Values and Vulnerabilities – Appendices

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Appendix A: Concordance between NVIS and Biomes

Our concordance system matches the descriptors of ecosystems used in the ES value database (hereafter *biome*) to the Major Vegetation Groups (MVGs) used in the (Australian) National Vegetation Information System (NVIS) – see Table 1, and associated explanatory notes.

Table 1: Major Vegetation Groups (MVGs) of the National Vegetation Information System (NVIS) matched to grouped biomes for the purpose of estimating water values

NUMBER	Description	Biome used when matching MVG to ES values
1	Rainforests and Vine Thickets	Forests
2	Eucalypt Tall Open Forests	Forests
3	Eucalypt Open Forests	Forests
4	Eucalypt Low Open Forests	Forests
5	Eucalypt Woodlands	Woodlands/Savanna
6	Acacia Forests and Woodlands	Woodlands/Savanna
7	Callitris Forests and Woodlands	Woodlands/Savanna
8	Casuarina Forests and Woodlands	Woodlands/Savanna
9	Melaleuca Forests and Woodlands	Woodlands/Savanna
10	Other Forests and Woodlands	Woodlands/Savanna
11	Eucalypt Open Woodlands	Woodlands/Savanna
12	Tropical Eucalypt Woodlands/Grasslands	Woodlands/Savanna
13	Acacia Open Woodlands	Woodlands/Savanna
14	Mallee Woodlands and Shrublands	Shrublands/Grasslands
15	Low Closed Forests and Tall Closed Shrublands	Shrublands/Grasslands
16	Acacia Shrublands	Shrublands/Grasslands
17	Other Shrublands	Shrublands/Grasslands
18	Heathlands	Shrublands/Grasslands
19	Tussock Grasslands	Shrublands/Grasslands
20	Hummock Grasslands	Shrublands/Grasslands
21	Other Grasslands, Herblands, Sedgelands and Rushlands	Shrublands/Grasslands
22	Chenopod Shrublands, Samphire Shrublands and Forblands	Shrublands/Grasslands
23	Mangroves	Wetlands (Mangroves)
24	Inland aquatic - freshwater, salt lakes, lagoons	Wetlands (Inland Aquatic)
25	Cleared, non-native vegetation, buildings	None
26	Unclassified native vegetation	None
27	Naturally bare - sand, rock, claypan, mudflat	None
28	Sea and estuaries	None
29	Regrowth, modified native vegetation	None
30	Unclassified Forest	Forest
31	Other Open Woodlands	Woodlands/Savanna
32	Mallee Open Woodlands and Sparse Mallee Shrublands	Shrublands/Grasslands

Explanatory notes.

- **Forests** (MVG 1-4) are easily distinguishable. They are generally >10m (most >30m) tall, single stemmed, with 30-70% foliage projective cover. In layman's terms they comprise tall Eucalypts and wet, closed canopy forests.
- **Woodlands/Savanna** (MVG 5-13) are also generally distinguishable. We use a cut off as >5m (up to 20m) tall, single stemmed, with 10-30% foliage projective cover. These areas are typically comprised of scattered trees with a grassy (occasionally shrubby) understory.
- **Shrublands/Grasslands** (MVG 16-22) are also generally distinguishable. We use a cut off of <5m tall, multi-stemmed trees and shrubs, with 20-70% foliage projective cover. These regions may have low scrub, shrubs and/or grasslands.
- There are two (three) vegetation groups which are difficult to easily classify for the purpose of matching to economic valuation data: MVG 14 (and 32) and 15. MVG 14 is low, but open; 15 is taller, but closed. Both are multi-stemmed (above 14 are single stemmed trees, below 15 are shrubs); although 14 is arguably closer to woodland and 15 is closer to heathland. There is clearly no perfect classification, so we have chosen a classification system that generates an unambiguous downward bias in 'value' (and thus impact) estimates: putting the low, multi-stemmed trees in with the shrublands/grasslands group (rather than in woodlands/savannas which generally have higher ecosystem service values). That is consistent with our putting the MVGs labelled forests and woodlands (MVG 6-9) into woodlands rather than forests (i.e., we are consistently classifying based on the lower structural formation).

Appendix B: Meta-analysis of ES value estimates

Table 2: A collection of meta-analyses considering socioeconomic variables and per-hectare ES values

Study; Biome; ES[1]	Statistically significant socio-economic relationships identified in the models					Other variables used in the model
	Area of study site / 'Abundance'	GDP	Population	Urban/ARIA+	Protected area status	
Lara-Pulido *et al.* (2018); Multiple biomes; Multiple ES	∂Ln($/ha) = between -0.3772 and -0.775 ∂Ln(Area of study site)		Measures of population included (generally positive)[2]		Interacted with measures of environmental protection and possibly dummy variable trap so coefficient not directly estimable	Dummy variables for type of Biome; Dummy variables for type of ES; Dummy variables for valuation method.
Chaikumbung *et al.* (2016); Wetlands; Multiple ES, with separate model for recreation[3]	∂Ln($/ha) = -0.768 ∂Ln(Area of study site)	∂Ln($/ha) = 1.01 ∂Ln(GDP per capita)			∂Ln($/ha) = + 1.865Dummy for Ramsar (other protection insignificant). (19% of sites protected)	Dummy variables for type of wetland and year published.
Carrasco *et al.* (2014); Tropical forests; Multiple ES	∂Ln($/ha) = 1.02×10^{-7} ∂Area (m^2)	∂Ln($/ha) = 0.137GDP-0.007 GDP[2][4]				∂Ln($/ha) = 0.003Access-$1.23 \times 10^{-6}$ Access^2 Access is calculated as the time to travel from each study site to the nearest city with a population of 50,000); CO_2, precipitation, temperature and bird species richness also included.
Salem and Mercer (2012); Mangroves; Multiple ES[5]	Area included but not sign.	∂Ln($/ha) = 0.79 ∂Ln(GDP per capita) for recreational values			∂Ln($/ha) = + 0.520xDummy for Ramsar or other state protection (48.6% of sites protected).	Dummy variables for type of ES; Dummy variables for valuation method; Dummy variables or large geographic areas (e.g., Oceania).

[1] Richardson and Loomis (2009) undertake a meta-analyses of studies that have estimated the value of threatened endangered and rare species, finding that values depend upon various factors (type of species, whether one is assessing use or non-use values), but their analysis does not include variables that describe the socioeconomic context in which the study was undertaken so is only of tangential interest to the task at hand. Noonan (2003) and Rosenberger and Loomis (2000) undertake meta-analyses of cultural values but they also fail to include socio-context variables, so are not included here.
[2] These measures interacted with measures of environmental protection and possibly dummy variable trap so coefficient not directly estimable.
[3] The report on many models; these results are from their model that considers recreational values only.
[4] GDP is a site-specific measure not a per capita estimate, so not directly comparable to other estimates.
[5] They estimate two models, the second including an interactive dummy for GDP per capita and recreational values. This estimate is calculated from their second model, allowing for that interaction.

Study; Biome; ES[1]	Statistically significant socio-economic relationships identified in the models					Other variables used in the model
	Area of study site / 'Abundance'	GDP	Population	Urban/ARIA+	Protected area status	
Brander *et al.* (2012); Mangroves; Multiple ES	∂Ln($/ha) = -0.43 ∂Ln(Area of study site) + 0.248 ∂Ln(Area of wetlands within 50km) (so combined effect of abundance, measured as area of site + area of local substitute, is negative)	∂Ln($/ha) = 0.785 ∂Ln(GDP per capita)	∂Ln($/ha) = 0.284∂Ln(population living within 50km radius)			ACCESS: A 1% increase in kms of road within 50km of a study site is associated with a .312% decrease in ES value estimates for mangroves. Dummy variables for type of ES
De Groot *et al.* (2012); Wetlands; multiple ES	∂Ln($/ha) = -0.321 ∂Ln(Area of study site) – 0.203 ∂Ln(Area of wetlands within 50km)	∂Ln($/ha) = 0.37 ∂Ln(country level GDP per capita)	∂Ln($/ha) = 0.339∂Ln(population living within 50km radius)			
Ghermandi *et al.* (2008); Wetlands; Multiple ES	∂Ln($/ha) = -0.241 ∂Ln(Area of study site) – 0.146 ∂Ln(Area of wetlands within 50km)	∂Ln($/ha) = 0.24∂Ln(GDP per capita)	∂Ln($/ha) = 0.275∂Ln(population living within 50km radius)	∂Ln($/ha) = + 0.970Urban Dummy	∂Ln($/ha) = 0.44 EnvStress Env Stress= 0 if Ramsar or national park 0.5 if Natural reserve 1 if unprotected	Valuation method (numerous dummies) Wetland type (numerous dummies)
Brander *et al.* (2006); Wetlands; Multiple ES	∂Ln($/ha) = -0.11 ∂Ln(Area of study site)	∂Ln($/ha) = 1.16∂Ln(GDP per capita)	∂Ln($/ha) = 0.47∂Ln(population living within 50km radius)	∂Ln($/ha) = + 1.11Urban Dummy	∂Ln($/ha) = + 1.32%ofwetland with Ramsar protection	Dummy variables for large geographic areas (e.g., Oceania) Valuation method (numerous dummies) Wetland type (numerous dummies); ES type

Table 3: A collection of meta-analyses considering socioeconomic variables and per-person ES values

Study; Biome; ES	Statistically significant socio-economic relationships identified in the models				Other variables used in the model
	Area of study site / 'Abundance'	GDP	Population	Protected area status	
Reynaud and Lanzanova (2017); Lakes; Recreation use values (TCM, CM, CV)	∂Ln($/person) = -0.14∂Ln (Ha lakes within 20km).[6]	Variable included but not significant		Protection included but insignificant	Dummy variables for type of ES Dummy variables for methodological choices; Other environmental variables (e.g., water stress, drought); and dummies for region (e.g., Europe, Pacific Asia)).
Reynaud and Lanzanova (2017); Lakes; Cultural use values (HP)	∂Ln($/person) = 1.56xDummy for lake>1000[7]				Lakes with more variation in water levels showing lower value estimates.
Wright and Eppink (2016); Multiple biomes; Cultural heritage values		Ln(per-capita GDP) included but statistically insignificant	∂Ln($/person) = 0.33∂Ln(population living within 10km radius).		Dummies for asset type (built, natural, traditional). Dummy variable for traditional knowledge positive and statistically significant. Dummies for type of scenario (adaptive re-use, spatial planning, conservation, preservation, restoration); country variance.
Siriwardena *et al.* (2016); Tree cover in urban environments (HP)		Positive and significant impact[8]	Positive and significant impact		
Ghermandi and Nunes (2013); Coastal recreation values		∂Ln($/person) = 0.804∂Ln(GDP per capita).	∂Ln($/person) = 0.431∂Ln(Pop density).	Protection included but insignificant	∂Ln($/person) = -0.557∂Ln (Accessibility) – a measure of travel time to nearest city. Dummies relating to method; type of recreational service; climate, biodiversity and anthropogenic stressors.
Brander *et al.* (2007); Coral reefs Recreation use value	∂Ln($/visit) = 0.956 ∂Ln (Km2 of site)		∂Ln($/visit) = 0.255 ∂Ln (no of visitors)		Dummies for valuation method; Dummy for East-African studies; Dummy to differentiate divers from those who only snorkel. Dummies relating to researchers.
Schägner *et al.* (2018) – recreational values, multiple biomes. [9]	∂Ln($/visit) = + 0.0073∂Ln(Ha of site in ha).	∂Ln($/visit) = 0.27 Regional unemployment rate Ln(GDP) was also considered but found insignificant [10]	∂Ln($/visit) = - 0.23 ∂Ln (no of visitors). Population of region was included, but insignificant		Multiple variables capturing biophysical characteristics of region (rainfall, sunshine days per year). Methodological dummies (TCM or CV; $per visit or $ per visitor day).

[6] Dummy variables identify a positive relationship between lake size and value but three dummies were included for three different lake sizes so the model may be over-specified.
[7] As above; the model may be over-specified.
[8] Coefficients are for the Heckman selection model so not directly interpretable as showing % impact on value estimates.
[9] In addition to estimating regression models that describe recreational values per visit, Schägner *et al.* (2018) provide a review of the meta-analyses undertaken by other researchers (which confirms the importance of contextual factors) and also a comparison between models that seek to describe $ per person/visit and $ per hectares. They conclude that the single most important determinant of differences in recreational values per hectare, is differences in the number of visitors.
[10] Perhaps because all studies included within this meta-analysis were undertaken in Europe with relatively similar GDP per capital.

Appendix C: NRM data used when contextualising transferred ES estimates

Table 4 provides data used when estimating population density and per-capita GDP for each NRM. Regional product is not reported on at the NRM level, so we developed our own proxy for GDP per capita. We relied on data for the year ended June 2016 (the most recent ABS census year), which gives average per-person income at $43,007[11]. This is approximately 62.35% of GDP per capita ($68,981 p.a.[12] in that year) in that same year. In the absence of better information, we thus estimated GDP for each NRM as:

$$per\ capita\ GDP_{NRM\ i} = \frac{1}{0.6235} \times \frac{average\ household\ income\ in\ NRM\ i}{2.55}$$

"Abundance" is estimated by dividing the hectares of each biome that are contained within each NRM by the size of each NRM (Table 5).

[11]Calculated by dividing the average household income of $109,668 ($2,109 per week x 52 – see http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/6523.02015-16?OpenDocument) by the average household size in 2016 (2.55 – see https://profile.id.com.au/australia/household-size).

[12] http://www.economywatch.com/economic-statistics/Australia/GDP_Per_Capita_Current_Prices_National_Currency/

Table 4: Population densities and estimates of per-capita GDP for, by NRM (calculated from 2016 ABS census data)

Code	Name	Population Density	Average weekly household income#	Dwellings *	Average household size^	Per-capita (HH) income	Inferred per-capita regional product
101	Central Tablelands	5.27	1,540	64,924	2.54	$31,467	$50,753
102	Central West	1.24	1,439	45,116	2.51	$29,752	$47,988
103	Greater Sydney	397.52	2,099	1,722,537	2.80	$38,970	$62,856
104	Hunter	21.61	1,585	277,772	2.55	$32,351	$52,178
105	Murray	2.56	1,422	44,609	2.41	$30,715	$49,540
106	North Coast	15.69	1,342	211,013	2.38	$29,306	$47,268
107	North West NSW	1.42	1,464	47,469	2.47	$30,850	$49,758
108	Northern Tablelands	1.79	1,322	28,424	2.48	$27,696	$44,670
109	Riverina	2.64	1,499	68,719	2.58	$30,256	$48,800
110	South East NSW	11.60	1,617	255,059	2.53	$33,292	$53,697
111	Western	0.12	1,404	16,506	2.34	$31,242	$50,390
201	Corangamite	30.23	1,555	160,617	2.54	$31,835	$51,347
202	East Gippsland	2.12	1,233	19,261	2.31	$27,692	$44,664
203	Glenelg Hopkins	4.61	1,401	49,702	2.48	$29,423	$47,456
204	Goulburn Broken	7.47	1,389	72,809	2.49	$28,957	$46,705
205	Mallee	1.63	1,343	26,176	2.47	$28,289	$45,628
206	North Central	8.11	1,382	97,541	2.44	$29,444	$47,490
207	North East	5.20	1,455	41,989	2.45	$30,892	$49,826
208	Port Phillip and Western Port	352.25	1,870	1,682,408	2.69	$36,161	$58,325
209	West Gippsland	11.09	1,411	77,819	2.44	$30,115	$48,573
210	Wimmera	1.88	1,307	18,569	2.35	$28,889	$46,596
301	Burnett Mary	5.70	1,257	133,685	2.37	$27,579	$44,482
302	Cape York	0.15	1,687	5,955	2.59	$33,923	$54,715
303	Condamine	8.22	1,513	76,221	2.57	$30,562	$49,293
304	Cooperative Management Area	0.03	1,252	411	3.04	$21,407	$34,528
305	Desert Channels	0.02	1,420	5,573	1.92	$38,533	$62,150
306	Fitzroy Basin	1.49	1,780	90,644	2.60	$35,618	$57,449
307	North Queensland Dry Tropics	1.72	1,632	90,674	2.56	$33,083	$53,360
308	Northern Gulf	0.05	1,323	3,870	1.86	$37,008	$59,690
309	Queensland Murray Darling Basin	0.41	1,431	18,216	2.41	$30,854	$49,764
310	Reef Catchments	14.74	1,702	53,012	2.58	$34,329	$55,369
311	South East Queensland	136.30	1,813	1,198,291	2.67	$35,332	$56,986
312	South West Queensland	0.04	1,375	3,511	2.15	$33,274	$53,668
313	Southern Gulf	0.13	1,999	10,940	2.49	$41,784	$67,394
314	Terrain NRM	12.14	1,507	103,892	2.44	$32,137	$51,834
315	Torres Strait	9.41	1,546	2,144	3.78	$21,278	$34,319
401	Adelaide and Mount Lofty Ranges	199.48	1,583	528,535	2.51	$32,837	$52,963
402	Alinytjara Wilurara	0.01	1,388	768	3.42	$21,094	$34,022
403	Eyre Peninsula	1.14	1,406	24,400	2.30	$31,738	$51,191
404	Kangaroo Island	1.07	1,198	2,089	2.25	$27,673	$44,633
405	Northern and Yorke	2.52	1,269	37,762	2.31	$28,529	$46,015
406	South Australian Arid Lands	0.02	1,861	3,787	2.25	$43,064	$69,458
407	SA Murray Darling Basin	2.18	1,338	50,819	2.43	$28,645	$46,201
408	South East	2.46	1,390	26,855	2.47	$29,309	$47,273
501	Northern Agricultural	0.82	1,590	26,570	2.41	$34,256	$55,251
502	Peel-Harvey	12.11	1,651	52,971	2.60	$33,007	$53,237
503	Perth	391.23	1,981	682,127	2.65	$38,864	$62,684
504	Rangelands	0.07	2,141	56,625	2.57	$43,315	$69,862
505	South Coast	0.81	1,532	27,062	2.51	$31,769	$51,240
506	South West	4.58	1,626	71,247	2.56	$33,033	$53,280
507	Wheatbelt	0.47	1,609	24,080	2.58	$32,452	$52,342
601	Cradle Coast	4.84	1,288	45,694	2.39	$28,077	$45,286
602	North	7.03	1,326	58,483	2.40	$28,713	$46,311
603	South	10.17	1,507	106,190	2.44	$32,077	$51,738
701	Northern Territory	0.17	2,176	79,981	2.83	$40,002	$64,519
801	ACT	168.30	2,333	150,944	2.63	$46,141	$74,421

Estimated from ABS 2016 census data, Tablebuilder: $\sum \frac{Number\ of\ households\ earning\ specified\ income\ x\ Mid-point\ of\ income\ category}{Total\ number\ of\ households\ providing\ income\ data}$

* Estimated using the ABS table-builder, 2016 census data; Total population divided by total dwellings.

