Analyzing changes in extent of a critically endangered ecosystem using the System of Environmental-Economic Accounting

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Abstract

Box gum grassy woodland in Australia is a threatened ecological community listed under the Environment Protection and Biodiversity (EPBC) Act 1999. This ecosystem occurs between the forests of the wetter coastal areas and the arid interior from Victoria to southern Queensland, but only about 5% of the pre-European settlement distribution remains. Historical and ongoing threats include land clearing due to agricultural development, grazing and firewood collection. In this paper, we apply the concepts in SEEA ecosystem accounting to develop land accounts with a view to producing accounts for the ecosystem services (e.g. carbon sequestration, carbon storage, biodiversity conservation, water filtration) from a box gum grassy woodland within a broader agricultural area. The study's ultimate aim is to highlight opportunities for win-win management situations and the situations where the multiple perspectives create conflict which mean that trade-offs need to be made by decision makers at national, regional and farm levels.

The land accounts produced so far draw on a range of data sources and highlight a number of issues with the remotely sensed input data and in defining the output areas. For the output areas we used the area identified in the EPBC Act 1999, which is based on the historical extent of the box gum grassy woodlands. This area was selected as it the area to

which the provisions of the EPBC Act 1999 apply. The area was further sub-divided by the natural resource management regions each of which has an agency dedicated to land management.

The input data is from a range of sources. The resolution of the remotely sensed data combined with the effects of aggregation, mean that additional information is needed to enable better analysis and decision making related to maintaining and restoring box gum grassy woodlands. In this, field-based data are needed to provide additional detail on species composition, particularly for isolated trees, as well as for estimates of ecosystem services, which will be done as part of the next stage of the project. Information on the value of agricultural production, which would come from the Australian Bureau of Statistics would enable the assessment of trade-offs between agriculture and the restoration and conservation of box gum grassy woodlands.

Questions to London Group:

- Does the London Group agree with the decision to use the output areas of the area listed under the EPBC Act 1999, subdivided by the land management regions?
- What experience have London Group members had with using remotely sensed data to estimate ecosystem condition and in particular age of different ecosystems?
- What experience have the London Group members had with combining field based measurements with remotely sensed data?
- What experience have the London Group members had with analysing drivers behind land cover changes?

Introduction

The spatial extent of an ecosystem is a critical part of its conservation assessment under the new IUCN Red Listed Ecosystems approach (Keith et al. 2013). Spatial data on whether a particular ecosystem is increasing or declining in extent are therefore critical to determine its status and whether interventions like greater protection are required.

The Australian White Box-Yellow Box-Blakely's Red Gum Grassy Woodland is a critically endangered ecosystem listed under the Environmental Protection and Biodiversity Conservation (EPBC) Act 1999[1]. This is a highly fragmented ecosystem, found between the forests of the wetter coastal areas and the arid interior from Victoria to southern Queensland. Remnants are characterised by an open woodland structure and are important habitat for a range of threatened species, both animals and plants (Department of Environment, Climate Change and Water NSW 2010).

Ecosystems are dynamic entities and extent will vary over time both due to natural processes and human intervention. A dynamic process model of box gum grassy woodland is shown in Figure 1. The main threatening processes for this ecosystem are clearing and grazing. However, the threatening processes are potentially reversible given enough time. Removing grazing pressure will allow regeneration in remnants which can replace mature trees as they reach the end of their lifespan. Environmental plantings can develop into mature woodlands. Also, abandoned agricultural land can potentially grow into mature woodlands (Geddes et al. 2010). In this study, we limit our scope to the trees characterising

[1] See EPBC Act 1999: https://www.environment.gov.au/epbc

box gum grassy woodland. In its natural state the ecosystem will also include native ground cover species as well as tree species. Native ground cover has additional threatening processes, for instance changed soil chemistry due to grazing, introduction of non-native plant species and grazing from non-native and native species. In addition, change in natural disturbance factors such as drought and fire due to climate change is not considered.

