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## Linkages between ecosystem services and human wellbeing: A Nexus Webs approach


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15

16 **ABSTRACT:**

17 Ecosystems provide benefits to people, and, in turn, people individually and collectively affect the  
18 functioning and wellbeing of ecosystems. Interdependencies between ecosystem services and  
19 human wellbeing are critical for the sustainable future of ecosystems and human systems alike, but  
20 they are not well understood. We offer an account of these interdependencies from the perspective  
21 of social psychology. Using the Nexus Webs framework (Overton et al., 2013), we explore how a  
22 fuller knowledge of coupled social-ecological systems will benefit resource management and  
23 decision-making in contested spaces. We challenge the tacit notion that ecosystem health and  
24 human wellbeing are linearly related, and suggest human wellbeing may affect ecosystem health.  
25 We outline the multiple construals of the construct ‘wellbeing’, and identify additional psychological  
26 constructs of importance. We examine how the benefits of ecosystems for human wellbeing may  
27 accrue differently across regions and across people. Four areas for future research are identified.

28

29 **Keywords:** ecosystem services; human wellbeing; social-ecological systems; social psychology;  
30 solastalgia; sense of place; locus of control

31

32 **Word count:** 12258

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## 37 **1. INTRODUCTION**

38 All human life depends on, and is a part of, ecosystems. Ecosystems provide benefits to  
39 people, 'ecosystem services', and in turn people individually and collectively affect the functioning  
40 and wellbeing of ecosystems. Developing a better comprehension of how ecological and social  
41 systems are coupled is critical to the sustained and sustainable functioning of both human systems  
42 and ecosystems (Millennium Ecosystem Assessment, 2003). In this paper, we employ the Nexus  
43 Webs framework (Overton, Colloff, Dunlop, Wallbrink, & Podger, 2013) to investigating these  
44 interdependencies. The Nexus Webs framework offers a method for integrating biophysical  
45 modelling, socio-economic modelling, and the assessment of human wellbeing, and promises to be a  
46 useful decision-support tool for resource managers and management. From a social psychological  
47 perspective, attention to some significant areas of the Nexus Webs approach will bolster the robust  
48 contribution the framework can make in the arena of contested resource use. The Web's current  
49 oversight of ecological feedbacks associated with human wellbeing is a particular focal point. In this  
50 paper we draw on empirical evidence from social and environmental psychology to illustrate how  
51 relationships and dependencies between human- and eco-systems often run counter to  
52 expectations. In so doing we identify four important areas for future research, and outline  
53 implications for contested resource use issues that can be managed with frameworks such as that  
54 offered by an improved Nexus Webs approach.

### 55 **1.1 Existing frameworks**

56 The importance of ecological systems and services for human wellbeing is increasingly well  
57 established and understood. The Millennium Ecosystem Assessment work (MEA; Millennium  
58 Ecosystem Assessment, 2003) provides an influential framework for analysing coupled social-  
59 ecological systems. Within this framework, ecosystem services are categorised into provisioning  
60 services (the products obtained from ecosystems), regulating services (the benefits derived from  
61 regulation of ecosystem processes), and cultural services (non-material benefits derived from  
62 ecosystems). The MEA also conceptualises close links between ecosystem services and human  
63 wellbeing, articulating four main wellbeing categories: security, basic material for a good life, health,  
64 and good social relations. Freedoms and choice cut across these four categories.

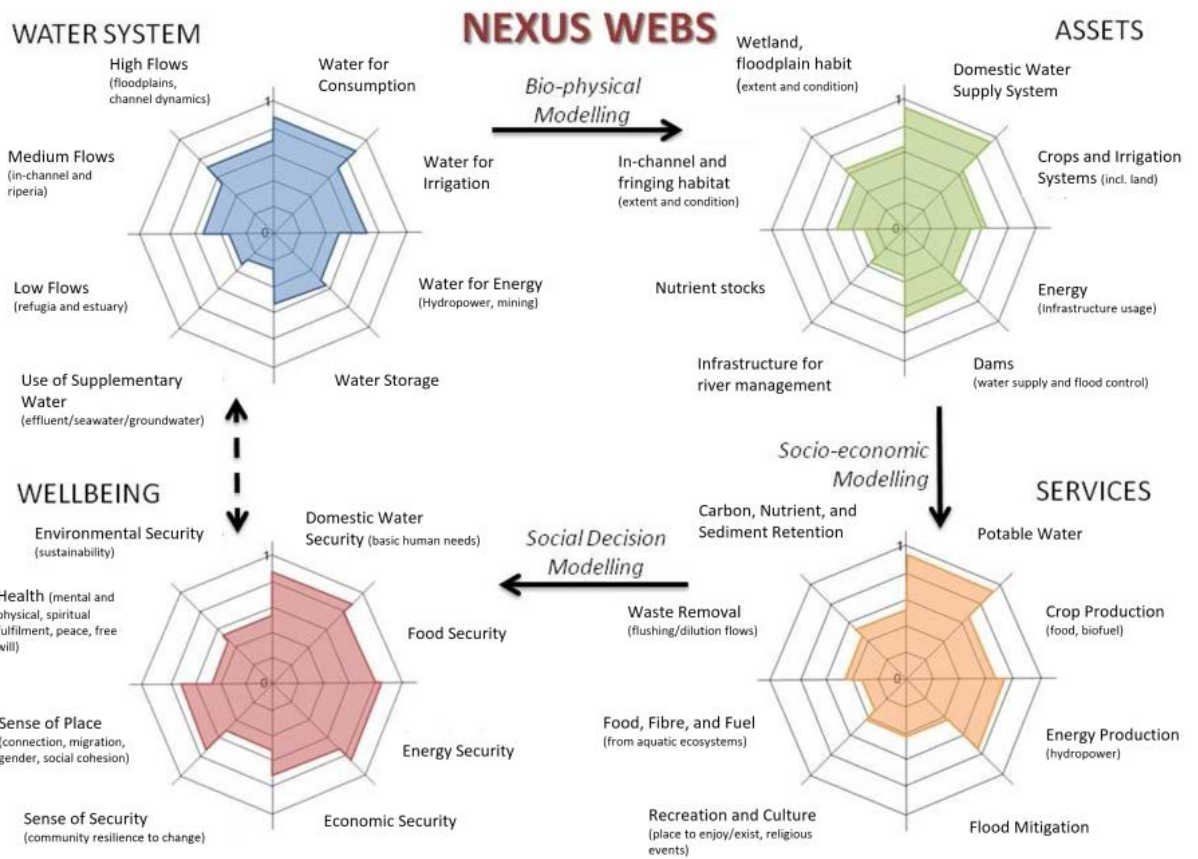
65 The MEA has been influentially globally, but retains some limitations. In particular, the  
66 nature of interconnections between provisioning, regulating, and cultural services, on the one hand,  
67 and the various aspects of wellbeing on the other, are under-researched. So too are the  
68 interconnections among security, basic material for a good life, health, and good social relations, as

69 aspects of wellbeing. We do not know, for example, whether there is a hierarchy of importance  
70 across these aspects of wellbeing or whether there are conditionalities among them. Critically, the  
71 MEA framework conceptualises the connections between ecosystem services and wellbeing as  
72 unidirectional. We suggest, as evidenced by findings in the social psychological sciences, that the  
73 influence flows the other way too.

