



Figure1: David Ascalon, depicting events from the Old Testament, Circa 2000, en.wikipedia.org as at 30 May 2007.

## The ecoservice values for some of Australia's natural coastal assets: How much are our coasts worth and what's missing from the mosaic?

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### Abstract

Although most Australians hold the country's natural coastal assets in high regard, the total dollar value of goods and services provided by these assets has only recently been partially estimated for Australia. Blackwell (2006a) provided an initial paper on the matter, scoping out the potential value from the macro scale using Costanza *et al.*'s (1997) heavily criticized biome values per hectare. Martinez *et al.* (2007) have subsequently provided similar estimates for nations from the global macro scale again drawing on the Costanza *et al.* (1997) (and Sutton and Costanza 2002) estimates highlighting the relative social, ecological and economic importance of our coasts globally.

While individual studies examining the value of particular ecosystem goods and services (ecoservices) provided by coastal natural resources have been conducted in Australia, they have been done so in a piecemeal fashion. None, to the author's knowledge, have attempted to identify what may be missing from the mosaic of ecoservice values for various coastal biomes. This paper bridges this gap in knowledge by presenting the results from a Coastal CRC project on the matter. When the mosaic of ecoservices for particular coastal ecosystems is created it becomes immediately apparent that any macro-level assessment is not sufficient in capturing the broad spectrum of ecoservice groupings provided by particular biomes, nor the various types of ecoservices within any particular category of ecoservice. The mosaic is far from complete and this paper provides some insights as to what is missing.

**Key words:** Coastal habitats, ecosystem goods and services, environmental valuation, Australia

## Introduction

The initial intentions of this paper were grand, attempting to value the ecosystem good and service values of some of Australia's natural coastal assets as part of a research project of the Cooperative Research Centre for Coastal Zone Estuary and Waterway Management (Blackwell 2006b). In so doing, it became apparent that our economic and ecological knowledge of the ecosystem goods and services (ecoservices) of coastal habitats is substantially limited.

This paper outlines the process taken and the knowledge gaps obtained by creating a mosaic of ecoservices for the following coastal habitats:

- Estuaries;
- Open Beaches;
- Seagrass/algal beds, sand and mud flats (i.e. sub tidal and inter tidal flats); and
- Mangroves and tidal salt marsh and salt pans.

Two steps were involved in the project. First, a rapid estimate was undertaken of the value of some of Australia's coastal ecosystems using the Costanza *et al.* (1997) estimates in their global assessment of ecosystems and multiplying these values by estimates of Australia's coastal ecosystem areas. The preliminary results from this first step were reported by Blackwell (2006a). Second, the domestic valuation literature was summarised and interpreted to obtain some aggregation for beach and estuary habitats where there were sufficient values. The first step is termed the macro-level assessment and the second step is termed the micro-level assessment.

The valuation of ecoservices is crucial to improved coastal management because currently there is a danger of valuing these services as zero. Without monetary values for coastal ecoservices, the value of forgone opportunities may not enter the policy decision process. For example, what's the lost value of ecoservices from allowing an aquaculture venture in a bay or from building a boat ramp that interferes with a major board surfing site? Without knowing the monetary value to society from a surf site or the conservation values of a bay's ecosystems the net gains or losses to society can only be speculated. These type of decisions require marginal value information. Costanza *et al.* (1997) were criticised in the literature for their total value approach to the assessment of the globe's ecoservices. Martinez *et al.* (2007) provided similar estimates for nations from the global macro scale drawing on the Costanza *et al.* (1997) (and Sutton and Costanza 2002) estimates highlighting the relative social, ecological and economic importance of our coasts globally. In contrast, Balmford *et al.* (2002) considered values for coastal ecosystems at the margin. This paper identifies marginal values where these are relevant.

## Ecoservices

Ecoservices are the benefits that humans gain from the goods and services provided by ecosystems. Consistent with the Millennium Ecosystem Assessment (2005), the broad view presented in this paper is that these goods and services fall into the following four broad categories:

- Provisioning services;
- Regulating services;
- Cultural services; and
- Supporting services.