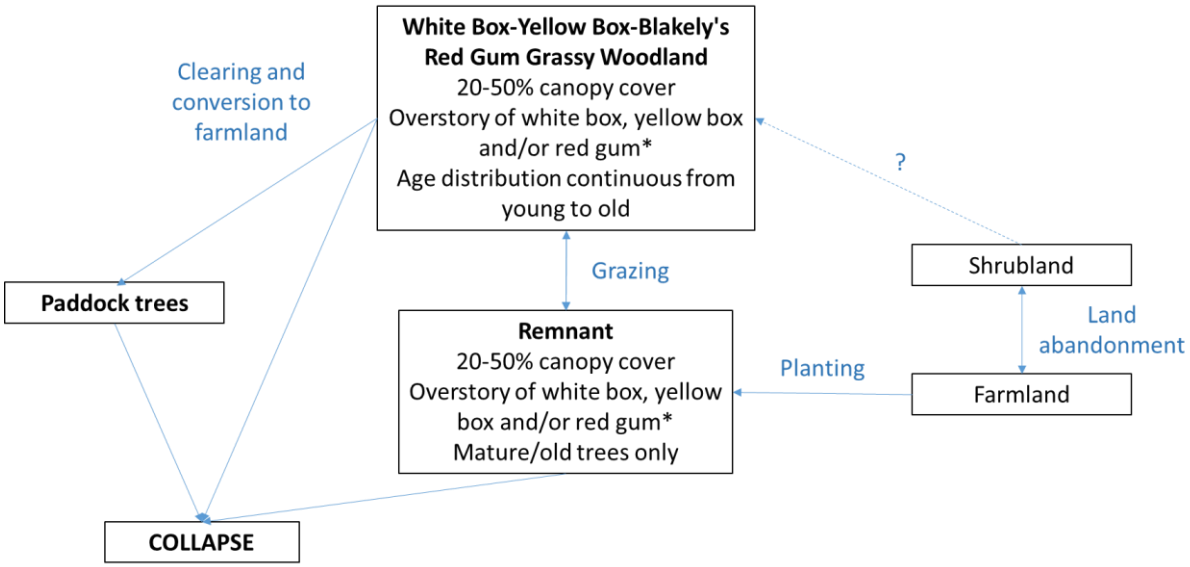


Figure 1. Process model of White Box-Yellow Box-Blakely's Red Gum Grassy Woodland ecological community, adapted from Tozer et al. (2014).
*or associated species, listed in Department of Environment, Climate Change and Water NSW (2010).

The System of Environmental-Economic Accounting (United Nations 2014) offers an internationally recognised standard for analysing land cover and land use change over time. In this paper, we discuss whether land accounting can be used to analyse rates of change in extent of box gum grassy woodland.

First, we give an overview of land cover in the box gum grassy woodland region. Second, we visually show extent and changes in extent using the natural resource management region Riverina as a case study. Third, we present a time series of box gum grassy woodland extent

in Riverina based on a land account. Based on this, we discuss methodological challenges in land accounting relating to our application and whether the land account is fit for purpose.

Methods

Box gum grassy woodland's natural extent is along the slopes and tablelands of Queensland, New South Wales, Australian Capital Territory and Victoria (Beadle 1981), in areas with rainfall level of 400-800 mm per year and altitude 170-1200 m above sea level. Many estimates of the boundary for the pre-European settlement extent of the ecosystem are possible, we have chosen the boundary referred to in the listing under the EPBC Act 1999 (Department of Environment, Climate Change and Water NSW 2010). Aligning the accounts with the area identified in the EPBC Act 1999 means that the management actions and policies enable by this legislation can be directly informed by the accounts

Within the boundary identified in the EPBC Act 1999 for the box gum grassy woodlands are 26 Natural Resource Management Regions, which are whole or partly within the region and are responsible for delivering management. As such, information for these regions are also used in the land accounts.

The current extent of the box gum grassy woodlands is only a fraction of the area listed in the in the EPBC Act 1999. Most of the area listed is dominated by agricultural land and also includes areas with other vegetation types (e.g. forests). In our analysis, box gum grassy woodland is defined as areas with canopy cover >20% which were not used for forestry or national parks in 2016 (see list of data sources in Table 1 in the appendix). While this

exclusion is based on land use, rather than land cover or ecosystem type, the areas used for forestry or national parks are for the most part different vegetation types than woodland.

