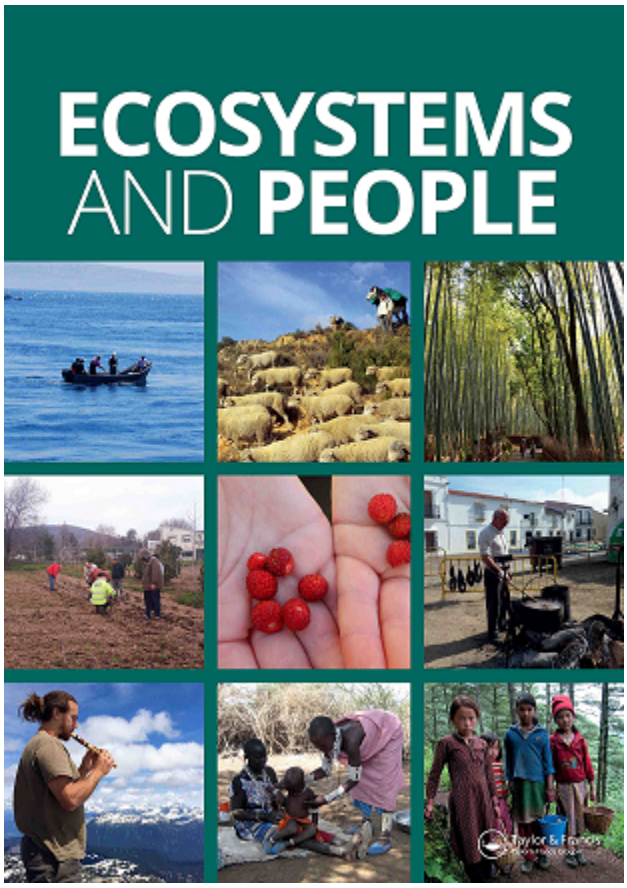

Using Indigenous mental models to conceptualise and report on ecosystems services and benefits

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Using Indigenous mental models to conceptualise and report on ecosystems services and benefits

Abstract:

We explore relations between Indigenous and the Western conceptualisation of flows of services from nature to people, and specifically, flow of ecosystem services as per SEEA-EA accounting framework. This case study was a partnership with the Nywaigi Traditional Owners from North Queensland Australia and was conducted as a series of workshops with the Nywaigi representatives. We present Nywaigi conceptualisation of the ecosystem services (and dis-services) linked to Mungalla Station on their Country. Starting from the Western point of view, we introduce "crosswalk" from SEEA-EA ecosystem services to Nywaigi conceptualisation; and starting from Nywaigi perspective, "mental map" that links Nywaigi wellbeing to SEEA-EA framework. Our findings indicate that some of the concepts are very similar between First Nation and SEEA-EA, and confirm importance to Nywaigi Traditional Owners of circular and interconnected conceptualisation of the nature-people system and of longer conceptualisation of time. Suggestions on further modifications to conceptualisations of nature-people-nature system are presented, and the temporal scale of expected changes is discussed. Specifically, we discuss concepts of flows of services from nature to nature; category of dis-services – explicit recognition that ecosystem flows can be beneficial but also detrimental for human wellbeing, both physical and mental/spiritual; and important role of outside influences (capitals other than natural capital) in determining the actual use of what ecosystem services might be supplying. Our findings support current 'relational turn' discussions in sustainability science, presenting empirical evidence of alternative conceptualisations that emphasise continually unfolding processes and relations.

Keywords:

Ecosystem services and dis-services; First Nations; Indigenous; SEEA EA; Traditional Owners; wetland restoration.

1 Introduction

In this paper we build on the previous work that explores relations between Indigenous people (First Nations; Traditional Owners) and the Western conceptualisation of flows of services from nature to people. Several structured approaches to evaluation and valuation of ecosystem services have been developed and applied (e.g. Millennium Ecosystem Assessment (MEA, 2005), Common International Classification of Ecosystem Services - CICES (Potschin & Haines-Young, 2018) and Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services - IPBES (Díaz et al., 2015), United Nations, 2021), helping decision-makers recognise the diverse forms of benefits provided by ecosystems to humans. Recent developments are increasingly recognising that flows are not only one way (from nature to people), but that reciprocal flows from people to nature, are equally important (Díaz et al., 2015; Cooper et al., 2016; Raymond et al., 2017; Pascual et al., 2017; Delevaux et al., 2018; Díaz et al., 2018; Morishige et al., 2018; Stoeckl et al 2021). There is also an acknowledgment that many ecosystem services are co-produced, with the resulting benefits being a result of combined natural and other (human, built) capitals (Jones et al., 2016; Costanza et al., 2017; Raymond et al., 2017).

The System of Environmental-Economic Accounting - Ecosystem Accounting (SEEA-EA), designed by the United Nations Department of Economic and Social Affairs (UN et al., 2021) (and officially published following endorsement by UN in 2024), is one such Western system

increasingly being used as a policy instrument (Farell et al., 2021; Edens et al., 2022; Lange et al., 2022; Chairat and Gheewala 2024; King et al., 2024). It comprises of a set of three main types of the environmental accounts, namely, the extent, condition and ecosystem services (ES) flow accounts. ES flow accounts record the contributions of ecosystems to society – monitoring their supply and use in economic and other human activity, by households, enterprises and government (UN et al., 2021). Conceptualisation and organisation of the ES in the SEEA-EA builds on the previous work (MEA, 2005; Díaz et al., 2015; Potschin & Haines-Young, 2018) and is similarly structured into three broad categories of services: provisioning; regulating and maintenance; and cultural.