74           The MEA framework has been recently superseded by the Intergovernmental Science-Policy  
75 Platform on Biodiversity and Ecosystem Services framework (IPBES; Diaz et al., 2015a, 2015b). This  
76 framework acknowledges the potential for bidirectionality between social-ecological systems;  
77 improved human wellbeing for instance, influences institutional and governance provision of  
78 ecosystem goods and services. Such interdependencies are consistent with a recent review of the  
79 links between ecosystem services and human wellbeing (Bennett et al., 2015), where it was posited  
80 that the answers to three key questions will improve decision-making for sustainable resource-use:  
81 *how are ecosystem services jointly produced by coupled social and ecological systems?; who benefits*  
82 *(and who loses) from ecosystem services?; and what governance arrangements will optimise*  
83 *practices and outcomes?* Our analysis broadly concerns the first two of these questions, and in  
84 particular, the social psychological factors implicated in the relationship between ecosystem services  
85 and human wellbeing.

## 86 **1.2 The Nexus Webs framework**

87           Resource management in contested spaces involves interactions between biophysical  
88 properties of ecosystems, evaluation of the assets associated with those ecosystems, evaluation of  
89 the services supported by those assets, and consideration of the many aspects of human wellbeing  
90 flowing from the assets and services. The Nexus Webs framework, shown in Figure 1 (Overton et al.,  
91 2013), was developed from work in integrated water management to capture the interplay between  
92 these factors. When integrated into resource management practice, it can be used as a decision-  
93 support tool, and can provide a pathway for major industries and other stakeholders to gain a social  
94 licence to operate.



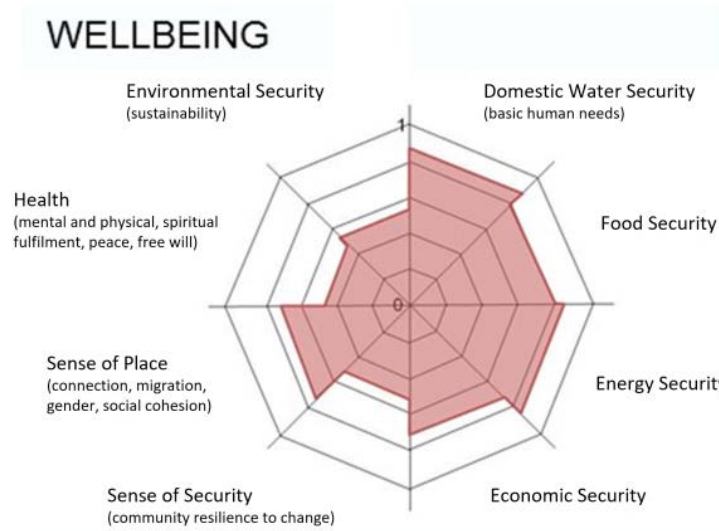
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96 **Figure 1. The Nexus Webs framework (modified from Overton et al., 2013, p. 10).**

97 Each of the Webs is comprised of a number of components. The set of components for each  
 98 Web depends on the domain (e.g., water, energy, biodiversity), and has to be ascertained for each  
 99 case. The four Webs are intended to be organised sequentially, and are connected via system  
 100 dynamics that are largely unspecified. In any particular domain, the nature and number of  
 101 components in each web has to be assessed, usually through consultation with stakeholders and  
 102 relevant community groups and members. The very process of engagement is likely to have ancillary  
 103 benefits too (such as greater acceptance and likelihood of adoption of recommendations through an  
 104 iterative process of consensus). The Nexus Webs approach is a simple way of summarising complex  
 105 system interactions for stakeholders and communities, and can be used to present likely futures  
 106 under different scenarios.

107 The Wellbeing Web, pictured in Figure 2, specifies eight components of human livelihood:  
 108 food security and domestic water security (basic human needs); energy security, economic security,  
 109 and sense of security (community resilience to change); environmental security (sustainability);  
 110 health (mental and physical health, spiritual/aesthetic value, peace, free will); and sense of place  
 111 (connection, migration, gender, social cohesion) (Overton et al., 2013). It is suggested that the size  
 112 and shape of the shaded area in the Wellbeing Web indicate a level of social wellbeing, distribution

113 of benefits to different stakeholders, and net trade-offs. In the example in Figure 2, eight areas have  
114 been chosen to represent the key wellbeing factors as a specific example. In other cases, it may be  
115 prudent to use more or fewer metrics.



116

117 **Figure 2. The Wellbeing Nexus Web (modified from Overton et al., 2013, p.15).**

118 The Nexus Webs approach has intuitive appeal and is easily communicable to stakeholders.  
119 However, from a social science perspective, aspects of the Nexus Webs approach and the Wellbeing  
120 Web in particular (and their attendant assumptions) are under-critiqued. For instance, the Webs  
121 framework does not currently capture feedbacks. As currently conceptualised, the framework  
122 suggests that an increase in an ecosystem service will translate directly to an increase in wellbeing,  
123 though the ecosystem services may well be differently influential. This latter point is consistent with  
124 the findings of Raudsepp-Hearne et al. (2010) that food production, which has increased over the  
125 last several decades, has outweighed the detrimental effects to wellbeing driven by declines in other  
126 ecosystem services, such as soil degradation and declining water quality. There is also an assumption  
127 of unidirectionality, with services impacting wellbeing but not vice-versa. This particular assumption  
128 deserves unpacking, as wellbeing may alter demand for or supply of particular ecosystem services,  
129 and changes in wellbeing may influence environmental degradation. This paper focuses on  
130 developing a fuller understanding of the connections between the services component and the  
131 wellbeing component of the Web framework.

132 What follows is a review of extant literature from the social sciences (and in particular the  
133 social and environmental psychological sciences) pertinent to unpacking these aspects and critiquing  
134 their assumptions. A fuller appreciation of wellbeing, and its antecedents and sequelae, will make

135 frameworks such as those offered in the Nexus Webs approach more useful as a decision-making  
136 tool for stakeholders. We start with an overview of how human wellbeing has traditionally been  
137 conceptualised and measured, and what is thought to influence it, and proceed to a review of what  
138 is known from the psychological sciences about wellbeing's interconnections with ecosystem  
139 services. From there we formulate four areas for future research exploration.

## 140 **2. HUMAN WELLBEING**

141           What is human wellbeing? A long history of investigation across many disciplines has  
142 resulted in an ambiguous concept with no universally accepted definition (Diener, 2000; McGillivray  
143 & Clarke, 2006; Summers et al. 2012). The term wellbeing is often used interchangeably with  
144 'quality of life', 'welfare', 'well-living', 'living standards', 'utility', 'prosperity', 'needs fulfilment',  
145 'development', 'empowerment', 'capability expansion', 'human development', 'poverty', 'happiness'  
146 and 'life satisfaction', often with no discussion of the distinctions between terms (McGillivray and  
147 Clarke, 2006; McCrea, Walton, & Leonard, 2014).