Results

Map 1 gives an overview of land cover in our study area in 2018. The area is dominated by agriculture, i.e. cropland and grassland used for pasture. Woodland vegetation occurs as patches in the agricultural landscape or as foothills towards higher elevation/rainfall areas with forest.

Map 2 shows tree cover types in relevant areas of Riverina in 2000. Open land dominates the landscape. Woodlands are highly fragmented across the landscape.

Map 3 shows tree cover types in Riverina in 2015. Most of the area did not change in terms of tree cover type from 2000 to 2015. Compared to tree cover in 2000 (Map 2), there was more area with woodland in 2015, although the changes are small. Tree cover changes between 2000 and 2015 can also be seen in Map 4. Although there is overall more woodland in 2018, some areas have been cleared and other regrown.

Box gum woodland extent in Riverina estimated using a land account is shown in Figure 2. Overall extent of box gum woodland in Riverina has increased over the period.

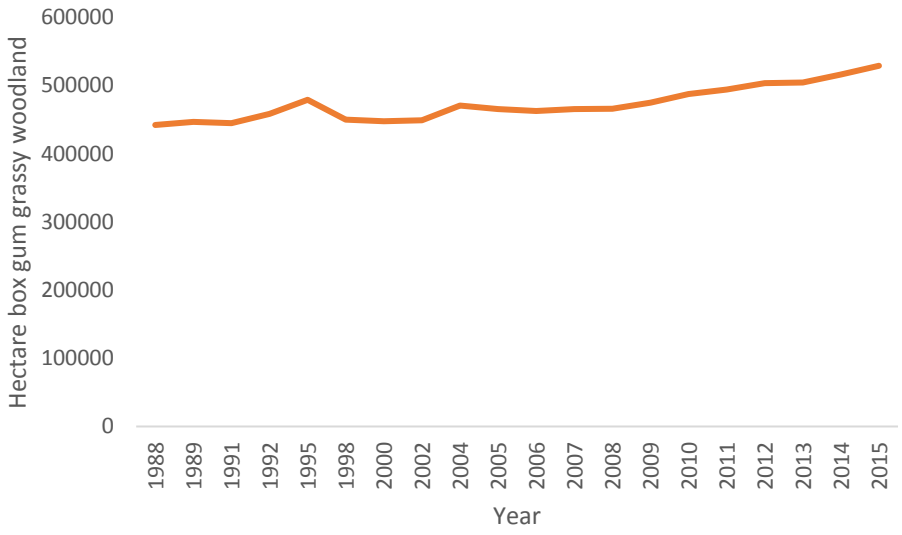


Figure 2. Estimated extent of box gum grassy woodland in Riverina using land accounting.

Discussion

It is important to note that changes in tree cover in Map 4 are not like for like. Existing tree covered areas in 2000 most likely contained box gum remnants which have a much higher value for biodiversity than recently regrown areas. The land account aggregates woodland extent for the whole reporting unit and is not able to distinguish between old remnants and new regrowth. This is an example of the modifiable areal unit problem (Lloyd 2014), where detail is lost when aggregating over a large area. Having ecosystem condition accounts, where old remnants are in better condition than regrowth areas, would help show these differences. This would be similar to what was done in the Central Highlands of Victoria, where forest condition was based on age since disturbance (See Keith et al 2017a,b). In this a matrix of ecosystem condition would be useful for understanding the changes in the box gum grassy woodlands and will be investigated going forward.

Another important point is that the tree cover dataset has a resolution of 30m. This resolution is too large to detect individual old box gum trees spread across the agricultural

landscape. These trees play an important role for biodiversity (Fischer and Lindenmayer 2002). Again, additional research can assist in assessing this issue. For example, using NCAS maps, land cover and ecosystem condition change matrices. This would also help to identify the extent to which box gum grassy woodland is overestimated because we are unable to determine tree species in the datasets (i.e. non-box gum species are incorrectly identified as box gums). This could probably be improved by using the NVIS pre-settlement vegetation extent to exclude other vegetation types than box gum woodland. On-ground field measurements would also address the issue.

From map 4, we see that regrowth has occurred on more marginal land used for grazing to the west of the region while clearing has happened in the more fertile and wetter areas to the east.