With wider use of the SEEA-EA accounts, there is also emerging literature on use of the accounts to record the contributions of nature to Indigenous peoples (Beamer et al., 2021; Normyle et al., 2021; Normyle et al., 2022; Finau et al., 2023; Woodward et al., 2023; Normyle et al., 2024). Importantly, SEEA-EA as a system does not specifically preclude inclusion of the Indigenous values: it does not, however, provide guidance to their inclusion either (Larson et al., in review). Emerging studies however do provide guidance on inclusion of Indigenous values into Western systems. For example, Stoeckl et al. (2021) discuss the critical importance of longer timelines, interconnections between and within the human and natural systems, reciprocal values (looking after Country), and the need for direct physical connections with the Country that strengthens spiritual connections.

Building on the previous work on inclusion of the Indigenous perspectives into Western approaches to measuring and valuing ES, we present a case study co-designed between one of the Australian First Nations, Nywaigi Traditional Owners, and Western scientists, exploring how the Nywaigi concept of the ES of importance to Nywaigi Traditional Owners fits – and does not fit - with the ES concepts and the SEEA-EA flow accounts. This project sought to follow best practice guidelines for designing and populating ecosystem accounts in

partnership with the Nywaigi (Nursey-Bray et al., 2023; Woodward et al., 2023). We also sought to avoid the noted issue whereby much literature focuses on accounting 'for' Indigenous people, rather than accounting 'by' Indigenous peoples (Buhr, 2011). Experimental methodology used to populate SEEA-EA flow accounts and the resulting accounts, as well as details of the co-design approach and guiding principles when working with the Indigenous peoples, are described in Jarvis et al. (2025).

In this paper we present Nywaigi Traditional Owners' conceptualisation of the ecosystem services (and dis-services) linked to Mungalla Station on their Country. We introduce the "cross-walk" from Western concept of SEEA-EA ES to Nywaigi conceptualisation; and the Nywaigi "mental map" that links Nywaigi wellbeing to SEEA-EA framework. Nywaigi suggestions on further modifications to conceptualisations of nature-people-nature system are presented, and the temporal scale of expected changes is discussed.

2 Methods

2.1 Nywaigi Traditional Owners and the Mungalla Homestead

Nywaigi people have occupied their Country in North Queensland for over 45,000 years. The location of their lands in tropical coastal area meant plentiful supplies of wildlife, fruits, berries and seafood. However, with the colonisation in 19th century, Nywaigi lands became the property of European settlers and from the 1860s onwards, Nywaigi had been forcibly removed from their traditional ancestral lands as the sugar cane and cattle industries encroached (MAT, 2018).

In April 2018, the Australian Federal Court formally recognised the Nywaigi People's native title rights and interests over almost 40,000 hectares of land and waters, including both exclusive (over about 8600 hectares) and non-exclusive (over about 30,000 hectares) native

title rights. The non-exclusive native title rights include rights to be present on the land, to hunt, fish and gather, to hold meetings and conduct ceremonies, and to maintain places of importance and areas of significance. Exclusive rights include Mungalla Station, a cattle property near Ingham, founded in 1882 on the lands of the Nywaigi people. Some hundred years later, in 1999, the property was purchased by the Indigenous Land Corporation, and the ownership of the 880 hectares that makes up the property today, was returned to the Nywaigi people (MAT, 2018). This project was linked to the planned restoration of the wetland located at Mungalla Station on Nywaigi Country.

2.2 Exploring Nywaigi concepts of ecosystem services flows and resulting benefits

At the start of this project, researchers presented to Nywaigi partners the key concepts and components of ecosystem services (ES), SEEA-EA, and flow accounts. Whilst Nywaigi understood the logic underpinning these approaches, concern was expressed at the linearity of the approach, focusing on the flows from Country to people. Similar to many other Indigenous groups, the Nywaigi worldview can be encapsulated in the phrase 'you care for Country and Country cares for you'. It was felt that the ES approaches and the SEEA-EA framework only capture the second half of this relationship, failing to fully recognise the cultural connections between Nywaigi people and Country underpinned by their role as traditional custodians of their traditional lands.

Concern Nywaigi expressed at the linearity of the SEEA EA approach, focusing only on the flows from Country to people, is similar to concerns reported in previous work with the Indigenous groups (Jarvis et al., 2022; Normyle et al., 2022; Larson et al., 2023; Normyle et al., 2024). Thus, researchers proposed a conceptual model that seeks to capture the interconnected and non-separable worldview held by many Indigenous peoples, based on the circular model reported in Stoeckl et al (2021) and aligned with SEEA-EA (Larson et al., in review). Conceptualisation of "Healthy Country" is well aligned with the SEEA-EA notion of

stock accounts, whilst flow accounts would then depict key flows (supply and use) between people and Country. Some flows may reflect ecosystem services supply and use (flow of services from Country to people), others may reflect stewardship (flow of services from people to Country). Both types of flows, ecosystem services and the stewardship have an impact on the condition, health and wellbeing of people (Stoeckl et al., 2021; Larson et al, in review). Such a circular conceptualisation of connections between people and the nature was deemed by Nywaigi as appropriate.

In discussions with the Nywaigi Project Reference Group (PRG), it was agreed to first capture perspectives on flows of services and perceived benefits to Nywaigi Traditional Owners from Country, through a development of a "mental map of Nywaigi wellbeing". Through a meeting and series of on-line and in-person interactions, Nywaigi then "translated" the benefits recorded in the mental map into a set of 17 statements, describing flows of ecosystem services and benefit between Nywaigi Traditional Owners and their Country. In addition, over three workshops with a total of eight women and nine men representing Nywaigi elders, mature people and youth, project identified 14 ecosystem service and 4 dis-service flows relating to culturally important species of plants, birds, fish and aquatic species, and land animals; providing provisioning and cultural services to Nywaigi.