The categorisation from the Ecosystem Assessment is very similar to that provided in Australian studies and the similarities are depicted in Figure 1.

Figure 1: Similarities between sources of ECOSERVICES categories

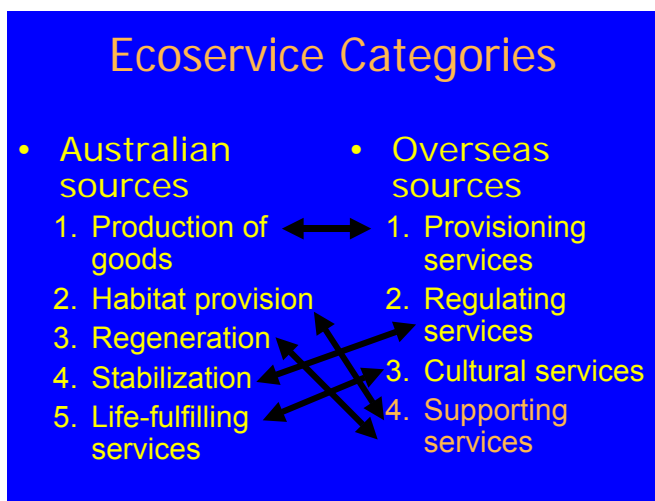


Table 1: The ecoservices of natural coastal assets of interest to the CRC – international monetary values

Category	Ecosystem Good or Service
Provisioning services	Fresh water Food Fibre ( <i>including clothing and shelter</i> ) Fuel Genetic resources Biochemicals, natural medicines and pharmaceuticals Ornamental resources
Regulating services	Air quality regulation Climate regulation Water regulation Erosion regulation Water purification Waste treatment Disease regulation Pest regulation <i>Population balance</i> <i>Translocation and dispersion</i> Natural hazard regulation
Cultural services	Cultural diversity Spiritual and religious values Knowledge systems Inspiration <i>Aesthetic and serenity values</i> Social relations Sense of place Cultural heritage, historic and artistic values Recreation and ecotourism <i>Non-use value (existence, bequest)</i>
Supporting services	Soil formation Photosynthesis Primary production Nutrient cycling/regulation Water cycling <i>Refugia function</i> <i>Nursery function</i>

Notes and sources: Categorisation and types of ecoservices come from modification of Millennium Ecosystem Assessment (2005) and synthesis with information from Robinson and Clouston (n.d.); Curtis (2004); Wilson *et al.* (2002) and deGroot *et al.* (2002). Italics represent added categories to the Millennium Assessment.

Importantly, the Millennium Ecosystem Assessment (2005) distinguishes supporting services as those which are necessary for the production of other ecoservices. Provisioning, regulating and cultural service impacts tend to be more direct and have short-term impacts on people. Some services fall between two categories depending on the time scale and immediacy of their impact on people. For example, erosion regulation may be categorised as both a regulating service and a supporting service.