148           Wellbeing has been investigated at a range of scales including individual, community,  
149 national, and international, with many organisations focused on tracking wellbeing across cultures  
150 and countries. Worldwide examples include the OECD Better Life Initiative (Durand, 2015), The  
151 World Values Survey (Inglehart, Puranen, Pettersson, Nicolas, & Esmer, 2005), the World Happiness  
152 Report (Helliwell et al. 2017), and the Gallup World Poll, with the Gallup wellbeing measure feeding  
153 into the Happy Planet Index (Abdallah, S., Thompson, S., Michaelson, J., Marks, N., & Steuer, N.,  
154 2009). The Millennium Ecosystem Assessment suggests that human wellbeing encompasses the  
155 following: basic material for a good life (livelihood, food, shelter, clothing, access to goods); health  
156 (feeling well, healthy physical environment), harmonious social relations (social cohesion, mutual  
157 respect, ability to help others), security (access to resources, personal safety, security from  
158 disasters), and freedom of choice (opportunity to achieve what an individual values) (MEA, 2005, V).  
159 However, this conceptualisation has also been criticised for failing to be all-encompassing (Summers  
160 et al. 2012).

161           Studies of wellbeing at the community level are often ambiguous, with measurable  
162 components overlapping with dimensions of 'resilience', the ability to recover, adapt, or transform  
163 in response to disturbances (Armitage, Bene, Charles, Johnson, & Allison, 2012; Hobman & Walker,  
164 2015; McCrea et al. 2014). In their assessment of the impacts of coal seam gas mining on  
165 communities in Queensland, McCrea et al. (2014) suggest that wellbeing should be thought of as a  
166 state, and resilience a process. Elsewhere, Schirmer and Berry (2014) have considered the  
167 components of wellbeing of thousands of Australians living in rural and regional areas. They suggest

168 wellbeing is comprised of safety, security, physical health, mental health, relationships, social  
169 networks, access to goods and services, and the fairness of the society in which they live.

## 170 **2.1 What influences wellbeing?**

171           The wellbeing of individuals and communities is shaped by many factors, such as a healthy  
172 natural and built environment; fair and stable governance, most particularly democracy, that  
173 provides opportunities for local people to participate; ready access to resources and capital (e.g.,  
174 food, water, shelter, safety, education and learning opportunities, health services, cultural and social  
175 opportunities); a diverse economy; local environmental quality; and demographics (e.g., age, marital  
176 status) (Bramley et al., 2009; Orviska et al., 2012; Schirmer & Berry, 2014; Smith et al., 2013).  
177 Cooperation and trust are also important. Cooperative contexts and tasks (as opposed to  
178 individualistic or competitive ones) can increase self-esteem and social support, and promote  
179 positive relationships, which in turn can contribute to increased subjective wellbeing (Tov & Diener,  
180 2009). Trust is often deemed necessary to facilitate cooperation, although some have questioned  
181 whether it is essential (Cook et al., 2005). Having a positive mood or disposition can in turn promote  
182 cooperation.

183           At higher levels of abstraction, cultural and societal factors play a fundamental role in group-  
184 level wellbeing. Large differences in subjective wellbeing between countries can be explained by  
185 variations in conditions such as food, health, and lack of corruption. There is evidence that some  
186 cultures tend to be happier even when conditions such as income are controlled for, perhaps due to  
187 differences in social support and positivity (Diener, 2012). Smith et al. (2013) highlight that, despite  
188 the importance of the role of spirituality and culture in communities, wellbeing indices rarely  
189 consider these aspects. Smith et al. cite a study by Swan and Raphael (1995) showing the importance  
190 of Aboriginal Australians' holistic view of health, where the spiritual, environmental, ideological,  
191 mental, and physical aspects are collectively known as 'cultural wellbeing'. Expanding on these ideas  
192 of wellbeing for Aboriginal Australians, Gee et al. (2014, p. 57) extend Swann and Raphael's analysis  
193 to describe nine 'guiding principles' that underpin social and emotional wellbeing for Aboriginal  
194 people in Australia: health as holistic, the right to self-determination, the need for cultural  
195 understanding, the impact of history on trauma and loss, recognition of human rights, the impact of  
196 racism and stigma, recognition of the centrality of kinship, recognition of cultural diversity, and  
197 recognition of Aboriginal strengths. These factors are substantially different from those that  
198 conventional wellbeing frameworks articulate for majority-culture Australians, or for majority groups  
199 in most developed Western countries. Clearly, human 'wellbeing' and its perceived



200 interdependencies with ecological health is as much a product of broader social and historical  
201 factors as it is of individual characteristics (see also Hung, 2013 and Zubrick et al., 2014).

202 By contrast, studies have demonstrated mixed results for the influence of income on  
203 wellbeing (Kahneman & Deaton, 2010). Graham and Pettinato (2006) summarise that economic  
204 growth is a necessary condition for achieving enhanced social wellbeing through the reduction of  
205 poverty and, on average, the wealthy are happier than the poor; however, once a certain income  
206 threshold is reached, there are no significant differences in happiness between wealthier and poorer  
207 societies. Further, Graham and Pettinato's (2006) findings suggest that variables such as *relative*  
208 income, changes in employment, and age are more important indicators of happiness in both  
209 developing and developed countries.

## 210 **2.2 Approaches to measuring wellbeing**

211 Objective, measurable indicators of wellbeing include material and social attributes such as  
212 access to physical resources, employment, income, education, health, and housing (King et al.,  
213 2014). These are the social and economic attributes that reflect life circumstances and can be easily  
214 measured at the population level. By contrast, subjective wellbeing refers to the thoughts and  
215 feelings an individual has about life's circumstances, and their stated levels of satisfaction with  
216 specific wellbeing dimensions (Diener, 2000; King et al., 2014). Numerous scales have been  
217 developed to measure subjective wellbeing, such as the Satisfaction with Life Scale (Diener et al.  
218 1985); Scale of Positive and Negative Experiences (Diener et al. 2009); Flourishing scale (Diener et al.  
219 2009); Quality of Life scale; and The Personal Wellbeing Index (Cummins, Lau and Davern, 2012; The  
220 International Wellbeing Group, 2013). Subjective wellbeing often does not correspond to objective  
221 indicators of wellbeing. People's sense of satisfaction or dissatisfaction is usually assessed by making  
222 social comparisons with other people, rather than against objective aspects of life (Pettigrew, 2016).

223 Solely focusing on objective or subjective wellbeing measures has been criticised for its  
224 limited assessment (Hagerty et al., 2001; King et al. 2014). Accordingly, much current research is  
225 focused on developing an aggregate measure of subjective and objective wellbeing, as well as  
226 considering and reflecting on the interconnectedness of social and ecological systems (Agarwala et  
227 al., 2014; Armitage et al., 2012; Ivaldi, Bonatti, & Soliani, 2016).