An on-Country and online workshop was then organised to discuss how to arrange this data into SEEA-EA compliant way (reported in Jarvis et al., 2025); but also in a way meaningful to Nywaigi, as reported in this paper. Discussion on Nywaigi conceptualisation of linkages between the Country and wellbeing included likely timeframes for the occurrence of the 35 ecosystem services, dis-services and benefits previously noted by Nywaigi. All findings, summaries, visuals and text were reported to the Nywaigi community, and in person and online workshops were conducted to check, modify and finalise them; before they went for approval by the PRG to share them with the scientific community, funding agency and wider.

3 Nywaigi conceptualisation and organisation of ecosystem services and benefits

3.1. Linking SEEA-EA Ecosystem Services concepts to Nywaigi concepts

A "crosswalk" table, providing linkages between services and dis-services identified during our study and the SEEA-EA classification of the ES (UN et al., 2021), was co-developed with the Nywaigi Traditional Owners and is presented in Table 1. At the left-hand side, table starts with the prescribed SEEA-EA ES categories, and SEEA-EA code and description is provided for each ES category identified as relevant in this study. Ecosystem services flows identified by Nywaigi are provided at the right-hand side of the Table 1, for relevant prescribed SEEA-EA ES categories.

It can be observed in Table 1 that some of the prescribed SEEA-EA ES categories are omitted (as they are of no cultural relevance to Nywaigi); others correspond to one Nywaigi equivalent service; while others contain more than one service to Nywaigi. For example, regulating service 2.2 - Rainfall pattern regulation service, is not included as it was not reported by Nywaigi participants. Soil quality regulation service - 2.5, is included in the table, as it provides the services of providing quality soil that is required to meet the Nywaigi reported benefit of having "Healthy soils for natural medicine, plants and wildlife". On the other hand, Biomass provision service – 1.7, Wild animals plants and other biomass, contains six services, all of them identified by Nywaigi as relevant and belonging to this category. What can also be observed in the table is that cultural services are the most numerous, corresponding to 14 out of the total of 30 species and service flows identified in this study. Benefits from country to Nywaigi people, recorded in the "mental map of Nywaigi

175 wellbeing" were not included within this crosswalk as they encapsule different types of
176 concepts to ES.

177

178 Table 1 Crosswalk from Nywaigi conceptualisation of ecosystem services, dis-services and
179 stewardship services to SEEA-EA ecosystem services classifications (* Final ecosystem
180 service, ** Intermediate ecosystem service, *** Final ecosystem disservice, **** Final
181 stewardship service)

SEEA EA categories	SEEA EA code and description	Flows of services identified by Nywaigi
Provisioning services		
Biomass provisioning services	1.6: Wild fish and other natural aquatic biomass provisioning services are the ecosystem contributions to the growth of fish and other aquatic biomass that are captured in uncultivated production contexts by economic units for various uses, primarily food production. This is a final ecosystem service.	Food - Wild fish and other aquatic animals*
	1.7: Wild animals, plants and other biomass provisioning services are the ecosystem contributions to the growth of wild animals, plants and other biomass that are captured and harvested in uncultivated production contexts by economic units for various uses. The scope includes non-wood forest products (NWFP) and services related to hunting, trapping and bio-prospecting activities; but excludes wild fish and other natural aquatic biomass (included in previous class). This is a final ecosystem service	Food - Wild land animals* Food - Wild birds* Food - Wild plants* Materials - Wild land animals* Materials - Wild plants* Natural medicine - Wild plants*
Regulating and maintenance services		
Global climate regulation services	2.1: Global climate regulation services are the ecosystem contributions to the regulation of the chemical composition of the atmosphere and oceans that affect global climate through the accumulation and retention of carbon and other GHG (e.g., methane) in ecosystems and the ability of ecosystems to remove (sequester) carbon from the atmosphere. This is a final ecosystem service.	Carbon management - Carbon sequestration, Carbon storage, Carbon sink*
Soil quality regulation services	2.5: Soil quality regulation services are the ecosystem contributions to the decomposition of organic and inorganic materials and to the fertility and characteristics of soils, e.g., for input to biomass production. This is most commonly recorded as an intermediate service.	Soil quality regulation**
Nursery population and habitat maintenance services	2.20: Nursery population and habitat maintenance services are the ecosystem contributions necessary for sustaining populations of species that economic units ultimately use or enjoy either through the maintenance of habitats (e.g., for nurseries or migration) or the protection of natural gene pools. This service is an intermediate service and may input to a number of different final ecosystem services including biomass provision and recreation-related services.	Nursery population - Small/bait fish providing food for larger fish** Habitat maintenance - Space for wildlife**
Cultural services		
Recreation-related services	3.1: Recreation-related services are the ecosystem contributions, in particular through the biophysical characteristics and qualities of ecosystems, that enable people to use and enjoy the environment through direct, in-situ, physical and experiential interactions with the environment. This includes services to both locals and non-locals (i.e. visitors, including tourists). Recreation-related services may also be supplied to those undertaking recreational fishing and hunting. This is a final ecosystem service.	Recreational fishing by non-Nywaigi recreational fishers - Wild fish and other aquatic animals* Recreation related visual amenity - Visitors seeing rare/endangered species - Wild land animals* Recreation related visual amenity - Visitors seeing rare/endangered species - Wild birds*
Visual amenity services	3.2: Visual amenity services are the ecosystem contributions to local living conditions, in particular through the biophysical characteristics and qualities of ecosystems that provide sensory benefits, especially visual. This service combines with other ecosystem services, including recreation-related services and noise attenuation services to underpin amenity values. This is a final ecosystem service.	Visual amenity - A welcome sight/good to see culturally important species - Wild fish and other aquatic animals, Wild birds, Wild land animals, Wild plants*
Education, scientific and	3.3: Education, scientific and research services are the ecosystem contributions, in particular through the biophysical characteristics and	Education - Knowledge sharing and skills from Elders to Nywaigi youth on Country*