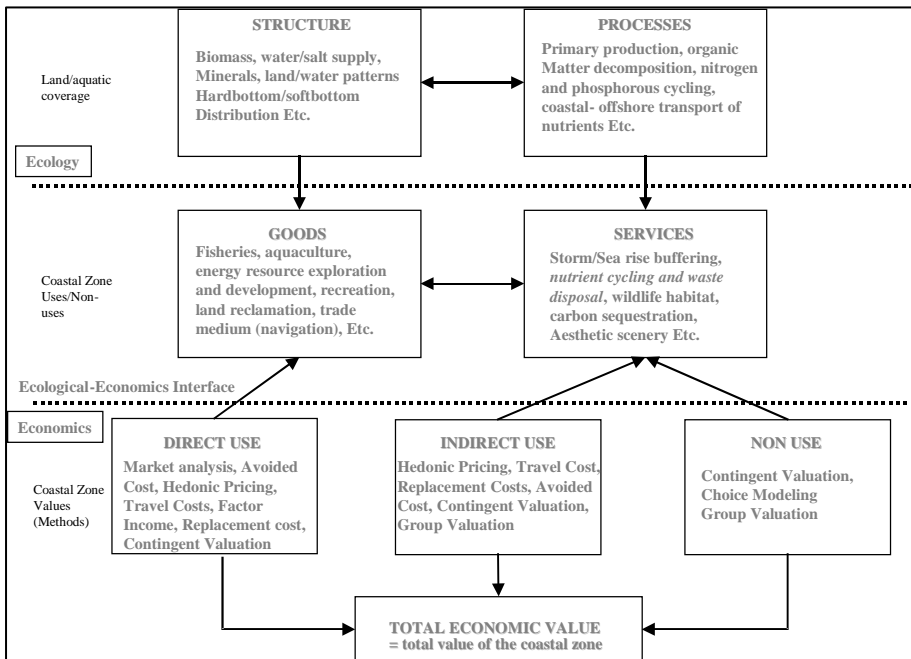
Table 1 presents a synthesis of ecoservice categorisation drawing mainly from the Millennium Ecosystem Assessment (2005), with some additional services drawn from Robinson and Clouston (n.d.); Curtis (2004); and Wilson *et al.* (2002). The table presents the ecosystem goods and services identified for the 4 coastal biomes of interest in this paper with sand and mudflats separately identified from seagrass and salt marsh and pans separately identified from mangroves.

The provisioning and regulating ecoservices tend to reflect direct use values whereas the cultural tend to reflect indirect use value or what is termed 'passive-use value' in the economic literature. Non-use value, such as existence value, which reflects no use is not represented in the summary figure of Wilson and Troy (2005, p.3) nor in the summary table of ecosystem goods and services for coastal habitat and landscape features of Wilson *et al.* (2002, p. 12). This was a limitation of the global assessment of ecoservices conducted by Costanza *et al.* (1997). Robinson and Clouston (n.d.), Curtis (2004) and Daily (1997) however refer to existence or non-use values.

### Coastal ecoservices and their monetary valuation

A framework for better understanding the role of ecology and economics in natural coastal asset valuation is illustrated in Figure 2. In the broadest sense, the land or aquatic coverage of coastal ecosystems provides particular uses and non-uses for humans that in turn are captured by particular economic valuation methods. For example, an estuary composed of plants and animals, salt water, mud, sand and rock may provide organic matter decomposition and nitrogen and phosphorus regulation, in turn providing fisheries, recreation and transport goods, nutrient cycling, waste disposal and aesthetic scenery services.

**Figure 2: Ecological economic interface of ecoservices and their valuation**



Source: Adaptation of Wilson *et al.* (2002) and Turner (2000).

The value of fisheries and transport goods and nutrient cycling and waste disposal may be captured through the prices and quantities traded for these goods on markets. The travel cost method may be used to reveal recreation values for an estuary by studying the travel patterns and expenditure of recreators where no recreation market exists. The hedonic price method may use the property market to reveal the value of a coastal view. The contingent valuation method or choice modelling method may be used to obtain people's stated willingness to pay for all of these goods and services. These latter stated preference methods are used by economists for ascertaining people's monetary values for the non-use of coastal ecosystems such as existence, bequest and vicarious values. Non-market valuation methods include travel cost, contingent valuation and choice modelling. Group valuation involves methods which reflect democratic processes of public decision-making through public debate not the aggregation of individual preferences. Citizens' juries and expert panels are included in the group valuation category. These approaches are summarised in Figure 3.