228 To summarise, the concept of human wellbeing has evolved from a narrow focus on  
229 objective measures (e.g., economic conditions, housing, education, and welfare) to one where  
230 complex and multidimensional components such as subjective wellbeing and ecological measures  
231 are included (King et al. 2014). Diener (2000) proposes that national accounts of subjective and

232 psychosocial wellbeing have become established in societies because wellbeing or quality of life  
233 includes more than economic indicators. But despite the large body of research, there remains no  
234 standard measurement of wellbeing (Diener & Tov, 2012). The International Wellbeing Group (2013)  
235 audited over 1200 instruments that claim to measure life quality in some form, and concluded that  
236 many of these measures are limited due to a focus on specific groups, or a failure to distinguish  
237 between subjective and objective dimensions. This suggests to us that applications such as the  
238 Nexus Webs framework may have to include key relevant indicators of wellbeing *in situ*, according to  
239 the needs and insights of particular stakeholders, and accordingly to the specific ecological  
240 circumstances confronting the individual or group. Locally relevant indicators of wellbeing will also  
241 help to take into account circumstances where individual preferences are formed in response to  
242 their available options, a phenomenon known as adaptive preferencing (Nussbam, 2000; Sen, 1999).

### 243 **3. CONNECTIONS BETWEEN ECOSYSTEM SERVICES AND WELLBEING: A SOCIAL AND** 244 **ENVIRONMENTAL PSYCHOLOGY PERSPECTIVE**

245 Ecosystem services are the benefits people derive from ecosystems (Roberts et al., 2015). It  
246 is tempting to assume that an increase in the particular services an ecosystem provides will confer a  
247 corresponding increase in human wellbeing to those living within that ecosystem and deriving  
248 services from it; but there are many reasons for resisting this temptation. In this section, we outline  
249 several approaches that have been used to investigate linkages between ecosystem services and  
250 human wellbeing in the social and psychological sciences, provide an overview of existing empirical  
251 research on ecosystem and human health relationships, and present several additional psychological  
252 constructs that might develop our understanding of the interrelations, interdependencies, and  
253 temporal considerations of ecosystems and wellbeing.

#### 254 **3.1 Ecosystem services, wellbeing, and psychology: A human needs approach**

255 Wellbeing can be thought of as derived through the attainment of human needs. Perhaps  
256 the most well-known (and most critiqued) construct emerging from psychology on this theme is  
257 Maslow's Hierarchy of Needs (1943). Maslow purports that the successful attainment of higher level  
258 needs (culminating in 'self-actualisation') are contingent on basic physiological needs (e.g., water,  
259 food, air) being met. Somewhere between basic physiological needs and self-actualisation are what  
260 Maslow termed 'deficiency needs' – the need for safety, affection, and belonging. As the fulfilment  
261 of these needs fluctuates so too does the person's wellbeing – deficiency in any of these categories  
262 will lead to stress, tension, and lower levels of wellbeing.

263           If the ability of ecosystems to provide adequate services for the most basic physiological  
264 needs in one domain (e.g., water security) is compromised, the level of services in other domains  
265 becomes irrelevant. That is, each domain must satisfy certain ‘basic requirements’ for each  
266 individual. It is far less clear, though, how fluctuating levels of ecosystem services in each domain  
267 might differentially impact the higher needs of people, and how ecosystem degradation might  
268 undermine deficiency needs over the long term.

269           This needs-based approach, originating in the psychological sciences, has gained momentum  
270 in the environmental sciences. In reviewing how ecosystem services might contribute to the  
271 wellbeing of New Zealanders, Roberts et al. (2015) draw upon a similar needs-based approach that  
272 describes nine fundamental human needs (Max-Neef, 1991): subsistence, protection, affection,  
273 understanding, participation, leisure, creation, identity, and freedom. Unlike Maslow’s hierarchical  
274 approach, Max-Neef posits that human needs are much more interrelated and interactive, and as  
275 such are analogous to non-human ecosystems. Roberts et al. articulate how ecosystem services  
276 might contribute to these nine fundamental human needs. They conclude that improved public  
277 decision-making depends upon more effectively measuring these different components of wellbeing,  
278 and a greater awareness of how ecosystem services contribute to each of these components. The  
279 contributions of ecosystem services identified by Roberts et al. are categorised under the following  
280 headings: subsistence, protection, affection, understanding, participation, leisure, creation, identity,  
281 and freedom.

282           Roberts et al.’s conceptualisation of ecosystem provision is comprehensive, but again it is  
283 largely unidirectional; ecosystems, through the various services they afford, contribute to the overall  
284 wellbeing of humans. What is not captured in these needs-based approaches is an element of  
285 wellbeing that has long occupied the interest of psychologists. This element, captured variously  
286 under concepts such as self-efficacy theory (Bandura, 1977), self-determination theory (Deci & Ryan,  
287 2011), effectance motivation (Harter, 1978; White, 1959), and learned helplessness (Seligman,  
288 1972), concerns the basic and chronic motivation for humans to master, or control, their own  
289 environment, and to respond adaptively to fluctuations within that environment (Maddux, 1995;  
290 Waytz et al., 2010). If efforts to adapt to environmental changes, or to effectively control one’s  
291 environment are thwarted, wellbeing is compromised. Similarly, compromised wellbeing may  
292 motivate compensatory responses; an individual may alter their behaviour and attitudes toward  
293 their ecological surroundings to make their environment more predictable, manageable, and  
294 understandable, thereby enhancing wellbeing (Waytz et al., 2010). This directly implies the capacity  
295 for bidirectionality between human wellbeing and ecosystem.

296 **3.2 Ecosystem health and human health: A reciprocal relationship**

297 A growing body of empirical evidence from the social psychological sciences and related  
298 disciplines suggests ecosystem health plays an important role in shaping people's subjective  
299 wellbeing (Albrecht, 2005, 2006; Higginbotham et al., 2007; Jardine, Speldewinde, Calver, &  
300 Weinstein, 2007; Rapport, 2002; Rapport & Singh 2006; Sandifer, Sutton-Grier, & Ward, 2015;  
301 Speldewinde, Cook, Davies, & Weinstein, 2009). To date, research on the human health impacts of  
302 ecosystem disruptions, such as climate change, has focused largely on the physical effects of  
303 extreme weather events, higher temperatures, and food shortages (Fritze et al., 2008). But direct  
304 impacts on mental health and wellbeing may also ensue through trauma and displacement from  
305 extreme events, as well as indirect effects related to disturbance of mental health determinants and  
306 distress about the future (Fritze et al., 2008). Such impacts are illustrated by research linking drought  
307 with reduced life satisfaction (Carroll, Frieters, & Shields, 2009), dryland salinity with hospitalisation  
308 rates for depression (Speldewinde et al., 2009), and declines in agricultural terms of trade with  
309 suicide rates (Fragar et. al., 2008). There is also evidence that enhanced ecosystem health improves  
310 wellbeing. For instance, an abundance and diversity of bird species, vegetation cover, and quality  
311 bushland has been linked to increased satisfaction with place and health benefits (Kuo, 2015; Luck,  
312 Davidson, Boxall, & Smallbone, 2011). Further, Kamitsis and Francis (2013) found that  
313 connectedness to and engagement with nature predicted greater subjective wellbeing, and that this  
314 was significantly mediated by spirituality. In addition to the importance of cultural spirituality in  
315 shaping conceptions of social ecological relations, Kamitsis and Francis's findings suggest spirituality  
316 also operates at an individual level to explain linkages between ecosystem health and wellbeing.

