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

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ABSTRACT:

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

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

Word count: 12258

1. INTRODUCTION

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

1.1 Existing frameworks

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

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

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

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

1.2 The Nexus Webs framework

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

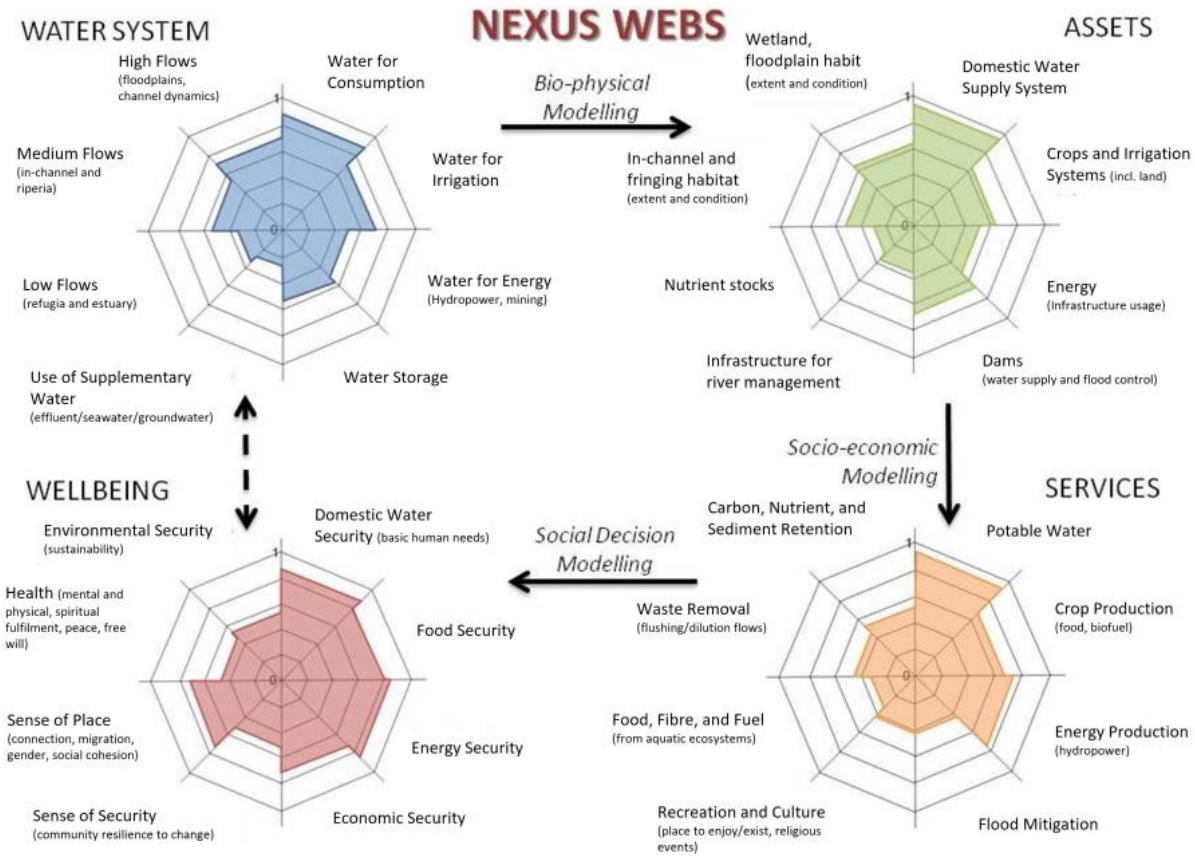

Figure 1. The Nexus Webs framework (modified from Overton et al., 2013, p. 10).

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

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

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

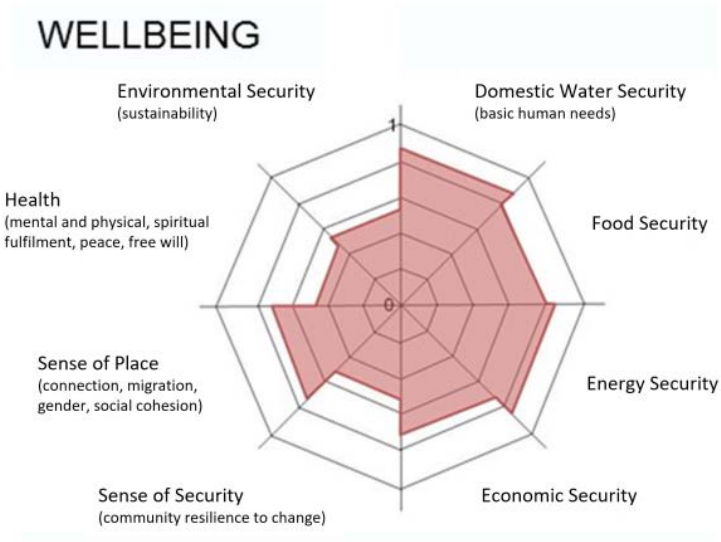

Figure 2. The Wellbeing Nexus Web (modified from Overton et al., 2013, p.15).

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

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

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

2. HUMAN WELLBEING

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

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

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

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

2.1 What influences wellbeing?

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

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

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

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

2.2 Approaches to measuring wellbeing

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

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

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

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

3. CONNECTIONS BETWEEN ECOSYSTEM SERVICES AND WELLBEING: A SOCIAL AND ENVIRONMENTAL PSYCHOLOGY PERSPECTIVE

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

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

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

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

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

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

3.2 Ecosystem health and human health: A reciprocal relationship

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

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

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

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

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

3.3 Solastalgia

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

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

3.4 Locus of Control

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

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

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

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

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

3.5 Sense of Place and Place Attachment

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

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

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

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

3.6 Environmental Worldviews

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

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

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

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

3.7 Sense of Justice and Relative Deprivation

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

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

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

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

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

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

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

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

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

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

4. TOWARD AN INTERDISCIPLINARY RESEARCH AGENDA

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

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	* Which dimensions of wellbeing are the most relevant to ecological systems? * What are the trade-offs and interdependencies between these dimensions? * Are wellbeing dimensions mediated and/or moderated by perceptions of the quality of biophysical environment?	Environmental worldviews Learned helplessness Locus of control
Identifying the primary relationships between ecosystem services and wellbeing	* How do direct experiences with different elements of the biophysical ecosystem influence wellbeing? * How do objective characteristics of ecosystem services relate to how they are perceived subjectively? * Are there 'tipping points' in ecological decline, beyond which wellbeing is affected in the long-term?	Locus of control Place attachment Institutional trust Social capital Solastalgia
Unpacking people's 'mental models' of human-environment interactions	* Do mental models systematically vary across different 'types' of stakeholders? * How are mental models informed by environmental worldviews? * How do mental models change in response to participatory stakeholder engagement (using Nexus Webs)?	Environmental worldviews Mental models Institutional trust
Analysing the distribution of costs and benefits of ecosystem services within and across catchments	* How does participatory stakeholder engagement (using Nexus Webs) influence social license to operate? * How does participatory stakeholder engagement (using Nexus Webs) influence perceptions of fairness and equity? * How does perceived fairness of the distribution of ecosystem services impact on decisions within and across catchments?	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

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

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

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

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

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

4.3 Articulate 'mental models' of how people understand the relationships between ecosystems, ecosystem services, and human wellbeing.

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

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

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

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

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

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

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

4.5 Conclusions

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

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

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689 **6. REFERENCES**

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