



## Publicly available datasets and their applicability for quantifying farm-scale natural capital

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Land cover and land use data are important sources of information for a wide range of scientific disciplines. Land cover is defined as the physical and biological cover of earth's surface which includes artificial surfaces, agricultural areas, and natural areas, while land use data is characterised according to its current and future use (e.g., residential, industrial, forestry, agricultural)<sup>1</sup>. These data help to compare the extent and condition of vegetation and changes to how land is utilised across regions over time.

Mapping enables the illustration of the spatial dimension of regions of interest and can be used to assess the relationship between natural capital distribution and land-use planning. Due to data availability and limitations to spatial resolution, much of the existing work on mapping natural capital has been focussed at regional (e.g., state/county), national, continental or even global scale<sup>2</sup>. However, to accurately estimate natural capital for smaller regions, including individual farms, mapping should be completed using data sources resolved at appropriate scales<sup>3</sup>. This is particularly important in regions with greater compositional heterogeneity.

In the context of the farm-scale Natural Capital Accounting/Farming For the Future (NCA/FFtF) project, accurately mapping the extent and condition of ecosystem assets is central to quantifying natural capital on farms. While much of the mapping and conceptual framework for these projects have been developed 'in house', there are a range of publicly available datasets which map the extent and condition of vegetation and land cover/land use across Australia. The argument has been made that these could be used to map natural capital to save on time and resources. Indeed, some of these products have been leveraged (e.g. ground cover/canopy cover) for initial mapping. However, the project takes a multi-dimensional approach in that it

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<sup>1</sup> García-Álvarez, D., Camacho Olmedo, M.T., Mas, J.F., Paegelow, M. (2022). Land Use Cover Mapping, Modelling and Validation. A Background. In: García-Álvarez, D., Camacho Olmedo, M.T., Paegelow, M., Mas, J.F. (eds) Land Use Cover Datasets and Validation Tools. Springer, Cham. [https://doi.org/10.1007/978-3-030-90998-7\\_2](https://doi.org/10.1007/978-3-030-90998-7_2)

<sup>2</sup> Blaschke, T. (2006). The role of the spatial dimension within the framework of sustainable landscapes and natural capital. *Landscape and Urban Planning*, 75:198-226; Verburg, P.H., Neumann, K., Nol, L. (2011). Challenges in using land use and land cover data for global change studies. *Global Change Biology*, 17:974-89.

<sup>3</sup> Caviglia-Harris, J.L., Harris, D.W. (2008). Integrating survey and remote sensing data to analyze land use at a fine scale: insights from agricultural households in the Brazilian Amazon. *International Regional Science Review*, 31:115-37.



combines satellite imagery/remote-sensed data with farm management information and field-based rapid assessment to further ground-truth mapping and improve accuracy.

The aim of this review is to test the argument for using publicly available datasets as a stand-alone alternative method of measuring natural capital on farms. We review the types of data available and their capacity to accurately (1) map features at the farm-scale and therefore, (2) identify and quantify assets of natural capital.

### **Dataset search**

While there are some publicly available datasets already leveraged by this project, a systematic approach was taken to identify additional sources. A Google and Google Scholar search was conducted using the following key words: “Australia”, “vegetation”, “map”, “land cover”, “land use” and “condition”. To maintain consistency between states, national vegetation extent or condition datasets were preferred, although regional datasets covering NSW, Tasmania or Victoria were also examined. This search returned a total of 5 datasets on land use and 2 national datasets on condition assessment (Table 1).

#### *National scale - Extent*

The Catchment Scale Land Use of Australia (CLUM) is a raster dataset that combines land use data for all state and territories. Compiled using broader-scale land use information, satellite data and field site validations, land use is classified by its prime use using a three-level hierarchical structure. Primary, secondary, and tertiary classes classify locations by the degree of modification from a natural state. There are six broad primary classes relating to land use. These are conservation and natural environments, production from natural environments, dryland and irrigated agriculture, intensive uses, and water. Secondary classes (N = 37) also specify land use (e.g. managed resource, plantation forest, grazing native vegetation) while tertiary classes (N = 192) further separate by commodity (e.g. sown grasses, seasonal horticulture, wilderness areas)<sup>4</sup>. The date of mapping and scale of mapping varies greatly (2008-2019 and 50-250 m pixels) reflecting the compilation of various source data.