317 Pathways from ecosystem degradation to psychological distress have been a particular focus  
318 of research in the agricultural domain. Broadly, these pathways include financial pressures due to  
319 reduced productivity and land values; and declines in population, social networks, community  
320 services, and employment opportunities (Jardine et al., 2007; Greenhill et al., 2017; Staniford,  
321 Dollard & Guerin, 2009; Caldwell & Boyd, 2009). But psychological quality of life has also been linked  
322 to people's 'sense of place' (Ogunseitn, 2005), and environmental degradation is thought to  
323 adversely influence this relationship (Rogan, O'Connor, & Horwitz, 2005). Degradation of physical  
324 surroundings can also lead to anxiety and feelings of helplessness (Sartore et al., 2008). Another  
325 posited pathway is 'Solastalgia', a sense of human distress induced by ecological decline (Albrecht,  
326 2005, 2006; Speldewinde et al., 2009).

327 While the pathways from environmental degradation to psychological distress and wellbeing  
328 are increasingly understood, the pathways from psychological distress to environmental

329 degradation, and from social systems to the provision of ecosystem service supply, are less clearly  
330 defined (Bennett et al., 2015).

331 In the agricultural domain, and following a needs based approach, Leviston, Price, and Bates  
332 (2011) suggest that Australian farmers differ in their stages of security, and therefore have different  
333 levels of wellbeing needs more or less satisfied. This in turn influences their engagement with land  
334 management practices that either promote or degrade wider ecosystem health. For example,  
335 converting to 'minimum till' or 'no till' practice to reduce input costs and time may be driven  
336 primarily by the need for financial security. In this case, concern for family livelihood takes  
337 precedence over caring for the natural environment or long term soil viability. Conversely,  
338 converting to minimum till or no till practice primarily for biodiversity purposes may satisfy higher  
339 levels of need: self-esteem and development, or, in a land management context, innovation and  
340 land stewardship. This is a case of the same segmented behaviour (minimum or no till) being driven  
341 by different levels of needs necessary for that individual's wellbeing; but in the former case it is less  
342 likely to 'spill over' into other realms of good practice associated with land stewardship (weed  
343 management, native vegetation retention, stocking practices and so on) (Leviston, Price, & Bates,  
344 2011). In short, promoting the uptake of the full suite of land management practices required to  
345 increase long-term services to the farmer and promote wider ecosystem health (and therefore  
346 increased services to the broader community) may only be possible once basic and overriding needs  
347 such as safety and security are satisfied.

### 348 **3.3 Solastalgia**

349 Solastalgia describes the relationship between ecosystem distress and human distress  
350 (Albrecht, 2005, 2006). The term solastalgia derives from the words 'nostalgia' (home-sickness) and  
351 'solace' (alleviation of distress). It is a painful experience related to the desolation or loss of the  
352 place where one resides, manifesting in a deteriorated sense of belonging or place identity. As such  
353 it can be characterised as 'homesickness one gets when one is still at 'home'' (Albrecht, 2005, p.17)  
354 stemming from an unwanted transformation of the environment. Maintenance of the state of one's  
355 environment is thought to comfort and provide solace, and solastalgia therefore is the sickness  
356 caused by a lack of solace from the environment. High levels of mental health issues and suicide in  
357 rural Australia may be related to landscape degradation (e.g., erosion, salinity, loss of biodiversity)  
358 and subsequent human distress (Albrecht, 2005). These psychological issues may be the  
359 manifestation of environmental distress. Links between distress and a sense of powerlessness have  
360 been demonstrated in Australian communities experiencing environmental degradation (Leviston et  
361 al., 2011).

362 Drawing on the Solastalgia literature and models of stress and coping (Baum, Fleming, &  
363 Singer, 1982; Lazarus & Folkman, 1984), Higginbotham et al. (2007) investigated the effects of  
364 ecosystem disturbance on environmental distress. They present environmental distress as a cycle:  
365 environmental changes elevate threat perceptions, resulting in social, economic, and psychological  
366 impacts that are followed by behavioural reactions that in turn influence the environment. Sense of  
367 place and trust in government and industry are thought to mediate threat appraisal, impacts, and  
368 actions. This thinking again highlights the reciprocal or bidirectional relationship between ecosystem  
369 health and wellbeing. That is, poor environmental conditions may impair human health and  
370 psychological resources, reducing the likelihood of pro-environmental behaviour, which  
371 subsequently further degrades ecosystems.

### 372 **3.4 Locus of Control**

373 The theory and concept of 'Locus of Control' (LOC), introduced by Rotter (1966), posits  
374 individuals with an 'internal' locus believe outcomes are contingent on their own actions, while  
375 those with an 'external' locus believe chance, fate, or powerful others control outcomes affecting  
376 them (see Levenson, 1974; Paulhus & Van Selst, 1990, for reviews and adaptations). LOC has  
377 important implications for wellbeing. People with an internal LOC are more able to adequately  
378 respond to stress than are others (Krause & Stryker, 1984), and ascribing control over one's life to  
379 external sources can be detrimental to wellbeing (DeNeve & Cooper, 1998). LOC has also been  
380 related to perceived income adequacy, an important component of subjective wellbeing (Danes &  
381 Rettig, 1993; Sumarwan & Hira, 1993). Perceived income inadequacy can trigger a sense of relative  
382 deprivation, if it is seen as unjust, and a sense of injustice coupled with a sense of internal control  
383 can lead to various forms of social protest (e.g., Walker, Wong, & Kretzschmar, 2002).

384 There is a host of empirical evidence that LOC might directly or indirectly influence  
385 ecosystem health (and therefore services). An internal locus has been found to predict  
386 environmentally responsible behaviour (Bamberg & Möser, 2007; Darner, 2009; Hines, Hungerford &  
387 Tomera, 1987; Huebner & Lipsey, 1981; Hwang, Kim & Jeng, 2000), attitudes (McCarty & Shrum,  
388 2001), environmental concern (Pettus & Giles, 1987), and pro-environmental land management  
389 behaviour (Leviston et al., 2011).

390 LOC is a good example of a psychological construct linked to wellbeing that also influences  
391 the ability of an ecosystem to provide adequate services. LOC is traditionally viewed as a fixed,  
392 largely immutable personality trait, and therefore something that is largely 'decoupled' from one's  
393 physical environment. Recent evidence casts significant doubt on this tradition (e.g., Ryon &  
394 Gleason, 2014). For instance, in a study of farmers' pro-environmental land management practice,

395 Price and Leviston (2014) found that different levels of severity of environmental degradation (in this  
396 case, brought about by long-term and severe drought) was associated with farmers' loci of control:  
397 farmers in regions more severely affected by drought were more likely to have external loci of  
398 control than farmers in neighbouring regions less severely impacted.

399 This seemingly symbiotic relationship between individual psychological differences and  
400 environmental quality suggests constructs such as LOC might be important indicators to include in  
401 investigations of ecosystem services and wellbeing. In particular, longitudinal monitoring programs  
402 would help unpack the reciprocal nature of the relationships between different aspects of  
403 ecosystem health and human wellbeing. For resource management, LOC, and what causes it to  
404 fluctuate, is important not just from a wellbeing perspective, but because of its close relationship  
405 with trust. Leviston et al. (2011) and Price and Leviston (2014) found that one's LOC directly and  
406 indirectly influences trust in and willingness to receive information from multiple sources (including  
407 natural resource management experts), such that an external LOC is associated with lower levels of  
408 both trust in expert information, and willingness to use information from resource management  
409 experts in their own land management activities (see also Duram, 1997). The erosion of trust in  
410 environmental agencies has broader social and cultural ramifications. Trust is critical for ensuring  
411 social license to operate, for instance (Moffat & Zhang, 2014). Further, trust is central to the  
412 generation of social capital; a community that questions the legitimacy of information from public  
413 and expert institutions is likely to have lower collective capacity to respond to environmental shifts  
414 (Leonard & Leviston, 2012; Putnam, 2009). The empirical evidence cited here suggests that a high  
415 level of ecosystem services is vital to regaining, building, and retaining trust in agencies.