Table 5: 'Abundance' of biomes, by NRM

Code	Name	Forests (ha)	Woodlands /Savannas (ha)	Shrublands /Grasslands (ha)	Wetlands (ha)	Forest abundance (ha/total ha)	Woodlands /Savanna abundance (ha/total ha)	Shrublands /Grasslands abundance (ha/total ha)	Wetlands abundance (ha/total ha)
101	Central Tablelands	256,794	599,594	263,033	12,322	8.54%	19.94%	8.75%	0.41%
102	Central West	175,760	2,847,959	1,008,566	120,180	1.92%	31.16%	11.03%	1.31%
103	Greater Sydney	375,185	413,238	41,468	36,117	30.84%	33.97%	3.41%	2.97%
104	Hunter	1,403,032	212,253	34,341	61,939	44.22%	6.69%	1.08%	1.95%
105	Murray	368,571	549,595	571,901	86,378	8.80%	13.12%	13.65%	2.06%
106	North Coast	1,852,594	60,383	49,703	102,912	62.62%	2.04%	1.68%	3.48%
107	North West NSW	420,984	2,773,945	717,262	107,491	5.16%	34.00%	8.79%	1.32%
108	Northern Tablelands	1,384,850	534,050	24,159	13,882	35.77%	13.80%	0.62%	0.36%
109	Riverina	348,822	489,953	711,507	123,755	5.21%	7.31%	10.62%	1.85%
110	South East NSW	1,550,443	1,200,395	199,380	81,387	28.34%	21.94%	3.64%	1.49%
111	Western	258,744	12,530,275	17,389,110	254,209	0.82%	39.85%	55.30%	0.81%
201	Corangamite	237,874	95,986	38,886	55,024	17.94%	7.24%	2.93%	4.15%
202	East Gippsland	1,480,582	349,492	40,224	23,481	70.86%	16.73%	1.93%	1.12%
203	Glenelg Hopkins	131,761	466,532	130,631	25,862	4.93%	17.46%	4.89%	0.97%
204	Goulburn Broken	705,299	380,903	18,787	31,695	29.43%	15.89%	0.78%	1.32%
205	Mallee	5,827	250,517	1,599,444	21,527	0.15%	6.38%	40.72%	0.55%
206	North Central	337,934	417,151	148,251	23,478	11.40%	14.07%	5.00%	0.79%
207	North East	1,003,047	408,148	20,016	20,808	50.65%	20.61%	1.01%	1.05%
208	Port Phillip and Western Port	347,669	96,036	56,086	7,180	27.29%	7.54%	4.40%	0.56%
209	West Gippsland	683,835	144,397	97,304	39,113	39.68%	8.38%	5.65%	2.27%
210	Wimmera	67,296	341,323	290,053	24,160	2.87%	14.57%	12.38%	1.03%
301	Burnett Mary	1,194,869	1,186,967	109,148	45,361	22.01%	21.87%	2.01%	0.84%
302	Cape York	612,727	8,804,566	950,023	141,120	6.03%	86.61%	9.35%	1.39%
303	Condamine	122,445	533,640	9,942	1,802	5.05%	22.00%	0.41%	0.07%
304	Cooperative Management Area	10,779	2,559,974	350,363	22,544	0.36%	86.39%	11.82%	0.76%
305	Desert Channels	2,989	14,959,257	33,806,027	120,767	0.01%	29.32%	66.25%	0.24%
306	Fitzroy Basin	1,934,716	4,384,547	293,788	93,249	12.48%	28.29%	1.90%	0.60%
307	North Queensland Dry Tropics	557,194	9,457,941	397,451	69,964	4.01%	68.10%	2.86%	0.50%
308	Northern Gulf	131,712	14,668,501	1,337,520	67,014	0.80%	89.49%	8.16%	0.41%
309	Queensland Murray Darling Basin	184,324	2,825,101	157,969	4,128	1.79%	27.50%	1.54%	0.04%
310	Reef Catchments	283,963	193,595	14,556	38,610	35.58%	24.26%	1.82%	4.84%
311	South East Queensland	538,310	225,661	42,541	40,135	23.85%	10.00%	1.88%	1.78%

Code	Name	Forests (ha)	Woodlands /Savannas (ha)	Shrublands /Grasslands (ha)	Wetlands (ha)	Forest abundance (ha/total ha)	Woodlands /Savanna abundance (ha/total ha)	Shrublands /Grasslands abundance (ha/total ha)	Wetlands abundance (ha/total ha)
312	South West Queensland	35,508	9,208,814	4,894,770	34,408	0.19%	49.21%	26.16%	0.18%
313	Southern Gulf	34,082	10,846,553	8,319,099	91,800	0.17%	55.68%	42.71%	0.47%
314	Terrain NRM	1,043,134	585,741	43,005	56,702	65.80%	36.95%	2.71%	3.58%
315	Torres Strait	17,505	29,969	11,184	21,291	24.39%	41.75%	15.58%	29.66%
401	Adelaide and Mount Lofty Ranges	9,728	59,059	16,332	10,112	1.47%	8.89%	2.46%	1.52%
402	Alinytjara Wilurara	0	8,991,788	19,038,950	97,955		31.94%	67.62%	0.35%
403	Eyre Peninsula	2,292	280,130	2,093,110	37,554	0.04%	5.41%	40.46%	0.73%
404	Kangaroo Island	0	63,674	147,641	2,901		15.07%	34.95%	0.69%
405	Northern and Yorke	22,619	456,778	649,087	25,537	0.68%	13.71%	19.48%	0.77%
406	South Australian Arid Lands	418	9,401,033	39,445,226	3,094,845	0.00%	18.04%	75.68%	5.94%
407	SA Murray Darling Basin	6,292	539,178	2,419,632	116,011	0.11%	9.66%	43.33%	2.08%
408	South East	0	106,301	331,440	57,804		4.05%	12.63%	2.20%
501	Northern Agricultural	40	577,660	2,526,171	71,601	0.00%	7.89%	34.49%	0.98%
502	Peel-Harvey	404,402	111,946	5,130	715	35.27%	9.76%	0.45%	0.06%
503	Perth	246,857	253,740	12,494	488	28.01%	28.80%	1.42%	0.06%
504	Rangelands	0	55,499,029	157,988,820	3,343,959		25.45%	72.46%	1.53%
505	South Coast	368,571	1,629,983	2,828,125	130,979	4.40%	19.46%	33.76%	1.56%
506	South West	1,266,448	374,093	118,393	4,054	31.74%	9.38%	2.97%	0.10%
507	Wheatbelt	35,278	1,781,662	3,278,941	109,568	0.28%	14.04%	25.85%	0.86%
601	Cradle Coast	843,152	299,547	657,348	55,121	47.43%	16.85%	36.98%	3.10%
602	North	658,190	316,192	283,095	31,194	33.63%	16.16%	14.47%	1.59%
603	South	992,223	433,055	506,354	137,767	41.10%	17.94%	20.97%	5.71%
701	Northern Territory	6,006,351	65,574,556	61,795,837	655,101	4.47%	48.79%	45.98%	0.49%
801	ACT	186,000	35,194	3,817	0	82.35%	15.58%	1.69%	0.00%
TOTAL		31,150,021	252,417,550	368,333,441	10,105,061	4.08%	33.03%	48.19%	1.32%

Appendix D: Regulating services

Data used to estimate regulating service transfer functions

We first consulted the TEEB database, identifying studies that had generated relevant estimates. If a study generated a value relevant to the mediation of water, we coded it as being related to water purification[13]. We supplemented the database with estimates from more recent studies, specifically (although not exclusively) looking for values in arid regions that comprise such a significant proportion of Australia's land mass (grasslands, woodlands, savannas), but for which there were very few values in the TEEB database. We converted all estimates to 2015 AUD and determined which biome they related to.

For each of value-estimate, we compiled information on size of the study site, population of country, area of country, and GDP per capita. In all cases, we ensured that relevant population and GDP per capita information was for the year in which the original study had been undertaken. If there was insufficient information provided in the TEEB database, we consulted the primary study; if the information in the primary study was insufficient, we looked elsewhere (e.g., consulting the World Bank, for population and per-capita GDP for each country, in the year during which the study took place). Our final list of estimates comprised 249 separate estimates across four grouped biomes for the six (sub) services above (see Table 6 for a complete listing from all studies used). In some cases, a single study used almost identical approaches to estimate multiple values for different sub-biomes (e.g., 4 different types of grass). In these situations, we recorded a single (mean) estimate in our database – rather than entering each separately. To do otherwise, would be to, essentially, weight our pooled estimates, in favour of a single study/approach. Summary statistics drawn from the studies of regulatory services, grouped by service and biome are provided in Table 6.

[13] Studies considering the mediation of soil and/or air, were not included (our focus is exclusively on water).

Table 6: Studies used when assessing water and other regulatory service values - per-hectare estimates for 'biomes' (subsequently linked to NVIS)

Grouped Biomes	Biome	Service	Reference	Country Area	Study Site Area	GDP Per Capita	Population Density	$ Per Hectare p.a. (AUD, 2015)
Arid & Woodlands	Alpine and sub-alpine grasslands	C-sequestration	Hönigová *et al.* (2012)	7,886,500	5,259	$32,436	132.63	$35.19
Arid & Woodlands	Aluvial meadows	C-sequestration	Hönigová *et al.* (2012)	7,886,500	16,005	$32,436	132.63	$62.55
Arid & Woodlands	Desert / semi-desert	Erosion	Dodds *et al.* (2008)	916,192,000	148,000,000	$57,221	31.96	$447.30
Arid & Woodlands	Desert / semi-desert	Flood control	Dodds *et al.* (2008)	916,192,000	148,000,000	$57,221	31.96	$3.77
Arid & Woodlands	Desert / semi-desert	Mediation - Air, Soil	Dodds *et al.* (2008)	916,192,000	148,000,000	$57,221	31.96	$-
Arid & Woodlands	Desert / semi-desert	Water purification	De Lange and van Wilgen (2010)	74,339,000	36,011,000	$12,016	67.81	$1.69
Arid & Woodlands	Desert / semi-desert	Water purification	De Lange and van Wilgen (2010)	74,339,000	8,310,000	$12,016	67.81	$4.21
Arid & Woodlands	Desert / semi-desert	Water purification	De Lange and van Wilgen (2010)	74,339,000	7,134,000	$12,016	67.81	$105.56
Arid & Woodlands	Desert / semi-desert	Water purification	Dodds *et al.* (2008)	916,192,000	148,000,000	$57,221	31.96	$160.42
Arid & Woodlands	Desert / semi-desert	Water purification	Kroeger and Manalo (2007)	916,192,000	19,900,000	$74,391	31.66	$13.24
Arid & Woodlands	Dry grasslands	C-sequestration	Hönigová *et al.* (2012)	7,886,500	7,604	$32,436	132.63	$15.64
Arid & Woodlands	Dry grasslands	Erosion	Hönigová *et al.* (2012)	7,886,500	973,633	$32,436	132.63	$241.09
Arid & Woodlands	Grasslands	C-sequestration	Ministerie van Landbouw (2006)[14]			$71,695	348.35	$201.70
Arid & Woodlands	Grasslands	C-sequestration	Predo (2003)	29,817,000		$2,651	267.18	$1,226.99
Arid & Woodlands	Grasslands	C-sequestration	Sala and Paruelo (1997)	915,896,000		$67,083	29.77	$604.67
Arid & Woodlands	Grasslands	Erosion	Barrow (1991)	915,896,000		$81,181	32.89	$65.16
Arid & Woodlands	Grasslands	Erosion	Dodds *et al.* (2008)	916,192,000	33,000,000	$57,221	31.96	$454.85
Arid & Woodlands	Grasslands	Erosion	Ministerie van Landbouw (2006)[15]	3,028,000		$71,695	348.35	$86.86
Arid & Woodlands	Grasslands	Erosion	Pimentel *et al.* (1995)	915,896,000	160,000,000	$59,878	28.01	$94.90
Arid & Woodlands	Grasslands	Erosion	Pimentel *et al.* (1995)	915,896,000	160,000,000	$59,878	28.01	$252.09
Arid & Woodlands	Grasslands	Flood control	Dodds *et al.* (2008)	916,192,000	33,000,000	$57,221	31.96	$13.21
Arid & Woodlands	Grasslands	Flood control	Hönigová *et al.* (2012)	7,886,500	5,259	$32,436	132.63	$1,550.07
Arid & Woodlands	Grasslands	Genepool	Perrings (1995)					$0.02
Arid & Woodlands	Grasslands	Genepool	Turpie (2003)	121,309,000	79,613,600	$9,680	38.24	$0.09
Arid & Woodlands	Grasslands	Mediation - Air, Soil	Dodds *et al.* (2008)	916,192,000	33,000,000	$57,221	31.96	$13.21
Arid & Woodlands	Grasslands	Mediation - Air, Soil	Sala and Paruelo (1997)	915,896,000		$67,083	29.77	$0.11
Arid & Woodlands	Grasslands	Mediation - Air, Soil	Sala and Paruelo (1997)	915,896,000		$67,083	29.77	$1.30

[14] Cited in van der Ploeg and De Groot (2010)
[15] Cited in van der Ploeg and De Groot (2010)

Arid & Woodlands	Grasslands	Water purification	Butcher Partners Limited et al. (2006)[16]	26,331,000	22,000	$54,570	15.89	$47.74
Arid & Woodlands	Grasslands	Water purification	Butcher Partners Limited et al. (2006)[17]	26,331,000	22,000	$54,570	15.89	$58.78
Arid & Woodlands	Grasslands	Water purification	De Lange and van Wilgen (2010)	121,309,000	34,919,000	$12,016	41.56	$17.34
Arid & Woodlands	Grasslands	Water purification	Dodds *et al.* (2008)	916,192,000	33,000,000	$57,221	31.96	$52.85
Arid & Woodlands	Grasslands	Water purification	Ministerie van Landbouw (2006)[18]			$71,695	348.35	$22.51
Arid & Woodlands	Grasslands	Water purification	Ministerie van Landbouw (2006)[19]			$71,695	348.35	$246.52
Arid & Woodlands	Heathlands	C-sequestration	Hönigová *et al.* (2012)	7,886,500	53	$32,436	132.63	$23.46
Arid & Woodlands	Mesic grasslands	C-sequestration	Hönigová *et al.* (2012)	7,886,500	38,661	$32,436	132.63	$39.09
Arid & Woodlands	Pastures and managed grasslands	C-sequestration	Hönigová *et al.* (2012)	7,886,500	702,162	$32,436	132.63	$39.09
Arid & Woodlands	Saltmarshes	C-sequestration	Hönigová *et al.* (2012)	7,886,500	99	$32,436	132.63	$31.28
Arid & Woodlands	Seasonally wet and wet grasslands	C-sequestration	Hönigová *et al.* (2012)	7,886,500	202,907	$32,436	132.63	$62.55
Arid & Woodlands	Forest fringe vegetation	C-sequestration	Hönigová *et al.* (2012)	7,886,500	406	$32,436	132.63	$39.09
Arid & Woodlands	Woodlands	C-sequestration	Emerton (1998)	2,318,000	70,000	$1,605	29.36	$12.47
Arid & Woodlands	Woodlands	C-sequestration	Ministerie van Landbouw (2006)[20]			$71,695	348.35	$685.78
Arid & Woodlands	Woodlands	Erosion	Ministerie van Landbouw (2006)[21]			$71,695	348.35	$87.10
Arid & Woodlands	Woodlands	Erosion	Rodríguez *et al.* (2006)	128,000,000	38,000	$6,664	21.84	$20.28
Arid & Woodlands	Woodlands	Genepool	Amigues *et al.* (2002)	54,756,699	1	$63,746	112.05	$172.46
Arid & Woodlands	Woodlands	Genepool	Blamey *et al.* (2000)	768,230,000	6,881,790	$65,750	2.41	$6.08
Arid & Woodlands	Woodlands	Genepool	Rodríguez *et al.* (2006)	128,000,000	38,000	$6,664	21.84	$2,015.39
Arid & Woodlands	Woodlands	Genepool	Turpie (2003)	121,309,000	7,116,279	$9,561	37.70	$63.37
Arid & Woodlands	Woodlands	Mediation - Air, Soil	Ministerie van Landbouw (2006)[22]			$71,695	348.35	$142.62
Arid & Woodlands	Woodlands	Water purification	Croitoru (2007)					$230.05
Arid & Woodlands	Woodlands	Water purification	De Lange and van Wilgen (2010)	74,339,000	40,287,000	$12,016	67.81	$7.00
Arid & Woodlands	Woodlands	Water purification	Ministerie van Landbouw (2006)[23]			$71,695	348.35	$0.37
Arid & Woodlands	Woodlands	Water purification	Ministerie van Landbouw (2006)[24]			$71,695	348.35	$68.84

[16] Cited in van der Ploeg and De Groot (2010)
[17] Cited in van der Ploeg and De Groot (2010)
[18] Cited in van der Ploeg and De Groot (2010)
[19] Cited in van der Ploeg and De Groot (2010)
[20] Cited in van der Ploeg and De Groot (2010)
[21] Cited in van der Ploeg and De Groot (2010)
[22] Cited in van der Ploeg and De Groot (2010)
[23] Cited in van der Ploeg and De Groot (2010)
[24] Cited in van der Ploeg and De Groot (2010)

Arid & Woodlands	Woodlands	Water purification	Ministerie van Landbouw (2006)[25]			$71,695	348.35	$346.36
Arid & Woodlands	Woodlands	Water purification	Ministerie van Landbouw (2006)[26]			$71,695	348.35	$1,241.58
Coastal	Coastal	Genepool	Chang *et al.* (2009)	9,688,000	77,004	$31,813	499.98	$6.25
Coastal	Coastal	Genepool	De Groot (1992)	3,376,000	270,000	$48,530	419.13	$284.71
Coastal	Coastal	Genepool	Turpie (2000)	88,580,000	82,373	$838	38.58	$58.13
Coastal	Coastal	Genepool	Turpie (2003)	121,309,000	60,504	$9,561	37.70	$370.12
Forests	Forests	C-sequestration	Curtis (2004)	768,230,000	894,400	$74,977	2.56	$22.03
Forests	Forests	C-sequestration	Emerton (1999)	19,981,000	11,449,110	$646	112.87	$29.43
Forests	Forests	C-sequestration	Krutilla (1991)	32,855,000		$14,141	81.04	$1,310.29
Forests	Forests	C-sequestration	Kumari (1996) - Tropical inland	32,855,000	72,816	$9,594	60.83	$593.37
Forests	Forests	C-sequestration	Naidoo and Ricketts (2006)	39,730,000	292,000	$5,903	14.59	$25.68
Forests	Forests	C-sequestration	Niskanen (1998)	51,089,000		$5,806	119.13	$1,664.11
Forests	Forests	C-sequestration	Pearce (2001)					$52.22
Forests	Forests	C-sequestration	Pearce (2001)					$65.48
Forests	Forests	C-sequestration	Pearce (2001)					$95.32
Forests	Forests	C-sequestration	Pearce (2001)					$160.80
Forests	Forests	C-sequestration	Pearce (2001)					$234.57
Forests	Forests	C-sequestration	Predo (2003)	29,817,000		$2,651	267.18	$3,405.58
Forests	Forests	C-sequestration	Wei *et al.* (2018)	938,821,100	3,311,900	$7,467	142.49	$254.13
Forests	Forests	C-sequestration	Xue and Tisdell (2001)	938,823,000	169,658	$2,525	132.29	$1,309.64
Forests	Forests	C-sequestration	Yaron (2001)	47,271,000	1,163	$1,905	32.31	$116.04
Forests	Forests	Erosion	Ammour *et al.* (2000)	10,716,000	6,500	$4,184	108.72	$63.85
Forests	Forests	Erosion	Chomitz and Kumari (1998)	24,836,000	51,860	$7,241	57.20	$26.98
Forests	Forests	Erosion	Chomitz and Kumari (1998)	29,817,000	51,860	$3,228	299.47	$367.80
Forests	Forests	Erosion	Cruz *et al.* (1988)	29,817,000	84,500	$2,412	228.85	$14.65
Forests	Forests	Erosion	Curtis (2004)	768,230,000	894,400	$74,977	2.56	$23.66
Forests	Forests	Erosion	Dodds *et al.* (2008)	916,192,000	74,000,000	$57,221	31.96	$454.85
Forests	Forests	Erosion	Emerton (1999)	19,981,000	1,272,699	$646	112.87	$561.54
Forests	Forests	Erosion	Niskanen (1998)	51,089,000		$5,806	119.13	$165.67
Forests	Forests	Erosion	Rosales *et al.* (2005)	23,080,000	288,150	$1,249	24.18	$5.74
Forests	Forests	Erosion	Wei *et al.* (2018)	938,821,100	3,311,900	$7,467	142.49	$15.82
Forests	Forests	Erosion	Xue and Tisdell (2001)	938,823,000	167,081	$2,525	132.29	$10.00
Forests	Forests	Flood control	Curtis (2004)	768,230,000	894,400	$74,977	2.56	$3.56
Forests	Forests	Flood control	Curtis (2004)	768,230,000	894,400	$74,977	2.56	$17.83
Forests	Forests	Flood control	Dodds *et al.* (2008)	916,192,000	147,000,000	$57,221	31.96	$11.32

