Biodiversity indicators and agriculture

Application and development of methods

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Introduction

Why? Land use change main threat to biodiversity – agriculture main land use change.

Chaudhary and Brooks (CB) method

- Builds on UNEP-SETAC working group
- Recommended by Food Agriculture Organization
- Characterisation Factors available in LCA software

Question:

1. What is it?
2. How is it implemented with existing LCA agricultural data sets?
3. What is the potential to develop it further?

Ecoregions and land use types

- 14 types of biomes used to define the ecoregions
- 867 distinct units of these 14 types of biome for the terrestrial world

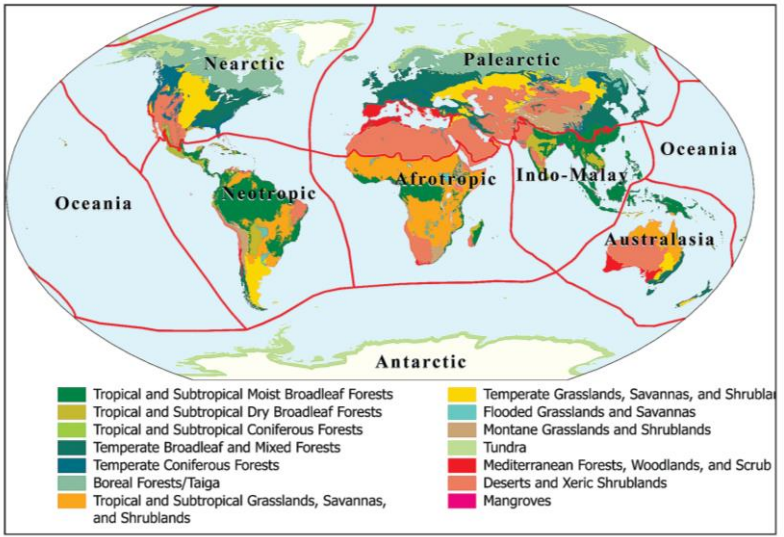
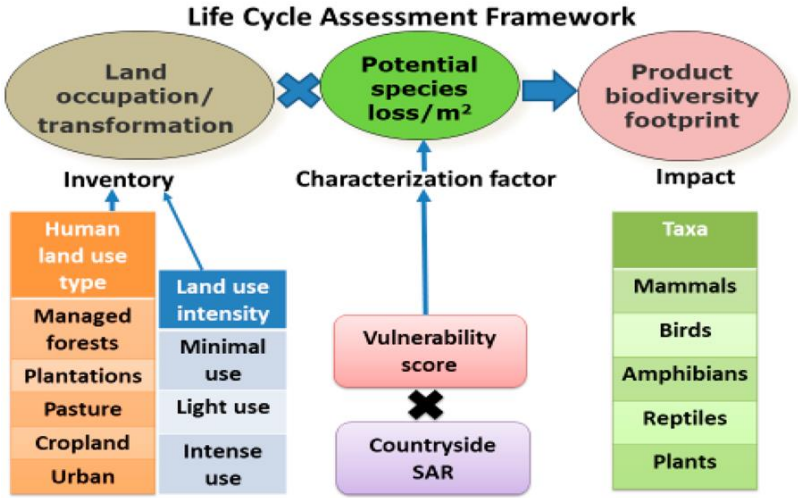


Figure 1. The ecoregions are categorized within 14 biomes and eight biogeographic realms to facilitate representation analyses.

What is the CB method?

- Species Area Relationship (SAR) is an empirical relationship which relates the amount of land to the number of species supported.
- Maps of land use change compared to the reference state are used to calculate the Potential Disappeared Species which is modified further by a vulnerability score.