The National Vegetation Information System (NVIS) is a nationwide data product that provides information on the extent and distribution of 32 vegetation types across Australian. Provided at a spatial resolution of 100 x 100 m, NVIS illustrates the changes in vegetation since European settlement. NVIS is mapped for extant (present) native vegetation extent and the estimated pre-1750 vegetation, the latter is used in the present study to identify biome type for state and transition models. The recommendation is that these datasets are intended for national-scale analysis and may only provide a guide when being applied at a finer resolution.

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<sup>4</sup>ABARES 2016, The Australian Land Use and Management Classification Version 8, Australian Bureau of Agricultural and Resource Economics and Sciences, Canberra. CC BY 3.0. <https://tinyurl.com/avu2s6tb>



### *National scale - Condition*

The Habitat Condition Assessment System (HCAS) is a national biodiversity habitat condition assessment dataset (250 x 250 m). It is based on the premise that habitat occurring in locations with similar environmental conditions should look similar when viewed using remote-sensed signals averaged across seasons and years. A change in condition for biodiversity may be likely where two similar locations have different remote-sensed signals.

The Landscape Options and Opportunities Calculator for Biodiversity (LOOC-B) is a standardised tool suitable for monitoring the change and predicted changes in biodiversity over time. The tool, developed by CSIRO, has recently been released for use in carbon projects and uses a machine learning approach to assess likely biodiversity change. The dataset is compiled at 100 x 100 m scale and has the potential to measure and forecast habitat condition, biodiversity persistence, habitat connectivity and threatened species habitat provision<sup>5</sup>.

### *Regional scale - Extent*

The state-based landcover and vegetation community datasets available for Victoria, Tasmania and New South Wales are the Victorian Land Cover Time Series dataset<sup>6</sup>, TASVEG and State Vegetation Type Map (SVTM), respectively.

## **Methods**

To understand how these publicly available datasets perform in determining natural capital on farms, natural capital asset registers were built for two farms using the respective datasets. Maps displaying the spatial distribution of each land cover category were produced and the total area of each category was calculated. These were compared with the natural capital asset tables calculated using the NCA/FFtF methodology.

Two farms, one located in Victoria (YQ) and one in NSW (FC), were selected as representative case study farms. Between them, the two farms contain a broad range of ecosystem states. A map was created using each dataset appropriate to location (NVIS, CLUM and Victorian Landcover for YQ and NVIS, CLUM and NSW SVTM for FC) and the total area of each category within the farm boundaries was calculated. For the CLUM dataset, total area was calculated from the Tertiary classification. Condition datasets (HCAS and LOOC-B) were not used as there was no straight-forward way to compare them with natural capital asset tables.

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<sup>5</sup> <https://apidoc.looc-b.farm/>

<sup>6</sup> Victoria also has a state-based vegetation classification system, Ecological Vegetation Classes (EVC) mapped at 25 X 25 m, but we considered the Land Cover Time Series dataset more appropriate for our purposes here because it classifies non-vegetation land cover as well.



## Results

Unsurprisingly, NVIS was the broadest classification resulting in the smallest number of asset classes per farm (Table 2; Table 3). The NVIS classification simply lumped most of the farm area into the ‘cleared, non-native vegetation, buildings’ category (Fig. 1; Table 2; Table 3) and lacks the distinction between natural capital asset classes evident in the NCA/FFtF mapping (Fig. 1). For example, it incorrectly mapped olive plantations as Tussock Grasslands on farm YQ and identified the area of reference woodland as modified native vegetation on farm FC.

The CLUM data layer performed well to spatially segment the map into similar “eco-units” and proportions as the NCA/FFtF methods. For farm YQ, the CLUM data layer performed marginally better than the NVIS data, further identifying areas of cropping and irrigated cropping (Fig. 1). Classification to tertiary levels resulted in multiple categories cropping to be identified such as dryland and irrigated cereals, pulses. While there are decision rules embedded within the classification system<sup>4</sup>, this amount of detail may risk false accuracy due to rotation systems. The large component of exotic woody vegetation (olive plantations) present on YQ was classified as region as ‘cereals’ and misclassified the native components on the farm as ‘grazing modified pastures’, ‘oilseeds’ and ‘pulses’ (south-western section of the property labelled as DG1/TW1 in the NCA/FFtF methodology). These inconsistencies demonstrate the complications of using out of date data for fine-scale mapping.