Loss of tree covered areas, can in our study be due to factors other than clearing. For instance, old trees dying because they are at the end of their lifespan, fire, disease and pests, changed soil conditions, or a combination of interacting factors producing 'eucalypt dieback'. On average, over the period 2009-2017, 530 ha of land was cleared per year in Riverina (New South Wales Government 2019).

Conclusions

There was more area with woodland tree cover in Riverina in 2018 than in 2001. However, over the period woodland tree cover was lost across the agricultural landscape while other areas had regrowth due to plantings or land abandonment. The land account is in its current form not able to distinguish between regrowth and remnants. Ecosystem condition accounts or matrices of change would address this issue, but it is not yet clear if there are data available that would enable this.

References

Beadle, NCW 1981. The vegetation of Australia. Vegetationsmonographien der einzelnen Großräume. Band IV.

Department of Environment, Climate Change and Water NSW 2010. National Recovery Plan for White Box - Yellow Box - Blakely's Red Gum Grassy Woodland and Derived Native Grassland. Department of Environment, Climate Change and Water NSW, Sydney.

Department of the Environment and Energy 2017. National Forest and Sparse Woody Vegetation Data (Version 1.0).

Fischer, J. & Lindenmayer, D.B. 2002. The conservation value of paddock trees for birds in a variegated landscape in southern New South Wales. 2. Paddock trees as stepping stones. *Biodiversity and Conservation* 11: 833. https://doi.org/10.1023/A:1015318328007

Friedl, M., D. Sulla-Menashe. MCD12Q1 MODIS/Terra+Aqua Land Cover Type Yearly L3 Global 500m SIN Grid V006. 2019, distributed by NASA EOSDIS Land Processes DAAC, https://doi.org/10.5067/MODIS/MCD12Q1.006.

Geddes LS, Hunt ID, Smallbone LT and Morgan JW 2011. Old field colonization by native trees and shrubs following land use change: Could this be Victoria's largest example of landscape recovery? Ecological Management & Restoration 12(1): 31-36.

Keith DA, Rodriquez JP, Brooks TM, Burgman MA, Barrow EG, Bland L, Comer PJ, Franklin J, Link J, McCarthy MA, Miller RM, Murray NJ, Nel J, Nicholson E, Oliveira-Miranda MA, Regan TJ, Rodriguez-

Clark KM, Rouget M and Spalding MD 2015. The IUCN red list of ecosystems: Motivations, challenges, and applications. Conservation Letters 8 (3): 214-226.

Keith et al. 2017a. Experimental ecosystem accounts for the Central Highlands of Victoria. http://www.nespthreatenedspecies.edu.au/publications-tools/experimental-ecosystem-accounts-for-the-central-highlands-of-victoria-full-report-high-res-40mb

Keith H, Vardon M, Stein JA, Stein JL, Lindenmayer D 2017b. Ecosystem accounts define explicit and spatial trade-offs for managing natural resources. Nature Ecology and Evolution 1: 1683 – 1692.