[25] Cited in van der Ploeg and De Groot (2010)
[26] Cited in van der Ploeg and De Groot (2010)

Forests	Forests	Flood control	Dodds *et al.* (2008)	916,192,000	58,000,000	$57,221	31.96	$5.66
Forests	Forests	Flood control	Dodds *et al.* (2008)	916,192,000	17,000,000	$57,221	31.96	$20.76
Forests	Forests	Flood control	Kramer *et al.* (1997)	58,154,000	26,787	$683	23.17	$10.93
Forests	Forests	Flood control	Kumari (1996) - Tropical inland	32,855,000	72,816	$9,594	60.83	$38.56
Forests	Forests	Flood control	Perrot-Maitre and Davis (2001)	194,395,000	1,823,640	$15,307	58.47	$46.64
Forests	Forests	Flood control	Rosales *et al.* (2005)	23,080,000	288,150	$1,249	24.18	$178.51
Forests	Forests	Flood control	Wei *et al.* (2018)	938,821,100	3,311,900	$7,467	142.49	$16.95
Forests	Forests	Flood control	Yaron (2001)	47,271,000	195,000	$1,905	32.31	$137.77
Forests	Forests	Genepool	Curtis (2004)	768,230,000	894,400	$74,977	2.56	$10.70
Forests	Forests	Genepool	Curtis (2004)	768,230,000	894,400	$74,977	2.56	$11.67
Forests	Forests	Genepool	Curtis (2004)	768,230,000	894,400	$74,977	2.56	$23.66
Forests	Forests	Genepool	Curtis (2004)	768,230,000	894,400	$74,977	2.56	$27.88
Forests	Forests	Genepool	Curtis (2004)	768,230,000	894,400	$74,977	2.56	$32.09
Forests	Forests	Genepool	Godoy *et al.* (1993)	2,281,000	1,653,000	$5,716	8.84	$255.57
Forests	Forests	Genepool	Horton *et al.* (2003)	835,814,000	19,000,000	$14,375	20.97	$102.16
Forests	Forests	Genepool	Hougner *et al.* (2006)	41,034,000	100	$81,870	22.01	$2,785.42
Forests	Forests	Genepool	Kniivilä *et al.* (2002)	30,459,000	20,000	$66,239	16.99	$704.26
Forests	Forests	Genepool	Kontoleon and Swanson (2003)	938,821,250	200,000	$3,699	137.24	$502.83
Forests	Forests	Genepool	Kramer *et al.* (1995)	58,154,000	44,515,421	$704	27.11	$61.80
Forests	Forests	Genepool	Loomis and Ekstrand (1998)	916,192,000	1,861,554	$73,780	30.80	$9,364.31
Forests	Forests	Genepool	Mallawaarachchi *et al.* (2001)	768,230,000	1,013,000	$68,046	2.44	$29.34
Forests	Forests	Genepool	Pagiola *et al.* (2004)	5,106,000	1,966,000	$11,122	82.00	$84.82
Forests	Forests	Genepool	Pagiola *et al.* (2004)	12,034,000	20	$2,266	44.12	$102.16
Forests	Forests	Genepool	Priess *et al.* (2007)	181,157,000	5,659	$3,587	118.41	$92.38
Forests	Forests	Genepool	Ricketts *et al.* (2004)	5,106,000	480	$10,818	80.81	$248.66
Forests	Forests	Genepool	Siikamäki and Layton (2007)	30,459,000	120,000	$62,836	16.96	$115.89
Forests	Forests	Genepool	Turpie (2003)	121,309,000	56,400	$9,680	38.24	$44.72
Forests	Forests	Genepool	Walsh *et al.* (1984)	915,896,000	485,623	$47,054	24.81	$89.77
Forests	Forests	Mediation - Air, Soil	Curtis (2004)	768,230,000	894,400	$74,977	2.56	$16.53
Forests	Forests	Mediation - Air, Soil	Curtis (2004)	768,230,000	894,400	$74,977	2.56	$20.49
Forests	Forests	Mediation - Air, Soil	Curtis (2004)	768,230,000	894,400	$74,977	2.56	$22.37
Forests	Forests	Mediation - Air, Soil	Dodds *et al.* (2008)	916,192,000	147,000,000	$57,221	31.96	$196.28
Forests	Forests	Mediation - Air, Soil	Dodds *et al.* (2008)	916,192,000	58,000,000	$57,221	31.96	$58.51
Forests	Forests	Mediation - Air, Soil	Dodds *et al.* (2008)	916,192,000	17,000,000	$57,221	31.96	$120.79
Forests	Forests	Mediation - Air, Soil	Ministerie van Landbouw (2006)[27]			$71,695	348.35	$1,426.17
Forests	Forests	Mediation - Air, Soil	Xue and Tisdell (2001)	938,823,000	167,081	$2,525	132.29	$69.33

[27] Cited in van der Ploeg and De Groot (2010)

Forests	Forests	Sediment	Wei *et al.* (2018)	938,821,100	3,311,900	$7,467	142.49	$345.26
Forests	Forests	Water purification	Anielski and Wilson (2005)	909,351,000	241,985,000	$73,499	3.45	$0.11
Forests	Forests	Water purification	Bann (1997)	17,652,000	1,813	$575	62.20	$6.48
Forests	Forests	Water purification	Curtis (2004)	768,230,000	894,400	$74,977	2.56	$14.02
Forests	Forests	Water purification	Curtis (2004)	768,230,000	894,400	$74,977	2.56	$18.80
Forests	Forests	Water purification	Cruz and Benedicto (2009)	9,147,000	6,067	$36,527	115.04	$32.40
Forests	Forests	Water purification	Cruz and Benedicto (2009)	9,147,000	6,067	$36,527	115.04	$177.31
Forests	Forests	Water purification	Dodds *et al.* (2008)	916,192,000	147,000,000	$57,221	31.96	$149.10
Forests	Forests	Water purification	Dodds *et al.* (2008)	916,192,000	58,000,000	$57,221	31.96	$86.82
Forests	Forests	Water purification	Dodds *et al.* (2008)	916,192,000	17,000,000	$57,221	31.96	$39.63
Forests	Forests	Water purification	Kaiser and Roumasset (2002)	916,192,000	39,562	$73,780	30.80	$2,175.07
Forests	Forests	Water purification	Perrot-Maitre and Davis (2001)	54,756,602	10,000	$61,048	110.48	$484.62
Forests	Forests	Water purification	Perrot-Maitre and Davis (2001)	768,230,000	100	$70,649	2.46	$138.09
Forests	Forests	Water purification	van Beukering *et al.* (2003)	181,157,000	2,500,000	$3,510	116.77	$80.20
Forests	Forests	Water purification	Wei *et al.* (2018)	938,821,100	3,311,900	$7,467	142.49	$184.68
Inland aquatic	Inland aquatic	C-sequestration	Anielski and Wilson (2005) - Temperate inland	909,351,000	83,199,800	$73,499	3.45	$6.66
Inland aquatic	Inland aquatic	C-sequestration	Kumari (1996) - Tropical inland	32,855,000	72,816	$9,594	60.83	$604.89
Inland aquatic	Inland aquatic	C-sequestration	Turpie *et al.* (1999) - Tropical inland	74,339,000	550,000	$1,521	13.77	$79.75
Inland aquatic	Inland aquatic	C-sequestration	Turpie *et al.* (1999) - Tropical inland	121,309,000	304,600	$9,312	37.14	$58.67
Inland aquatic	Inland aquatic	C-sequestration	Turpie *et al.* (1999) - Tropical inland	121,309,000	243,000	$9,312	37.14	$53.48
Mangroves	Mangroves	Genepool	Bann (1999)	32,855,000	27,000	$10,791	68.96	$1,108.29
Mangroves	Mangroves	Genepool	Bann (1999)	32,855,000	1,690	$10,791	68.96	$50.57
Mangroves	Mangroves	Genepool	Bann (1999)	32,855,000	1,667	$10,791	68.96	$15,802.68
Mangroves	Mangroves	Genepool	Barbier and Strand (1998)	194,395,000	83,500	$13,228	37.35	$2,539.33
Mangroves	Mangroves	Genepool	Barbier *et al.* (2002)	51,089,000	168,400	$5,046	114.24	$162.06
Mangroves	Mangroves	Genepool	Bennett and Reynolds (1993)	32,855,000	8,728	$7,007	53.37	$5,621.04
Mangroves	Mangroves	Genepool	Burbridge (1982)	181,157,000	205,000	$3,821	121.74	$180.52
Mangroves	Mangroves	Genepool	Christensen (1982)	51,089,000	4,000,000	$5,400	115.29	$15.06
Mangroves	Mangroves	Genepool	Christensen (1982)	51,089,000	4,000,000	$5,400	115.29	$32.50
Mangroves	Mangroves	Genepool	Christensen (1982)	51,089,000	4,000,000	$5,400	115.29	$133.50
Mangroves	Mangroves	Genepool	Crossman *et al.* (2018)	768,230,000	357,000	$90,224	3.10	$99.76
Mangroves	Mangroves	Genepool	Gammage (1997)	2,072,000	26,772	$3,736	260.63	$5,384.85
Mangroves	Mangroves	Genepool	Gunawardena and Rowan (2005)	6,271,000	200	$2,480	292.97	$5.70
Mangroves	Mangroves	Genepool	Ron and Padilla (1999)	29,817,000	111	$2,467	234.21	$1,218.59
Mangroves	Mangroves	Genepool	Lal (1990)	1,827,000	38,500	$6,006	45.69	$1,441.40
Mangroves	Mangroves	Genepool	Levine and Mindedal (1998)	31,007,000		$1,865	277.00	$1,621.58
Mangroves	Mangroves	Genepool	Morton (1990)	768,230,000	54	$83,441	2.71	$10,072.37

Mangroves	Mangroves	Genepool	Naylor and Drew (1998)	70,000	1,562	$4,287	154.78	$1,585.99
Mangroves	Mangroves	Genepool	Nickerson (1999)	29,817,000	123,000	$3,228	299.47	$102,756.09
Mangroves	Mangroves	Genepool	Samonte-Tan *et al.* (2007)	29,817,000	253	$2,895	283.99	$458.05
Mangroves	Mangroves	Genepool	Sathirathai (1998)	51,089,000	400	$5,781	116.45	$237.63
Mangroves	Mangroves	Genepool	Tri *et al.* (2000)	31,106,000	21,000	$1,181	255.23	$33,674.40
Mangroves	Mangroves	Genepool	Turpie (2000)	88,580,000	55,154	$838	38.58	$86.82
Mangroves	Woodlands	Genepool	Turpie (2003)	121,309,000	7,116,279	$9,561	37.70	$16.72
Mangroves and coastal wetlands	Coastal wetlands	C-sequestration	Crossman *et al.* (2018)	768,230,000	357,000	$90,224	3.10	$246.50
Mangroves and coastal wetlands	Coastal wetlands	C-sequestration	Tong *et al.* (2007)	938,821,250	1,100	$4,049	138.05	$267.67
Mangroves and coastal wetlands	Mangroves	C-sequestration	Crossman *et al.* (2018)	768,230,000	357,000	$90,224	3.10	$445.38
Mangroves and coastal wetlands	Mangroves	C-sequestration	Emerton (2005)	17,652,000	1,800	$778	71.58	$3.56
Mangroves and coastal wetlands	Mangroves	C-sequestration	Sathirathai (1998)	51,089,000	400	$5,781	116.45	$463.42
Mangroves and coastal wetlands	Mangroves	C-sequestration	Turpie *et al.* (1999) - Tropical coastal	78,638,000	1,275,000	$425	22.36	$4.16
Wetlands	Coastal	Mediation - Air, Soil	Houde and Rutherford (1993)					$88.91
Wetlands	Coastal wetlands	Flood control	Beaumont *et al.* (2008)	24,193,000	45,500	$63,558	247.96	$19,446.14
Wetlands	Coastal wetlands	Flood control	Beaumont *et al.* (2008)	24,193,000	45,500	$63,558	247.96	$-
Wetlands	Coastal wetlands	Flood control	Costanza *et al.* (1989)	915,896,000	18,146	$48,154	25.53	$752.18
Wetlands	Coastal wetlands	Flood control	Dugan and Dugan (1990)	24,193,000		$49,150	239.18	$16,725.63
Wetlands	Coastal wetlands	Flood control	Farber (1987)	915,896,000	64,752	$48,154	25.53	$2.58
Wetlands	Coastal wetlands	Flood control	Farber (1987)	915,896,000	64,752	$48,154	25.53	$43.85
Wetlands	Coastal wetlands	Flood control	Farber (1987)	915,896,000	64,750	$47,054	24.81	$2.33
Wetlands	Coastal wetlands	Flood control	King and Lester (1995)	24,193,000		$67,221	253.47	$14,321.03
Wetlands	Coastal wetlands	Flood control	Ledoux (2004)					$470.79
Wetlands	Coastal wetlands	Flood control	Pyo (2001)	9,692,000		$33,382	502.31	$6,546.37
Wetlands	Coastal wetlands	Flood control	Tong *et al.* (2007)	938,821,250	1,100	$4,049	138.05	$1,538.76
Wetlands	Coastal wetlands	Genepool	Coreil (1993)	915,896,000	4,000,000	$81,181	32.89	$176.29
Wetlands	Coastal wetlands	Genepool	Crossman *et al.* (2018)	768,230,000	357,000	$90,224	3.10	$49.00
Wetlands	Coastal wetlands	Genepool	Do and Bennett (2005)	31,007,000	4,000,000	$1,865	277.00	$4,072.35
Wetlands	Coastal wetlands	Genepool	Everard (2009)	24,193,000	440	$67,221	253.47	$16.54
Wetlands	Coastal wetlands	Genepool	Johnston *et al.* (2002)	915,896,000	22,500	$81,181	32.89	$3,865.04
Wetlands	Coastal wetlands	Genepool	Lynne *et al.* (1981)	915,896,000	205,733	$41,331	23.58	$3.51
Wetlands	Coastal wetlands	Genepool	Nunes *et al.* (2004)	29,414,000	55,000	$62,614	198.68	$52.30

Wetlands	Coastal wetlands	Water purification	De Groot (1992)	3,376,000	270,000	$58,105	442.88	$11,482.09
Wetlands	Coastal wetlands	Water purification	Emerton and Kekulandala (2002)	6,271,000	3,068	$3,014	303.93	$130.21
Wetlands	Inland aquatic	Erosion	Turpie *et al.* (1999) - Tropical inland	121,309,000	304,600	$9,312	37.14	$47.47
Wetlands	Inland aquatic	Flood control	Anielski and Wilson (2005) - Temperate inland	909,351,000	83,199,800	$73,499	3.45	$1,340.54
Wetlands	Inland aquatic	Flood control	Anielski and Wilson (2005) - Temperate inland	909,351,000	2,836,800	$73,499	3.45	$513.10
Wetlands	Inland aquatic	Flood control	New Zealand Department of Conservation (2007)	26,331,000	7,300	$56,097	16.04	$1,227.20
Wetlands	Inland aquatic	Flood control	Dubgaard *et al.* (2002)	4,243,000	290	$86,201	125.01	$25.29
Wetlands	Inland aquatic	Flood control	Emerton and Bos (2004)	6,271,000		$3,167	306.42	$3,384.46
Wetlands	Inland aquatic	Flood control	Gerrard (2004)	23,080,000	2,000	$1,249	24.18	$2,748.18
Wetlands	Inland aquatic	Flood control	(Leschine *et al.*, 1997)	915,896,000		$81,181	32.89	$14,615.51
Wetlands	Inland aquatic	Flood control	Turpie *et al.* (1999) - Tropical inland	74,339,000	550,000	$1,521	13.77	$1.18
Wetlands	Inland aquatic	Flood control	Turpie *et al.* (1999) - Tropical inland	121,309,000	243,000	$9,312	37.14	$18.05
Wetlands	Inland aquatic	Genepool	Anielski and Wilson (2005) - Temperate inland	909,351,000	2,836,800	$73,499	3.45	$381.26
Wetlands	Inland aquatic	Genepool	Chong (2005)	17,652,000	183	$1,004	75.18	$112.02
Wetlands	Inland aquatic	Genepool	Chong (2005)	17,652,000	183	$1,004	75.18	$224.05
Wetlands	Inland aquatic	Genepool	Folke (1991)	41,034,000		$87,479	22.29	$17.43
Wetlands	Inland aquatic	Genepool	Gerrard (2004)	23,080,000	2,000	$1,559	25.78	$1,578.96
Wetlands	Inland aquatic	Genepool	Kumari (1996) - Tropical inland	32,855,000	72,816	$9,594	60.83	$46.53
Wetlands	Inland aquatic	Genepool	Luisetti *et al.* (2008)	24,193,000	5,500	$67,221	253.47	$93.47
Wetlands	Inland aquatic	Genepool	Mallawaarachchi *et al.* (2001)	768,230,000	1,013,000	$68,046	2.44	$4,583.85
Wetlands	Inland aquatic	Genepool	Turpie *et al.* (1999) - Tropical	121,309,000	243,000	$9,312	37.14	$111.33
Wetlands	Inland aquatic	Genepool	Turpie *et al.* (1999) - Tropical inland	74,339,000	550,000	$1,521	13.77	$12.49
Wetlands	Inland aquatic	Mediation - Air, Soil	Kumari (1996) - Tropical inland	32,855,000	72,816	$9,594	60.83	$68.24
Wetlands	Inland aquatic	Mediation - Air, Soil	Lant and Roberts (1990)	915,896,000		$62,398	28.73	$738.84
Wetlands	Inland aquatic	Water purification	Chong (2005)	17,652,000	183	$1,004	75.18	$560.12
Wetlands	Inland aquatic	Water purification	Dubgaard *et al.* (2002)	4,243,000	2,200	$86,201	125.01	$226.82
Wetlands	Inland aquatic	Water purification	Emerton (1998)	19,981,000	529	$646	112.87	$19,499.40
Wetlands	Inland aquatic	Water purification	Emerton (2005)	19,981,000	529	$676	116.48	$3,983.03
Wetlands	Inland aquatic	Water purification	Emerton (2005)	19,981,000	529	$676	116.48	$6,970.31
Wetlands	Inland aquatic	Water purification	Gerrard (2004)	23,080,000	1,933	$1,249	24.18	$70.12
Wetlands	Inland aquatic	Water purification	Karanja *et al.* (2001)	19,981,000	71,100	$687	124.39	$54.68
Wetlands	Inland aquatic	Water purification	Karanja *et al.* (2001)	19,981,000	71,100	$687	124.39	$194.40
Wetlands	Inland aquatic	Water purification	Meyerhoff and Dehnhardt (2007)	34,895,000	15,000	$62,224	235.60	$18,204.17
Wetlands	Inland aquatic	Water purification	Schuijt (2002)	19,981,000	529	$722	128.71	$3,597.11