The CLUM data for FC further separated the farm into ‘grazing native vegetation’ and ‘grazing modified pastures’, resulting in seven asset classes for Farm FC (*cf.* three asset classes for NVIS and 11 for the NCA/FFtF methodology). However, the classifications did not match the NCA/FFtF mapping. While it did identify areas of native vegetation accurately in the southern section of farm FC (Fig. 2, labelled RW in NCA/FFtF map), the CLUM dataset incorrectly labelled much of it as ‘grazing native vegetation’ rather than conserved remnant forest (*i.e.*, residual native cover). The break-down of primary, secondary, and tertiary classes for farms YQ and FC, according to CLUM are provided as supplementary information.

Of the state-based maps, the Victorian landcover data layer was the most resolved with a wide range of categories representing features on the farm (16 asset classes *cf.* five asset classes using NVIS and 14 asset classes using the NCA/FFtF methodology). However, this data layer is known to perform poorly in classifying native ecosystem types. This might explain why the ‘Native Grass Herb’ category was detected throughout the farm and in regions classified as mostly exotic pastures or cropping by the NCA/FFtF maps. While the majority of farm YQ is classified by the VIC Landcover layer as dryland cropping it is missing large component of exotic woody vegetation (olive plantations) and irrigated cropping (Fig. 1). This is likely due to recent land use changes and may be rectified in future releases of the Landcover data but illustrates the risks of relying on out-of-date data. Further, differences within asset types (*e.g.* pastures, crops, woodlands) that are evident in the NCA/FFtF mapping are overlooked by the Landcover dataset (Fig. 1). However, the Landcover data does detect some classes (*e.g.*, wetland seasonal, wetland perennial) not covered by the NCA/FFtF methodology. For farm



FC, while the NSW SVTM dataset returned eight asset classes (*cf.* 11 for NCA/FFtF methodology), it only classified native vegetation with the majority (83.5%) of the farm labelled as unclassified (Fig. 2).

## Discussion

The various datasets each have their advantages and drawbacks. None of the publicly available datasets – on their own – can map the *extent* and *condition* of natural capital assets at the spatial resolution required across intensively managed production areas (crops and pastures), semi-natural areas used for production (grassy woodlands and grasslands) and remnant vegetation. That is, there is no single dataset that spans the geographic coverage (i.e., national) with the adequate spatial resolution (pixel size), temporal resolution (up to date) and asset resolution (i.e., distinguish between different asset types) to generate meaningful natural capital accounts. Therefore, the bespoke model that we have developed for NCA/FFtF, based on an amalgam of existing datasets, remote-sensed imagery, farmer-provided information and ground-truthed via rapid assessment inspections, is required to reliably and consistently map and quantify farm-scale natural capital assets.

State-based datasets are typically more spatially resolved than the national datasets. However, the classification nomenclature varies substantially between states making cross-state comparisons intractable. For example, the Victorian Land Cover dataset consists of 19 classes including native/planted vegetation, built and urban areas. In comparison, TASVEG and SVTM (and Victorian EVC) provide information on vegetation communities only (and their respective vegetation classifications differ between states – and differ from those in Queensland, South Australia and Western Australia). While TASVEG provides classification for non-native plantations, urban areas and agricultural land, SVTM describes only native vegetation, categorising cleared regions as “not classified”. The state-based vegetation mapping (TASVEG, VIC EVC, NSW SVTM, QLD Regional Ecosystems) provide a high degree of spatial and vegetation community (floristic) resolution for areas of remnant vegetation. As such, they provide a useful template for mapping remnant native vegetation (and are used as such in the NCA/FFtF methodology) but need to be reconciled between states and do not provide enough information about variation in condition or non-vegetation areas to be used for building accounts on their own.

National datasets have the advantage of consistency across states. However, the NVIS and CLUM datasets do not provide the level of spatial, or asset resolution required to build farm-scale natural capital accounts. That is, subtle variation in land use and condition are not reflected in these datasets – even the use of tertiary classification in CLUM did not result in a complete set of asset classes. For example, narrow shelterbelts or tree lanes may be missed in national datasets because their spatial resolution is too coarse and variation in condition of asset types (e.g., Reference woodland through to Transitioning Woodland 4 or Derived Grassland



1 through to Derived Grassland 6) is overlooked. However, there may be value in using the CLUM dataset a 'first cut' for broadly classifying asset types.