SEEA EA categories	SEEA EA code and description	Flows of services identified by Nywaigi
research services	qualities of ecosystems, that enable people to use the environment through intellectual interactions with the environment. This is a final ecosystem service.	Education - Right people (Nywaigi) to be trained on Country* Education - Advising non-Nywaigi people on traditional protocols and how to behave on Country*
Spiritual, artistic and symbolic services	3.4: Spiritual artistic and symbolic services are the ecosystem contributions, in particular through the biophysical characteristics and qualities of ecosystems, that are recognised by people for their cultural, historical, aesthetic, sacred or religious significance. These services may underpin people's cultural identity and may inspire people to express themselves through various artistic media. This is a final ecosystem service.	Spiritual, and symbolic - Pride belonging and practicing culture on Country* Spiritual, and symbolic - Nywaigi understanding Nywaigi cultural system and protocols* Spiritual, and symbolic - Young Nywaigi people on Country, and engaged, avoiding social ills* Spiritual and symbolic aspects (feelings) of healthy people eating healthy food from Country (avoiding social ills)*
Other cultural services	3.5	Spiritual and symbolic aspects (feelings) of making traditional items (spears, baskets, shields, stone tools) from materials on Country* Seasonal indicators /other cultural services uses - Wild birds, Wild plants*
Flows of non-use services		
Ecosystem and species appreciation services	4.1: Ecosystem and species appreciation concerns the wellbeing that people derive from the existence and preservation of the environment for current and future generations, irrespective of any direct or indirect use.	Ecosystem and species appreciation services - Feeling connection to Country & Nywaigi people*
Additional category from Nywaigi and other research with First Nations groups		
Stewardship services	Stewardship services are the set of practices that involve sustainably managing the natural resources and harvests of lands, territories, waters, and coastal seas. Stewardship services relate specifically to upholding these caring responsibilities for future generations. This is a final ecosystem service.	Maintaining healthy Country by monitoring and caring for Country****
Additional category from Nywaigi		**Ecosystem dis-services identified by Nywaigi**
Ecosystem dis-services provided by unwanted species	Ecosystem dis-services are the ecosystem contributions that are negatively impacting on wellbeing of local people. This includes impacts of weeds, ferals and pests within the ecosystem. This is a final ecosystem (dis)service.	Spiritual dis-services - feelings of sadness and frustration that Country is unhealthy - Wild birds considered to be pests*** Spiritual dis-services - feelings of sadness and frustration that Country is unhealthy - Wild invasive and pest fish and other aquatic animals*** Spiritual dis-services - feelings of sadness and frustration that Country is unhealthy - Wild feral land animals*** Spiritual dis-services - feelings of sadness and frustration that Country is unhealthy - Wild invasive plants***

In addition, some ES flows identified by Nywaigi as important to them, did not fit in any of the SEEA-EA ES categories prescribed, yet similar types of services have been previously reported by other First Nation groups (Carnell et al., 2023; Nursey-Bray et al., 2023; Normyle et al., 2024). We have thus added another category of services to our table, Stewardship services, a set of practices that involve sustainable management of the Country, and relate specifically to upholding caring responsibilities for future generations (Table 1).

We have also added a new category of Ecosystem dis-services to include species providing dis-services to Nywaigi by negatively impacting their wellbeing. This category includes

191 invasive and pest species of animals and plants Nywaigi would prefer not to have on their
192 Country (Table 1). It is important to note that dis-services to Nywaigi caused by the pests and
193 weeds go beyond conceptualisation of "threats" in Pressures/threats accounts of SEEA-EA.
194 For example, category 'invasive pest - fish' refers to the presence of tilapia in the waters at
195 Mungalla. Tilapia compete with native fish for food and habitat, and also disturb sediment
196 and plant life, impacting on water quality. Thus, tilapia does present a threat to biodiversity
197 and to provisioning and cultural ecosystem services, by the impacts it has on native fish and
198 aquatic plants. Accordingly, the impact of tilapia should be reflected in the biodiversity and
199 condition accounts. However, beyond this threat to the ecosystem, presence of tilapia is also
200 directly providing a spiritual dis-service to the Nywaigi Traditional Owners: it breaks
201 people's hearts to see their Country unhealthy. The awareness by Nywaigi Traditional
202 Owners that Mungalla is not maintained in the condition required by their roles as traditional
203 custodians creates feelings that Nywaigi are not appropriately fulfilling their cultural
204 responsibility for Caring for Country, to ancestors and to future Nywaigi. Thus, the dis-
205 services capture the feelings of sadness and frustration that Country is unhealthy, and are
206 captured as cultural dis-services within the accounts and within the crosswalk table.

207 *3.2. Linking Nywaigi Traditional Owners' concepts to SEEA-EA Ecosystem Services concepts*
208 As a way that closer reflects their conceptualisation, Nywaigi study participants have also
209 explored organisation of concepts recorded (services flows and benefits) using circular
210 representation of links between nature and people.