**Figure 3: Market and non-market valuation approaches and coastal ecosystems**

<p><b>Market Approaches</b></p> <ul style="list-style-type: none"> <li>• <b>Market values (MV)</b>; the value of goods are determined through what is traded on markets either as expenditure or revenue; the value of landed catch of prawns, muscles and scallops provides a measure of the value of these goods for human consumption.</li> <li>• <b>Replacement cost (RC)</b>: services could be replaced with man-made systems; nutrient cycling waste treatment can be replaced with costly treatment systems.</li> <li>• <b>Avoided Cost (AC)</b>: services allow society to avoid costs that would have been incurred in the absence of those services; flood control (barrier islands) avoids property damages, and waste treatment by wetlands avoids incurred health costs.</li> <li>• <b>Marginal Product Estimation (MP)</b>: Service demand is generated in a dynamic modeling environment using production function (i.e., Cobb-Douglas) to estimate value of output in response to corresponding material input.</li> <li>• <b>Factor Income (FI)</b>: services provide for the enhancement of incomes; water quality improvements increase commercial fisheries harvest and thus, incomes of fishermen.</li> </ul> <p><b>Non-market analyses</b></p> <ul style="list-style-type: none"> <li>• <b>Travel Cost (TC)</b>: service demand may require travel, whose costs can reflect the implied value of the service; recreation areas attract distant visitors whose value placed on that area must be at least what they were willing to pay to travel to it.</li> <li>• <b>Hedonic Pricing (HP)</b>: service demand may be reflected in the prices people will pay for associated goods: For example, housing prices along the shore of pristine freshwater lakes tend to exceed the prices of inland homes.</li> <li>• <b>Contingent Valuation (CV) and Choice Modeling</b>: service demand may be elicited by posing hypothetical scenarios that involve some valuation of alternatives; people would be willing to pay for increased water quality in freshwater lakes and streams.</li> <li>• <b>Group Valuation (GV)</b>: This approach is based on principles of deliberative democracy and the assumption that public decision making should result, not from the aggregation of separately measured individual preferences, but from <i>open public debate</i>.</li> </ul>
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Source: Wilson *et al.* (2002) with market value and choice modelling additions.

The structure of coastal ecosystems provides primary goods and processes that in turn provide services to all life on earth, including humans. The structures and processes of coasts are endowed to humans and interpreted through ecology. The goods typically represent, in an economic sense, direct use values while the services represent indirect use and non-use values. Thus the interface of ecology and economics provides a framework for interpreting and valuing in monetary terms coastal ecoservices.

### The Macro-level Assessment

Table 2 provides a summary of the area estimates and value per square kilometre obtained through the macro-assessment. While estuary, beach, and mangrove areas are relatively small

their ecoservice values per square kilometre are relatively high (beach values were attained in the micro-assessment – see below). There is a high degree of variation between area and value per area with substantial total values obtained for large ecosystem areas such as open ocean and shelf.

**Table 2: Indicative values of ecoservices of selected Australian ecosystems**

Category	Ecosystem	Sub-ecosystem	Area of selected ecosystems (km <sup>2</sup> ) a	Value /km <sup>2</sup> (\$AUS 2005) b	Total annual value (\$AUS billion 2005)
Marine			12,438,119	103,704	1,359.3
	Open ocean		10,256,150	45,314	464.7
	Coastal		2,181,969	728,645	894.5
		Estuaries	16,592	4,105,563	68.1
		Open beaches	14,686	-	-
		Seagrass/algae beds	51,217	3,417,227	175.1
		Coral reefs	48,960	1,092,383	53.5
		Shelf	2,065,200	289,504	597.9
Terrestrial			-	124,604	-
	Forest		-	174,287	-
		Tropical	-	360,891	-
		Temperate/boreal	-	54,304	-
	Grass/rangelands		-	41,717	-
	Wetlands		-	2,658,582	-
		Tidal marsh/mangroves	21,790	1,796,364	39.1
		Swamps/floodplains	-	3,520,801	-
	Lakes/rivers		-	1,528,078	-
	Desert		-	-	-
	Tundra		-	-	-
	Ice/rock		-	-	-
Cropland		-	16,543	-	
Urban		-	-	-	

Notes and Sources: a. Sources for areas as provided in **Error! Reference source not found.** b. Conversion and indexation of Costanza *et al.* (1997) 1994 estimates per ha. – Means 'not yet known'.

These preliminary findings suggest that estuaries appear to be the most valuable per square kilometre for their ecoservices, such as removing nutrients from wastewater and providing for storm and flood protection, transportation and fisheries. On a total-value basis, Australia's continental shelf appears the most valuable asset, due to its size, followed by open oceans, seagrass beds, estuaries, coral reefs and mangroves.

