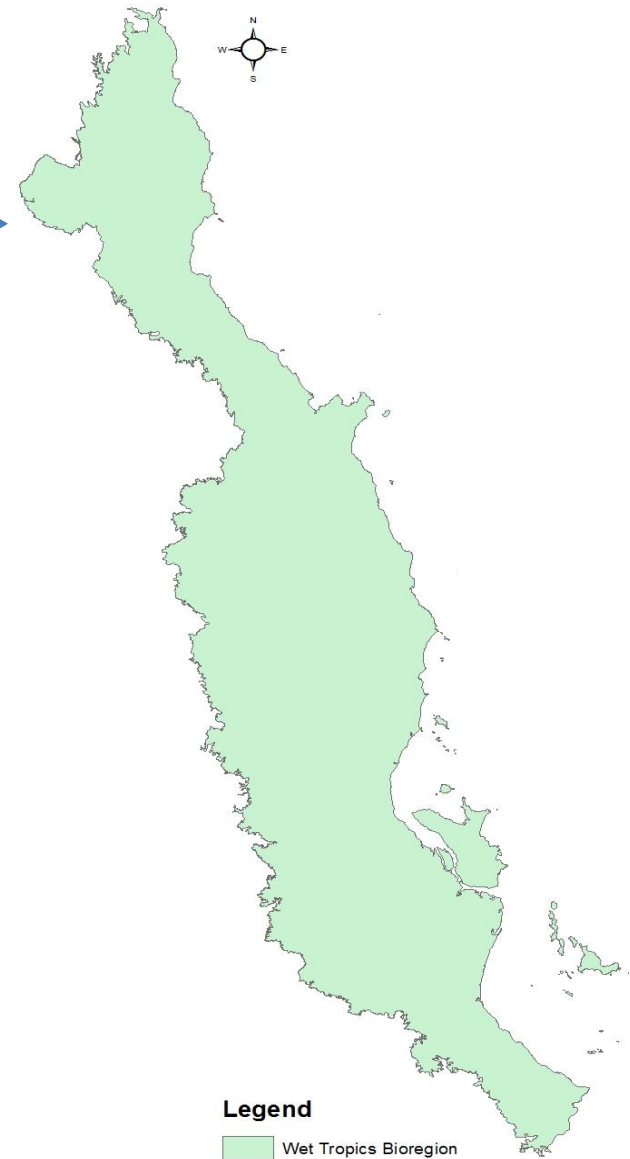- ➤ Located in northeast Queensland

Fig. Wet Tropics Bioregion

(Goosem et al., 1999; WTMA, 2008, 2009, 2012; Pert et al., 2012)

Global scale significance of the Wet Tropics

➢ **Second most irreplaceable** World Heritage Area on the Planet

➢ **Sixth irreplaceability** based on all species, **eighth** based on threaten species among the protected areas in the globe

➢ More primitive plant taxa than any other area on the Earth. Primitive family **Austrobaileyaceae** is available only in the WT.

➢ Contribution to global biodiversity (% of the world's total found in the WT) - Vascular plant species **1.7%**, Mammal species **2.5%**, Bird species **3.4%**, Amphibian species **1.1%**

➢ The rainforests of the WT is one of the oldest **rainforests** on the Earth

➢ Catchment of Great Barrier Reef

Bertzky et al. 2013; Le Saout et al. 2013; Olson et al. 2000; Metcalf and Ford 2009; WTMA 2009; Stork et al. 2011; Hillbert et al. 2014; Commonwealth of Australia 1986; Government of Australia 2007

National scale significance of the Wet Tropics

➢ The largest remaining rainforests in Australia

➢ Contribution to Australia's biodiversity (% of Australia's total found in the WT)- vascular plants 26%, Conifers 37%, ferns-65%, birds- 40%

➢ More than 400 plants and 76 animal species are rare, vulnerable or endangered

➢ More than 23% of tourism activity of Queensland although it is a bit larger than 1% of Queensland