Land use impact – and importance of time

- Assumption that land can regenerate to a reference state over time –slope of line to regenerate actually more in the order of 1:100
- Impact a function of change in ecosystem quality by the time to regenerate ie ΔQ*Δt

Transformation –function of ΔQ for a particular change in land use and the time to return to the reference state

Occupation – like transformation but limited to the period of use – which will be relatively small when expressed in terms of time for a yield

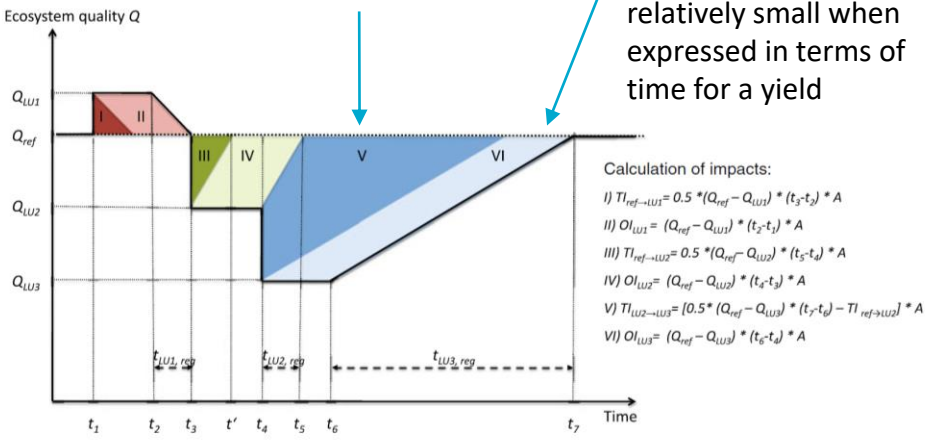


Fig. 1 Simplified illustration of transformation impact (*TI*) and occupation impact (*OI*) for three land use types with different regeneration rates ($t_{LU1,\,reg}$, $t_{LU2,\,reg}$ and $t_{LU3,\,reg}$). For simplicity, the area A of occupation or transformation, which would embrace the third dimension, is not shown in the graph, but in the equations

Maths...

Species lost a function of the habitat area available, species affinity (h) for the habitat divided by original habitat area – then expressed using the species area curve (z)

$$S_{\text{lost},g,j,\text{regional}} = S_{\text{org},g,j}\left[1 - \left(\frac{A_{\text{new},j} + \sum_{i=1}^{n} h_{g,i,j}A_{i,j}}{A_{\text{org},j}}\right)^{z_j}\right] \quad (1$$

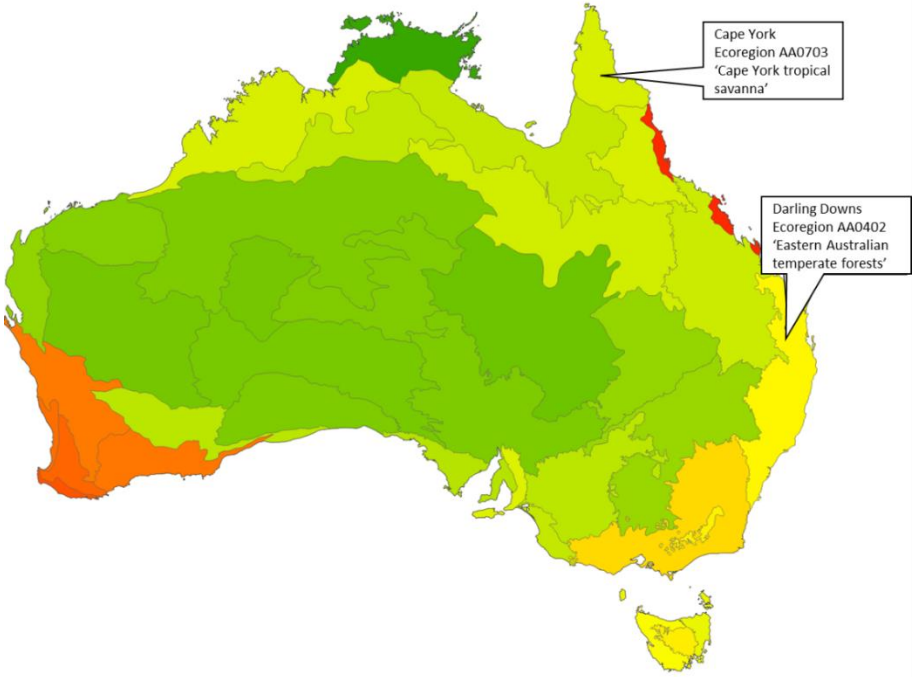
CF occupation a function of how common the habitat area (a) is and its proportion in the land area converted (p)

$$\text{CF}_{\text{regional,occ},g,i,j} = \frac{\partial S_{\text{lost},g,j} a_{i,j}}{\partial A_{\text{lost},g,j} p_{i,j}}$$