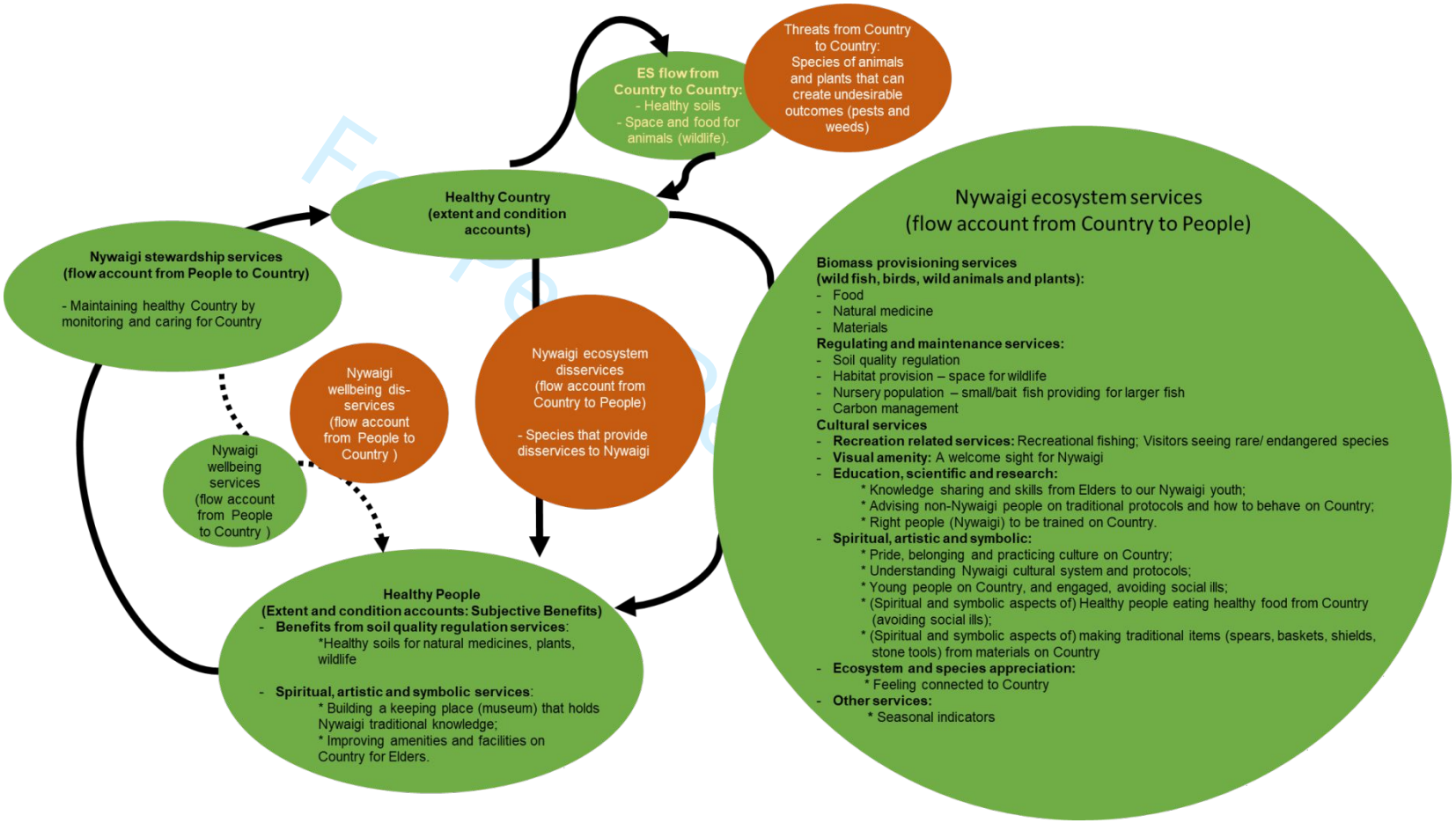
211 ES of importance to Nywaigi people are perceived as flows from Country to People (Figure 1
212 panel A, Nywaigi Ecosystem Services). These include biomass provisioning services (such as
213 wild fish, birds, wild animals and plants for food, natural medicine and the materials);
214 Regulating and maintenance services (such as soil quality regulation, habitat provision,
215 nursery populations and carbon management); and a range of Cultural services (recreation

related services, visual amenity, education scientific and research, spiritual artistic and symbolic, ecosystem and species appreciation, and other services).

This flow of ES creates a range of benefits to Nywaigi Traditional Owners (Figure 1 Panel A, Healthy People). These benefits include benefits from soil quality regulation services that result in healthy soils for natural medicines, plants and wildlife; but also Spiritual, artistic and symbolic services such as building a keeping place (museum) that holds Nywaigi traditional knowledge; and improving amenities and facilities on Country for Elders. These benefits are linked to wetland restauration activities through both financial benefits (improve income flow from tourism activities i.e. visitors to the wetlands) and through human and social benefits (improved capacity of Nywaigi Traditional Owners to undertake such projects). On the left hand side of the figure, there are Nywaigi stewardship services – flow of benefits from People to Country. Maintaining healthy Country by monitoring and caring for Country will result in a direct wellbeing benefit to Nywaigi (dotted back-flow in Figure 1, Panel A), as well as (ecological) benefit to the Country.

Flows of benefits from People to Country are expected to lead to a creation of a "positive spiral" (Figure 1 Panel B), where the extent and condition of the Country will improve due to Nywaigi caring, and will as a result create more and better services to Nywaigi in the future. This is the key to Nywaigi conceptualisation, that future timelines and benefits are of equal and greater importance to the people than the present, with the main consideration of how the current flow of services can continue growing into post-wetland restoration time. Thus, the benefits of importance to Nywaigi do not occur at the same time: some happen closer to now (Figure 1 Panel A), the other additional benefits are created only later in time (Figure 1 Panel B, Healthy People).