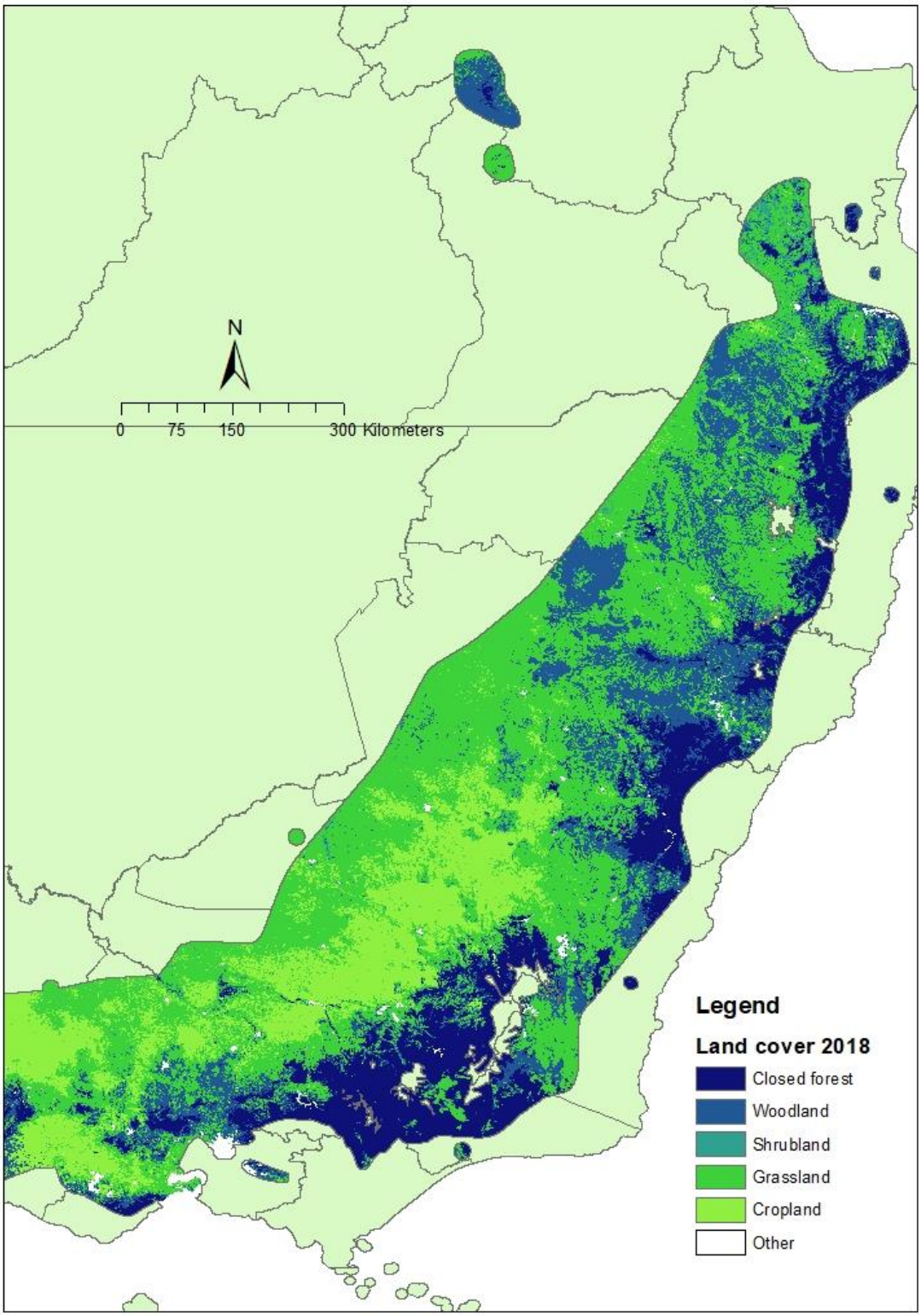
Lloyd, C. D. 2014. Exploring spatial scale in geography. Wiley Blackwell.

New South Wales Government 2019. NSW Woody Vegetation Change 2017/18 spreadsheet. https://www.environment.nsw.gov.au/topics/animals-and-plants/native-vegetation/reports-and-resources/reports