While HCAS represents a significant advance to informing and assessing naturalness, there are several limitations to its applicability. These include poor performance in locations influenced by 'run-on' water rather than rainfall and the assumption that reference condition sites are in fact representative of reference condition<sup>7</sup>. Furthermore, the dataset has difficulties differentiating between habitat that may look similar but have very different values for habitat quality (e.g. eucalypt/pine plantations and native forests).

Similarly, the LOOC-B tool has significant limitations for the purposes of natural capital accounting. Most particularly, LOOC-B currently produces a single value for the farm rather than values at the asset level (Supplementary information 1). While this does not provide information on natural capital asset classes per se, it may be useful as a layer providing broad habitat condition values from which mapping or indices of natural capital could be developed. Alternatively, it could be used to test/validate existing natural capital measures. However, we urge caution because once again, this tool allocated highest habitat condition to olive plantations.

### **Summary**

There are three areas of inadequacy in the publicly available datasets: spatial resolution, discrimination between asset types, and consistency in mapping between states. When choosing mapping sources, it is important to consider the size of the smallest features you aim to detect. The national (50 m, 100 m, or 250 m resolution) and state-based (30 m resolution) datasets are at a scale greater than appropriate for the NCA/FFtF project, which aims to detect and quantify narrow (<10 m) shelterbelts and windbreaks. While publicly available datasets may be useful for understanding the broad landscape condition, they are not accurate enough for detecting and quantifying natural capital on farms alone. Furthermore, the national datasets (NVIS, CLUM) do not provide enough information on type of land-use or vegetation condition to differentiate among natural capital asset types (e.g. compare the number of asset classes in Tables 2 and 3 between the national datasets and our bespoke mapping). Finally, while the state-based vegetation maps do provide fine-scale resolution of vegetation communities, the inconsistencies between states in vegetation classification typologies preclude their application across state boundaries. In comparison, the current project methodology leverages publicly available datasets and combines them with additional mapping, management information and field assessments to produce a bespoke, highly resolved, detailed map. This allows for the calculation of natural capital at a finer scale than could be achieved with any single data layer. We conclude that no single

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<sup>7</sup> Williams, K., Harwood, T., Lehmann, E.A., Ware, C., Lyon, P., ... Ferrier, S. (2021). Habitat Condition Assessment System (HCAS version 2.1) Enhanced method for mapping habitat condition and change across Australia. Canberra, Australia: CSIRO. csiro:EP2021-1200. <https://doi.org/10.25919/n3c6-7w60>



publicly available data set can act as a stand-alone alternative method to measure natural capital at the farm-scale.

Table 1: Summary of datasets returned from Google and Google Scholar keyword search

Name	Spatial coverage and resolution/Temporal resolution	Link
NVIS	National 100 x 100m. Revised 2020	<a href="https://www.dccew.gov.au/environment/land/native-vegetation/national-vegetation-information-system/data-products">https://www.dccew.gov.au/environment/land/native-vegetation/national-vegetation-information-system/data-products</a>
Catchment Scale Land Use of Australia (CLUM)	National 50 x 50m. Revised 2020	<a href="https://www.environment.gov.au/mapping/rest/services/abares/CLUM_50m/MapServer">https://www.environment.gov.au/mapping/rest/services/abares/CLUM_50m/MapServer</a>
Habitat Condition Assessment System (HCAS)	National 250 x 250m. Calculated over several epochs	<a href="https://publications.csiro.au/publications/publication/PIcsiro:EP2021-1200">https://publications.csiro.au/publications/publication/PIcsiro:EP2021-1200</a>
Landscape Options and Opportunities Calculator for Biodiversity (LOOC-B)	National 100 x 100 m. Calculated over several epochs (2012-2020)	<a href="https://looc-b.farm/">https://looc-b.farm/</a>
New South Wales State Vegetation Type map (SVTM)	NSW for native vegetation only 5 x 5 m Revised 2022	<a href="https://datasets.seed.nsw.gov.au/dataset/nsw-state-vegetation-type-map">https://datasets.seed.nsw.gov.au/dataset/nsw-state-vegetation-type-map</a>
Victorian Land Cover Time series	VIC only 30 x 30 m Calculated over several epochs (1987-2019)	<a href="https://www.environment.vic.gov.au/biodiversity/Victorias-Land-Cover-Time-Series">https://www.environment.vic.gov.au/biodiversity/Victorias-Land-Cover-Time-Series</a>
TASVEG	Tasmania only 250 x 250 m Revised 2020	<a href="https://nre.tas.gov.au/conservation/development-planning-conservation-assessment/planning-tools/monitoring-and-mapping-tasmanias-vegetation-(tasveg)">https://nre.tas.gov.au/conservation/development-planning-conservation-assessment/planning-tools/monitoring-and-mapping-tasmanias-vegetation-(tasveg)</a>