## Micro-assessment

The micro-assessment collated valuation estimates from Costanza *et al.* (1997) and Australian and other overseas studies as summarised in Table 3 for each of the coastal habitats of the project.

Some values were aggregated from the domestic literature to gauge the magnitude of values within specific economic measure types (the distinction was not made in the aggregation of estimates by Costanza *et al.* 1997) as depicted in Table 4.

**Table 3: Cross tabulation of international, including Costanza *et al.* (1997), and domestic estimates**

Category	Ecoservice	Coastal asset					
		Estuaries	Open Beaches and dunes	Seagrass/Algal beds	Sand and mudflats	Mangroves	Tidal saltmarsh, salt pans
Provisioning services	Fresh water	■3	□				
	Food	■1 ■1	□	■21 ■4 □16	■4	■24,25,26 □20,21,22	■19 □20
	Fibre (including clothing and shelter)	■1 ■3	□	■17 □18		■24 □23	■
	Fuel	■3	□			□	
	Genetic resources		?			□	□
	Biochemicals, natural medicines and pharmaceuticals		□	□18		□	
	Ornamental resources	□	■10 <sup>1</sup>	□18		□	
Regulating services	Air quality regulation	□	□	□		□	□
	Climate regulation	□				□	□
	Water regulation	■3 □6,9 <sup>2</sup>	□			□	
	Erosion regulation		■9 □12	□		□	□
	Water purification	□6		□18		□3	
	Waste treatment	■3	■10			■2	■
	Disease regulation		□				
	Pest regulation		□				
	Population balance	■	?	□			
	Translocation and dispersion		□	□?		□	
	Natural hazard regulation	■1 □6 ■3	■11 □12	□18	□12,18	■3	■19
	Cultural services	Cultural diversity	?	?	?	?	?
Spiritual and religious values			□			□	
Knowledge systems		■	□	□	□	□	□
Inspiration			□				
Aesthetic and serenity values		■5	■12, 13	■4	■4	□	
Social relations			□				
Sense of place		■4	□	■4	■4		■4
Cultural heritage, historic and artistic values		■4 <sup>3</sup>	□			■24	
Recreation and ecotourism		■1,2,3,4,5,6 ■1,4,5,6 <sup>4</sup>	■10,20 □14,15,16,17,18,19 ■7,9,14 □8,13,15	□3 ■4 □16	■4	■3 ■3	■4
Non-use value (existence, bequest)		■5,7,8 □3,6 ■5	■20 <sup>5</sup> □17 <sup>6</sup> ■11	□		□3 □21	
Supporting services	Soil formation		□			□	□
	Photosynthesis			□		□	□
	Primary production			■4,17	■4	□	■4
	Nutrient cycling/regulation	■1	■10	■■ □16	□	■2	■3
	Water cycling		□			□	
	Refugia function	■	□	□	□	■	■
	Nursery function	■■	□	■17 □18	□	■26	■4