(A) Now to near future



(B) Near future into the future

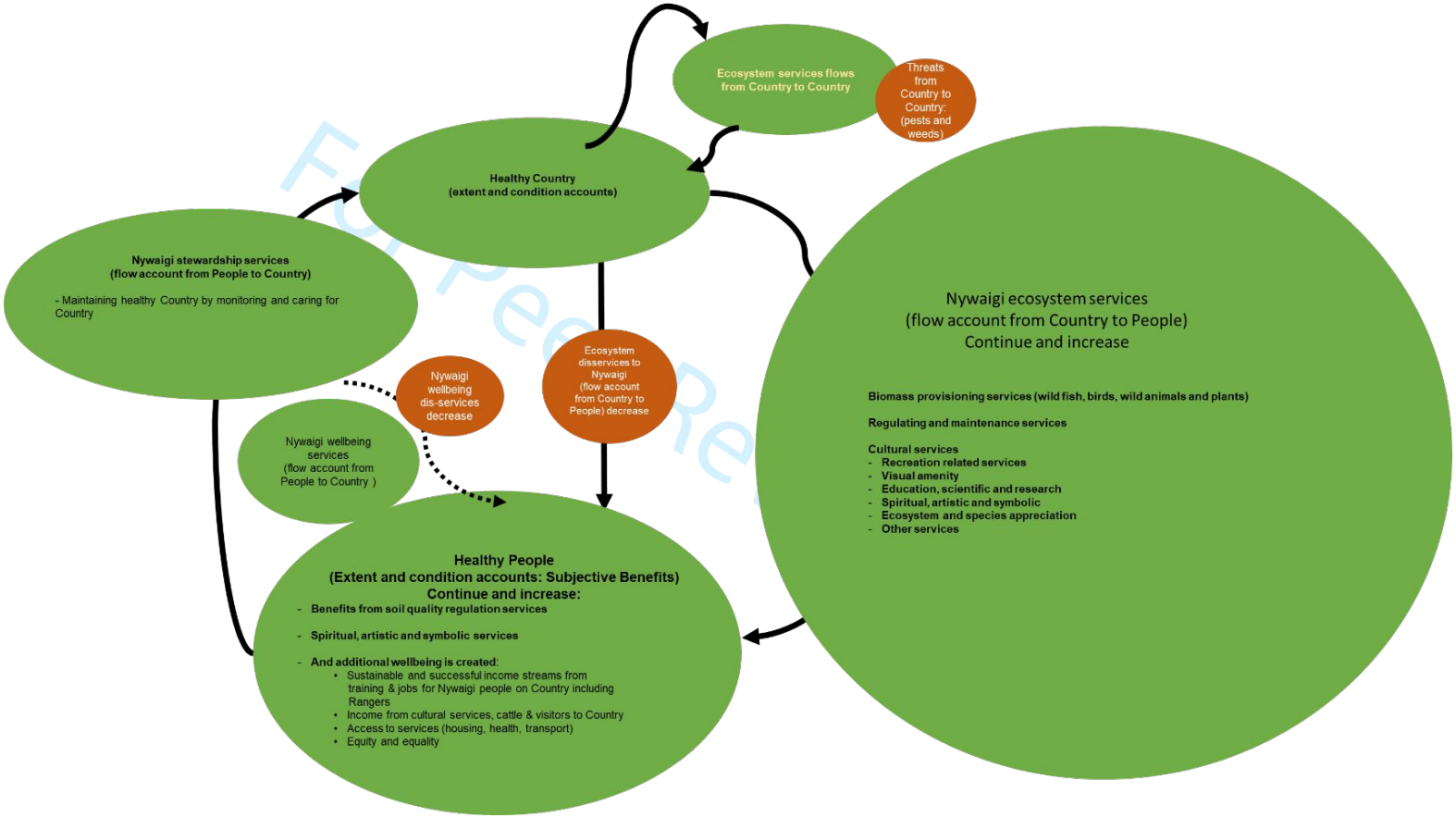


Figure 1. Full details of the text from 17 wellbeing statements and the culturally important species, incorporated into the Nywaigi Traditional Owners' benefits positive spiral, A) Now to near future; and B) Near future into the future. Circles for 'good things' shown in green, the threats and dis-services from invasive species and weeds shown in red. Note that green circles get bigger and red circles smaller in B compared to A showing anticipated benefits of wetland restoration

239 Figure 1 (Panels A and B) also incorporates two new concepts created by Nywaigi, that are
240 additional to previous circular conceptualisations (Stoeckl at el., 2018, 2021, Larson et al in
241 press). The first additional concept is what Nywaigi refer to as "Ecosystem services flows
242 from Country to Country" (Figure 1, Panels A and B, yellow text), and examples of such
243 benefits include healthy soils and space and food for animals (wildlife). Conceptually, these
244 flows very much resemble concepts of supporting and regulating services.