### 416 **3.5 Sense of Place and Place Attachment**

417 Sense of Place refers to the emotional and physical bonds an individual has with a physical  
418 place. It has three dimensions – place attachment, place identity, and place dependence. It is  
419 manifest most visibly in the ways people feel about and use the landscape (Seddon, Duany, &  
420 Tredennick, 1972). People's connection to place and the formation of emotional attachments has  
421 been extensively explored in the literature (see Brehm, Eisenhauer, & Stedman, 2013; Devine-  
422 Wright, 2009; Trentelman, 2009 for detailed definitions and an overview of related concepts).  
423 Generally of interest to place-based studies is how people perceive, experience, and value the  
424 environment (Cheng et al., 2003). These place-based values in turn influence the trade-offs people  
425 make when adapting to ecological changes in their environment; what is worth preserving and what  
426 is worth relinquishing will be made within values frameworks, at both individual or group levels, that  
427 articulate what is important in people's lives and how this connects with where they live (Graham et

428 al., 2013; Tschakert et al., 2017) It is thought that place-based meanings are generated through  
429 place-based experiences (Rudestam, 2014) and people with a greater sense of place are more likely  
430 to conserve or care for their local environment (Leonard et al. 2013) or display increased levels of  
431 pro-environmental attitudes and behaviour (see Ryan, 2005; Stedman, 2003; Vorkinn & Riese, 2001).  
432 Further, encouraging place attachment may directly lead to an increase in pro-environmental  
433 behaviour (Scannell & Gifford, 2010).

434 Sense of Place is generally viewed positively, as something to be promoted, and as  
435 contributing to overall wellbeing. Indeed, issues of identity comprise one of Max-Neef's nine  
436 fundamental human needs, and continuity of place is an important component in reinforcing and  
437 maintaining identity (Adger et al., 2013; Hernandez et al., 2010). However, some research suggests  
438 that it might also have unintended and undesirable consequences.

439 Marshall et al. (2012) investigated the transformational capacity of peanut farmers to adapt  
440 to the altered productivity of natural resources (exacerbated by climate change). They found a  
441 strong negative correlation between transformational capacity and place attachment. Other  
442 research has indicated that striving for higher levels of place attachment, identity, and dependency  
443 might drive a shift in population to more bushfire prone areas, in turn placing further strain on  
444 ecosystem management (Anton & Lawrence, 2014). Place attachments and identity may also  
445 increase place-protective actions that are ecologically counterproductive, such as local place-based  
446 opposition to the construction of wind farms (Devine-Wright, 2009). As such, place attachment can  
447 constrain adaptations necessary for long-term ecosystem health (see Bonaiuto, Alves, De Dominicis,  
448 & Petruccelli, 2016 for a review of literature assessing place attachment and adaptation and  
449 maladaptation responses). This hints at an intriguing paradox for frameworks such as the Nexus  
450 Webs: that too much of a particular aspect of wellbeing might under some circumstances degrade  
451 ecosystem services.

### 452 **3.6 Environmental Worldviews**

453 People's subjective perception of their relationship with nature can shape their responses to  
454 debates surrounding the allocation of ecosystem services (Price, Walker, & Boschetti, 2014). These  
455 multiple views of human-environment relationships, based on cultural perspectives, compete and  
456 conflict both between and within individuals (Douglas & Wildavsky, 1982). Price et al. (2014)  
457 conceive of two underlying dimensions of worldviews: a 'ductile' perspective, where the ecosystem  
458 is viewed as altered by physical activity and is ill-equipped or unable to recover from damage; and an  
459 'elastic' perspective, where the ecosystem is viewed as resilient and capable of recovering from



460 damage. Elastic views are associated with support for environmental exploitation and resistance to  
461 policies aimed at protecting the environment; ductile views have the opposite associations.

462 It is important to note that in this theoretical framework, worldviews are not stable  
463 characteristics of individuals, but rather are socially available discursive resources able to be drawn  
464 upon by all people in a community, including stakeholders in contested land use arenas. Although  
465 conceptually these worldviews are socially available discursive resources, there are consistent  
466 patterns of individual differences in endorsement of one worldview or another (Price, Walker, &  
467 Boschetti, 2014).

468 These competing worldviews may underlie differences in the subjective perception of the  
469 contribution (and potential future contributions) of ecosystem services to increases or decreases in  
470 wellbeing. These worldviews, and other 'mental models' of human-environment interrelations  
471 (Richert, Boschetti, Walker, Price, & Grigg, 2016), are therefore also critical in determining how  
472 conflicts surrounding the provision of natural resources might best be resolved. For instance,  
473 designing participatory decision-making processes that encourage stakeholders to acknowledge the  
474 different sets of biases and assumptions they each bring to the table may be an effective means of  
475 consensus building (Boschetti, Richert, Walker, Price, & Dutra, 2012).

### 476 **3.7 Sense of Justice and Relative Deprivation**

477 In their recent review, Bennett et al. (2015) highlight the centrality of understanding who  
478 benefits and who loses from changes in ecosystem services in improving decision-making for  
479 sustainable resource use. This is squarely an issue of social justice, about which the social sciences  
480 have had much to say (Jost & Kay, 2010).

481 The distinction between *distributive* and *procedural* justice is vital – the former refers to  
482 judgements of the fairness of the distribution of the rewards and punishments of life; the latter to  
483 judgements of the rules and procedures that generate patterns of reward distribution. Judgements  
484 about the two forms of justice are often independent, and people often accept apparently unjust  
485 distributive outcomes if they accept as fair the procedures that produced those outcomes (Syme,  
486 Nancarrow, & McCreddin, 1999).

487 Relative deprivation (RD) is the sense of being unfairly deprived of something one feels  
488 entitled to, and can be made about individual or about group outcomes (Walker & Smith, 2002). The  
489 shape of behavioural responses to RD depends critically on whether it is an individual or a group  
490 outcome being judged: individual RD typically leads to individual-level behaviours; group RD leads to  
491 group-level behaviours. If we consider the case of the health of a whole ecosystem, and its

492 attendant ecosystem services, we can easily imagine how outcomes affecting people can be  
493 assessed individually (an individual farmer facing restrictions on the amount water that can be  
494 drawn from a basin, for example) or collectively (the impact of changes to water rights on a whole  
495 downstream community). Both cases may be judged to be unfair, but the consequences will likely be  
496 very different (the individual farmer may change farming practices, or may leave the land; a  
497 community may agitate collectively for political action).