➢ Indigenous heritage values- Queensland National Heritage Listing

➢ Added to the National Heritage List
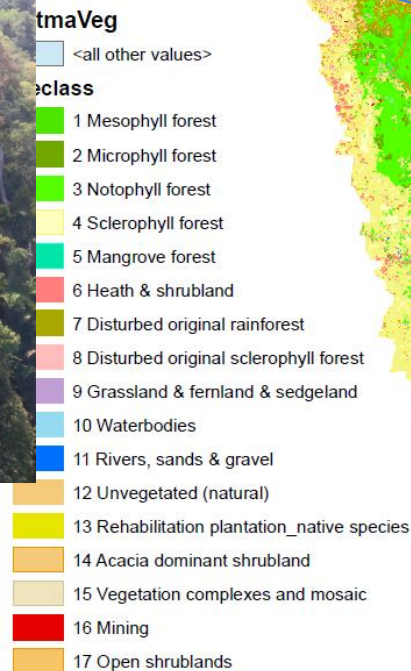
Wet Tropics Bioregion

Rainforests-disturbed

Rainforests

Sclerophyll forests

Sclerophyll forests-disturbed

Mangrove forests

tmaVeg
- <all other values>

eclass
- 1 Mesophyll forest
- 2 Microphyll forest
- 3 Notophyll forest
- 4 Sclerophyll forest
- 5 Mangrove forest
- 6 Heath & shrubland
- 7 Disturbed original rainforest
- 8 Disturbed original sclerophyll forest
- 9 Grassland & fernland & sedgeland
- 10 Waterbodies
- 11 Rivers, sands & gravel
- 12 Unvegetated (natural)
- 13 Rehabilitation plantation_native species
- 14 Acacia dominant shrubland
- 15 Vegetation complexes and mosaic
- 16 Mining
- 17 Open shrublands

Capacities of ecosystem services supply

Reclass no	Land cover type	Ecological integrity	Abiotic heterogenity	Biodiversity	Biotic waterflows	Metabolic efficiency	Energy capture (Radiation)	Reduction of nutrient loss	Storage capacity (SOM)	Regulating services	Local climate regulation	Global climate regulation	Flood protection	Groundwater recharge	Air quality regulation	Erosion regulation	Nutrient regulation	Water purification	Pollination	Cyclone protection	Provisioning services	Livestooks	Fodder	Capture fisheries	Aquaculture	Wild foods	Timber	Wood fuel	Energy	Biochemicals and medicines	Freshwater	Habitat	Cultural services	Recreation and Aesthetic values	Intrinsic value of biodiversity	Total value of ESS
1	Mesophyll forest	32	3	5	5	4	5	5	5	45	5	4	4	3	5	5	5	5	5	4	30	0	0	0	0	5	5	5	5	5	0	5	10	5	5	85
2	Microphyll forest	26	3	4	4	3	4	4	4	42	5	4	3	2	5	4	5	5	5	4	29	0	0	0	0	5	5	5	5	5	0	4	10	5	5	81
3	Notophyll forest	28	3	5	5	3	4	4	4	41	5	4	3	1	5	4	5	5	5	4	30	0	0	0	0	5	5	5	5	5	0	5	10	5	5	81
4	Sclerophyll forest	22	3	4	2	3	3	4	3	23	4	3	2	1	2	2	2	2	2	3	20	2	0	0	0	1	4	2	5	3	0	3	6	2	4	49
5	Mangrove forest	23	2	3	4	3	3	3	5	30	3	3	5	3	2	5	4	0	0	5	19	0	0	0	0	3	3	2	3	3	0	5	9	5	4	58
6	Heath & shrubland	30	3	4	4	5	4	5	5	20	3	3	2	2	0	0	3	4	2	1	11	2	0	0	0	0	1	1	2	2	0	3	6	3	3	37
7	Disturbed original rainforest	18	3	3	2	2	2	3	3	24	3	2	1	1	3	3	3	3	3	2	11	0	0	0	0	2	2	2	2	1	0	2	5	2	3	40
8	Disturbed original sclerophyll	16	3	3	1	2	2	3	2	11	2	1	1	1	1	1	1	1	1	1	10	0	0	0	0	1	2	1	2	2	0	2	4	2	2	25
9	Grassland, fernland & sedgeland	23	3	3	3	3	3	4	4	20	2	1	1	1	0	5	5	5	0	0	7	3	0	0	0	2	0	0	0	0	0	2	4	2	2	31
10	Waterbodies	21	3	3	0	4	4	3	4	7	2	1	1	2	0	0	1	0	0	0	14	0	0	3	0	4	0	0	0	0	5	2	9	5	4	30
11	Beaches, Sands & gravel	10	3	3	1	1	1	0	1	14	0	0	5	1	0	0	3	3	0	2	3	0	0	0	0	0	0	0	1	0	0	2	7	5	2	24
12	Unvegetated (natural)	6	3	3	0	0	0	0	0	4	0	0	1	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	4	4	0	8
13	Rehabilitation plantation_nati	10	2	3	1	1	1	1	1	15	3	2	1	1	1	2	1	2	1	1	14	0	0	0	0	1	3	2	3	2	0	3	6	3	3	35
14	Acacia dominant shrubland	13	2	2	0	1	2	3	3	8	1	1	0	1	0	1	1	1	2	0	9	2	0	0	0	1	1	2	1	0	0	2	4	2	2	21
15	Vegetation complexes and mo	16	3	3	2	2	2	2	2	13	2	2	0	1	0	2	2	2	2	0	7	2	0	0	0	1	0	1	1	0	0	2	4	2	2	24
16	Mineral extraction sites	4	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	Open shrublands-exotics dom	10	1	1	0	2	2	2	2	7	0	1	0	0	0	2	2	2	0	0	4	2	0	0	0	0	0	0	1	1	0	0	1	0	1	12