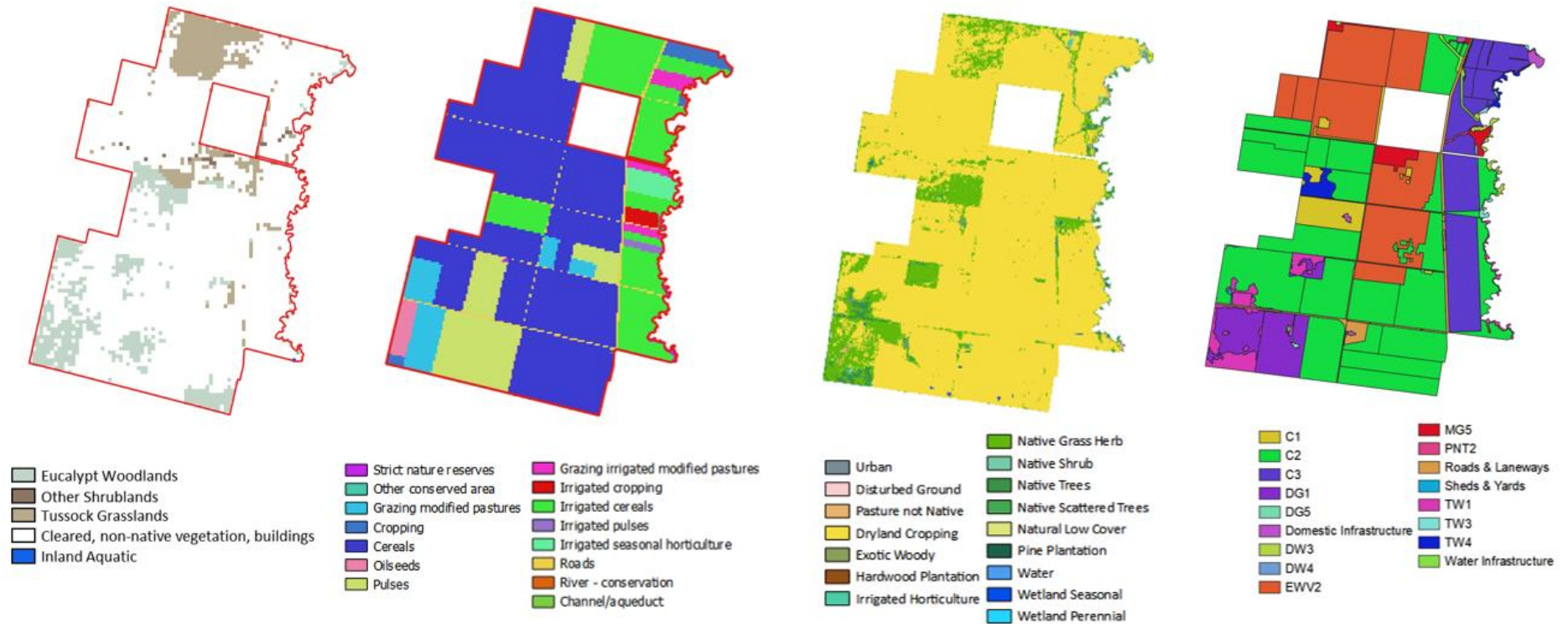


Figure 1: Comparison of spatial distribution of natural capital assets on farm YQ generated using NVIS, CLUM, VIC land cover and the NCA/FFtF methodology (from left to right).



Table 2: Comparison of Farm YQ asset registers calculated using NVIS, Victorian Land Cover and NCA/FFtF methodology.