498         We are not aware of research that specifically uses RD to examine human responses to  
499 changes in ecosystem services, but we can suggest that if deprived individuals feel entitled to  
500 something (e.g., an ecosystem service), they are more likely to feel resentful if their access is  
501 hindered or denied. We do not know whether people feel entitled to some services more than  
502 others, or who feels entitled to which service. Responses to deprivation depend on patterns of  
503 attribution for the current situation (Walker, Wong, & Kretzschmar, 2002) – feeling self-blame can  
504 reduce the sense of entitlement, so any investigation in this area must also ask the extent to which  
505 people feel responsible for the quality/decline of ecosystem services. A further factor influencing  
506 resentment is the ease with which people can imagine how better outcomes could have occurred  
507 (competing alternatives). There is also recent evidence (Walker, Leviston, Price, & Devine-Wright,  
508 2015) that, for Australians who perceived that the quality of the environment had declined, an  
509 accompanying sense of RD predicted support for collective environmental behaviours and for a  
510 range of national environmental policies. The link between RD and these outcomes was mediated by  
511 the strength of place attachment.

512         RD focuses on distributive justice. In terms of procedural justice, the perceived legitimacy of  
513 relevant authorities to regulate distributive processes is critical (Hough, Jackson, & Bradford, 2013).  
514 Legitimacy stems from assessments of the fairness of decision-making procedures used by  
515 authorities and institutions. Perceptions of procedural fairness build values that lead people to feel a  
516 long-lasting personal obligation to accept decisions and support rules. Fairness of outcomes has little  
517 direct influence over perceived legitimacy (Syme, Nancarrow, & McCreddin, 1999). Procedural  
518 fairness is important partly because of the link between procedural fairness and issues of social  
519 identity (Tajfel & Turner, 1986). Fair treatment communicates to a group's members that they are  
520 highly valued, respected, and included, in turn leading to increased feelings of self-worth and  
521 wellbeing.

522         Judgements about procedural fairness are also closely related to perceptions of trust, which  
523 are central to all models of Social Licence to Operate (SLO; Moffatt & Zhang, 2014). Important  
524 predictors of trust are the anticipated impact on social infrastructure, the quality and the quantity of

525 contact the community has had with the company, and a sense of procedural fairness in the way the  
526 company interacts with the community over the proposed venture.

527 Moffat and Zhang (2014) have researched SLO in the mining sector, finding trust to be the  
528 strongest determinant of SLO. Richert, Rogers, and Burton (2015) used the SLO concept in a way  
529 more directly relevant to the relationships between ecosystems, ecosystem services, wellbeing, and  
530 SLO. They found that most people in their survey of Western Australian residents supported the  
531 development of the oil and gas sector in the state, because of perceived economic benefit, but  
532 support and perceived social legitimacy are higher when the sector provides for marine biodiversity  
533 offsets as a means of protecting the environment.

534 While yet to be empirically established, it seems likely that perceptions of justice and  
535 injustice are related in frameworks such as Nexus Webs because of their centrality to a sense of  
536 security, including economic security, a sense of place, and through the 'good social relations'  
537 constituent of wellbeing.

#### 538 **4. TOWARD AN INTERDISCIPLINARY RESEARCH AGENDA**

539 Connecting ecosystems, ecosystem services, and human wellbeing through frameworks such  
540 as Nexus Webs promises to be of value for decision-making for, and governance of, ecosystems. It  
541 also affords an opportunity for inter- and cross-disciplinary cooperation to jointly produce a more  
542 comprehensive system of knowledge. In this review, we have identified several key areas where  
543 social and environmental psychology can contribute to understanding the interlinkages and  
544 interrelationships of social-ecological systems. We see four areas as being most important for future  
545 research, each with a set of empirical research questions (these are summarised in Table 1,  
546 alongside the social psychological concepts of relevance to the research questions listed).

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555 **Table 1. Summary of proposed research agenda investigating linkages between social-ecological systems.**

Research area	Research Questions	Social-Psychological Concepts
Identifying the primary dimensions of wellbeing in relation to ecosystems	<ul style="list-style-type: none"> <li>* Which dimensions of wellbeing are the most relevant to ecological systems?</li> <li>* What are the trade-offs and interdependencies between these dimensions?</li> <li>* Are wellbeing dimensions mediated and/or moderated by perceptions of the quality of biophysical environment?</li> </ul>	Environmental worldviews  Learned helplessness  Locus of control
Identifying the primary relationships between ecosystem services and wellbeing	<ul style="list-style-type: none"> <li>* How do direct experiences with different elements of the biophysical ecosystem influence wellbeing?</li> <li>* How do objective characteristics of ecosystem services relate to how they are perceived subjectively?</li> <li>* Are there 'tipping points' in ecological decline, beyond which wellbeing is affected in the long-term?</li> </ul>	Locus of control  Place attachment  Institutional trust  Social capital  Solastalgia
Unpacking people's 'mental models' of human-environment interactions	<ul style="list-style-type: none"> <li>* Do mental models systematically vary across different 'types' of stakeholders?</li> <li>* How are mental models informed by environmental worldviews?</li> <li>* How do mental models change in response to participatory stakeholder engagement (using Nexus Webs)?</li> </ul>	Environmental worldviews  Mental models  Institutional trust
Analysing the distribution of costs and benefits of ecosystem services within and across catchments	<ul style="list-style-type: none"> <li>* How does participatory stakeholder engagement (using Nexus Webs) influence social license to operate?</li> <li>* How does participatory stakeholder engagement (using Nexus Webs) influence perceptions of fairness and equity?</li> <li>* How does perceived fairness of the distribution of ecosystem services impact on decisions within and across catchments?</li> </ul>	Distributive and procedural justice  Relative deprivation  Environmental worldviews  Locus of control  Social license to operate  Institutional trust

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558 **4.1 Identify the important dimensions of human wellbeing in the context of ecosystems and**  
 559 **ecosystem services.**

560 Approaches to the conceptualisation and measurement of human wellbeing have yielded a  
 561 broad, and often disparate, set of wellbeing sub-dimensions. The abundance of wellbeing  
 562 dimensions in the extant literature represents both a challenge and an opportunity. On the one

563 hand, the abundance makes it more difficult to precisely define the outcomes of interest in  
564 ecosystem service provision. On the other hand, it allows for contextual specificity; that is, we are  
565 able to consider a comprehensive set of human impacts when determining those most relevant to  
566 the functioning of ecological systems.

567 Working from a paradigm that explicitly acknowledges the bidirectionality of social-  
568 ecological systems, we propose a renewed research effort focused on identifying the primary  
569 dimensions of wellbeing as they relate to ecosystem services. Embedded within this are several sub-  
570 topics: are primary dimensions of wellbeing the same across people and across biophysical domains?  
571 Are some dimensions more critical than others; that is, can some dimensions be foregone with little  
572 impact on overall levels of wellbeing? Are there trade-offs between these dimensions, or do they  
573 fluctuate independently of one another? Finally, what are the relationships between objective and  
574 subjective aspects of wellbeing within an ecosystem context, and are these mediated or moderated  
575 by (perceived and objective) aspects of the biophysical environment?