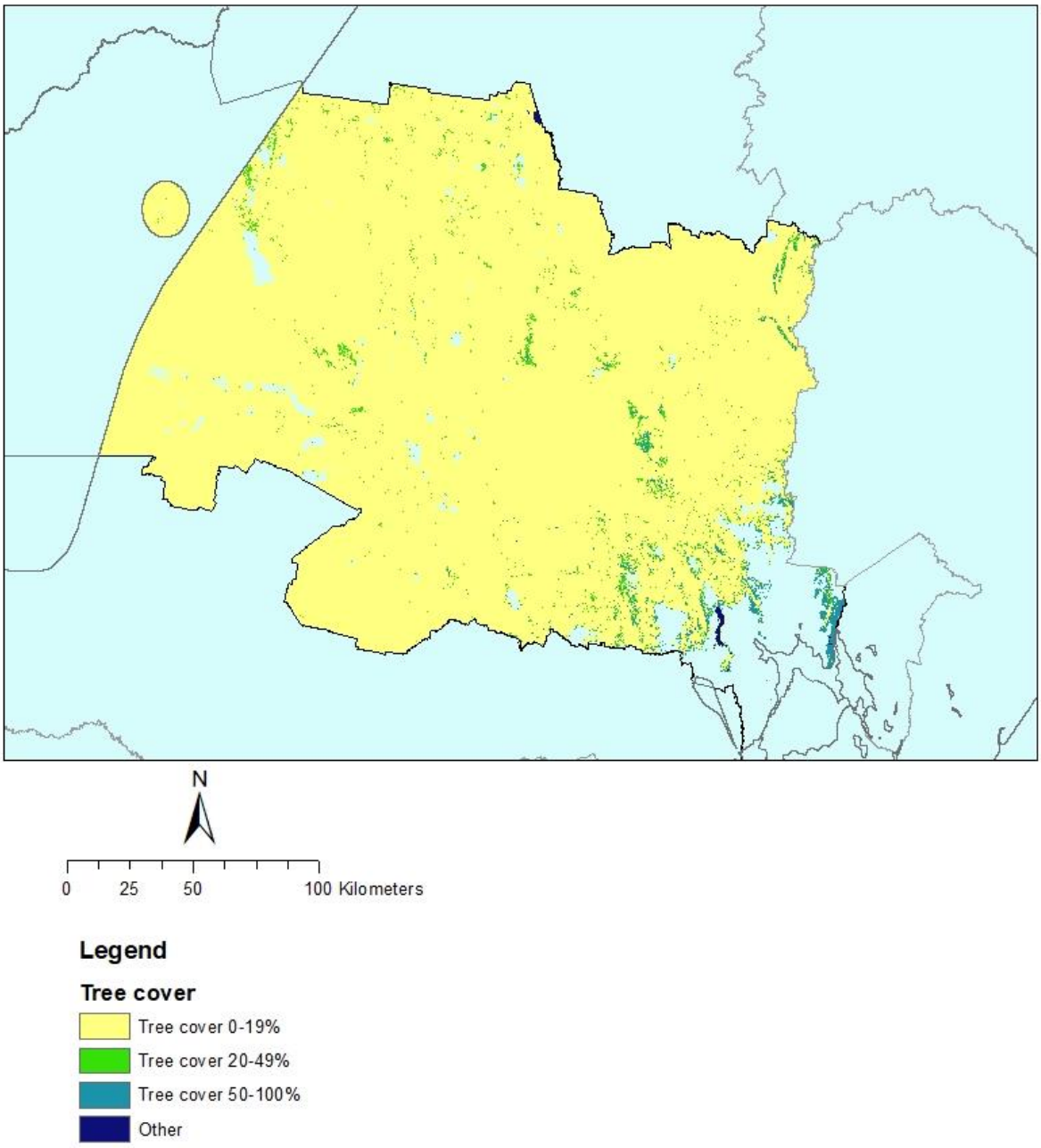
Townshend, J. 2016. Global Forest Cover Change (GFCC) Tree Cover Multi-Year Global 30 m V003, distributed by NASA EOSDIS Land Processes DAAC, https://doi.org/10.5067/MEaSUREs/GFCC/GFCC30TC.003.

Tozer MG, Leishman MR, Auld TD 2014. Ecosystem risk assessment for Cumberland Plain Woodland, New South Wales, Australia. Austral Ecology 40: 400-410.