NVIS		CLUM		VIC Land Cover Time Series		NCA/FFtF	
National	Area (Ha)	National	Area (Ha)	State	Area (Ha)	Property	Area (ha)
Eucalypt Woodlands	580	Strict nature reserves	16.5	Native Grass Herb	641.3	TW 1 - regen - few exotics in groundlayer	154.9
Other Shrublands	20	Other conserved area	4.5	Native Shrub	1.1	TW 3 - little regen - mostly exotic groundlayer	40.6
Tussock Grasslands	482	Grazing modified pastures	276.75	Native Trees	86.4	TW 4 - no regen - exotic groundlayer	58.7
Inland Aquatic	1	Cropping	86	Native Scattered Trees	28.8	DG 1 - diverse native groundlayer	339.4
Cleared, non-native vegetation, buildings	4159	Cereals	2782.5	Natural Low Cover	1.3	MG 5 - perennial exotic groundlayer	87.8
		Oilseeds	68.25	Pine Plantation	0.1	EWV2 - Perennial Horticulture	1219.2
		Pulses	637.75	Disturbed Ground	4.3	PNT 2 - maturing (10-40 years)	10.2
		Grazing irrigated modified pastures	87.5	Pasture Not Native	20.4	C3 - Irrigated crop	671.1
		Irrigated cropping	34	Dryland Cropping	4430.3	C1 - Non-irrigated crop with scattered trees	170.7
		Irrigated cereals	1010.5	Exotic Woody	1.8	C2 - Non-irrigated crop - no trees	2314.5
		Irrigated pulses	20.5	Hardwood Plantation	0.2	Domestic Infrastructure	25.4
		Irrigated seasonal horticulture	79.5	Irrigated Horticulture	14.4	Roads & Laneways	135.3
		Roads	134.25	Urban	9.4	Sheds & Yards	2.1
		River - conservation	6.25	Water	0.1	Water infrastructure (dams, channels)	20.9
		Channel/aqueduct	5.25	Wetland Seasonal	9.8		
				Wetland Perennial	0.3		