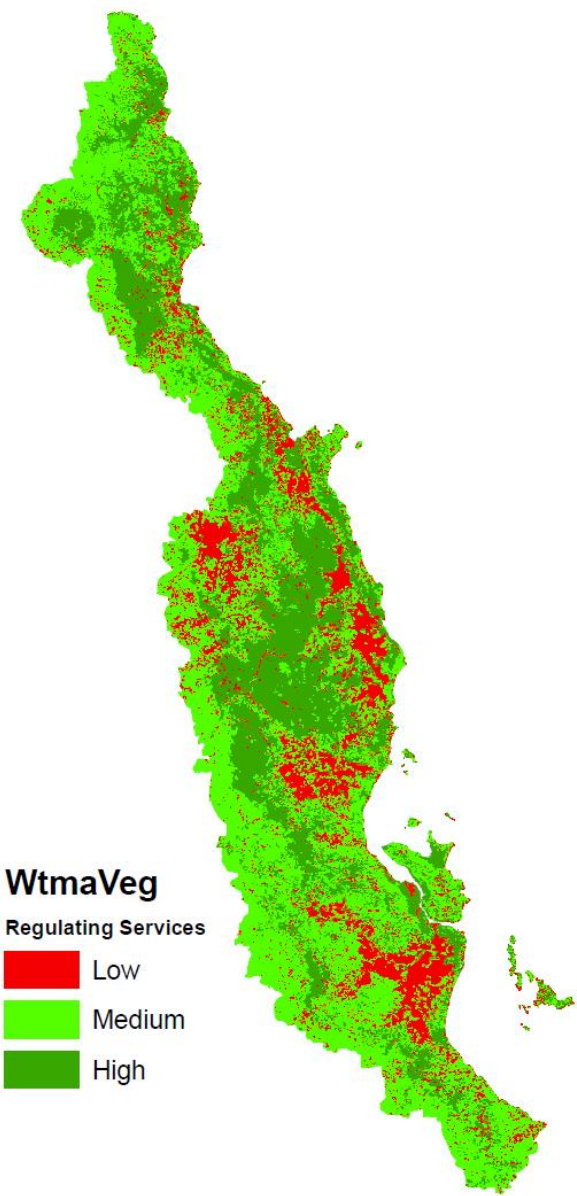Scale for assessing capacities:

0= no relevant capacity
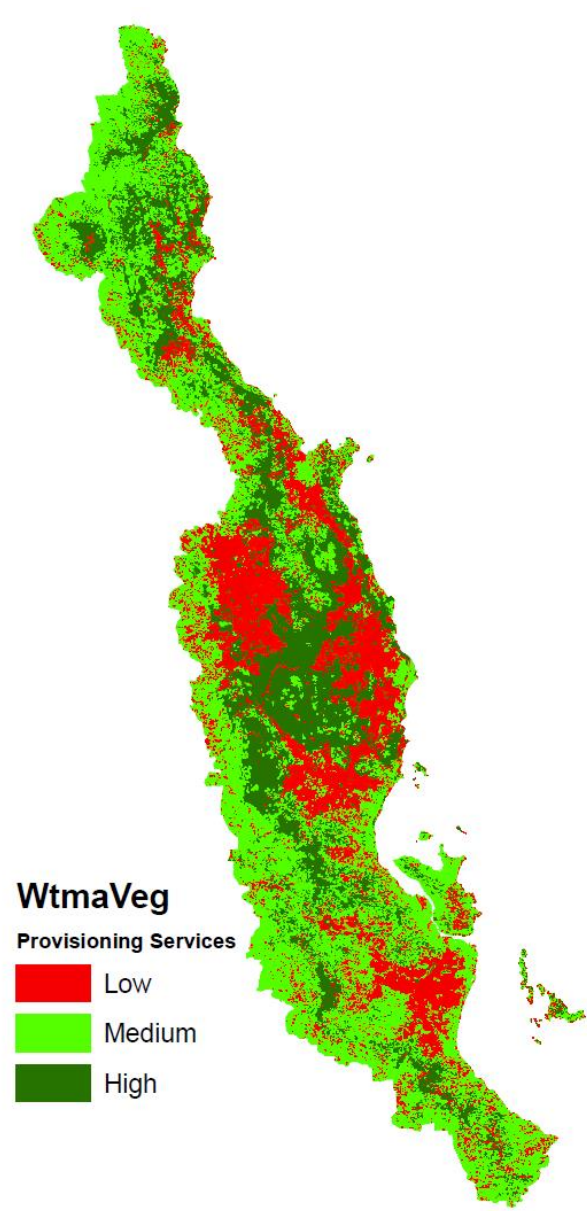
1= low relevant capacity

2= medium relevant capacity