Wetlands	Inland aquatic	Water purification	Turpie *et al.* (1999) - Tropical inland	74,339,000	550,000	$1,521	13.77	$33.38
Wetlands	Inland aquatic	Water purification	Turpie *et al.* (1999) - Tropical inland	121,309,000	304,600	$9,312	37.14	$8.53
Wetlands	Inland aquatic	Water purification	Turpie *et al.* (1999) - Tropical inland	121,309,000	243,000	$9,312	37.14	$123.01
Wetlands	Inland aquatic	Water purification	Verma *et al.* (2001)	297,319,000	3,200	$1,331	347.96	$818.49
Wetlands	Inland aquatic	Water purification	Verma *et al.* (2001)	297,319,000	3,200	$1,331	347.96	$6,279.82
Wetlands	Mangroves	Erosion	Emerton (2005)	17,652,000	1,800	$778	71.58	$217.12
Wetlands	Mangroves	Erosion	Ruitenbeek (1994)	181,157,000		$4,504	128.61	$166.61
Wetlands	Mangroves	Erosion	Samonte-Tan *et al.* (2007)	29,817,000	253	$2,553	250.51	$1,424.13
Wetlands	Mangroves	Flood control	Badola and Hussain (2005)	297,319,000	326	$1,609	378.76	$1,629.86
Wetlands	Mangroves	Flood control	Bann (1997)	17,652,000	12,000	$575	62.20	$70.15
Wetlands	Mangroves	Flood control	Bann (1999)	32,855,000	1,690	$10,791	68.96	$1,780.44
Wetlands	Mangroves	Flood control	Barbier *et al.* (2002)	51,089,000	168,400	$6,500	126.36	$4,617.21
Wetlands	Mangroves	Flood control	Barbier (2007)	51,089,000	164,500	$6,041	117.74	$17,575.08
Wetlands	Mangroves	Flood control	Cooper *et al.* (2009)	2,281,000	140,000	$7,134	13.08	$1,710.49
Wetlands	Mangroves	Flood control	Emerton (2005)	17,652,000	1,800	$778	71.58	$56.95
Wetlands	Mangroves	Flood control	Gunawardena and Rowan (2005)	6,271,000	200	$2,480	292.97	$657.69
Wetlands	Mangroves	Flood control	Naylor and Drew (1998)	70,000	1,562	$4,652	152.59	$3,799.47
Wetlands	Mangroves	Flood control	Sathirathai (1998)	51,089,000	400	$5,781	116.45	$16,867.52
Wetlands	Mangroves	Mediation - Air, Soil	Pyo (2001)	10,021,000	28,320	$25,387	502.31	$20.49
Wetlands	Mangroves	Sediment	Pyo (2001)	10,021,000	28,320	$25,387	502.31	$6.46
Wetlands	Mangroves	Water purification	Pyo (2001)	10,021,000	28,320	$25,387	502.31	$1,387.98
Wetlands	Mangroves	Water purification	Turpie *et al.* (1999) - Tropical coastal	78,638,000	1,275,000	$425	22.36	$0.83
Wetlands	Coastal wetlands	Erosion	Montenegro *et al.* (2005)	29,817,000	3,000	$2,691	272.84	$22,645.67

Transfer functions

We used the data from the studies in Table 6 to develop transfer functions – regressing logged estimates of per-hectare values against (logged) measures of abundance (calculated as area of study site divided by area of country), per-capita GDP and the population density of the country in which the study had been undertaken (for the relevant year). Consistent with this practice, we used quantile regression (rather than OLS) when estimating transfer functions[28]. The small number of estimates available for any particular biome precluded us from estimating a separate transfer function for each, so we estimated a single function for each type of value, across all (grouped) biomes (Table 7).

Although we were able to find six separate water-value estimates for the (grouped) biome 'woodlands', they were generated from just two studies, only one of which provided enough information for us to also estimate study area and thus 'abundance'. As such, the data used to estimate the transfer function for water purification included only one woodland/savanna value estimate. Aiming to reduce transfer error by pooling (Brouwer *et al.*, 2015), we decided to group woodland/savanna and shrubland/grassland estimates together. We did however, allow for the fact that there is lower rainfall (and thus lower opportunity for water purification services to be provided) in shrublands/grasslands than elsewhere – using a 'base' price for shrublands that was one-half the median value associated with the large grouped biome. Consistent with previous situations in which we have had to exercise 'researcher' judgement, this generates an unambiguous downward bias in final estimates since a higher overall value would obtain if we used the same base value across all woodlands/savannas/shrublands and grasslands. Further research could usefully investigate water purification values in these regions, using refined/improved estimates to better ground the estimates used here.

Table 7: Quantile regression results from meta-analyses of water and other regulatory values - data collated from (van der Ploeg & De Groot, 2010) and elsewhere; p-values (in brackets) for robust standard errors

	Model 1 Water purification	Model 2 Erosion	Model 3 Flood control[29]	Model 4 Genepool[30]	Model 5 C-sequestration	Model 6 Mediation
Ln (StudyArea / CountryArea)	-0.3178	0.0434	-0.2698	-0.0753	-0.1744	0.3606
	(0.009)	(0.902)	(0.253)	(0.505)	(0.195)	(0.293)
LnPopDensity	0.8324	0.9833	0.3211	0.4430	0.2457	-0.2302
	(0.011)	(0.363)	(0.655)	(0.131)	(0.530)	(0.605)
LnGDPPerCapita	0.1087	0.9101	-0.3271	-0.0210	-0.0689	-0.8271
	(0.675)	(0.099)	(0.253)	(0.944)	(0.795)	(0.293)
Constant	-1.6665	-7.6835	4.4280	2.7794	2.5696	14.9564
	(0.632)	(0.300)	(0.427)	(0.421)	(0.364)	(0.240)
N	45	20	37	68	28	10
Pseudo R-squared	0.3184	0.2001	0.1528	0.0667	0.0767	0.2190

[28] We also ran models using OLS regression; the sign and magnitude of coefficients were similar to those reported here (within about 10%-20%) but generally larger. P-values were generally lower (with statistically significant coefficients for most models).

29 There were 30 separate estimates of flood control values in wetlands, so we tried a regression on that subset only; again, none of the coefficients were statistically significant.

[30] We also ran regressions investigating genepool estimates within particular biomes for which we had relatively large sample sizes (23 Mangroves; 20 forests); none of those coefficients were statistically significant.

Equations used to generate NRM specific estimates

In all cases, studies specific to woodlands/savannas and shrublands/grasslands were sparse, so those two biomes were grouped. Consistent with our approach used when estimating water values, we divided the median of this large grouped biome by two to estimate a base value for shrublands/grasslands. When considering gene-pool/habitat values we distinguished between freshwater and marine environments; there are numerous studies of both wetlands and mangroves – so it was possible to retain the benefits of 'pooling' without combining MVG 23 and 24. There were also a handful of studies that provided estimates of gene-pool values in estuaries (MVG 28), so we considered them separately.

We used the coefficients from Model 1 (Table 7) in conjunction with data from Table 8, matched to similar data for each NRM to generate NRM-specific estimates of (a) per-hectare water values and (b) total water values, for each grouped biome. We used the coefficients from Model 2 (Table 7) in conjunction with data from Table 9, matched to similar data for each NRM in the equations below to generate NRM-specific estimates of erosion control values. The meta-regressions reported on in Table 7 do not find any statistically significant coefficients for models 3 – 6 so we do not use a transfer function to estimate NRM-specific values for flood control, genepool/nursery values, carbon C-sequestration or the mediation of soil and air. Instead, we simply pooled estimates (Brouwer *et al.*, 2015) multiplying the median value-per hectare by the total number of hectares within each NRM to estimate total NRM values. We repeated the estimation process, using per-hectare values associated with the lower (Q1) and upper (Q3) quartiles, as a somewhat crude sensitivity analysis.

Service-specific data are provided below.

Water

Table 8: Summary statistics relevant to studies reporting estimates for water purification, by grouped biome

Biome(s) and Statistic	Value Per Hectare (2015 AUD p.a.)	Pop Density - study country (persons per km^2)	GDP Per Capita - study country (2015 AUD p.a.)	'Abundance' (Area of Study Site divided by Area of study country)
Forests				
N	15	15	15	15
Mean	$262.17	62.814	$46,177.80	0.036
Median	$86.82	31.958	$57,221.00	0.001
Q1	$18.80	3.449	$7,467.15	0.000
Q3	$184.68	115.035	$73,498.71	0.019
Min	$0.11	2.464	$575.37	0.000
Max	$2,175.07	142.488	$74,977.10	0.266
Woodlands, savannas, shrublands and grasslands				
N	10	10	10	10
Mean	$46.88	44.018	$35,805.38	0.174
Median	$32.54	36.758	$33,293.08	0.104
Q1	$7.00	31.664	$12,016.21	0.022
Q3	$58.78	67.814	$57,221.00	0.288
Min	$1.69	15.892	$12,016.21	0.001
Max	$160.42	67.814	$74,390.87	0.542
Wetlands				
N	20	20	20	20
Mean	$3,681.55	187.052	$14,494.77	0.006
Median	$393.47	124.393	$1,331.27	0.001
Q1	$62.40	56.160	$686.68	0.000
Q3	$5131.43	325.942	$17,349.40	0.003
Min	$0.83	13.774	$424.50	0.000
Max	$19,499.40	502.307	$86,201.23	0.080

Formulae used to generate NRM-specific estimates of water purification values

$$Forest\ water\ purification\ value\ per\ hectare_{NRM\ i} = 86.82 + Forest\ water\ adjustment_{\ NRM\ i}$$

$$Forest\ water\ adjustment_{\ NRM\ i} = -1.6665 - 0.3178\left(Ln(Abundance\ of\ Forests\ NRM_i) - Ln(0.001)\right) + 0.8324\left(Ln(Pop\ Density\ \ NRM_i) - Ln(31.958)\right) + 0.1087 * (\mathrm{Ln}(GDP\ Per\ Capita\ NRM_i) - Ln\ (57{,}221))$$

$$Woodlands\ water\ purification\ value\ per\ hectare_{NRM\ i} = 32.54 + Woodlands\ water\ adjustment_{\ NRM\ i}$$

$$Woodlands\ water\ adjustment_{\ NRM\ i} = -1.6665 - 0.3178\left(Ln(Abundance\ of\ Woodlands\ NRM_i) - Ln(0.104)\right) + 0.8324\left(Ln(Pop\ Density\ \ NRM_i) - Ln(36.758)\right) + 0.1087 * (\mathrm{Ln}(GDP\ Per\ Capita\ \ NRM_i) - Ln\ (33{,}293.08))$$

$$Shrublands\ \ water\ purification\ value\ per\ hectare_{NRM\ i} = 32.54/2 + Shrubllands\ water\ adjustment_{\ NRM\ i}$$

$$Shrublands\ water\ adjustment_{\ NRM\ i} = -1.6665 - 0.3178\left(Ln(Abundance\ of\ Arid\ lands\ NRM_i) - Ln(0.104)\right) + 0.8342\left(Ln(Pop\ Density\ \ NRM_i) - Ln(36.758)\right) + 0.1087 * (\mathrm{Ln}(GDP\ Per\ Capita\ \ NRM_i) - Ln\ (33{,}293.08)$$

$$Wetlands\ water\ purification\ value\ per\ hectare_{NRM\ i} = 393.47 + Wetlands\ adjustment_{\ NRM\ i}$$

$$Wetlands\ water\ adjustment_{\ NRM\ i} = -1.6665 - 0.3178\left(Ln(Abundance\ of\ Wetlands\ NRM_i) - Ln(0.001)\right) + 0.8342\left(Ln(Pop\ Density\ \ NRM_i) - Ln(124.393)\right) + 0.1087 * (\mathrm{Ln}(GDP\ Per\ Capita\ \ NRM_i) - Ln\ (1{,}331.27))$$

Erosion control

Table 9: Summary statistics relevant to studies reporting estimates for erosion control, by grouped biome

Biome(s) and Statistic	Value Per Hectare (2015 AUD p.a.)	Pop Density - study country (persons per km²)	GDP Per Capita - study country (2015 AUD p.a.)	'Abundance' (Area of Study Site divided by Area of study country)
Forests				
N	11	11	11	10
Mean	$155.51	114.519	$15,177.76	0.017
Median	$26.98	112.866	$4,183.53	0.002
Q1	$14.65	31.958	$2,412.06	0.001
Q3	$367.80	142.488	$7,467.15	0.012
Min	$5.74	2.558	$645.59	0.000
Max	$561.54	299.472	$74,977.10	0.081
Woodlands, savannas, shrublands and grasslands.				
N	9	9	9	6
Mean	$194.40	111.554	$55,318.88	0.112
Median	$94.90	31.958	$59,878.28	0.142
Q1	$86.86	28.007	$57,221.00	0.036
Q3	$252.09	132.632	$71,694.66	0.175
Min	$20.28	21.836	$6,664.39	0.000
Max	$194.40	111.554	$55,318.88	0.112
Wetlands				
N	5	5	5	4
Mean	$4,900.20	152.135	$3,967.70	0.001
Median	$217.12	128.612	$2,690.80	0.000
Q1	$166.61	71.577	$2,553.26	0.000
Q3	$1,424.13	250.507	$4,504.22	0.001
Min	$47.47	37.144	$777.92	0.000
Max	$22,645.67	272.838	$9,312.29	0.003

Formulae used to generate NRM-specific estimates of erosion control

$$Forest\ erosion\ control\ value\ per\ hectare_{NRM\ i} = 26.98 + Forest\ erosion\ adjustment_{\ NRM\ i}$$

$$Forest\ erosion\ adjustment_{\ NRM\ i} = -7.6835 - 0.0434\left(Ln(Abundance\ of\ Forests\ NRM_i) - Ln(0.00246)\right) + 0.9833\left(Ln(Pop\ Density\ \ NRM_i) - Ln(110.79)\right) + 0.9101(\mathrm{Ln}(GDP\ Per\ Capita\ NRM_i) - Ln\ (3705.79))$$

$$Woodlands\ erosion\ control\ value\ per\ hectare_{NRM\ i} = 94.90 + Woodlands\ erosion\ adjustment_{\ NRM\ i}$$

$$Woodlands\ erosion\ adjustment_{\ NRM\ i} = -7.6835 - 0.0434\left(Ln(Abundance\ of\ Woodlands\ NRM_i) - Ln(0.1425)\right) + 0.9833\left(Ln(Pop\ Density\ \ NRM_i) - Ln(29.98)\right) + 0.9101*(\mathrm{Ln}(GDP\ Per\ Capita\ \ NRM_i) - Ln\ (57{,}210.00))$$

$$Shrublands\ water\ erosion\ control\ value\ per\ hectare_{NRM\ i} = 94.90/2 + Shrublands\ erosion\ adjustment_{\ NRM\ i}$$

$$Shrublands\ erosion\ adjustment_{\ NRM\ i} = -7.6835 - 0.0434\left(Ln(Abundance\ of\ Arid\ lands\ NRM_i) - Ln(0.1425)\right) + 0.9833\left(Ln(Pop\ Density\ \ NRM_i) - Ln(29.98)\right) + 0.9101*(\mathrm{Ln}(GDP\ Per\ Capita\ \ NRM_i) - Ln\ (57{,}210.00))$$

$$Wetlands\ erosion\ control\ value\ per\ hectare_{NRM\ i} = 217.12 + Wetlands\ erosion\ adjustment_{\ NRM\ i}$$

$$Wetlands\ erosion\ adjustment_{\ NRM\ i} = -7.6835 - 0.0434\big(Ln(Abundance\ of\ Wetlands\ NRM_i) - Ln(0.0001)\big) + 0.9833\ \big(Ln(Pop\ Density\ \ NRM_i) - Ln(161.04)\big) + 0.9101*(\mathrm{Ln}(GDP\ Per\ Capita\ \ NRM_i) - Ln\ (2{,}622.03))$$

Flood control

Table 10: Summary statistics relevant to studies reporting estimates for flood control, by grouped biome

Biome(s) and Statistic	Value Per Hectare (2015 AUD p.a.)
Forests	
N	11
Mean	$44.41
Median	$17.83
Q1	$10.93
Q3	$46.64
Min	$3.56
Max	$178.51
Woodlands, savannas, shrublands and grasslands.	
N	3
Mean	$522.35
Median	$13.21
Q1	$3.77
Q3	$1550.07
Min	$3.77
Max	$1,550.07
Wetlands	
N	30
Mean	$4,416.27
Median	$1,439.65
Q1	$56.94
Q3	$4617.21
Min	$-
Max	$19,446.14

Mediation of air and soil

Table 11: Summary statistics relevant to studies reporting estimates for mediation (air and soil) values, by biome

Biome(s) and Statistic	Value Per Hectare (2015 AUD p.a.)
Forests	
N	8
Mean	$241.31
Median	$63.92
Q1	$21.43
Q3	$158.54
Min	$16.53
Max	$1,426.17
Woodlands, savannas, shrublands and grasslands	
N	5
Mean	$31.45
Median	$1.30
Q1	$0.11
Q3	$13.21
Min	$-
Max	$142.62
Wetlands	
N	4
Mean	$229.12

Median	$78.58
Q1	$44.37
Q3	$413.88
Min	$20.49
Max	$738.84

Genepool/habitat/nursery values

Table 12: Summary statistics relevant to studies reporting estimates for genepool/nursery/habitat values, by biome

Biome(s) and Statistic	Value Per Hectare (2015 AUD p.a.)
Forests	
N	20
Mean	$734.50
Median	$91.08
Q1	$30.72
Q3	$252.12
Min	$10.70
Max	$9,364.31
Woodlands, savannas, shrublands and grasslands	
N	6
Mean	$376.24
Median	$34.72
Q1	$0.09
Q3	$172.46
Min	$0.02
Max	$2,015.39
Inland Aquatic (MVG 24)	
N	17
Mean	$905.67
Median	$111.33
Q1	$46.53
Q3	$381.26
Min	$3.51
Max	$4,583.85
Mangroves (MVG 23)	
N	24
Mean	$7,679.40
Median	$783.17
Q1	$93.29
Q3	$3962.09
Min	$5.70
Max	$102,756.10
Coastal/estuaries (MVG 28)	
N	4
Mean	$179.81
Median	$171.42
Q1	$32.19
Q3	$327.42
Min	$6.25
Max	$370.12

Carbon sequestration

Table 13: Summary statistics relevant to studies reporting estimates for C-sequestration values, by biome

Biome(s) and Statistic	Value Per Hectare (2015 AUD p.a.)
Forests	
N	15
Mean	$622.58
Median	$160.80
Q1	$52.22
Q3	$1309.64
Min	$22.03
Max	$3,405.58
Woodlands, savannas, shrublands and grasslands	
N	14
Mean	$219.97
Median	$39.09
Q1	$31.28
Q3	$201.70
Min	$12.47
Max	$1,226.99
Inland Aquatic (MVG 24) – C-sequestration	
N	5
Mean	$160.69
Median	$58.67
Q1	$53.49
Q3	$79.75
Min	$6.66
Max	$604.89
Mangroves (MVG 23)- C-sequestration	
N	6
Mean	$238.45
Median	$257.08
Q1	$4.16
Q3	$445.38
Min	$3.56
Max	$463.42

Appendix E: Cultural use values

Data used to estimate cultural use-values

Table 14 lists studies, together with associated value estimates, and the contextual socio-economic data, used to estimate cultural use values.