CF transformation then occupation by the time to regenerate (t)

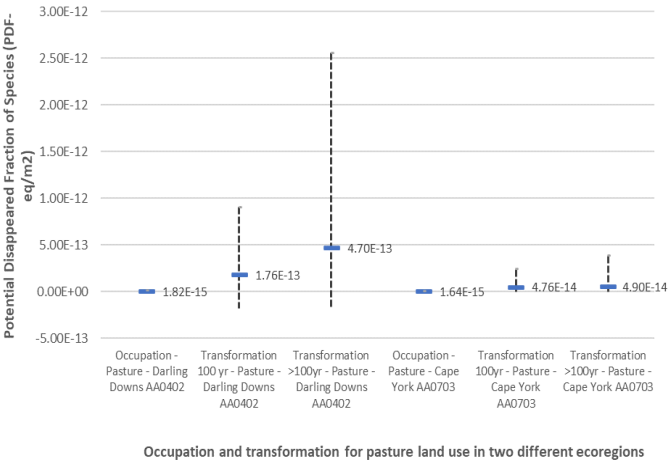
$$\text{CF}_{\text{regional,trans},g,i,j} = 0.5 t_{\text{reg},g,i,j} \text{CF}_{\text{reg,occ},g,i,j}$$

Ecoregions


Cape York
Ecoregion AA0703
'Cape York tropical
savanna'
Darling Downs
Ecoregion AA0402
'Eastern Australian
temperate forests'

AREA, same land use type, different ecoregions

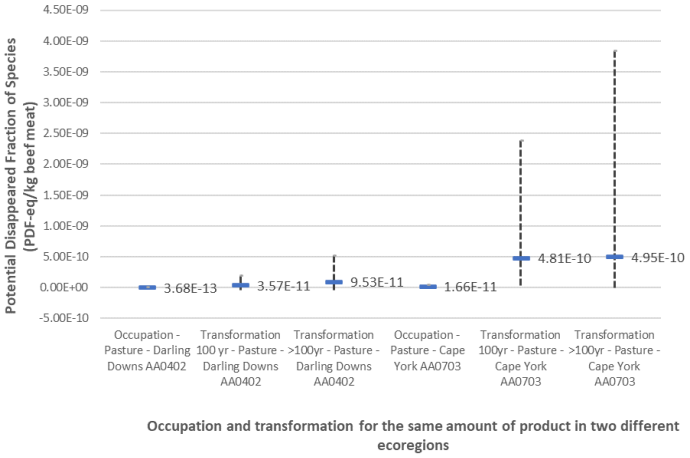
- Per unit of area
  - Cape York pasture appears to have a lower Potentially Disappeared Fraction of Species (PDF)
  - There is very large uncertainty in the characterisation factors which means that the comparison is not significantly different – ie Cape York range falls within the range of Darling Downs.



Occupation and transformation for pasture land use in two different ecoregions

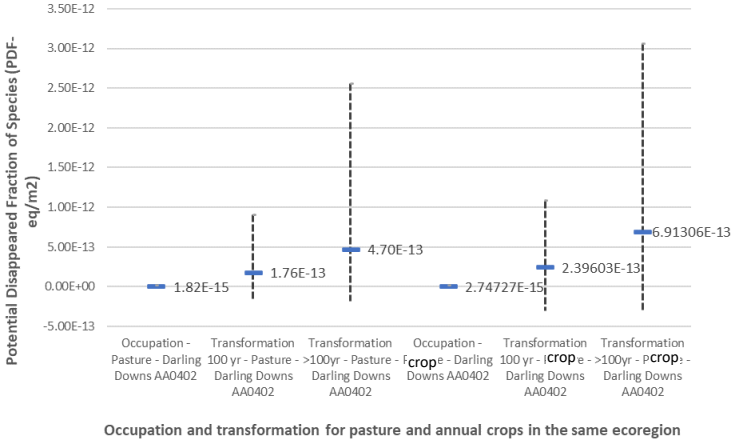
YIELD, same land use type, different ecoregions

- Per YIELD of beef meat
  - Cape York appears to have the greater PDF due to greater land area needed for the same output
  - Limitations for uncertainty for the comparison remain.