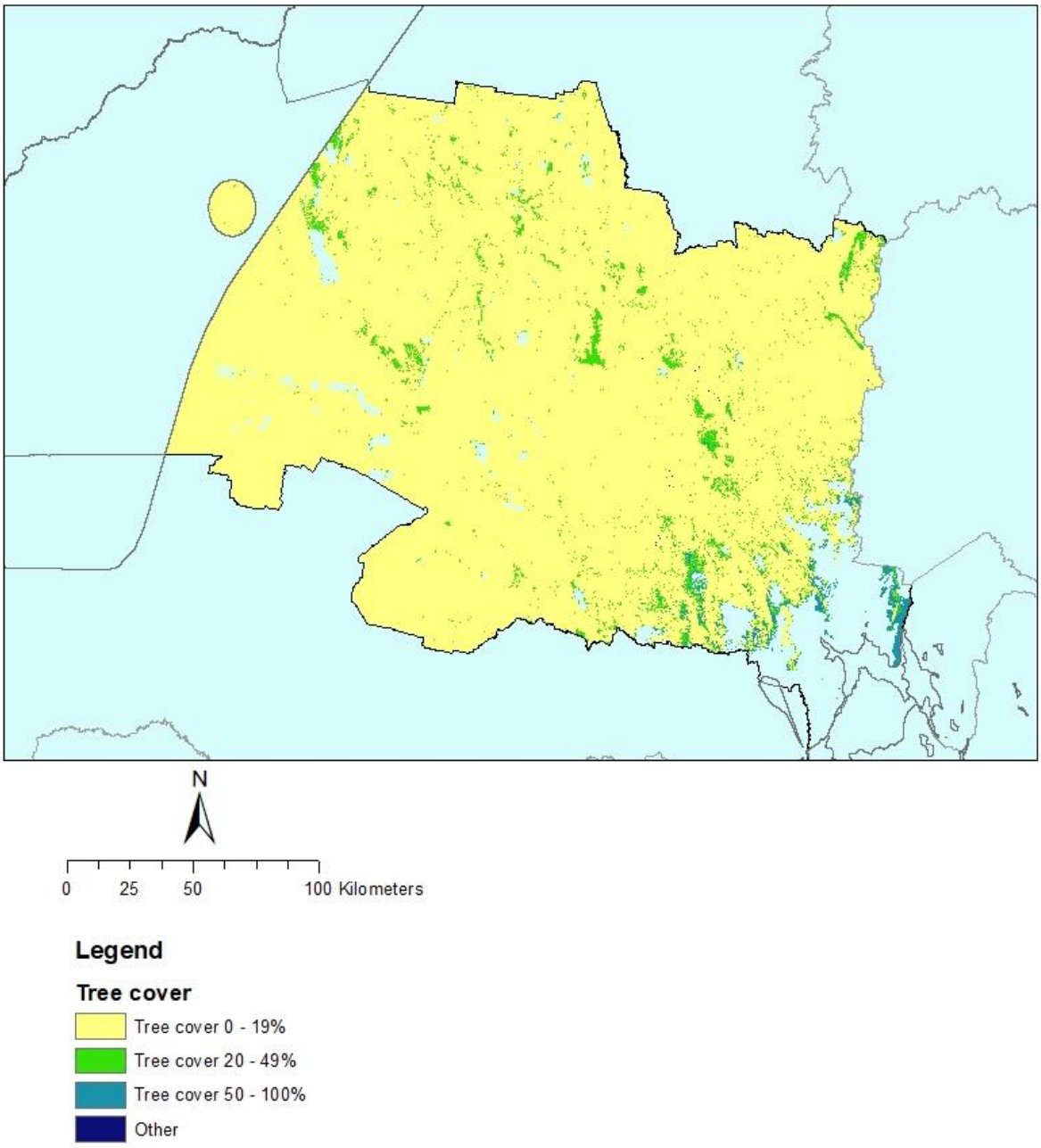
United Nations 2014. System of Environmental-Economic Accounting 2012. Central Framework.