Notes and sources: See Table 1 for ecoservice categorisation. ■. Costanza *et al.* (1997) estimate. ■. International peer reviewed literature estimate. ■. Domestic peer reviewed literature estimate □. Domestic non-peer reviewed literature. □. No economic values in peer reviewed literature but expected to be substantial. ?. A degree of uncertainty is involved. [1] de Groot (1992); [1] Robinson 2001 (collection of original domestic studies and estimates); [2] van Bueren & Bennett (2004); [3] Clouston (2002); [4] Driml & McBride (1982); [5] Morrison & Bennett (2001); [6] Jensen (2003); [7] Windle & Rolfe (2005); [8] Rolfe & Windle (2005); [9] Mattinson & Morrison (1984); [10] Carlsen (1997); [11] Raybold and Mules (1999); [12] Fraser & Spencer (1998); [13] McCartney (2006); [14] Blackwell (2003); [15] Pitt (1992); [16] Kinhill & Stearns and Riedel & Byrne (1983); [17] Tisdell & Wilson (2000); [18] Andersen *et al.* (1996); [19] Burger (1996); [20] Wilson & Tisdell (2003); [21] Watson *et al.* (1993) [1] Kaoru *et al.* (1995); [2] Lal (1990); [3] Identified by Wilson *et al.* (2002); [4] Johnston *et al.* (2002); [5] Harris (1984); [6] Carson & Mitchell (1993); [7] Bell & Leeworthy (1990); [8] Bell & Leeworthy (1986); [9] Silberman & Klock (1988); [10] Smith *et al.* (1997); [11] Hall *et al.* (2002); [12] Posford Duvivier (2002); [13] Amarasooriya (2001); [14] Loomis & Larson (1994); [15] Leeworthy and Wiley (2003); [16] Florida Department of Environment Protection (2000); [17] Thoraug (1990); [18] South China Sea Institute of Oceanology (1990); [19] King & Lester (1995); [20] Postford Duvivier (1996); [21] Ruitenbeek (1992); [22] Christensen (1992); [23] Gammage (1994); [24] Ruitenbeek (1994); [25] Ronnback (1999); [26] Barbier & Strand (1998). Except for Costanza *et al.* (1997), Wilson *et al.* (2002) and de Groot (1992), the remaining references can be obtained from the author upon request.

<sup>1</sup> Contained within tourism expenditure.

<sup>2</sup> No areal or population statistics available with publication so could not be converted to an aggregated areal estimate.

<sup>3</sup> Not identified separately because associated with sense of place.

<sup>4</sup> No spatial context given so no areal estimates available.

<sup>5</sup> Only non-use values for turtle conservation. Urban beach non-use values not yet determined.

<sup>6</sup> Only non-use values for turtle conservation. Urban beach non-use values not yet determined.

**Table 4: Some individual Australian study estimates**

<i>Biome and ecoservice</i>	<i>Value \$AUD/km<sup>2</sup>/yr</i>			<i>Notes if any</i>	<i>Source c</i>
	<i>Willingness to pay</i>	<i>Consumer surplus</i>	<i>Market values</i>		
<b>Estuary</b>					
Protection	128,272			MV, underestimate	Windle and Rolfe (2005)
Improved water quality	540,750				Van Beuren & Bennett (2004)
Recreational boating		32,125		Excl. demand growth	Driml & McBride (1982)
Fishable water	1,764,020				Morrison & Bennett (2004)
Swimmable water	1,395,152				Morrison & Bennett (2004)
Fish species conservation	170,738				Morrison & Bennett (2004)
Food – estuarine dependent and opportunist fisheries			3,386	Not exhaustive	Robinson (2001) <b>d</b>
Recreational fishing			20,262	Overestimate	Robinson (2001)
Port services			3,425	Areal sensitivity	Robinson (2001)
<b>Total estuary</b>	<b>2,063,060a</b>	<b>32,125</b>	<b>27,072</b>		
<b>Open beach</b>					
Amenity - Ocean views			1,824,891		Fraser & Spencer (1998); McCartney (2006)
Natural hazard regulation					Raybold & Mules (1999)
- sand replenishment, prevention of tourism and recreation expenditure loss			1,969,244		
- public property damage			2,076		
Recreation & Tourism	2,240,136		1,732,660	Areal sensitivity	Carlsen (1997)
- urban		499,067,489		Areal sensitivity	Blackwell (2003)
- non-urban		3,060,713			Pitt (1992)
- turtle preservation	3,411,578				Tisdell & Wilson (2000)
- turtle watching		992,469	13,211,882		Tisdell & Wilson (2000)
- non-use	6,720,409b				Carlsen (1997)
<b>Total beach</b>	<b>9m-10m</b>	<b>1m-502m</b>	<b>3.8m-13m</b>		

Sources and notes: **a.** The highest value of water quality benefits was taken and fish species conservation was added to protection because it is a separate service. **b.** Extrapolated using ratio from Carlsen (1997) from other studies of use and non-use values. This is not a consumer surplus (CS) measure but a user surplus measure mainly using the surrogate travel cost method, not CS but willingness to pay. MV = marginal value. Excl. = excludes. **c.** The details of these references can be obtained from the author upon request. **d.** Robinson's (2001) paper collated a number of market based studies from around Australia.