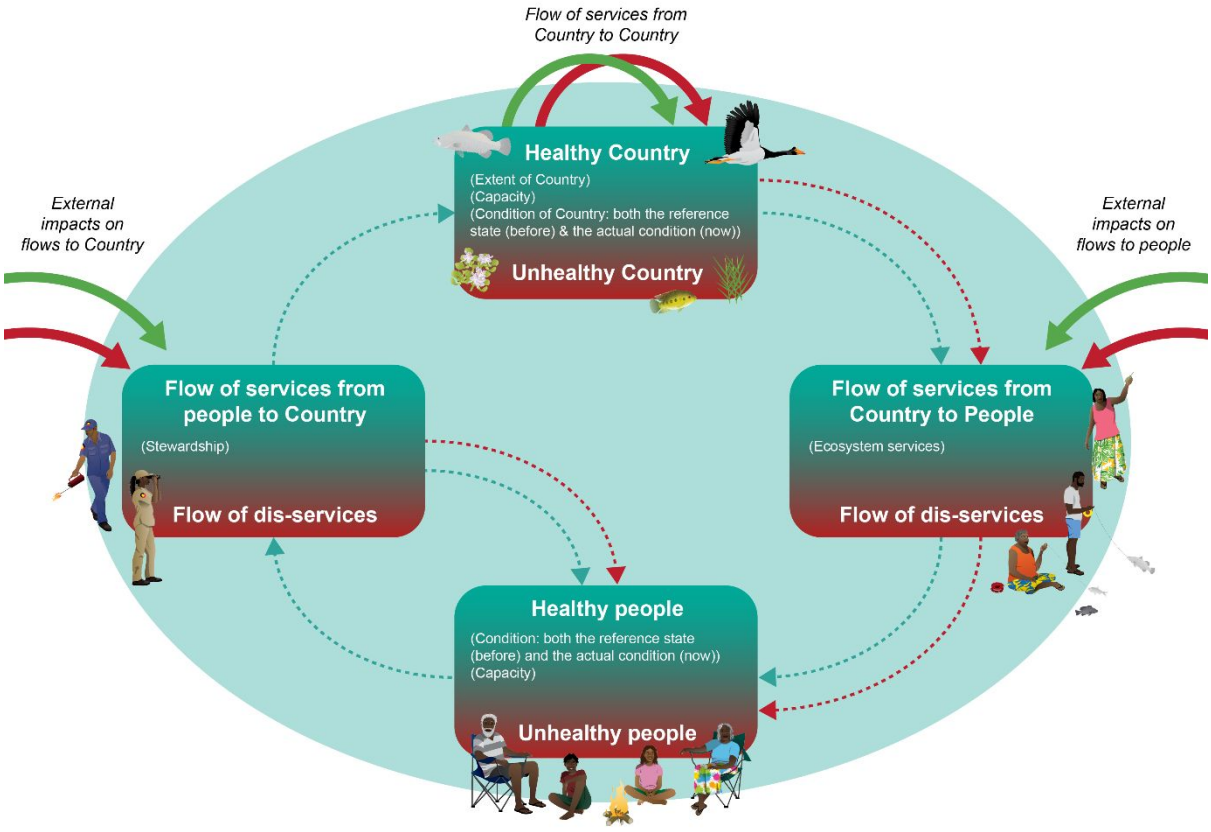
245 The other additional concept, introduced in the previous section, relates to the idea of dis-
246 services (Figure 1, Panels A and B, red circles). For each flow of services, there is also a flow
247 of "dis-services", as long as Country and/or People are unhealthy. Flow of ecosystem dis-
248 services from Country to People is essentially linked to dis-services that flow in the opposite
249 direction, from People to Country, stemming from Nywaigis' inability to look after Country
250 in the ways they would prefer to (not fulfilling traditional custodianship role appropriately
251 and thus letting down their ancestors and future generations) – due to capacity, financial and
252 access constrains. Thus, both internal (health of the Nywaigi Traditional Owners) and
253 external constraints (financial, access) impact on Nywaigi capacity to look after the Country.
254 Should the capacity not improve, it could indeed result in a "negative spiral", where the flows
255 of dis-services will increase, reducing both the health of the Country and health of its people.

256 *3.3. Revisiting opening conceptual models*

257 In the final workshop, original conceptualisation based on Stoeckl et al. (2018, 2021) and
258 Larson et al. (in press) was revisited, and was amended as to include additional learnings
259 stemming from this project (Figure 2). As in previous conceptualisations, Healthy Country
260 provides flows of ecosystems services that result in benefits to people, Healthy People. On
261 the left-hand side of the Figure 2, are stewardship services – flow of benefits from People to
262 Country. Maintaining healthy Country by monitoring and caring for Country will result in a

263 direct wellbeing benefit to Nywaigi Traditional Owners, as well as (ecological) benefit to the
264 Country.

265 The two new concepts created by Nywaigi are also incorporated, additional to previous
266 circular conceptualisations: the concept of "Flow of services from Country to Country" (top
267 of Figure 2) and the concept of dis-services (red colouring and red arrows in Figure 2). For
268 each flow of services, there is also a flow of "dis-services", as long as Country and/or People
269 are unhealthy. A third new concept is that of arrows coming from outside this system, and
270 influencing flow of services, both from Country to people and from people to Country. These
271 can be negative influences (red arrows) such as for example restricted access to parts of the
272 Country, or pollution; but can also be positive influences (green arrows), such as funding for
273 Caring for Country activities.



274

Figure 2. Circular conceptualisation of flows of services from Country to People, and from People to Country, that also includes dis-services, flow of services and dis-services from Country to Country, and external influences. Figure attribution to Ella Schirru @science.graphics.by.ella. Symbols courtesy of the NESP Resilient Landscapes Hub (nesplandscapes.edu.au) and from Integration and Application Network (ian.umces.edu/media-library).

We note that the temporal dimensions of Nywaigi conceptualisation is considerably longer than those commonly considered by Western scientists: the present is seen as a component of the past (preserving and honouring culture) and the future (with aspirations for future). Thus, for Nywaigi Traditional Owners, current time is a bridge from past to the better future. Flow of benefits from nature to people, and from people to nature, is seen as a continuous spiral evolving through time. Nywaigi aspire for this spiral to be an upwards one, a vision of the improving connection between people and the Country over time, with management and restoration activities improving the condition and extent of the Country (Figure 3). In turn, the health of the Country, "looked after properly", will increase continuously, and so will flow of ecosystem services, improving the health of the people; who then can look after Country better, leading to future increases in ecosystem services flows and resulting benefits. But this spiral can also be reversed into a downwards spiral when country is degraded (what happened post colonisation), leading to deterioration of the condition of both people and Country.