3= high relevant capacity
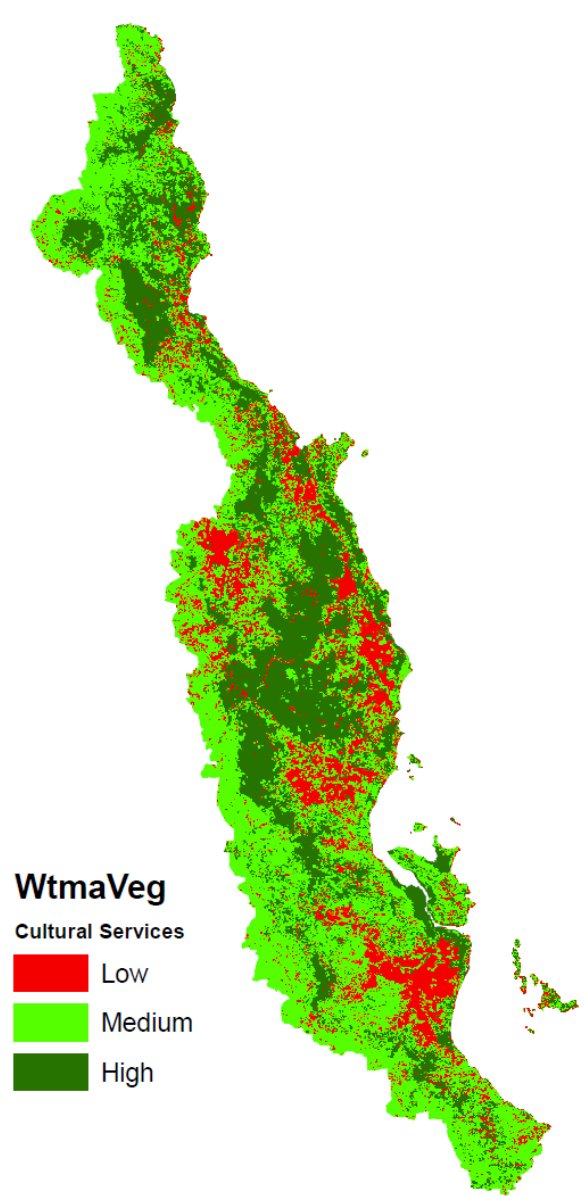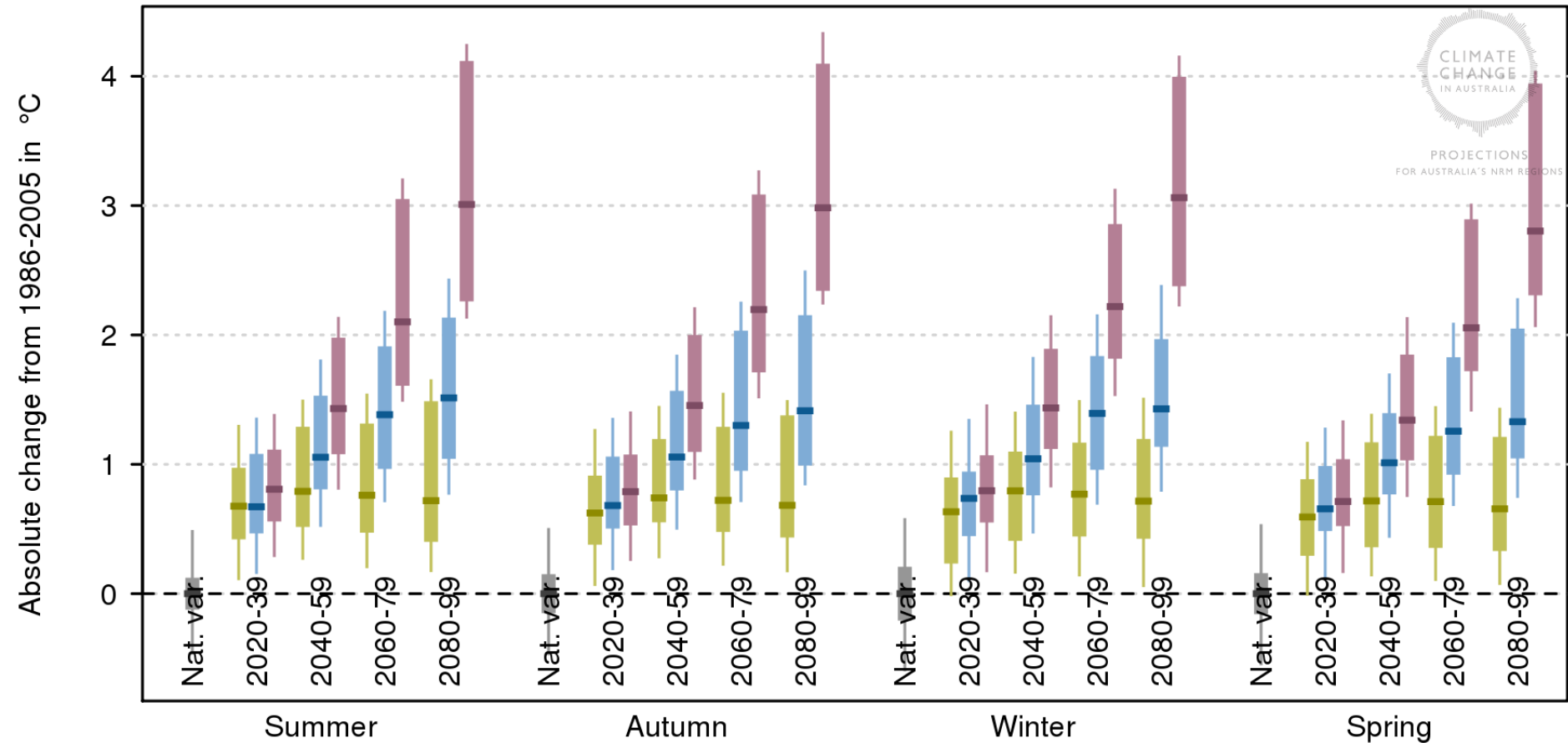
4= very high relevant capacity