The available estimates in the domestic and international literature for the coastal biomes are quite different. There is not a complete coverage of estimates for any particular ecosystem good or service for any particular coastal ecosystem. However, there are generally more estimates available for the provisioning services of food for example and the cultural services of recreation and tourism. There is a general paucity of estimates at home and abroad for seagrass and algae beds, sand and mudflats and for mangroves and saltpans and marshes. The mixing of different economic measures is not suggested but instead categorising them according to the methods of estimation is suggested. Separate presentation will avoid treating all measures as the same when in fact they are not. For example, consumer surplus is maximum willingness to pay net of the price of provision. In contrast, market values represent gross measures and not net gains to society from the sale of a good or service. Domestically there is no estimate for the nutrient cycling service of estuaries that contributed to over 50% of their value in the Costanza et al. (1997) study. Despite this, the range of values for estuaries is in the order of \$2m Australian dollars, 2005, per km<sup>2</sup> per year which is a similar order of magnitude to the value of Costanza et al. (1997) without cross combining values from different methods and without capturing all their potential value. Beaches also had substantial values ranging in order of magnitude from a million to half a billion dollars per km<sup>2</sup> per year, again without capturing all their potential value. For example, beach waste removal nutrient regulation, air quality and climate regulation functions and cultural heritage and social interaction values are not captured.

## Discussion and future research

There is some duplication of the domestic literature on coastal ecoservice valuation with that of Costanza *et al.* (1997) and with the international literature as depicted in Table 4. The duplication typically occurs in the areas of recreation and ecotourism service valuation and market values associated with food and fibre provisioning services. The Costanza *et al.* (1997), international and domestic estimates are far from complete, even in areas that have received the most research effort.

Table 3 is offered as a way forward for future practitioners to guide valuation research. The notable gaps are domestic information on seagrass/algae beds and sand and mudflats and mangroves and tidal saltmarsh and salt pans. There is also a need for research to move away from the traditional areas of inquiry to ecoservices not yet studied domestically. Non-use values of beaches and nutrient cycling in estuaries are two examples. Also, the filtration and nutrient cycling functions of beaches has not yet been recognized in the ecoservice or economic literature.

Duplication across international and domestic sources, may provide the best place to begin value transfer but there is an exponential (cubed) degree of error in the any given areal estimate. Confidence intervals for estimates are recommended as a way forward in presenting coastal ecosystem values to take account of the likely error in the estimation process.

Overall, there is insufficient information to estimate the value of goods and services provided by the Australia's natural coastal assets. There is however, sufficient information to start aggregating certain measures domestically and then filling gaps where generic service estimates are available from abroad or as domestic estimates become available. For the relative value of coastal ecosystems, local contextual information is important to bear in mind in terms of local coastal management issues.

Studies from the United States and south east Asia may be useful as points of reference for the values attained domestically. Similarities in ecoregions exist between Australia and south east Asia and also for socio-economic characteristics with the United States. Individual studies are always preferred, but time and cost constraints may warrant transfer approaches.

Other areas for future research effort include:

- the spatial assessment of coastal ecosystems of total values across time given changes in their ecological integrity;
- estimating values for Australian rocky reefs and shores;
- studying dis-services and their interplay with services of coastal ecosystems (pest infestations in mangroves are an example);
- developing a spatial context for Australia's coastal habitat values using hydrographical and geographical information systems to account for marginal values;
- providing greater integration between natural scientists and economists studying in this area to provide improve our knowledge of the nature of coastal ecoservices and their monetary values.
- providing a requirement of future economic valuation studies to include a spatial dimension to their estimates to allow the ecoservice mosaic to grow.
- The development of new valuation methods to capture the ecoservice values for which there are currently few or imperfect estimates available.

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