576 **4.2 Identify the primary relationships between ecosystem services and human wellbeing (bi-**  
577 **directional as well as unidirectional).**

578 The second area of research concerns the deliberative and systematic investigation of  
579 bidirectionality between ecosystem services and human wellbeing. Most, if not all, of the research  
580 outlined in this paper has not explicitly set out to identify bidirectionality; rather these causal  
581 possibilities have been inferred or established post-hoc. Disentangling causality more formerly  
582 requires suitable research design, including longitudinal investigations and experimental  
583 intervention studies.

584 Working within such designs, critical questions include the following: How does experience  
585 of the biophysical ecosystem (e.g., droughts, floods, bushfires) influence levels of wellbeing, and are  
586 these effects different for different dimensions of wellbeing? How do objective characteristics of  
587 ecosystem services relate to subjective characteristics, and are these relationships direct, or  
588 mediated by elements such as social capital and community service provision? Are the relationships  
589 between ecosystem services and wellbeing direct and linear, or are there optimal ranges? What  
590 roles do aspects of personal sense of control and place attachment play in moderating relationships  
591 between wellbeing and ecosystem services? And finally, what are the 'threshold points' beyond  
592 which ecosystem service decline has a significant, meaningful, lasting impact on dimensions of  
593 wellbeing, and vice-versa?

594 **4.3 Articulate ‘mental models’ of how people understand the relationships between ecosystems,**  
595 **ecosystem services, and human wellbeing.**

596 People’s perceptions of the world, including human-environment interactions, we argue,  
597 should be *as* fundamental a consideration in natural resource management as ‘objective’  
598 relationships between social and biophysical systems. This is especially so in contested resource-use  
599 arenas, where stakeholders bring with them their own set of values, beliefs, worldviews, and  
600 knowledge systems, each of which shape negotiations. The biases and distortions inherent in  
601 people’s ‘mental models’ of human-environment interactions will influence receptivity to ‘objective’  
602 ecological models in several ways. For instance, people may discount the probability or relevance of  
603 distant events, may consider other modelling outputs as irrelevant to their everyday lives, or may be  
604 skewed by deeply held ideological beliefs (Boschetti, Walker, & Price, 2016). They may also be  
605 distorted by misperceptions regarding other people’s environmental preferences and beliefs. For  
606 instance, people tend to assume that others think as they do, and this cognitive bias can constrain  
607 shifts in thinking (Leviston, Walker, & Morwinski, 2013).

608 Investigating people’s mental models (simplified mental representations of physical reality  
609 and how systems work) of the interactions between ecosystems and human wellbeing is, we think,  
610 an important and fruitful avenue of future research, encompassing such questions as the following:  
611 Do people’s mental models of the dynamics of human-environment interactions vary fundamentally  
612 across the general public, decision-makers, stakeholders, and scientists? Can we use these mental  
613 models to identify patterns or clusters of people or of models? What are the major points of  
614 difference between different mental models and scientific models? How malleable and subject to  
615 social influence are these mental models? How do different mental models relate to different  
616 worldviews about human-nature interactions, and to narratives and beliefs about environmental  
617 decline and recovery, and about social change? How are these mental models related to judgements  
618 about procedural and distributive justice?

619 Finally, when stakeholders participate in an intervention based on approaches such as the  
620 Nexus Webs framework, how do their mental models of the ecosystem, ecosystem services, and  
621 wellbeing change? Can such frameworks be used to overcome competing or conflicting mental  
622 models of ecosystems and their management?

623 **4.4 Analysis of the distribution of costs and benefits of services across and within ecosystem**  
624 **catchments.**

625 Our final area of future research concerns spatial and distributive considerations. Although  
626 frameworks such as Nexus Webs rely on comparisons (between scenarios, sectors, regions,  
627 catchments, or groups of beneficiaries), more work is needed to examine the social and political  
628 consequences of the costs and benefits of ecosystem services accruing differently both between and  
629 within different catchments. Such differentials have implications for social license to operate,  
630 acceptance of decisions influencing the distribution of services, trust in systems and authorities, and  
631 fostering or dampening a sense of grievance, resentment, or deprivation.

632 It is plausible, for instance, that proposals for operations with equivalent impacts on  
633 ecosystems could enjoy vastly different levels of community support. Firstly, relevant ideologies,  
634 including values about nature and conservation, and even the acceptability of development in areas  
635 of high ecosystem value, are not evenly distributed over space (Butz & Eyles, 1997; Hemson,  
636 Maclennan, Mills, Johnson, & Macdonald, 2009; Raymond & Brown, 2007). Rather, we see  
637 geographical places as spaces where values tend to 'cluster', as people coalesce in space with like-  
638 minded people, and are influenced by the people and environment around them – we can think of  
639 these clusters as 'ideological catchments'.

640 Further, structural elements of communities might influence the management and quality of  
641 ecosystem services. For instance, if communities are better resourced, better connected, and are  
642 higher in other levels of social and political capital, enterprises with reasonable, or even positive,  
643 ecological outcomes might face vocal opposition, while a less ecologically desirable but similar  
644 proposition might face little community resistance in areas with few social resources. These  
645 structural elements might also have important linkages with the notion of adaptive preferences,  
646 whereby people tend to adjust to, and form preferences for, the unfavourable circumstances they  
647 find themselves in. If this extends to ecological preferences, whereby people come to prefer  
648 degrading environments, it has important implications for the assessment of wellbeing in connection  
649 to ecological outcomes. Within this research area, particular questions might include the following:  
650 Can social licence to operate be conceptualised as an outcome of applying a framework similar to  
651 Nexus Webs to contested ecosystem management? Who gains the licence, and to do what? How  
652 does perceived benefit (and cost) to self, family, neighbourhood, and region influence judgements of  
653 trust and legitimacy? How are objective and subjective costs and benefits distributed within and  
654 between communities? Are these distributions, and the processes that produced them, seen as fair?  
655 How are current distribution patterns of costs and benefits seen to project into the future? Do  
656 people anticipate their livelihoods improving or worsening, and with what consequence? And finally,  
657 what influence do the attitudes and future projections of 'influential outsiders' (such as city-dwelling  
658 populations remote to a particular catchment) impart on decisions within ecosystem catchments?

659 **4.5 Conclusions**

660 We envisage that the pursuit of such a research agenda will result in more powerful and  
661 nuanced predictive models of the factors influencing both wellbeing and the acceptability of  
662 decisions related to the provision of ecosystem services. Further, a systematised approach to the  
663 interrelations between human wellbeing and ecosystem services would yield an inventory of critical  
664 determinants of the acceptability of resource-use proposals. Such an inventory, based on  
665 distributive and procedural fairness principles, objective and perceived ecological and social costs  
666 and benefits, and socio-cultural characteristics of catchment communities, would better enable  
667 decisions that result in the optimised functioning of both social and ecological systems. These  
668 understandings could also be used to iteratively update and refine the Nexus Webs framework. This  
669 would arm resource use planners with a decision support tool that more accurately reflects the  
670 trade-offs to be considered between different components of the web during stakeholder decision-  
671 making.

672 More broadly, the proposed research agenda would progress our current understanding and  
673 measurement of ecological indicators. By systematically measuring and identifying how, when, and  
674 why variations in human conditions influence ecological health over both time and space, we can  
675 develop indicators and models that more fully account for, and anticipate the impact of, the  
676 reciprocal nature of human-environment interactions.

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