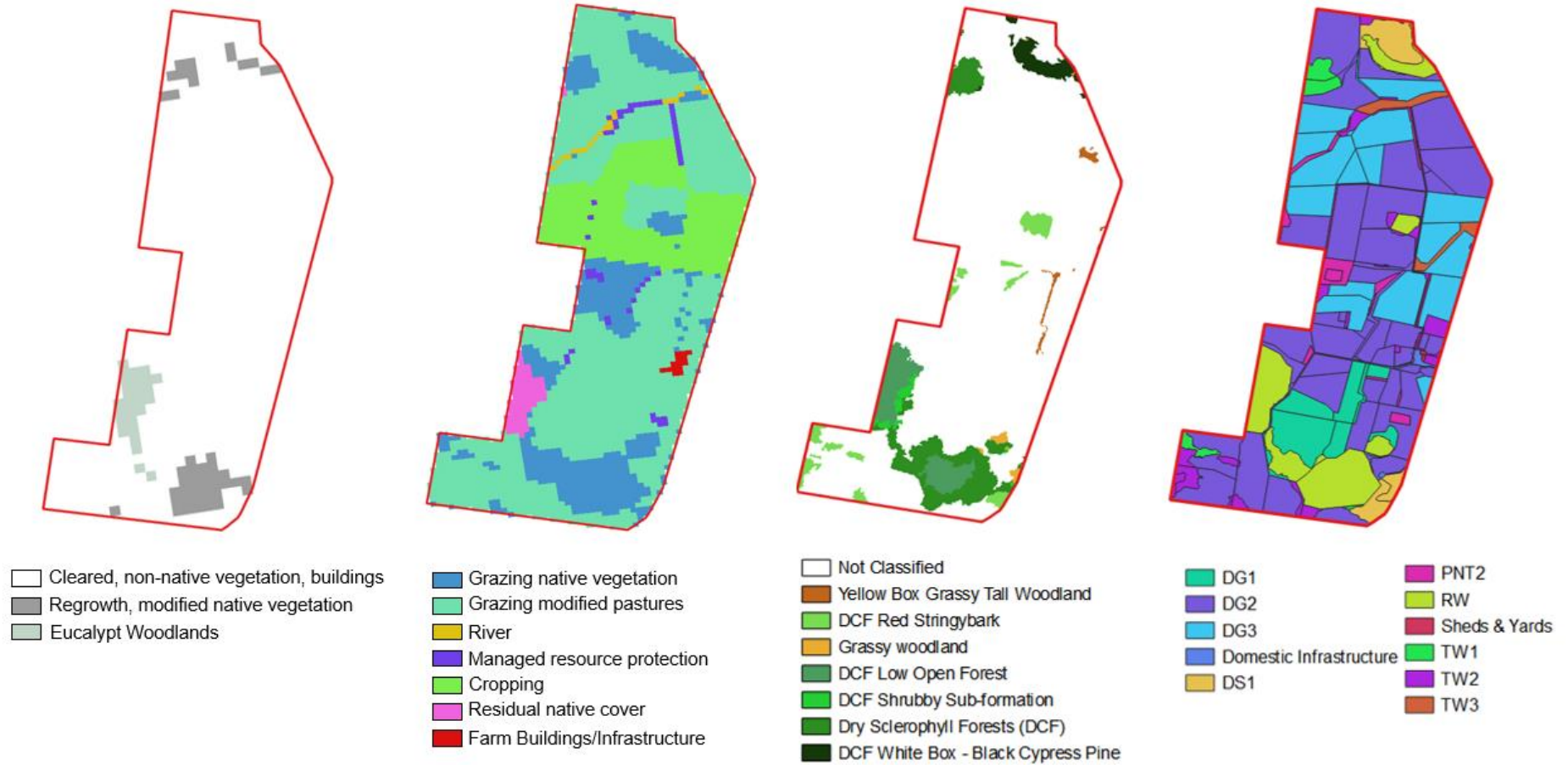


Figure 2: Comparison of spatial distribution of natural capital assets on farm FC generated using NVIS, CLUM, SVTM and the NCA/FFtF methodology (from left to right).

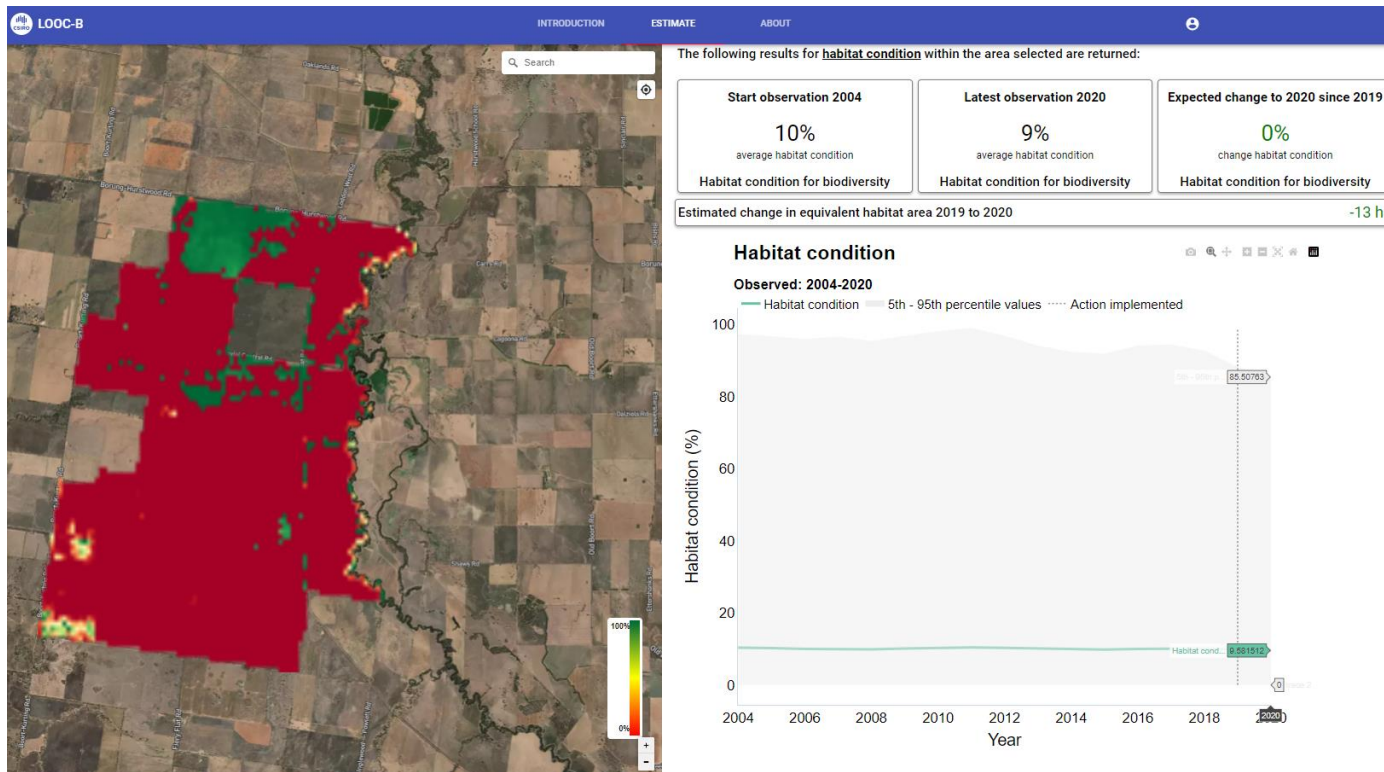


Table 3: Comparison of farm FC asset registers calculated using NVIS, CLUM, STVM and NCA/FFtF methodology.