Table 14: Studies reporting estimates of cultural use values, with estimates of 'abundance' and both the GDP per capita and population density of country in which study was undertaken

Grouped biome	Biome	Reference	GDP Per Capita (AUD, 2015)	Abundance[31]	Pop Density (Persons per km²)	Value Per Hectare (AUD, 2015)	Value Per Person (AUD, 2015)
Multiple	Multiple Ecosystems	Emerton (1999)	$635	0.00130	109.43	$19.12	$59.44
Multiple	Multiple Ecosystems	Seenprachawong (2002)	$6,110	0.00078	125.41	$1,758.25	$2,026.79
Multiple	Multiple Ecosystems	Turpie (2003)	$9,561	0.05916	37.70	$806.41	
Multiple	Multiple Ecosystems	Walpole *et al.* (2001)	$3,635	0.00095	108.72	$4.56	$21.87
Cultivated	Agricultural	Bernues *et al.* (2014)	$42,332	0.00160	93.14	$275.51	$20.13
Cultivated	Agricultural	Huang and Wang (2015)	$54,762	0.00043	631.58	$640.32	$475.24
Drylands (exc forests)	Grasslands	Brookshire *et al.* (1982)	$46,444	0.00014	25.29	$43.03	
Drylands (exc forests)	Grasslands	Cowling *et al.* (1997)	$8,966	0.07007	33.98	$1.82	
Drylands (exc forests)	Grasslands	Dodds *et al.* (2008)	$57,221	0.03602	31.96	$1,892.99	
Drylands (exc forests)	Grasslands	Hönigová *et al.* (2012)	$32,436	0.54270	132.63	$49.13	$28.15
Drylands (exc forests)	Shrublands	Dodds *et al.* (2008)	$57,221	0.16154	31.96	$30.20	
Drylands (exc forests)	Shrublands	Eslamian *et al.* (2016)	$7,682	0.00002	48.71		$16.85
Drylands (exc forests)	Shrublands	Fatahi (2013)	$10,696	0.00049	45.25	$6.50	$2.04
Drylands (exc forests)	Shrublands	Kroeger and Manalo (2007)	$74,391	0.02172	31.66	$9.71	$197.20
Drylands (exc forests)	Shrublands	Taylor *et al.* (2017)	$82,551	0.07067	35.04	$27.66	$939.64
Drylands (exc forests)	Savanna	Barnes (2002)	$6,606	0.47656	2.50	$4.72	
Drylands (exc forests)	Woodlands	Croitoru (2007)				$258.62	
Drylands (exc forests)	Woodlands	Englin et al (2008) - cited in Holmes *et al.* (2016)	$67,083	0.01120	29.77		$314.41
Drylands (exc forests)	Woodlands	Fleischer and Tsur (2009)	$42,951	0.00254	309.14	$1,223.10	$96.10
Drylands (exc forests)	Woodlands	Roesenberger and Loomis (2001) - cited in Holmes *et al.* (2016)					$85.48
Coastal	Coastal	Andersson *et al.* (2015)	$90,224	0.00008	3.10	$91.49	$163.46
Coastal	Coastal	Anning (2012)	$85,048	0.00001	2.87		$22.48
Coastal	Coastal	Blackwell (2007)	$72,564	0.00000	2.49		$1,385.82
Coastal	Coastal	Cruz *et al.* (2011)	$36,287	0.00066	115.27	$24.61	$82.53
Coastal	Coastal	De Groot (1992)	$58,105	0.07998	442.88	$658.31	

[31] Abundance = Area of site / area of Country

Coastal	Coastal	Farr and Stoeckl (2018)	$87,730		2.96		$281.53
Coastal	Coastal	Gopalakrishnan *et al.* (2011)	$80,014		34.06		$110.76
Coastal	Coastal	Hamilton and Morgan (2010)	$79,366		33.82		$135.93
Coastal	Coastal	Hoagland *et al.* (1995)	$59,006		26.95		$117.87
Coastal	Coastal	Pascoe (2019)	$91,337	0.00158	3.14	$61.90	$71.44
Coastal	Coastal	Pascoe *et al.* (2014)	$85,048	0.00020	2.87	$184.22	$66.02
Coastal	Coastal	Pearson *et al.* (2002)	$74,977	0.00001	2.56		$25.70
Coastal	Coastal	Prayaga (2017)	$84,777	0.00049	2.77	$47.91	$34.12
Coastal	Coastal	Prayaga *et al.* (2010)	$84,777	0.00049	2.77	$16.07	$28.18
Coastal	Coastal	Raybould *et al.* (2013) - Augusta-Margaret River WA	$118,523	0.00007	2.91	$17.96	$36.70
Coastal	Coastal	Raybould *et al.* (2013) - Clarence Valley NSW	$89,748	0.00007	2.91	$30.87	$49.42
Coastal	Coastal	Raybould *et al.* (2013) - Sunshine Coast QLD	$81,589	0.00009	2.91	$13.04	$43.36
Coastal	Coastal	Raybould *et al.* (2013) - Surf Coast VIC	$79,483	0.00004	2.91	$38.74	$30.28
Coastal	Coastal	Rolfe and Gregg (2012)	$85,931	0.00976	2.91	$80.36	$720.23
Coastal	Coastal	Samonte-Tan *et al.* (2007)	$2,895	0.00019	283.99	$338.14	$58.16
Coastal	Coastal	Windle and Rolfe (2013) - Gold Coast QLD	$87,730	0.00009	2.96	$6,609.13	$466.28
Coastal	Coastal	Windle and Rolfe (2013) - Moreton Bay QLD	$87,730	0.00020	2.96	$858.46	$94.28
Coastal	Coastal	Windle and Rolfe (2013) - Sunshine Coast QLD	$87,730	0.00008	2.96	$7,556.20	$927.87
Coastal	Coastal	Windle *et al.* (2017) - Gladstone Beach	$91,337	0.00003	3.14	$1,387.24	$1,092.63
Coastal	Coastal	Windle *et al.* (2017) - Gladstone Land Based Rec	$91,337	0.00136	3.14	$56.66	$2,378.35
Coastal	Coastal	Windle *et al.* (2017) - Gladstone Rec Fishing	$91,337	0.00003	3.14	$1,347.07	$1,078.16
Coastal	Coastal	Zhang *et al.* (2015)	$85,931	0.00001	2.91	$1,234.41	$253.69
Forests	Forests	Bellu and Cistulli (1997)	$52,252	0.00431	193.27	$490.72	$26.06
Forests	Forests	Bowker *et al.* (2009)	$74,391	0.08746	31.39	$278.59	$474.52
Forests	Forests	Brown (1993)	$1,391	1.00000	46.65	$11.38	
Forests	Forests	Curtis (2004)	$74,977	0.00241	2.56	$8.15	
Forests	Forests	Cruz and Benedicto (2009)	$36,527	0.00066	115.04	$391.21	
Forests	Forests	Deisenroth *et al.* (2009)	$81,181	0.00037	32.88	$4.73	$225.49
Forests	Forests	Dodds *et al.* (2008)	$57,221	0.24231	31.96	$3,536.85	
Forests	Forests	Dubgaard (1998)	$80,440	0.11784	123.34	$257.19	
Forests	Forests	Echeverría *et al.* (1995)	$8,554	0.00196	63.80	$564.74	
Forests	Forests	Edwards (1991)	$6,296	0.02888	40.44	$1,508.32	$711.28

Forests	Forests	Englin and Shonkwiler (1995) - cited in Holmes *et al.* (2016)	$46,444	0.00022	25.29		$78.24
Forests	Forests	Gundimeda *et al.* (2006)	$1,399	0.05274	360.38	$265.77	$83.92
Forests	Forests	Gwee *et al.* (2019)	$16,357	0.00907	91.38	$49.10	$591.75
Forests	Forests	Knapman and Stoeckl (1995)	$46,468	0.00005	2.22	$222.40	$2,479.77
Forests	Forests	Kniivilä *et al.* (2002)	$66,239	1.00000	16.99	$5.41	
Forests	Forests	Kramer *et al.* (1995)	$704	0.00017	27.11	$37.40	
Forests	Forests	Krutilla (1991)	$7,187	0.07737	76.25	$285.56	
Forests	Forests	Kumari (1996)	$9,594	0.00222	60.83	$33.05	
Forests	Forests	Maille and Mendelsohn (1993)	$714	0.00001	21.80		$739.39
Forests	Forests	Maille and Mendelsohn (1993)	$70,324	0.00009	55.24		$676.78
Forests	Forests	Mohd-Shahwahid and McNally (2001)	$4,530	0.60978	61.70	$3.16	$4.86
Forests	Forests	Naidoo and Adamowicz (2005)	$687	0.24523	124.39	$1.96	$94.39
Forests	Forests	Pak and Türker (2006)	$13,489	0.00000	82.17	$6.27	$46.98
Forests	Forests	Phillips *et al.* (2007)	$81,181	0.00928	32.57	$19.87	
Forests	Forests	Scarpa *et al.* (2000)	$64,291	0.00159	87.17		$165.12
Forests	Forests	Shultz *et al.* (1998)	$10,203	0.00124	76.88	$3,463.73	$27.67
Forests	Forests	Simões *et al.* (2013)	$36,287	0.00001	115.27	$8,952.89	$37.97
Forests	Forests	Smith and Kopp (1980) - cited in Holmes *et al.* (2016)	$40,546	0.00001	22.81	$43.47	$43.47
Forests	Forests	Stoeckl and Mules (2006)	$72,564	0.00208	2.49	$832.61	$930.38
Forests	Forests	Tammi *et al.* (2017)	$74,207	0.04793	17.99	$278.28	$252.54
Forests	Forests	Termansen *et al.* (2013)	$95,919	0.14331	131.29		$96.10
Forests	Forests	Tobias and Mendelsohn (1991)	$8,035	0.00196	62.19	$134.50	$85.59
Forests	Forests	van Beukering *et al.* (2003)	$3,510	0.01380	116.77	$27.45	$8.53
Wetlands	Coastal wetlands	Bell (1989)	$62,398		28.73	$3,435.48	
Wetlands	Coastal wetlands	Bell (1997)	$51,204	0.00012	25.75	$3,254.44	
Wetlands	Coastal wetlands	Bergstrom *et al.* (1990)	$55,636	0.00144	26.45	$280.75	
Wetlands	Coastal wetlands	Costanza *et al.* (1989)	$48,154	0.00039	25.53	$25.69	
Wetlands	Coastal wetlands	Emerton and Kekulandala (2002)	$3,014	0.00049	303.93	$181.88	$37.31
Wetlands	Coastal wetlands	Farber (1987)	$52,903	0.00029	25.98	$32.02	
Wetlands	Coastal wetlands	Farber (1996)	$81,181	0.00133	32.88	$67.81	$165.77
Wetlands	Coastal wetlands	Rolfe and Dyack (2010)	$80,907	0.00130	2.69	$135.31	$1,208.17
Wetlands	Coastal wetlands	White *et al.* (2000)	$2,575	0.00003	256.01	$324.48	
Wetlands	Inland aquatic	Amacher *et al.* (1989)	$81,181	0.00022	32.89	$143.37	
Wetlands	Inland aquatic	New Zealand Department of Conservation (2007)	$56,097	0.00006	16.04	$68.91	
Wetlands	Inland aquatic	Dodds *et al.* (2008)	$57,221	0.04730	31.96	$30.20	
Wetlands	Inland aquatic	Dubgaard *et al.* (2002)	$92,014	0.00017	126.70	$107.14	
Wetlands	Inland aquatic	Gerrans (1994)	$83,441	0.00000	2.71	$6,728.47	$21.47

Wetlands	Inland aquatic	Hellerstein (1991) - cited in Holmes *et al.* (2016)	$47,054	0.00048	24.81		$263.70
Wetlands	Inland aquatic	Kirkland (1988)	$56,097	0.00027	16.04	$1,365.85	$7.46
Wetlands	Inland aquatic	Knapman and Stoeckl (1995)	$46,468	0.00258	2.22	$38.48	$381.00
Wetlands	Inland aquatic	Kumari (1996)	$9,594	0.00222	60.83	$13.44	
Wetlands	Inland aquatic	Lant and Roberts (1990)	$62,398		28.73	$738.84	
Wetlands	Inland aquatic	Loomis (2012)	$79,366	0.00030	33.76	$19.34	$63.59
Wetlands	Inland aquatic	Navrud and Mungatana (1994)	$1,495	0.00033	42.48	$975.61	$48.91
Wetlands	Inland aquatic	Navrud and Mungatana (1994)	$1,495	0.00033	42.48	$1,873.18	$188.31
Wetlands	Inland aquatic	Postel et al. (1997) in Daily (1997)	$62,398		28.73	$524.34	
Wetlands	Inland aquatic	Tammi *et al.* (2017)	$74,207	0.04793	17.99	$126.37	$122.57
Wetlands	Inland aquatic	Thibodeau and Ostro (1981)	$47,803	0.00000	25.05	$1,853.01	
Wetlands	Inland aquatic	Treiman *et al.* (2014)	$57,221	0.14964	31.96	$0.74	$34.39
Wetlands	Inland aquatic	Turpie *et al.* (1999) - Tropical inland	$9,312	0.00181	37.14	$2.51	$301.62
Wetlands	Inland aquatic	Verma *et al.* (2001)	$1,331	0.00001	347.96	$3,190.06	$6.21
Wetlands	Inland aquatic	Whitehead *et al.* (2009)					
Wetlands	Inland aquatic	Zekri *et al.* (2011)	$31,573	0.00000	9.83	$8,736.23	$171.45
Wetlands	Mangroves	Dehghani *et al.* (2010)	$6,649	0.00052	43.22	$749.02	$38.61
Wetlands	Mangroves	Ammour *et al.* (2000)	$2,137	0.00053	41.77	$32.00	
Wetlands	Mangroves	Bann (1999)	$10,791	0.00005	68.96	$6.32	
Wetlands	Mangroves	Bennett and Reynolds (1993)	$7,007	0.00027	53.37	$985.68	
Wetlands	Mangroves	Cooper *et al.* (2009)	$7,134	0.06138	13.08	$849.09	$1,192.18
Wetlands	Mangroves	Pyo (2001)	$25,387	0.00542	469.11	$350.99	$34.08
Wetlands	Mangroves	Tri *et al.* (2000)	$1,181	0.00068	255.23	$130.06	

Transfer functions

In line with Wei *et al.* (2018), we work with the per-person estimates; recreation use values are almost always estimated using methods that rely on per-person (or per household) expressions of value/utility, so this allows us to better contextualise estimates that arise from tourists[32]. As previously, we used quantile regression, estimating a separate transfer function for all cultural use values for all terrestrial biomes (except coastal/beaches); and coastal values (beach recreation). Results are reported in Table 15.

Table 15: Quantile regression results from meta analyses of cultural use values - data collated from (van der Ploeg & De Groot, 2010) and elsewhere; p-values (in brackets) for robust standard errors.

Models with dependent variable = Ln(Value per Person)

	Model A Terrestrial (excludes coastal)	**Model B Drylands (excludes wetlands)**	**Model C Forests**	**Model D Wetlands**	**Model E Coastal (beach recreation)[33]**
LnPopDensity	-0.6719 (0.001)	-0.8008 (0.019)	-0.6664 (0.029)	-0.4912 (0.104)	0.0657 (0.993)
LnGDPPerCapita	0.0294 (0.910)	0.0033 (0.992)	0.0203 (0.950)	-0.1405 (0.611)	0.2318 (0.994)
Ln(StudySiteArea /Country Area)	0.0915 (0.147)	0.0980 (0.263)	0.0843 (0.319)	0.1756 (0.208)	-0.1402 (0.791)
Constant	7.7800 (0.003)	8.0439 (0.066)	7.7507 (0.063)	8.8914 (0.023)	0.6417 (0.999)
N	47	27	22	18	22
Pseudo R-squared	0.2117	0.2292	0.2572	0.2619	0.0263

Equations used to generate NRM specific estimates

The functions were used in conjunction with data from ABS (relating to NRM area, population density and incomes/regional product) to generate contextualised estimates of per-person use-values associated with each biome within each NRM. For 'drylands', we used the coefficients from the relevant meta-regression (Model B, Table 15) to develop a transfer function, populated with data describing both the study sites (Table 16) and each NRM. As previously, we divided the median estimate for the grouped biome that describes woodlands/savannas/shrublands and grasslands by two, using that as the base value for shrublands and grasslands. Per person use-values were assumed constant for beaches and wetlands.

Use values are relevant to both residents and tourists, but to the best of our knowledge, there are no publicly available data sets that would allow us to estimate net domestic tourism at each NRM. So we estimate total use values for residents and international tourists separately.

[32] To understand the importance of this note that per-hectare estimates can only be derived from travel costs studies by using a formula similar to that below:

$$\frac{(\text{Per} - \text{tourist values} \times \text{Number of tourists}) + (\text{Per} - \text{resident values} \times \text{Number of residents})}{\text{Area of study site}}$$

Even if all studies from which we derive estimates had made available data on both the number of residents and the number of tourists visiting an area this year, we would not have 'matching' tourism data for our NRMs, so are unable to appropriately contextualise per-hectare estimates when transferring.

[33] These values are unaffected by terrestrial pests but we have nevertheless retained them here for completeness.

1. Lacking the data to do otherwise, we assume that all resident use values are associated with the NRM in which a person lives. We multiplied per-person values by estimates of the number of residents within each NRM to generate whole-of-NRM estimates.
2. For International tourists, we multiplied NRM-specific estimates of per-person use values (Table 16) by estimates of the number of international tourists going to each NRM. The boundaries of tourism regions for which data are available do not generally coincide with NRM regions, so when estimating tourism numbers to each NRM, we assumed that visitor numbers (reported by Tourism Region (see Table 17) were scattered equally across space.