Regulating services

Provisioning services

Cultural services

WtmaVeg
Regulating Services
- ■ Low
- ■ Medium
- ■ High

WtmaVeg
Provisioning Services
- ■ Low
- ■ Medium
- ■ High

WtmaVeg
Cultural Services
- ■ Low
- ■ Medium
- ■ High

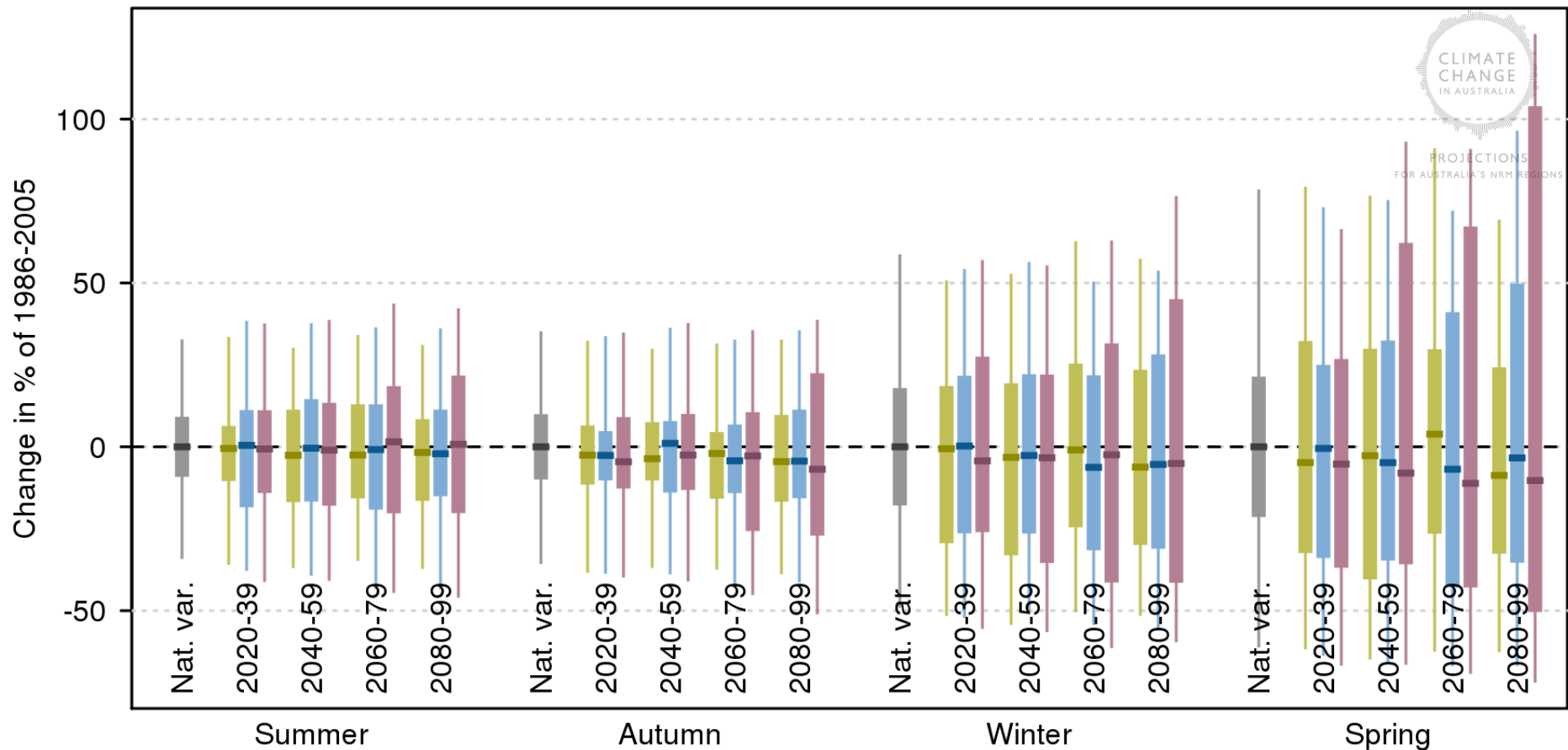# Climate change for Wet Tropics: Seasonal Temperature Change

Model: CMIP5
Left to right: RCP2.6, RCP4.5, RCP8.5
The horizontal line indicates the median
CSIRO climate change tools

Climate change for Wet Tropics: Seasonal Precipitation Change

Model: CMIP5
Left to right: RCP2.6, RCP4.5, RCP8.5
The horizontal line indicates the median
CSIRO climate change tools

Examples of climate change impacts on ecosystem services of the Wet Tropics

Ecosystem service	Impact	Impact trend (+/-)
Climate regulation	Upland forests will release stored carbon to the atmosphere due to temperature rise	-
Water regulation and Water provision	30% additional water are added by cloud strippers in the WT, which will be dramatically impacted by temperature rise	-
Cyclone protection	More pest and disease in mangroves, changing spatial redistribution of mangroves, salinity intrusion	-
Habitat provision	More than 50% of upland rainforests habitat will be lost even at 1°C temperature rise	-
Timber provision	More pest and diseases, will favour vines, fast growing trees and invasion; may positively impact growth rate due to elevated CO_2	-/+

Stork et al. 2011; McJannet et al. 2008; Semeniuk 1994, OCC 2008, Moran and Turton 2014; Hillbert et al. 2001; Laurance 1991, 1997, Kleinbauer et al. 2010, Lawler 2009