NVIS		CLUM		STVM		NCA/FFtF	
National	Area (Ha)	National	Area (Ha)	State	Area (Ha)	Property	Area (ha)
Eucalypt Woodlands	26	Managed resource protection	13.5	Not classified	666.1	DG 1 - diverse native ground layer	54.72
Cleared, non-native vegetation, buildings	729	Residual native cover	17.75	Yellow Box Grassy Tall Woodland	4.9	DG 2 - diverse native ground layer - some exotics	375.72
Regrowth, modified native vegetation	45	Grazing native vegetation	150.75	Grassy woodland	3.1	DG 3 - mixed ground layer with many exotics	177.47
		Grazing modified pastures	470	Dry Sclerophyll Forests (DCF)	51.9	DS 1 - Native - naturally occurring	26.93
		Cropping	137.5	DCF Low Open Forest	30.7	Domestic Infrastructure	2.15
		Farm buildings/infrastructure	3.5	DCF Shrubby Sub-formation	5.3	PNT - maturing (10-40 years)	20.01
		River	5.5	DCF Red Stringybark	21.8	RW	82.86
				DCF White Box - Black Cypress Pine	13.8	Sheds & Yards	0.39
						TW 1 - some historical clearing - regeneration - ground layer with high native diversity	13.16
						TW 2 - some regeneration - some exotics in ground layer	33.88
						TW 3 - little regeneration - mostly exotic ground layer	11.56



Supplementary information 1: LOOC-B habitat condition in the 'monitoring' mode for biodiversity (farm YQ). Habitat condition is generated as an annual time-series (2012-2020) at 100m resolution by combining estimates of long-term plant growth data and annual predicted woody vegetation cover. Habitat condition for year 2020 is 9.58 (with 5<sup>th</sup> and 95<sup>th</sup> confidence intervals 0 and 85.5).





Supplementary information 2: Categorisation of farm FC Primary, Secondary and Tertiary classes as determined by the CLUM 3-tiered hierarchical classification system.

Primary	Secondary	Tertiary	Tertiary class area (Ha)
<b>YQ</b>			
Conservation and natural environments	Nature conservation	Strict nature reserves	16.5
Conservation and natural environments	Nature conservation	Other conserved area	4.5
Production from dryland agriculture and plantations	Grazing modified pastures	Grazing modified pastures	276.75
Production from dryland agriculture and plantations	Cropping	Cropping	86
Production from dryland agriculture and plantations	Cropping	Cereals	2782.5
Production from dryland agriculture and plantations	Cropping	Oilseeds	68.25
Production from dryland agriculture and plantations	Cropping	Pulses	637.75
Production from irrigated agriculture and plantations	Grazing irrigated modified pastures	Grazing irrigated modified pastures	87.5
Production from irrigated agriculture and plantations	Irrigated cropping	Irrigated cropping	34
Production from irrigated agriculture and plantations	Irrigated cropping	Irrigated cereals	1010.5
Production from irrigated agriculture and plantations	Irrigated cropping	Irrigated pulses	20.5
Production from irrigated agriculture and plantations	Irrigated seasonal horticulture	Irrigated seasonal horticulture	79.5
Intensive uses	Transport and communication	Roads	134.25
Water	River	River - conservation	6.25
Water	Channel/aqueduct	Channel/aqueduct	5.25
<b>FC</b>			
Conservation and natural environments	Managed resource protection	Managed resource protection	13.5
Conservation and natural environments	Other minimal use	Residual native cover	17.75
Production from relatively natural environments	Other minimal use	Grazing native vegetation	150.75
Production from dryland agriculture and plantations	Grazing modified pastures	Grazing modified pastures	470
Production from dryland agriculture and plantations	Cropping	Cropping	137.5
Intensive uses	Residential and farm infrastructure	Farm buildings/infrastructure	3.5
Water	River	River	5.5



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