Table 16: Summary statistics relevant to studies reporting estimates for cultural use values, by biome

Biome(s) and Statistic	Area of Study Site / Area of country (Hectares)	GDP Per Capita - study country (2015 AUD p.a.)	Pop Density - study country (persons per km²)	Value Per Hectare – NOT USED (2015 AUD p.a.)	Value Per Person (2015 AUD p.a.)
Coastal/Beaches					
N	23	27	27	20	26
Mean	0.00415	$79,650	36.97	$1,032.64	$375.20
Median	0.00009	$85,048	2.96	$85.93	$102.52
Q1	0.00003	$79,365.98	2.91	$34.81	$43.36
Q3	0.00049	$89,747.68	3.14	$1,046.43	$466.28
Min	0.00000	$2,895	2.49	$13.04	$22.48
Max	0.07998	$118,523	442.88	$7,556.20	$2,378.35
Wetlands					
N	33	36	36	35	18
Mean	0.00994	$40,445	73.14	$1,067.92	$238.15
Median	0.00039	$47,978	31.96	$181.88	$93.08
Q1	0.00017	$7,070.74	24.93	$32.02	$34.39
Q3	0.00144	$62,398.12	48.30	$985.68	$263.70
Min	0.00000	$1,181	2.22	$0.74	$6.21
Max	0.14964	$92,014	469.11	$8,736.23	$1,208.17
Woodlands/Savanna, Shrublands/grasslands					
N	12	12	12	12	8
Mean	0.11614	$41,187	63.16	$302.75	$209.98
Median	0.02887	$44,698	32.97	$36.61	$90.79
Q1	0.00151	$9,830.99	30.72	$8.10	$22.50
Q3	0.11611	$62,151.94	46.98	$172.05	$255.80
Min	0.00002	$6,606	2.50	$1.82	$2.04
Max	0.54270	$82,551	309.14	$1,892.99	$939.64
Forests					
N	33	33	33	28	22
Mean	0.11225	$37,700	71.29	$775.53	$358.22
Median	0.00241	$36,527	60.83	$178.45	$95.24
Q1	0.00037	$7,186.77	27.11	$15.63	$43.47
Q3	0.07737	$70,324.19	91.38	$440.97	$591.75
Min	0.00000	$687	2.22	$1.96	$4.86
Max	1.00000	$95,919	360.38	$8,952.89	$2,479.77

$$Forest\ recreation\ use\ value\ per\ person_{NRM\ i} = 95.24 + Forest\ use - value\ adjustment_{\ NRM\ i}$$

$$Forest\ use - value\ adjustment_{\ NRM\ i} = 8.0439 + 0.0980\left(Ln(Abundance\ of\ Forests\ NRM_i) - Ln(0.00241)\right) - 0.8008\left(Ln(Pop\ Density\ \ NRM_i) - Ln(60.83)\right) + 0.992 * (\mathrm{Ln}(GDP\ Per\ Capita\ NRM_i) - Ln\ (36{,}527))$$

$$Woodlands\ recreation\ use\ value\ per\ person_{NRM\ i} = 90.79 + Woodlands\ use - value\ adjustment_{\ NRM\ i}$$

$$Woodlands\ use - value\ adjustment_{\ NRM\ i} = 8.0439 + 0.0980\left(Ln(Abundance\ of\ Woodlands\ NRM_i) - Ln(0.02887)\right) - 0.8080\left(Ln(Pop\ Density\ \ NRM_i) - Ln(32.97)\right) + 0.992*(\mathrm{Ln}(GDP\ Per\ Capita\ \ NRM_i) - Ln\ (44{,}698))$$

$$Shrublands\ \ use - \ value\ per\ person_{NRM\ i} = 90.79/2 + Shrubllands\ use - value\ adjustment_{\ NRM\ i}$$

$$Shrublands\ water\ adjustment_{\ NRM\ i} = 8.0439 + 0.0980\left(Ln(Abundance\ of\ Shrublands\ NRM_i) - Ln(02887)\right) - 0.8080\left(Ln(Pop\ Density\ \ NRM_i) - Ln(32{,}97)\right) + 0.992*(\mathrm{Ln}(GDP\ Per\ Capita\ \ NRM_i) - Ln\ (44{,}698)$$

Table 17: Estimated numbers of International tourists, to tourism regions, during year ending Sept 2016

Tourism Region Code	Name	State	Numbers of tourists ('000s)
1R010	South Coast	New South Wales	140
1R040	Sydney	New South Wales	3521
1R050	Snowy Mountains	New South Wales	19
1R060	Capital Country	New South Wales	26
1R070	The Murray	New South Wales	23
1R080	Riverina	New South Wales	29
1R090	Central NSW	New South Wales	43
1R100	Hunter	New South Wales	156
1R140	New England North West	New South Wales	33
1R150	Outback NSW	New South Wales	10
1R180	Central Coast	New South Wales	50
1R190	Blue Mountains	New South Wales	108
1R200	North Coast	New South Wales	324
2R010	Melbourne	Victoria	2499
2R020	Wimmera	Victoria	16
2R030	Mallee	Victoria	26
2R040	Great Ocean Road	Victoria	195
2R050	Western Grampians	Victoria	16
2R060	Bendigo Loddon	Victoria	24
2R070	Peninsula	Victoria	58
2R080	Central Murray	Victoria	15
2R090	Goulburn	Victoria	23
2R100	High Country	Victoria	31
2R110	Lakes	Victoria	24
2R120	Gippsland	Victoria	24
2R130	Melbourne East	Victoria	42
2R140	Geelong and the Bellarine	Victoria	54
2R150	Macedon	Victoria	8
2R160	Spa Country	Victoria	8
2R170	Ballarat	Victoria	24
2R180	Central Highlands	Victoria	16
2R190	Upper Yarra	Victoria	49
2R200	Murray East	Victoria	61
2R210	Phillip Island	Victoria	43
3R010	Gold Coast	Queensland	1014
3R020	Brisbane	Queensland	1183
3R030	Sunshine Coast	Queensland	272
3R040	Fraser Coast	Queensland	136
3R060	Darling Downs	Queensland	44
3R070	Bundaberg	Queensland	40

Tourism Region Code	Name	State	Numbers of tourists ('000s)
3R080	Central Queensland	Queensland	104
3R090	Mackay	Queensland	43
3R100	Whitsundays	Queensland	229
3R110	Northern	Queensland	125
3R120	Tropical North Queensland	Queensland	877
3R140	Outback	Queensland	28
4R010	Limestone Coast	South Australia	44
4R020	Murraylands	South Australia	11
4R030	Fleurieu Peninsula	South Australia	22
4R040	Adelaide	South Australia	391
4R050	Barossa	South Australia	13
4R060	Riverland	South Australia	9
4R070	Flinders Ranges and Outback	South Australia	43
4R080	Clare Valley	South Australia	4
4R110	Eyre Peninsula	South Australia	19
4R120	Yorke Peninsula	South Australia	7
4R130	Kangaroo Island	South Australia	44
4R140	Adelaide Hills	South Australia	9
5R120	Experience Perth	Western Australia	875
5R130	Australia's Golden Outback	Western Australia	55
5R140	Australia's South West	Western Australia	180
5R160	Australia's North West	Western Australia	74
5R170	Australia's Coral Coast	Western Australia	80
6R030	East Coast	Tasmania	11
6R060	North West	Tasmania	53
6R080	Wilderness West	Tasmania	11
6R100	Hobart and the South	Tasmania	195
6R110	Launceston, Tamar and the North	Tasmania	93
7R010	Darwin	Northern Territory	131
7R050	Barkly	Northern Territory	16
7R070	Alice Springs	Northern Territory	116
7R100	Kakadu Arnhem	Northern Territory	34
7R110	Katherine Daly	Northern Territory	39
7R140	MacDonnell	Northern Territory	2
7R150	Lasseter	Northern Territory	161
8R990	Canberra	Australian Capital Territory	207
TOTAL			14782

Appendix F: Cultural non-use values

Data used to estimate cultural non-use values

Table 18 lists the studies used in this assessment.

Table 18: Studies reporting estimates of cultural non-use values, with estimates of 'abundance' and both the GDP per capita and population density of country in which study was undertaken

Grouped biome	Biome	Reference	GDP Per Capita (AUD, 2015)	Abundance[34]	Pop Density (Persons per km²)	Value Per Hectare (AUD, 2015)	Value Per Person (AUD, 2015)
Coastal	Coastal	Lara-Pulido *et al.* (2018)	$15,910	0.00127	64.76	$564.54	
Forests	Forests	Lara-Pulido *et al.* (2018)	$15,910	0.00127	64.76	$652.29	
Wetlands	Wetlands	Lara-Pulido *et al.* (2018)	$15,910	0.00127	64.76	$703.48	
Arid	Grasslands	Marzetti *et al.* (2011)	$62,614	0.00033	198.68		$26.15
Agricultural	Agricultural	Bernues *et al.* (2014)	$42,332	0.00160	93.14	$609.48	$609.48
Agricultural	Agricultural	Huang and Wang (2015)	$54,762	0.00043	631.58	$360.74	$43.58
Coastal	Coastal	De Groot (1992)	$58,105	0.07998	442.88	$38.27	
Forests	Forests	Horton *et al.* (2003)					$44.57
Forests	Forests	Walsh et al. (1984) - cited in Holmes *et al.* (2016)	$47,054	0.00442	24.81	$0.04	
Forests	Forests	Ren and Yun (2018)	$11,289	0.00052	146.89	$3,301.42	$41.99
Forests	Forests	Navrud and Strand (2018)	$42,595	1.28317		$28.82	$21.13
Forests	Forests	Diafas *et al.* (2017)	$1,814	0.00042	83.02	$49.00	$58.31
Forests	Forests	Amirnejad *et al.* (2006)	$9,126	0.01153	42.25	$373.99	$11.97
Forests	Forests	Amiri *et al.* (2015)	$10,089	0.00000	47.58	$922.24	$3.43
Forests	Forests	Diamond et al. (1991) - cited in Holmes *et al.* (2016)	$59,463	0.00105	27.25	$0.21	
Forests	Forests	Gilbert et al. (1990) - cited in Holmes *et al.* (2016)	$59,463	0.00001	27.25	$2.18	$15.94
Forests	Forests	McFadden et al. (1990) - cited in Holmes *et al.* (2016)	$59,463	0.00059	27.25	$0.21	$113.01
Forests	Forests	Pope and Jones (1990) - cited in Holmes *et al.* (2016)	$55,636	0.00084	26.45	$0.21	$165.17
Forests	Forests	Bennett (1984)	$48,115	0.00027			$4.44
Forests	Forests	Adger *et al.* (1995)	$12,638				$101.60
Forests	Forests	Kreiger -- cited in Anielski and Wilson (2005)	$74,314		31.66		$33.74
Forests	Forests	Tangua et al (1993) - cited in Anielski and Wilson (2005)	$74,160				$51.03
Forests	Forests	Strand *et al.* (2017)	$33,438	0.46436			$23.39
Forests	Forests	Range from Ruitenbeek (1990) Lescuyer (2000) and Yaron (2001) - cited in (Lescuyer, 2007)	$1,905		32.31	$51.21	

[34] Abundance = Area of site / area of Country

Forests	Forests	Tao *et al.* (2012)	$7,467	0.00097	142.49	$5,846.02	$2,015.87
Forests	Forests	Siikamäki and Layton (2007)	$62,836	0.00394			$50.58
Forests	Forests	Shechter *et al.* (1998)	$37,555	0.00462			$1.97
Forests	Forests	Kontoleon and Swanson (2003)					$23.21
Forests	Forests	Turpie (2003)	$9,561	0.00046	37.70	$17.32	
Wetlands	Wetlands	MacDonald *et al.* (2011)	$84,771	0.00006			$37.02
Wetlands	Wetlands	Kirkland (1988)	$56,097	0.00027	16.04		$152.48
Wetlands	Wetlands	Lant and Roberts (1990)	$62,398		28.73	$738.84	$116.24
Wetlands	Wetlands	Loomis (2012)	$79,366	0.00030	33.76	$31.55	$103.74
Wetlands	Wetlands	Wei *et al.* (2015)	$5,712	0.00100	140.39	$733.44	$19.91
Wetlands	Wetlands	Lan *et al.* (2015)	$10,639	0.00002	146.03		$23.38
Wetlands	Wetlands	Jin *et al.* (2016)	$9,370	0.00511	144.54	$122.46	$24.36
Wetlands	Wetlands	Kabir *et al.* (2013)	$1,441	0.01350	1210.72	$7.40	$4.86
Wetlands	Wetlands	Ndebele and Forgie (2017)	$83,485	0.00000	16.18	$1,730.62	$22.03
Wetlands	Wetlands	Shamsudin *et al.* (2011)	$10,231	0.00326	44.71	$25.34	$2.76
Wetlands	Wetlands	Whitehead *et al.* (2009)	$79,420	0.00000			
Wetlands	Wetlands	Morrison and Bennett (2004)	$70,649	0.00005	2.46		$0.52
Wetlands	Rivers - Savannas	Zander and Straton (2010)	$80,907	0.02890	2.69	$5.42	$120.66
Wetlands	Rivers - Savannas	Zander *et al.* (2013)	$80,907	0.00683	2.69	$20.94	$90.69
Wetlands	Rivers - Savannas	Johnston *et al.* (2002)	$62,831	0.00026			
Wetlands	Rivers - Savannas	Bennett *et al.* (1998)	$63,956	0.00003			$5.62
Wetlands	Rivers - Savannas	Morrison (2002)	$70,649	0.00016	2.46		$3.86
Wetlands	Rivers - Savannas	Windle and Rolfe (2005)	$76,269	0.00006	2.59	$21.22	$0.92
Multiple	Biodiversity	Kragt and Bennett (2011)	$84,777	0.00007	2.77		$6.07
Multiple	Biodiversity	Bennett *et al.* (2008)	$80,907	0.00102	2.69		$11.20
Multiple	Biodiversity	Heberlein *et al.* (2005)	$68,683	0.00495			
Multiple	Multiple	Seenprachawong (2002)	$6,110	0.00078	125.41	$-	$31.16
Multiple	Multiple	Rolfe *et al.* (2000)	$80,907		2.69		$261.72
Multiple	Multiple	MacDonald *et al.* (2011)	$84,771	0.06905			$1.54
Multiple	Multiple	Turpie (2003)	$9,561	1.00570	37.70	$0.37	$6.88
Multiple	Riparian	Kragt and Bennett (2011)	$84,777	0.00007	2.77		$2.39
Multiple	Riparian	Amigues *et al.* (2002)	$62,733				$16.01
Multiple	Riparian	Mallawaarachchi *et al.* (2001)	$65,750	0.00000	2.41		$26.42
Multiple	Riparian	Bennett *et al.* (2008)	$80,907	0.00102	2.69		$5.46
Arid	Desert / semi-desert	Kroeger and Manalo (2007)	$74,391	0.02172	31.66	$6.60	$148.87
Arid	Desert / semi-desert	Taylor *et al.* (2017)	$82,551	0.07067	35.04	$2.38	

Arid	Desert / semi-desert	Turpie (2003)	$9,561	0.36744	37.70	$0.10	
Arid	Grasslands	Barrivk and Beazley (1983) - cited in Holmes *et al.* (2016)	$48,154	0.00063	25.53	$0.47	
Arid	Grasslands	Cerda (2013)	$20,974	0.00012			$13.47
Woodlands	Woodlands	Rolfe *et al.* (2000)	$65,750	0.00896	2.41		$27.67
Woodlands	Woodlands	Mallawaarachchi *et al.* (2001)	$65,750	0.00003	2.41		$1.72
Coastal	Coastal	Loureiro and Loomis (2013)					$10.72
Coastal	Coastal	Landry *et al.* (2020)				$22.34	$8.08
Arid	Desert / semi-desert	Richer (1995)	$60,258	0.00753		$105.24	$73.43

Transfer functions

It is difficult to tell whether it is better to transfer estimates using per-person values (thus aligning with methodological approaches) or per-hectare values (aligning with the place-based nature of estimates). When determining the best way to generate NRM-specific estimates of non-use values, we thus started by generating two very coarse whole-of Australia estimates (based on $ per hectare, and $ per person):

- Method 1: We multiplied the median per-hectare value estimates for different biomes by total hectares of each biome.
- Method 2: We multiplied the median per-person value estimates for different biomes by population estimates

We then compared the two coarse estimates to gauge the 'plausbility' of approaches. The whole-of Australia estimates (summed over all biomes) that are obtained from Method 1 were smaller but nonetheless, approximately equal to those obtained from Method 2. There are, however, substantial differences if comparing non-use value estimates for individual biomes. We thus chose to use Method 1 (per-hectare estimates) when generating estimates of non-use values for each NRM – reasoning that this provides a better 'place-based' approach since it is grounded in per-hectare estimates.

We thus used data from our compilation of studies to estimate transfer functions, regressing logged estimates of per-hectare non-use values against (logged) estimates of 'abundance' (study-site-area/country area), per-capita GDP and the population density of the country in which the study had been undertaken (for the relevant year) - Table 19.

Table 19: Quantile regression results from meta-analyses of cultural non-use values; p-values (in brackets) for robust standard errors

Models with dependent variable = Ln(Value per Hectare)				
	Model A Terrestrial (excludes marine/reef)	**Model B Drylands (excludes wetlands and marine/reef)**	**Model C Forests**	**Model D Wetlands**
LnPopDensity	0.3885 (0.694)	4.5405 (0.003)	3.6184 (0.028)	1.5951 (0.054)
LnGDPPerCapita	-0.0561 (0.960)	-0.8217 (0.363)	-2.0711 (0.114)	1.7539 (0.169)
Ln(StudySiteArea /Country Area)	-0.3601 (0.195)	-0.4045 (0.007)	-0.2773 (0.096)	-0.3161 (0.033)
Constant	-0.2054 (0.988)	-9.9464 (0.458)	7.2758 (0.671)	-20.8333 (0.163)
N	29	19	13	10
Pseudo R-squared	0.1593	0.4900	0.5914	0.2761

Equations used to generate NRM specific estimates

We used the coefficients from the transfer functions Model B (Table 19) to contexutalise dryland values, and coefficients from Model D to contextualise wetland values. As previously, we divided the median estimate for the grouped biome that describes woodlands/savannas/shrublands and grasslands by two, using that as the base value for shrublands and grasslands. Table 20 provides summary statistics of non-use values from these studies, by biome (matched to MVGs). The equations used to generate specific estimates are set out below it.

Several researchers in Australia and elsewhere have considered the issue of *distance decay,* which describes the phenomena where people who live close to an environmental asset hold higher non-use values than people who live further away. There is mixed evidence of its existence in Australia: Rolfe and Windle (2012), for example, find evidence that residents of Queensland have higher non-use values for the Great Barrier Reef than people who live elsewhere – although they find little to no evidence of distance decay in their 2003 study of non-use values in the Fitzroy estuary (Rolfe & Windle, 2003). Morrison and Bennett (2004) find that some non-use values for rivers in South-Eastern Australia are lower amongst people who live close to the rivers than for people who live further away[35], but Zander *et al.* (2013)'s research suggests that distance decay may be present for rivers in Northern Australia. Evidently, the presence/absence of distance decay is context specific. We do not have enough information to appropriately test for, and where necessary, nuance estimates to allow for distance decay across all biomes and NRMs – so we instead assume it is absent, noting this issue as a potentially important one for future research.