AREA, same ecoregion, different land use type

- AREA
  - Crops has a bigger PDF than and area of pasture in the same ecoregion.
  - Limitations for uncertainty for the comparison remain.

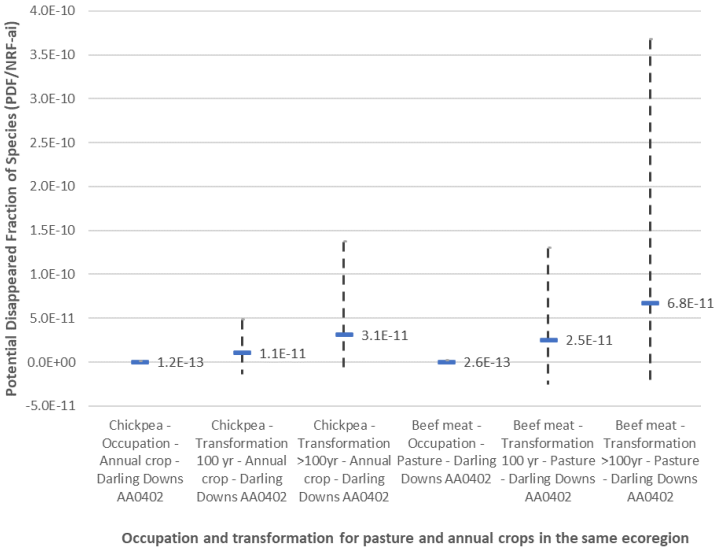


Occupation and transformation for pasture and annual crops in the same ecoregion

FUNCTIONAL UNIT, same ecoregion, different land use type

	g/serve	NRF-ai/serve	NRF-ai/kg	kg/NRF-ai	ha/kg	ha/NRF-ai
Chickpeas, canned, drained	150	0.105	0.700	1.43	0.00313	0.00448
Beef, diced, lean, raw	95	0.134	1.4105	0.709	0.0203	0.0144

- NUTRIENT RICH FOOD – adequate intake (NRF-ai) (Ridoutt 2021)
  - Beef appears to be double – but difference much less than area use due to higher nutrient value of meat.
  - Limitations for uncertainty for the comparison remain.



Allocation….

- Allocation for chickpeas?
  - In most crop rotations, chickpeas are grown to support the main crop, which is wheat.
  - Provide N which increases the yield for wheat

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Next steps

- Review data sets in AusAgLCI for occupation and transformation
- Reduce uncertainty
  - High because uses 14 biomes for the whole world – even through there are 804 ecoregions. For example, the CF for the biome of 'Tropical and Subtropical Grasslands, Savannas and Shrubland', which is a main biome in the Cape York ecoregion, is calculated as part of the same biome for large parts of Africa and South America.
  - Biodiversity Habitat Index (Hoskins, Harwood et al. 2020) has a similar conceptual basis (species area curve) but much greater resolution and lower uncertainty (in the order of +-20%).
  - Focus on affinity and calculation of how unique a land area (considers interconnectivity between locations) - building blocks of both indicators (but different conceptual model for expressing it).