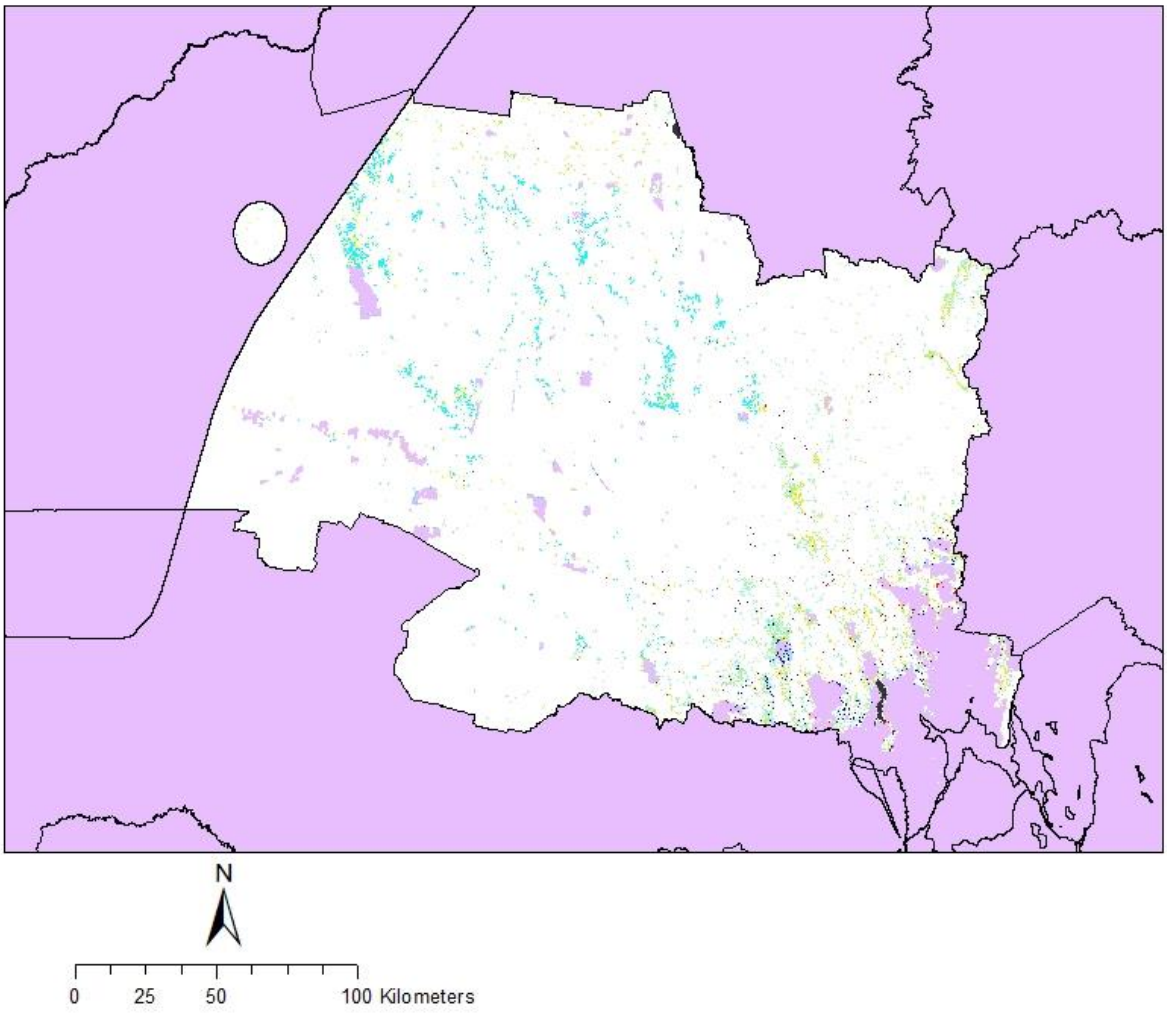
Map 1: Overview of land cover in the area where box gum grassy woodland may occur and/or is likely to occur. MODIS/Terra+Aqua Land Cover Type 2018.



Map 2: Tree cover in Riverina in 2000 based on Global Forest Cover Change (GFCC) Tree Cover.



Map 3: Tree cover in Riverina in 2015based on Global Forest Cover Change (GFCC) Tree Cover.



Map 4: Vegetation change in Riverina 2000 – 2015 based on Global Forest Cover Change (GFCC) Tree Cover.

Appendix

Table 1. Data sets and sources.

Data	Year	Source
Ecological Communities of National Environmental Significance boundaries	2018	Department of the Environment and Energy http://www.environment.gov.au/fed/catalog/search/resource/downloadData.page?uuid=%7B184A3793-2526-48F4-A268-5406A2BE85BC%7D
Global Forest Cover Change (GFCC) Tree Cover Multi-Year Global	2000 2015	Townshend (2016). https://doi.org/10.5067/MEaSUREs/GFCC/GFCC30TC.003. https://lpdaac.usgs.gov/products/gfcc30tcv003/
MODIS Land Cover Type (MCD12Q1), with International Geosphere-Biosphere Programme classification	2001-2018	Friedl and Sulla-Menashe (2019) https://lpdaac.usgs.gov/products/mcd12c1v006/
National Carbon Accounting System	1988, 1989, 1991, 1992, 1995, 1998, 2000, 2002, 2004-2016	Department of the Environment and Energy Direct transfer
National scale land use data	2016	Australian Bureau of Agricultural and Resource Economics http://www.agriculture.gov.au/abares/aclump/land-use/data-download
Natural Resource Management regions	2016	Australian Bureau of Statistics https://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/1270.0.55.003July%202016?OpenDocument