Table 20: Summary statistics relevant to studies reporting estimates of non-use values, by biome

Biome(s) and Statistic	Area of Study Site / Area of country (Hectares)	GDP Per Capita - study country (2015 AUD p.a.)	Pop Density - study country (persons per km^2)	Value Per Hectare (2015 AUD p.a.)	Value Per Person (2015 AUD p.a.)
Beaches					
N	2	2	2	3	2
Mean	0.04063	$37,007	253.82	208.38	$9.40
Median	0.04063	$37,007	253.82	$38.27	$9.40
Q1	0.00127	$15,909	64.76	$22.34	$8.08
Q3	0.07998	$58,105	442.88	$564.54	$10.72
Min	0.00127	$15,910	64.76	$22.34	$8.08
Max	0.07998	$58,105	442.88	$564.54	$10.72
Wetlands					
N	18	19	15	11	16
Mean	0.00339	$52,895	123.92	$376.43	$45.57
Median	0.00026	$63,956	28.73	$31.55	$22.71
Q1	0.00005	$10,639	2.69	$20.94	$4.36
Q3	0.00326	$79,420	140.39	$733.44	$97.22
Min	0.00000	$1,441	2.46	$5.42	$0.52
Max	0.02890	$84,771	1210.72	$1,730.62	$152.48
Forests					
N	17	21	14	14	18
Mean	0.10461	$34,947	54.41	$803.23	$154.52
Median	0.00097	$37,555	35.00	$38.91	$37.86
Q1	0.00046	$10,088	27.25	$0.21	$15.94
Q3	0.00442	$59,462	64.76	$652.29	$58.31
Min	0.00000	$1,814	24.81	$0.04	$1.97
Max	1.28317	$74,314	146.89	$5,846.02	$2,015.87
Woodlands/Savanna & Shrublands/Grasslands					
N	9	9	7	5	6
Mean	0.05305	$54,444	47.63	$22.96	$48.55
Median	0.00753	$62,613	31.66	$2.38	$26.91
Q1	0.00033	$48,153	2.41	$0.47	$13.47
Q3	0.02172	$65,749	37.70	$6.60	$73.43
Min	0.00003	$9,561	2.41	$0.10	$1.72
Max	0.36744	$82,551	198.68	$105.24	$148.87

[35] These were implicit prices of 'healthy vegetation' and 'native fish species' in the Gwydir and Murrumbidgee river catchments; distance decay was, in contrast, apparent for use-values in those catchments (associated with the implicit prices for swimming and fishing).

$$Forest\ non-use\ value\ per\ hectare_{NRM\ i} = 38.91 + Forest\ non-use\ value\ adjustment_{\ NRM\ i}$$

$$Forest\ non-use\ value\ adjustment_{\ NRM\ i} = -9.9464$$

$$-0.4045\left(Ln(Abundance\ of\ Forests\ NRM_i) - Ln(0.00097)\right)$$

$$+4.5405\left(Ln(Pop\ Density\ \ NRM_i) - Ln(35.00)\right)$$

$$-0.8217 * (\mathrm{Ln}(GDP\ Per\ Capita\ NRM_i) - Ln\ (37{,}555))$$

$$Woodlands\ non-\ use\ value\ per\ hectare_{NRM\ i} = 2.38 + Woodlands\ non-use\ value\ adjustment_{\ NRM\ i}$$

$$Woodlands\ non-use\ value\ adjustment_{\ NRM\ i} = -9.9464$$

$$-0.4045\left(Ln(Abundance\ of\ Woodlands\ NRM_i) - Ln(0.00480)\right)$$

$$+4.5405\left(Ln(Pop\ Density\ \ NRM_i) - Ln(31.66)\right)$$

$$-0.8217 * (\mathrm{Ln}(GDP\ Per\ Capita\ NRM_i) - Ln\ (62{,}614))$$

$$Shrublands\ non-\ use\ value\ per\ hectare_{NRM\ i} = 2.38/2 + Shrublands\ non-use\ value\ adjustment_{\ NRM\ i}$$

$$Shrublands\ non-use\ value\ adjustment_{\ NRM\ i} = -9.9464$$

$$-0.4045\left(Ln(Abundance\ of\ Shrublands\ NRM_i) - Ln(0.00480)\right)$$

$$+4.5405\left(Ln(Pop\ Density\ \ NRM_i) - Ln(31.66)\right)$$

$$-0.8217 * (\mathrm{Ln}(GDP\ Per\ Capita\ NRM_i) - Ln\ (62{,}614))$$

$$Wetlands\ non-use\ value\ per\ hectare_{NRM\ i} = 31.55 + Wetlands\ non-use\ value\ adjustment_{\ NRM\ i}$$

$$Wetlands\ non-use\ value\ adjustment_{\ NRM\ i} = -20.8333$$

$$-0.3161\left(Ln(Abundance\ of\ Shrublands\ NRM_i) - Ln(0.00026)\right)$$

$$+1.5951\left(Ln(Pop\ Density\ \ NRM_i) - Ln(28.73)\right)$$

$$+1.7539 * (\mathrm{Ln}(GDP\ Per\ Capita\ NRM_i) - Ln\ (63{,}956))$$

Appendix G: Indigenous cultural values

The inextricable link between Indigenous cultural values and the health/condition of land and sea country (referred to simply as 'country') is widely documented (Hill *et al.*, 2011). Some benefits which Indigenous people derive from country are 'tangible' (e.g., subsistence values from the food harvested). Other benefits – such as those associated with culture, tradition and spirituality – are intangible, but nonetheless crucially important. For Indigenous people, going out 'on country' generates documented improvements in mental and physical health and in social wellbeing (Burgess *et al.*, 2005; Garnett *et al.*, 2009) – similar to the physical and mental health impacts that have also been observed for non-Indigenous urban dwellers who are able to spend time 'with nature' (Bratman *et al.*, 2012). Being out on country also provides Indigenous people with opportunities to gather food and bush medicines for personal consumption, ceremony and tradition. Eco-enterprises associated with land and sea management activities create employment for the Indigenous people and active involvement in other industry sectors such as mining and tourism, help reduce welfare dependence (Zander & Garnett, 2011). Healthy ecosystems are known to contribute to education outcomes with visits 'on country' providing appropriate forums for cultural knowledge exchange (Casimirri, 2003; ANSC, 2004; Ammann, 2007; ANKN, 2008; Abah *et al.*, 2015). Moreover, there are significant ties to country – even those who live far from their traditional lands, report measurable increases in wellbeing from knowing that their country is being looked after (Larson *et al.*, 2018).

Studies considered when attempting to generate a monetary 'placeholder' value for this important category of services are briefly reviewed below.

- Some studies have sought to generate monetary estimates of the 'value' of Indigenous cultural connections to country by considering benefits derived therein, and then determining how much it would cost to achieve similar outcomes (e.g., health, education, self-confidence) using formal western methods of doing so. See, for example, a recent study of ecosystem service values on an Indigenous property in the Northern Territory (Sangha *et al.*, 2017). This study used monies expended on Indigenous people in the form of social security to generate estimates of the value of these services to Indigenous people. The logic for using this expenditure for the value of services people accrue from their coastal and marine resources is that social security payments contribute to health, education and security – all of which are services that ecosystems provide to Indigenous people. Final estimates were in the order of $22,000 per person per annum. In a more recent study of marine ecosystem service values in the Northern Territory, Sangha *et al.* (2019) use $5,500 per person (25% of $22,000) as a rough estimate of these values.

- With/without studies are also considered an appropriate means of estimating values that are not directly observable. A study that looked at the opportunity cost of poverty in Thamarrurr (Wadeye) in the NT (Taylor & Stanley, 2005) compared what was actually produced/earned in Wadeye, with what *could* potentially be produced if none of the problems associated with poverty were present (including, but not limited to poor health and educational outcomes). The report concluded that there was a foregone output opportunity, associated with poverty, equal to $43.8M per annum, and that an additional $4M per annum was spent on 'remedial' costs (e.g., court fees) that would not need to be paid, should conditions be improved. Together, these costs were about $22,761 per person (per annum) – an amount almost equal to that generated by Sangha *et al.* (2017), above.

- Zander and Straton (2010) report on a choice-modelling study, undertaken in three river catchments across Australia's north. Respondents were asked to express preferences for different development options that would impact areas in and around the rivers. Despite having

significantly lower incomes, and facing significantly higher living costs (e.g., prices in local stores), the welfare impacts of changes to the natural environment were much larger for Aboriginal than non-Aboriginal respondents. Indigenous people were, on average, willing to pay between $252 and $1752, per person, for changes that improved the local condition of water holes from 'poor' to 'good'.

- There have been several assessments of the *social return on investments* in Indigenous land and sea management programs undertaken by Social Ventures Australia (SVA) in communities across Australia. These include:
    - Kanyirninpa Jukurrpa's (KJ) on-country programs in Western Australia (Social Ventures Australia Consulting, 2014). KJ's programs mostly comprise ranger teams involved in fire management and the monitoring of threatened species, return to country trips and participation in culture and heritage program. Collectively, the programs are estimated to have generated returns for community members (beyond monies paid as salaries), valued at approximately $3867 per person per annum and divided as follows:
        - $1774 per person per annum in cultural values[36]. These include: reinforcement of traditional authority structures, maintaining connection to country, preserving cultural knowledge, instilling a sense of hope and pride in young people, transferring knowledge from the older to the younger generation, increased personal fulfilment through reengagement with country, strengthening of (cultural) leadership.
        - $2133 per person per annum[37] in social and economic values. These include: increased information relevant to preserving Native Title, stronger foundation and purpose for community, less time spent in lock-up, increased income, increased pride in family who are rangers, creation of a community meeting place, increased personal pride, increased enjoyment, less drinking, positive role models, increased willingness to navigate whitefella world, positive peer network).
    - The Warddeken Indigenous Protected Area (IPA) and associated Indigenous Ranger programs in the Northern Territory (Social Ventures Australia Consulting, 2016b). These programs fund ranger teams and culturally focused activities linked to work undertaken on the IPA, with associated economic activities (Carbon offset sales). Collectively, these are estimated to have generated returns for community members which amount to approximately $2,648 per person per annum. These were divided between those flowing to rangers, and those accruing to the community at large.
        - $994 per person per annum for rangers[38] which include: increased skills through training and experience, increased confidence, better health and wellbeing, increased pride and sense of self, better caring for country.
        - $1654 per person per annum[39] for the wider community. These benefits included: more role models for young people, rangers and families living on country, less violence, IPA leveraged for additional funding and economic opportunities, increased respect from non-Indigenous community, better cultural asset management, connection to country strengthened, culture and language conserved, more burning using cultural practices, less noxious weeds, and less ferals.

[36] Calculated by dividing their total estimate of cultural values ($17,337,000) by 5 (years relevant to the study) by 2000 (estimated population of the community)
[37] $21,332,000 divided by 5 (years) divided by 2000 (population)
[38] $7,159,039 divided by 6 (years) divided by estimated population (1200)
[39] $11,914, 922 divided by 6 (years) divided by estimated population (1200)

- Girrigin's IPA and associated ranger programs in QLD (Social Ventures Australia Consulting, 2016a). People associated with these programs manage the land and sea environment (e.g., threatened and invasive species management and monitoring, feral animal and weed control, fire management, cultural site maintenance, public area maintenance and research, monitoring and data collection) and support traditional owners of land and sea within the Girringun IPA to take ownership of the natural and cultural heritage management of their country. Collectively, these programs are estimated to have generated returns for community members which amount to approximately $2902 per person per annum. These were divided between those flowing to rangers, and those accruing to the community at large.
    - $1105 per person per annum for rangers[40] (benefits as for Warddeken)
    - $1797 per person per annum[41] for the wider community (benefits as for Warddeken).

[40] $4,642,219 divided by 6 (years) divided by estimated community population (700)
[41] $7,551,437 divided by 6 (years) divided by estimated community population (700)

Appendix H: Companion animals

Following the lead of O'Sullivan (2012), we consider different groups of animals/types of industries: (1) animals kept primarily as household pets (including horses for 'recreational/social' purposes and animals such as working farm dogs); and (2) animals associated with the racing industry (greyhound dogs and horses). To the best of our knowledge, no Australian researcher has generated pure welfare estimates for these animals, so we use measures of 'value' that are comparable to those used for portfolio industries – namely (1) expenditures by owners of domesticated animals; and (2) incomes earned for the dog and racing industry.

For cats, dogs and other small domestics animals, we use data from Animal Medicines Australia (2016) which reports average expenditure on pets per (owner) household (Table 21), and pet ownership by state (Table 22) to generate estimates of the expected expenditure per capita on different pets, for different states (expenditure per owner household * % of households owning * average household size) - Table 23. This allows us to allocate values across the landscape using ABS census data on usual place of residence. We note that the observed spatial variation in expenditure per capita is entirely based on observed differences in the average number of pets per household, with expenditure per pet assumed constant across Australia. Animal Medicines Australia (2016) notes the very small sample size in the NT, recommending that those estimates be treated with some caution. Rather than using their reported NT estimates (which collectively add to $710 p.a.), we thus use the Australian mean values for residents of that territory.

We use information about (a) ownership; (b) expenditure; and (c) stabling, to generate spatially explicit estimates of expenditure on recreational horses. O'Sullivan (2012) suggests that about 2% of Australian's own (recreational) horses. Unable to find better information regarding the location of recreational horses, we assume a constant rate of horse ownership across the entire country. Macleay (2018) found that more than 70% of owners kept their horses within 5kms of their place of residence (8.9% had horses 6-10km; the remaining with horses more distant) –in the absence of better information, we thus allocate values spatially according to the distribution of population.

Gordon (2001) estimates that the annual costs of up-keep for recreational horses (which include agistment /stabling, feed, veterinary, dentist and farrier) are approximately $3000 in rural areas and $11,000 in metropolitan areas; the higher urban costs reflecting the need for stabling (converted to 2015 AUD). She also notes the significant expenditure differentials between what Gordon terms low-cost '*paddock bashers'* and high-cost '*serious event city horses'* (with all manner of horse, and expenditure, between). So we use Gordon (2001)'s estimates of costs which relate to horses kept for recreational purpose only: $8774 in metropolitan areas (converted to 2015 AUD); and $1500 for horses kept permanently in pasture. Our estimates thus understate the true costs of keeping a '*serious event city horse',* but are nevertheless consistent with those of the RSPCA[42] who suggest that it costs about $8400 per annum to keep a horse. Associated feed costs are also consistent with Macleay (2018)'s estimates of feed costs (she did not include other expenses) – reported at, on average, $2280 per horse, per annum[43]. Our exclusion of 'serious event' city horses, is also consistent with results from Macleay (2018)'s survey of horse owners, who reports that only 2.1% of the horses covered by her study were permanently stabled.

[42]"Farriery every 6-8 weeks = $50-$80 per month, feeding costs (when not on grass alone)= $200-$400 per month, worming every 6-8 weeks =$15 per month, veterinary care (vaccines / wound care etc) =$100 per month, annual dentistry= $10 per month, agistment fees =$120-300 per month" – quoted from RSPCA website, https://kb.rspca.org.au/knowledge-base/when-is-the-right-time-to-buy-a-horse-pony-for-my-child/

[43]These numbers are slightly lower than estimates from a report from the horse industry council, which surveyed more than 3000 horse owners (only 6% of which were racers) noting that they collectively spent about $40m during the 2014/15 financial year – about $13,000 per respondent per annum http://www.horsecouncil.org.au/wp-content/uploads/2015/08/2014-15.jpg

When attempting to allow for different cost-structures in urban and rural areas, we use the ARIA+ scores to provide a nuanced, sliding-scale estimate of the cost-per horse. This effectively assumes that expenditure falls by 5.53% for each one-point increase in ARIA+ (with a total fall in expenditures from 8774, for ARIA+=0 to 1500 for ARIA+=15):

$$Value\ per\ horse\ in\ NRM_i = \$8774 \times (1 - ARIA + score\ in\ NRM_i \times 0.055))$$

Table 21: Pet ownership and average expenditure across all of Australia, 2016

Animal	Estimated number in Aus	Average per (owner) household	Estimated number per 100 people	Households with these animals ('000)	Estimated expenditure per (owner) household
Dogs	4,759.7	1.3	20	3,600	1,975
Cats	3,883.6	1.4	16	2,700	1,480
Fish	8,729.5	8	37	1,100	403
Birds	4,187.4	3.9	18	1,100	444
Small mammals	536.9	1.9	2	283	464
Reptiles	415.5	1.7	2	250	633

Table 22: Pet ownership by state/territory - % of households with at least one animal, 2016

Animal	Aus	NSW	ACT	VIC	TAS	QLD	SA	WA	NT
Dogs	38	38	43	40	43	37	45	33	45
Cats	29	25	34	34	30	26	37	28	45
Fish	12	15	16	11	14	9	9	9	18
Birds	12	14	16	10	7	10	13	12	27
Small mammals	3	3	2	4	5	2	4	3	9
Reptiles	3	3	0	3	0	2	4	1	9
Other pets	3	2	7	4	5	2	3	4	0
Any pet	62	60	75	65	66	59	68	57	82

Table 23: Expected expenditure, per capita, on pets by state/territory, 2016

Animal	Aus	NSW	ACT	VIC	TAS	QLD	SA	WA	NT
Dogs	289	289	327	304	327	281	342	251	289
Cats	165	142	194	194	171	148	211	159	165
Fish	19	23	25	17	22	14	14	14	19
Birds	20	24	27	17	12	17	22	20	20
Small mammals	5	5	4	7	9	4	7	5	5
Reptiles	7	7	-	7	-	5	10	2	7
Sum of all	505	490	577	546	541	469	606	451	505

Appendix I: Infrastructure

We focus on the values associated with infrastructure such as buildings, roads, wharfs, pipes and wiring; and goods such as wooden furniture that may be susceptible to pests. We rely primarily on the ABS experimental estimates of the value of capital stock, for each state (ABS, 2017). These estimates provide information on: gross fixed capital formation, end of year net capital stock and the consumption of fixed capital, for numerous different categories of equipment/infrastructure and for different industries. We use estimates of net capital values, focusing on just a subset of all types of capital – specifically those relating to the electricity gas and water industry, and the housing stock (dwellings). We do this because the international literature suggests that these are the types of infrastructure most susceptible to pests. There is, for example, much evidence of the damage which Zebra mussels have caused to infrastructures associated with power and water generation (see, for example, Lovell *et al.* (2006) and Arthur *et al.* (2015)). Terrestrial pests are also a threat to infrastructure that is essential to the generation and transport of electricity (Burnett *et al.*, 2008) and to people's homes.

Not all infrastructure is susceptible to damage from pests. The national accounts show that in 2017, about 24% of the capital in the electricity, gas and water sector was <u>industrial machinery and equipment</u> that could potentially be damaged by pests: other equipment (e.g., computing, electronics, motor vehicles) is unlikely to be susceptible. We thus estimate that the value of utilities 'at risk' (to pests) is 24% of the net capital stock for utilities. We convert that to spatially explicit estimates in several related steps. First, we annualise estimates, and divide through by state population, to derive an estimate of the average per-capita value of utilities 'at risk', for each state. We then exploit some mathematical tautologies to convert the state-wide per-capita estimates into NRM-specific estimates of the value per hectare and total value of utilities 'at risk' (using ALUM data on utilities in each NRM).

We followed a similar procedure for dwellings – noting that not all of the housing stock is susceptible to damage from pests (e.g., there are many brick homes with metal frames). We are unaware of any Australian study from which we could determine the percent of housing stock is 'at risk' (to pests), but note that in the US Guillebeau *et al.* (2008) report that quotes for repairs from termite damage range from about $18,500 to $129,000 (AUD, 2015). This is between 6 and 40% of the median value of houses in their study area [44]. In the absence of other information, we tentatively suggest that it may be appropriate to use the same % here (24%) as for utilities. We thus estimate the value of the dwelling stock 'at risk' at 24% of the net capital stock.

As previously, we annualise the total stock values and then divide by (state) population to estimate the average per-capita value of dwellings 'at risk', for each state. We then derive NRM-specific values, estimating the value per hectare and total value, of dwellings 'at risk' (using the ALUM estimates of residential land per NRM).

We estimate that the value of utilities 'at risk' (to pests) is 24% of the net capital stock for utilities. We then convert that to spatially explicit estimates in several related steps. First, we annualise

[44] The expected value of damages depends on the probability of incursions, and will thus be less that the value of stock 'at risk'. Guillebeau *et al.* (2008) also report that in the U.S, pest management firms earned approximately $12.58 billion (AUD, 2015) in revenue from residential (general insect control and termites) and commercial services – we estimate this at approximately 0.03% of the value of the housing stock; in New Orleans termites are annually responsible for an estimated $100 million in damage to homes and businesses in the – approximately 0.26% of the value of the housing stock (a cursory google search => Population of New Orleans about 400,000 – average household size 2.6 so estimated number of dwellings = 150,000. Median home price in New Orleans placed at $176,000 ($257,000 AUD, 2015) so very rough estimate of the value of housing stock = 150,000 * 257,000 = 38,550 million. If 100 million damage each year then suggests 0.26% value of housing stock damaged each year). Collective value of all US homes estimated at $46,489b (AUD 2015) in late 2017. http://zillow.mediaroom.com/2017-12-28-All-U-S-Homes-Worth-Cumulative-31-8-Trillion

estimates, and divide through by state population, to derive an estimate of the average per-capita value of utilities 'at risk', for each state. We then exploit some mathematical tautologies to convert the state-wide per-capita estimates into NRM-specific estimates of the value per hectare of utilities 'at risk' (using ALUM data on utilities in each NRM):

$$\frac{value\ of\ utilities\ at\ risk\ in\ NRM_i}{hectare} = \frac{State\ capital\ at\ risk}{State\ Population} \times \frac{Population\ of\ NRM_i}{Hectares\ of\ Utilities\ in\ NRM_i}$$

We then generate estimates of the total value of utilities 'at risk' in each NRM:

$$= \frac{value\ of\ utilities\ at\ risk\ in\ NRM_i}{hectare} \times Hectares\ of\ utilities\ n\ NRM_i$$

We use a similar approach for dwellings. We annualise the total stock values and then divide by (state) population to estimate the average per-capita value of dwellings 'at risk', for each state.