Examples of ecosystem service based adaptation options to climate change

Regulating services

Ecosystem services	Target impacts	Adaptation options	Opportunities
Climate regulation	Temperature rise; More intense tropical cyclone	Upland forests conservation; Planting relatively higher wood density trees; agroforestry	Habitat for biodiversity; water regulation; landscape rehabilitation; soil improvement
Water regulation	Temperature rise; Changing pattern of rainfall	Avoiding disturbances in upstream vegetation; Riparian restoration, Forest restoration with high regulation capacity; Protection of upland forests	Native biodiversity enrichment; carbon credit; habitat connectivity; credit for biodiversity conservation; recreation and aesthetic value; native biodiversity habitat
Cyclone protection	More intense tropical cyclone; sea level rise; salinity intrusion	Mangroves protection; Facilitation of inward movement of mangroves; Restoration of littoral forests and coastal plantation with native species	More blue carbon; protection of coastal community & infrastructure, eco-tourism

Rebbeck et al. 2007, Curran et al. 2008, Battaglia 2011, Murphy et al. 2012; Baral et al. 2012, Palmer et al. 2008, Scott et al. 2008, Hansen et al. 2003, Robledo & Forner 2005, Sáenz & Mulligan 2013; Spalding et al. 2014, Semeniuk 1994, Alongi 2008, Ross et al. 2000, McIvor et al. 2012a

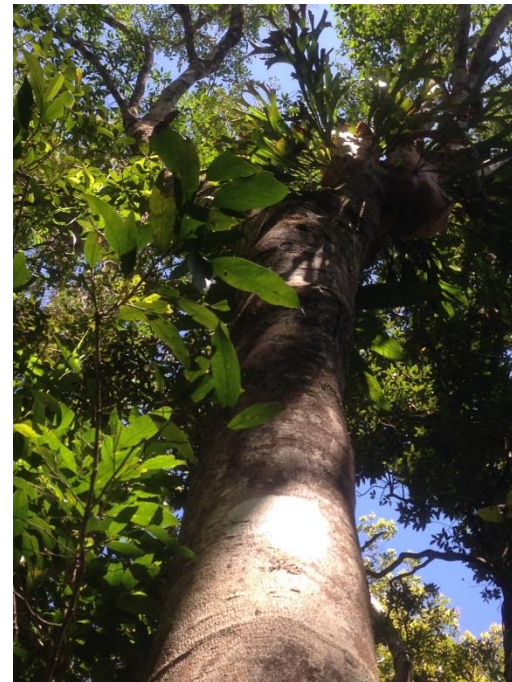## Usefulness of mangroves for coastal protection and erosion control

➢ Reduce wave energy and water velocity, and erosion

➢ Increase sedimentation and reduce movement of sediments

➢ Effective in trapping fine sediment particles

➢ Increase soil cohesion and act as a barrier between soil and water

➢ Wave heights can be reduced by 13% to 66% over 100 m of mangroves

➢ Storm surge height can be reduced between 4 to 48 cm per kilometre of passage through mangroves

Gedan et al.2011, Shepard et al. 2011, Spalding et al. 2014; Wolanski 1995, Young & Harvey 1996; McIvor et al. 2012a; Krauss et al. 2009, McIvor et al. 2012b; Zhang et al. 2012

Examples of ecosystem service based adaptation to climate change

Provisioning services

Ecosystem services	Target impacts	Adaptation options	Opportunities
Habitat provision	Temperature rise	More ecological connectivity	Carbon credit
Timber provision	More intense tropical cyclone	Planting native tropical cyclone resistant trees; exotics from cyclone prone provenances; use of reduced impacts logging	Secure productivity even after tropical cyclone

Heller & Zavaleta 2009, Lawler 2009, Shafer 1999; Timber Queensland 2012, Metcalfe et al. 2008, Roberts et al. 2009, Galatowitscha et al. 2009

Ranking of cyclone resistance trees*

Scientific name	Common name	Cyclone resistance
Elaeocarpus angustifolius/grandis	Silver quandong	Very Good
Eucalyptus cloeziana	Gympie messmate	Good
Eucalyptus grandis	Rose gum(flooded gum)	Good
Eucalyptus pellita (young trees < 8 yo)	Red mahogany (pellita)	Good
Eucalyptus pellita (older trees > 8 yo)	Red mahogany (pellita)	Good
Flindersia brayleyana	Queensland maple	Good

(*assuming category 2 cyclone) based on post tropical cyclone Yasi field observations by DAFF (after Timber Queensland 2012, full list is available in www.timberqueensland.com.au)

Conclusion

➢ Adaptation should be ecosystem service based
➢ Opportunities of multiple benefits
➢ Scale matter

Acknowledgements