1 km2 grid for globe – can be downscaled to farm level

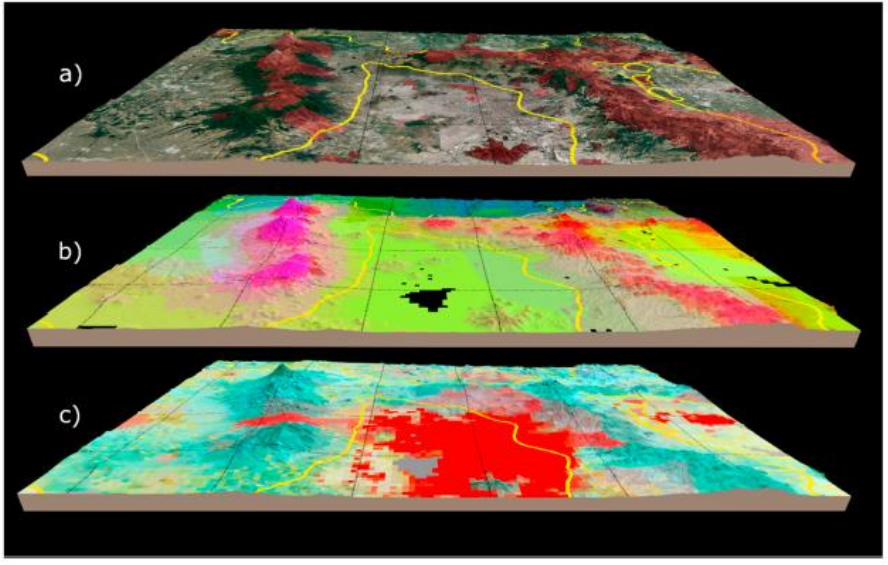

Fig. 1. The spatial resolution problem in global biodiversity assessments. (a) a true colour satellite overlay of Mexico city and surrounds; also overlayed are protected areas (in red), a 30km grid (black lines) and ecoregional boundaries (yellow lines). Note; the geographic/topographic biases in location for protected areas and urban/agricultural development. (b) the same region but showing differences in the composition of ecological communities occurring in each 1 km grid-cell prior to habitat transformation; similar colours represent similar communities. (c) downscaled land-use mapping from Hoskins et al. (2016) where red depicts urbanisation, yellow represents cropping regions and green shows natural environments – note: colours show proportional values of land-use with the transparency set as the proportion of each land-use and, as such, blended colours represent cells with mixed land-uses.

Uncertainty in key parameters low and can be compared and update Chaudhary and Brooks

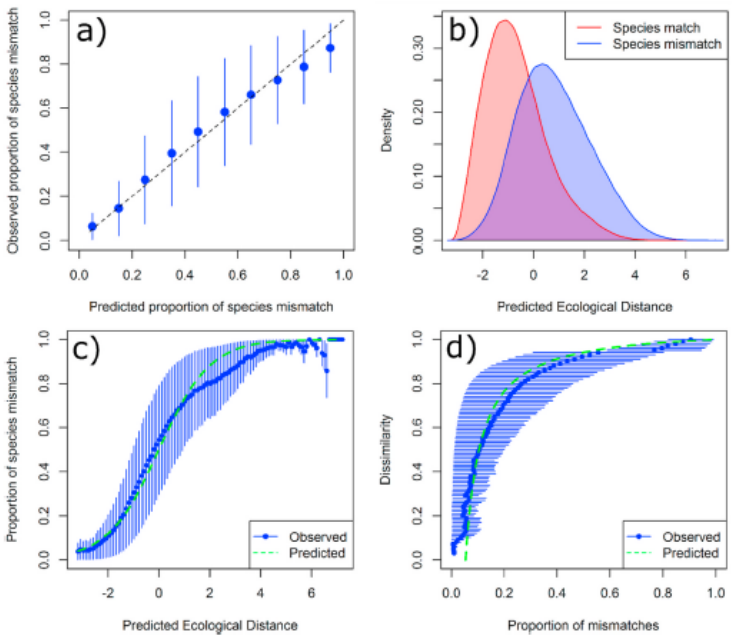

Fig. 3. Example model fit and validation outputs. (a) observed proportion of species mismatches for 10 bins, against predicted proportion of species mismatches. (b) density of observed species matches and mismatches, against predicted ecological distance (in logit space). (c) observed (blue) and predicted (green) proportion of species mismatches for 100 bins, against predicted ecological distance (in logit space). (d) comparison of observed (blue) and predicted (green) compositional dissimilarity, against the proportion of mismatches. All error bars show the observed proportion of matches and mismatches ± the variance. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

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