Table 24: Net capital stock for dwellings (ALUM 5.4): total value, value 'at risk' and value per hectare, by state

	Population	Net capital stock	Capital stock 'at risk'		
State	Persons	($m)	Total value* ($m)	Annualised value# ($m p.a.)	Annualised value per capita ($ p.a.)
NSW	7,467,920	549,487	131,877	6,728.267	$900.96
VIC	5,919,036	460,529	110,527	5,639.006	$952.69
QLD	4,690,525	363,092	87,142	4,445.920	$947.85
SA	1,673,783	108,733	26,096	1,331.399	$795.44
WA	2,468,022	208,514	50,043	2,553.157	$1,034.50
TAS	508,981	32,096	7,703	393.001	$772.13
NT	226,276	18,739	4,497	229.434	$1,013.95
ACT	396,853	34,789	8,349	425.960	$1,073.34
TOTAL	23,351,396	1,775,979	426,234	21,746.144	

* 25% of Net capital stock

\# assumes a 3% discount rate and a 30 year time horizon: = $\frac{0.03*(\text{Total value})}{1-1.03^{-30}}$

We then derive NRM-specific values, estimating the value per hectare, of dwellings 'at risk' (using the ALUM estimates of residential land per NRM).

$$\frac{value\ of\ dwellings\ at\ risk\ in\ NRM_i}{hectare} = \frac{State\ capital\ at\ risk}{State\ Population} \times \frac{Population\ of\ NRM_i}{Hectares\ of\ dwellings\ in\ NRM_i}$$

The per-hectare estimates are used in the spread model, but we also estimate the total value of dwellings 'at risk' in each NRM:

$$= \frac{value\ of\ dwellings\ at\ risk\ in\ NRM_i}{hectare} \times Hectares\ of\ dwellings\ n\ NRM_i$$

Table 25: Net capital stock for electricity, gas, water and waste (ALUM 5.6): total value, value 'at risk' and value per hectare, by state

	Population	Net capital stock	Capital stock 'at risk'		
State	Persons	($m)	Total value* ($m)	Annualised value# ($m p.a.)	Annualised value per capita ($ p.a.)
NSW	7,467,920	97,681	23,443	1,196.04	$160.16
VIC	5,919,036	97,879	23,491	1,198.49	$202.48
QLD	4,690,525	63,375	15,210	776.00	$165.44
SA	1,673,783	26,746	6,419	327.49	$195.66
WA	2,468,022	35,993	8,638	440.70	$178.57
TAS	508,981	8,790	2,110	107.65	$211.50
NT	226,276	4,131	991	50.56	$223.44
ACT	396,853	4,537	1,089	55.56	$140.00
TOTAL	23,351,396	339,132	81,392	4,152.49	

* 25% of Net capital stock

\# assumes a 3% discount rate and a 30 year time horizon: = $\frac{0.03*(\text{Total value})}{1-1.03^{-30}}$

Appendix J: ES estimates by NRM

Table 26: Values at risk by asset and NRM ($m p.a.)

NRM		Portfolio	Water and subsistence	Regulatory Services	Cultural Services	Companion Animals	Infrastructure	Sum
Central Tablelands	101	$683.27	$48.24	$250.4	$108.8	$101.9	$175.32	$1,367.97
Central West	102	$2,056.53	$155.07	$907.6	$97.6	$68.9	$120.40	$3,406.11
Greater Sydney	103	$1,066.80	$62.71	$306.1	$3,198.9	$3,163.5	$5,118.74	$12,916.72
Hunter	104	$741.89	$143.86	$669.9	$415.1	$450.4	$750.92	$3,171.98
Murray	105	$1,592.56	$86.80	$451.4	$72.4	$67.3	$113.94	$2,384.35
North Coast	106	$891.26	$197.14	$883.4	$377.7	$324.7	$533.24	$3,207.34
North West NSW	107	$2,833.52	$163.53	$931.6	$99.9	$70.0	$124.33	$4,222.93
Northern Tablelands	108	$589.29	$133.81	$626.2	$98.0	$42.8	$74.84	$1,565.04
Riverina	109	$3,008.85	$102.38	$517.6	$153.6	$102.4	$187.84	$4,072.68
South East NSW	110	$745.39	$201.04	$959.0	$353.5	$403.6	$683.43	$3,346.00
Western	111	$839.08	$606.13	$4,468.9	$198.7	$20.8	$40.92	$6,174.46
Corangamite	201	$1,363.46	$45.13	$215.8	$223.9	$286.4	$471.19	$2,605.83
East Gippsland	202	$260.16	$139.41	$646.8	$91.8	$29.6	$51.51	$1,219.28
Glenelg Hopkins	203	$2,436.63	$36.43	$194.6	$116.3	$84.0	$142.16	$3,010.07
Goulburn Broken	204	$1,848.78	$82.13	$386.9	$128.6	$125.7	$209.72	$2,781.91
Mallee	205	$1,989.38	$35.03	$235.8	$49.1	$42.9	$74.62	$2,426.79
North Central	206	$2,080.84	$51.76	$257.1	$118.2	$164.8	$274.99	$2,947.77
North East	207	$433.82	$102.36	$478.6	$115.5	$70.2	$118.77	$1,319.27
Port Phillip and Western Port	208	$1,634.37	$37.42	$175.8	$2,561.1	$3,219.6	$5,225.14	$12,853.48
West Gippsland	209	$1,390.95	$77.46	$359.2	$110.9	$131.2	$218.95	$2,288.67
Wimmera	210	$1,152.08	$28.15	$159.6	$34.3	$29.4	$50.46	$1,454.03
Burnett Mary	301	$1,582.44	$153.51	$767.9	$356.0	$191.9	$352.75	$3,404.46
Cape York	302	$51.42	$342.72	$2,307.5	$273.8	$7.8	$17.14	$3,000.40
Condamine	303	$1,505.33	$27.87	$146.5	$78.0	$118.9	$218.48	$2,095.08
Cooperative Management Area	304	$35.64	$75.04	$555.6	$121.6	$0.7	$1.18	$789.78
Desert Channels	305	$704.85	$676.03	$6,070.5	$272.4	$5.4	$11.89	$7,741.11
Fitzroy Basin	306	$1,888.17	$322.75	$1,766.1	$275.3	$133.5	$262.18	$4,648.00
North Queensland Dry Tropics	307	$1,452.63	$346.44	$2,130.0	$323.3	$127.3	$258.90	$4,638.54
Northern Gulf	308	$539.28	$412.34	$3,010.2	$514.9	$3.7	$8.01	$4,488.32
Queensland Murray Darling Basin	309	$2,056.89	$94.92	$606.5	$73.9	$24.9	$48.89	$2,906.00
Reef Catchments	310	$521.68	$45.57	$241.7	$83.9	$81.5	$152.19	$1,126.52

South East Queensland	311	$1,663.26	$73.89	$336.7	$2,083.1	$1,999.1	$3,560.34	$9,716.27
South West Queensland	312	$295.15	$287.07	$2,214.4	$100.0	$3.8	$8.40	$2,908.82
Southern Gulf	313	$588.03	$399.18	$2,990.1	$233.3	$14.1	$30.30	$4,255.00
Terrain NRM	314	$1,344.00	$131.80	$634.9	$161.2	$146.1	$282.05	$2,700.05
Torres Strait	315	$0	$14.04	$72.0	$6.3	$4.0	$9.02	$105.40
Adelaide and Mount Lofty Ranges	401	$715.46	$7.60	$38.6	$621.8	$1,022.4	$1,312.98	$3,718.89
Alinytjara Wilurara	402	$2.78	$388.32	$3,579.0	$161.2	$1.7	$2.60	$4,135.52
Eyre Peninsula	403	$959.68	$47.45	$320.1	$49.3	$37.9	$55.71	$1,470.13
Kangaroo Island	404	$104.29	$4.59	$30.7	$18.7	$3.3	$4.66	$166.33
Northern and Yorke	405	$1,628.81	$33.54	$207.3	$50.2	$64.0	$86.55	$2,070.38
South Australian Arid Lands	406	$215.53	$1,725.81	$11,269.7	$363.7	$5.6	$8.43	$13,588.84
South Australian MDB	407	$1,822.63	$90.12	$544.8	$80.9	$90.5	$122.30	$2,751.15
South East	408	$1,477.06	$29.84	$160.4	$40.8	$47.9	$65.65	$1,821.64
Northern Agricultural	501	$2,049.52	$73.03	$474.4	$66.0	$35.8	$77.80	$2,776.60
Peel-Harvey	502	$442.42	$37.97	$168.6	$169.8	$74.3	$167.17	$1,060.29
Perth	503	$154.87	$30.70	$150.2	$792.7	$1,115.3	$2,193.51	$4,437.38
Rangelands	504	$618.98	$4,113.15	$31,209.7	$1,198.6	$71.4	$176.54	$37,388.44
South Coast	505	$1,873.61	$157.60	$941.4	$119.0	$35.9	$82.34	$3,209.90
South West	506	$1,627.54	$118.19	$544.4	$168.8	$107.2	$221.16	$2,787.27
Wheatbelt	507	$2,555.16	$129.81	$849.3	$269.6	$33.5	$75.33	$3,912.77
Cradle Coast	601	$685.64	$108.99	$525.0	$113.7	$70.7	$107.24	$1,611.29
North	602	$742.85	$80.05	$381.3	$130.4	$92.5	$138.19	$1,565.28
South	603	$362.41	$157.04	$748.1	$242.2	$170.8	$255.22	$1,935.83
Northern Territory	701	$662.23	$3,062.67	$21,424.0	$1,351.4	$9.0	$279.99	$26,789.28
ACT	801	$16.34	$17.12	$77.5	$155.1	$294.8	$481.52	$1,042.37
TOTAL		$62,585.49	$16,352.75	$111,577.40	$19,844.80	$15,247.30	$25,898.04	$251,505.91

Appendix K: Damages as a percentage of current values

Table 27: Studies used when estimated damages/WTP as a percent of current values

Reference	Asset	ES	Pest	Biome	AUD 2015 estimate	Units	Comments	WTP/Damage as percent of current values
Adams *et al.* (2011)	Cultural	Use value	Weeds	Multiple	$9.32	per visit	Aus-wide comparison per person	2.23%
Akter *et al.* (2015)	Cultural	Use value	Aquatic	Inland aquatic	$3.05	per person	QLD per person	0.72%
	Cultural	Use value	Aquatic	Inland aquatic	$1.74	per person	Pooled per person	0.43%
	Cultural	Use value	Aquatic	Inland aquatic	$1.74	per person	VIC per person	0.42%
	Cultural	Use value	Aquatic	Inland aquatic	$0.44	per person	NSW per person	0.11%
	Cultural	Use value	Invertebrates	Back yard	$85.00	per person	QLD per person	20.07%
	Cultural	Use value	Invertebrates	Back yard	$77.15	per person	Pooled per person	18.64%
	Cultural	Use value	Invertebrates	Back yard	$53.61	per person	NSW per person	12.99%
	Cultural	Use value	Invertebrates	Back yard	$47.95	per person	VIC per person	11.75%
	Cultural	Use value	Invertebrates	Back yard	$36.18	per person	NSW per person	8.77%
	Cultural	Use value	Invertebrates	Back yard	$30.95	per person	VIC per person	7.58%
	Cultural	Use value	Invertebrates	Back yard	$30.51	per person	Pooled per person	7.37%
	Cultural	Use value	Invertebrates	Back yard	$11.77	per person	QLD per person	2.78%
	Cultural	Non-use (biodiversity)	Multiple/any	Multiple	$14.82	per person	QLD per person	12.43%
	Cultural	Non-use (biodiversity)	Multiple/any	Multiple	$11.33	per person	NSW per person	18.08%
	Cultural	Non-use (biodiversity)	Multiple/any	Multiple	$10.90	per person	Pooled per person	9.58%
	Cultural	Non-use (biodiversity)	Multiple/any	Multiple	$9.15	per person	VIC per person	24.08%
Alvarez (2016)	Infrastructure	Housing repair costs	Invertebrates	Urban	$0.29	per resident	Aus-wide	0.03%
Andreu et al. (2009)[45]	Multiple	Multiple	Aquatic	Multiple	$0.06	per person	Aus-wide	0.00%
	Multiple	Multiple	Aquatic	Multiple	$0.18	per person	Aus-wide	0.00%
	Multiple	Multiple	Weeds	Multiple	$0.03	per person	Aus-wide	0.00%
Aukema *et al.* (2011)	Infrastructure	Infrastructure	Invertebrates	Multiple	$12.62	per resident	Aus-wide	1.14%
Beville *et al.* (2012)	Cultural	Use value	Weeds	Inland aquatic	$50.42	per visit	Aus-wide	12.08%
Burnett *et al.* (2006)	Cultural	Non-use value	Weeds	Multiple	$27.58	per resident	Aus-wide	24.24%

[45] cited in Vilà *et al.* (2010)

Reference	Asset	ES	Pest	Biome	AUD 2015 estimate	Units	Comments	WTP/Damage as percent of current values
	Infrastructure	Electricity	Vertebrates	Multiple	$0.06	Direct estimate	N/A - direct estimate	3.11%
	Water	Water	Weeds	Multiple	$101.11	per resident	Aus-wide	14.55%
Chang *et al.* (2012)	Cultural	Non-use (biodiversity)	Invertebrates	Forests	$12.03	per resident	Aus-forests	30.91%
	Cultural	Use value	Invertebrates	Forests	$7.05	per resident	Aus-forests	7.10%
	Cultural	Use-value	Weeds	Multiple		Direct estimate	N/A - direct estimate	10.00%
Currie *et al.* (2009)	Water	Water	Weeds	Multiple	$0.06	Direct estimate	N/A - direct estimate	3.53%
De Lange and van Wilgen (2010)	Cultural	Non-use (biodiversity)	Weeds	Woodlands / Savanna		Direct estimate	N/A - direct estimate	4.29%
	Cultural	Non-use (biodiversity)	Weeds	Shrublands / Grasslands		Direct estimate	N/A - direct estimate	1.44%
	Cultural	Non-use (biodiversity)	Weeds	Woodlands / Savanna		Direct estimate	N/A - direct estimate	1.24%
	Cultural	Non-use (biodiversity)	Weeds	Shrublands / Grasslands		Direct estimate	N/A - direct estimate	1.14%
	Cultural	Non-use (biodiversity)	Weeds	Shrublands / Grasslands		Direct estimate	N/A - direct estimate	0.84%
	Water	Water	Weeds	Shrublands / Grasslands		Direct estimate	N/A - direct estimate	36.61%
	Water	Water	Weeds	Woodlands / Savanna		Direct estimate	N/A - direct estimate	18.66%
	Water	Water	Weeds	Woodlands / Savanna		Direct estimate	N/A - direct estimate	6.83%
	Water	Water	Weeds	Shrublands / Grasslands		Direct estimate	N/A - direct estimate	5.47%
	Water	Water	Weeds	Shrublands / Grasslands		Direct estimate	N/A - direct estimate	3.25%
Eiswerth *et al.* (2005)	Cultural	Use value	Weeds	Multiple		Direct estimate	N/A - direct estimate	1.98%
Engeman *et al.* (2004)	Multiple	Multiple	Vertebrates	Inland aquatic	$189.15	per hectare	Aus-wide	7.80%
Epanchin-Niell and Liebhold (2015)	Cultural	Use-value	Vertebrates	Urban	$8.34	per resident	Aus-wide cultural use-values	7.33%
García-Llorente *et al.* (2011)	Multiple	Multiple	Weeds and Vertebrates	Multiple	$86.20	per resident	All values; Aus-wide	1.03%
Gong *et al.* (2009)	Multiple	Multiple	Vertebrates	Multiple	$6.23	per resident	Aus-wide	0.06%
Guillebeau *et al.* (2008)	Infrastructure	Housing	Invertebrates	Urban		Direct estimate	N/A - direct estimate	1.08%
Gutrich *et al.* (2007)	Cultural	Use value	Invertebrates	Multiple	$66.33	per resident	Aus-wide	15.89%
	Infrastructure	Housing and public Infrastructure	Invertebrates	Multiple	$124.97	per resident	Aus-wide	11.27%
Kaiser and Roumasset (2002)	Water	Water	Vetebrates and Invertebrates	Forests	$2,375.36	per hectare	Aus forests	93.54%

Reference	Asset	ES	Pest	Biome	AUD 2015 estimate	Units	Comments	WTP/Damage as percent of current values
McIntosh *et al.* (2010)	Multiple	Multiple	Aquatic	Inland aquatic	$121.44	per resident	Inland aquatic water + regulating + cultural	12.66%
Panzacchi et al (2007)[46] -	Multiple	Multiple	Vertebrates	Multiple	$0.13	per person	Aus-wide	0.00%
Pejchar and Mooney (2009)[47]	Cultural	Use value	Vertebrates	Multiple	$0.56	per person	Aus - all recreation	0.16%
	Cultural	Use value	Weeds	Woodlands / Savanna	$2.61	per hectare	Aus - recreation woodlands	2.87%
	Regulating	Carbon Sequestration	Weeds	Woodlands / Savanna	-$4.48	per hectare	Aus - carbon woodlands	-11.46%
	Water	Water	Weeds	Woodlands / Savanna	$188.77	per hectare	Aus - water from woodlands	659.47%
Pimentel *et al.* (2005)	Multiple	Multiple	Aquatic	Multiple	$14.92	per resident	Aus-wide	0.14%
	Multiple	Multiple	Invertebrates	Multiple	$129.27	per resident	Aus-wide	1.20%
	Multiple	Multiple	Pathogens - plant	Multiple	$165.66	per resident	Aus-wide	1.54%
	Multiple	Multiple	Vertebrates	Multiple	$253.88	per resident	Aus-wide	2.36%
	Multiple	Multiple	Weeds	Multiple	$222.70	per resident	Aus-wide	2.07%
Scalera and Zaghi (2004)[48]	Multiple	Multiple	Aquatic	Multiple	$0.03	per person	Aus-wide	0.00%
Tait *et al.* (2017)	Cultural	Non-use (biodiversity)	Vertebrates	Forests	$14.96	per resident	Aus-forests	38.44%
Turpie and Heydenryck (2000)[49]	Cultural	Non-use (existence)	Weeds	Woodlands / Savanna	$2.99	per hectare	Aus - non-use woodlands	125.47%
van der Gaag (2007)[50]	Multiple	Multiple	Invertebrates	Multiple	$0.03	per person	Aus-wide	0.00%
White and Harris (2002)[51]	Multiple	Multiple	Vertebrates	Multiple	$0.46	per person	Aus-wide	0.00%
	Multiple	Multiple	Vertebrates	Multiple	$0.02	per person	Aus-wide	0.00%
Windle *et al.* (2009)	Cultural	Non-use and use	Multiple/any	Woodlands / Savanna	$2.53	per hectare	Aus-wide	9.82%
Zavaleta (2000)	Regulating	Regulating	Weeds	Multiple	$0.40	per resident	Aus-wide	0.04%
	Water	Water	Weeds	Multiple	$0.36	per resident	Aus-wide	0.05%
Zander and Straton (2010)	Cultural	Non-use and use	Multiple/any	Woodlands / Savanna	$30.42	per resident	Aus-wide	26.74%

[46] cited in Vilà *et al.* (2010)

[47] compiled from numerous sources

[48] cited in Vilà *et al.* (2010)

[49] cited in Pejchar and Mooney (2009)

[50] cited in Vilà *et al.* (2010)

[51] cited in Vilà *et al.* (2010)

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