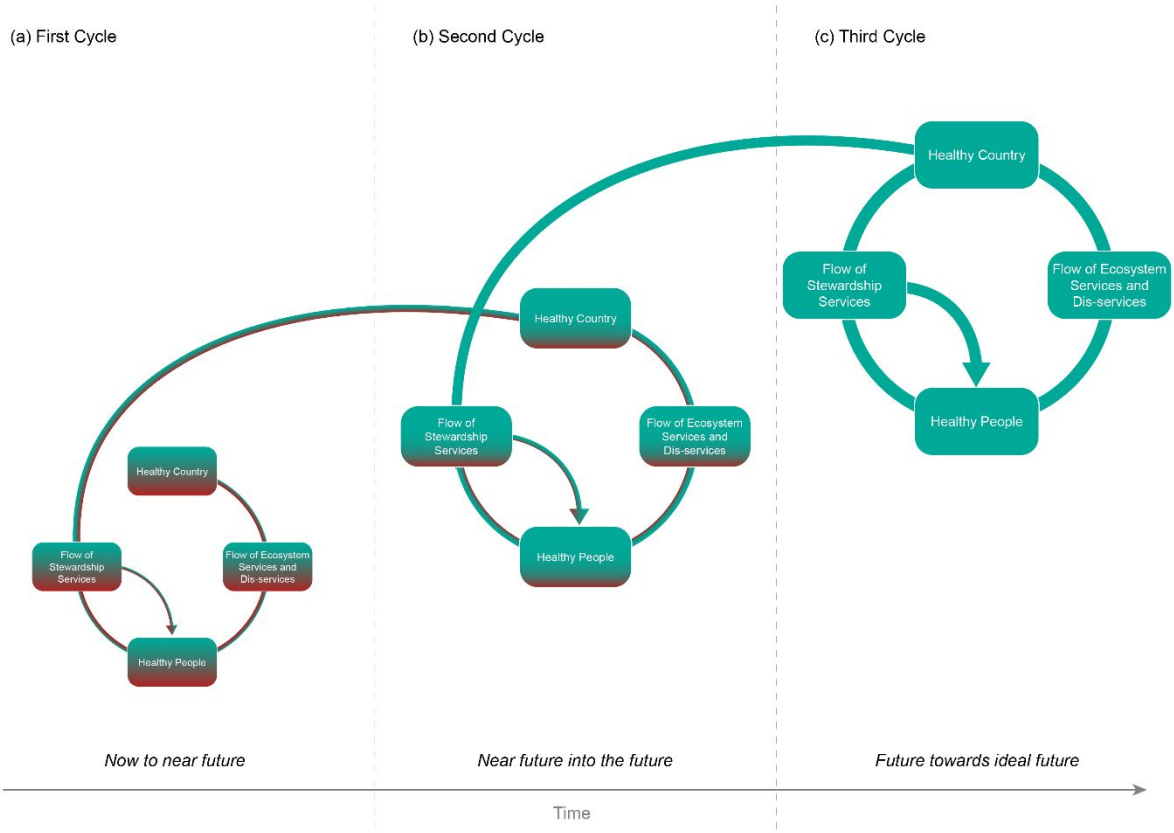


Figure 3. Conceptual spiral of connection between people and the Country over time, upwards spiral when the Country is "looked after" continuously increasing the health of the Country, flow of ecosystem services and health of people, who then can look after Country better leading to future increases; this would also require succession planning and training of the Nywaigi for the future. It could also be a downward spiral of deterioration of people and Country, if Country is not looked after; or if capacity of people is not built and they are not able to get the benefits from the wetland restoration. The red shading represents ecosystem dis-services and the social ills that are happening now, and are decreasing and then disappearing into the future. Figure attribution to Ella Schirru @science.graphics.by.ella

4. Discussion

In this paper we present Nywaigi Traditional Owners conceptualisation of the ecosystem services (and dis-services) linked to Mungalla Station on their Country: both, as a "cross-walk" from ES to Nywaigi conceptualisation; and as a "mental map" of how Nywaigi see their country and their wellbeing, related to concepts of ES. We discuss here our learnings, on circularity and interconnectedness, on services from Country to Country, dis-services, outside influences and timelines.

The circular interconnected conceptualisation of links between Nature and the People was proposed in earlier work with the Indigenous people (Díaz et al., 2015; Jacobs et al., 2016; Lyver et al., 2017; Pascual et al., 2017; Kadykalo et al., 2019; Matuk et al., 2020;). Relational logic, typical for Indigenous people's conceptualisation emphasises complex interactions, fluid boundaries and multiscale perspectives, with time, space and entities interconnected, cyclical and inter-generational (Pérez-Hämmerle et al., 2025). Gallhofer et al. (2000), working with the Australian Aboriginals, New Zealand Maori and Canadian First Nations people, discuss their similarities in conceptualising environment as a deep respect for the earth, an appreciation of the interrelatedness and interdependence between people and the environment, and the subjective character of the environment. Teixidor Toneu et al. (2025) argue that practising reciprocity can result in positive reciprocal contributions between people and nature, leading to more equitable, inclusive and effective conservation and sustainability policy and practices. Stoeckl et al. (2021) presented a cyclical and integrated human-nature model developed with the Ewamian Aboriginal Corporation, where nature provides benefits to people via ecosystem services and where people also provide benefits to nature; and where Nature, Society, Ecosystem Services and Stewardship are interconnected. Larson et al. (in review) then provide a conceptual linking of this circular model to SEEA-EA conceptualisation of stocks and flows. This circular conceptual framework also recognises the wellbeing benefits that flow back to people directly as a consequence of stewardship activities, be that for First Nations caring for Country (Larson et al., 2023), or for volunteering in nature activities (Black & Living, 2004; Choi & Kim, 2011; Molsher & Townsend, 2016). Whilst not described within SEEA-EA (or developed as part of this project), Healthy People account tables could also be developed to capture the extent of different features/ aspects of human wellbeing connected to Country and culture (Larson et al. in review).

Work presented in this paper builds on previous circular conceptualisations, but two important new concepts are added, that of "Ecosystem services flows from Country to Country" and that of dis-services. Nywaigi conceptualise ecosystem services as two types: services that create benefits to Country and services that create benefits to people. Services that create benefits to Country (Country to Country ecosystem services, Figure 2) are conceptually similar to Western classifications of regulating and maintenance services. Similar finding was noted by Stoeckl et al (2021), where several maintenance and regulating services (air filtration, water purification, carbon sequestration, Table 1 in Stoeckl et al. 2021) were classified as "important", but as services that do not "fit" into Indigenous conceptualisation of benefits. Our findings indicate that this might be due to conceptual separation of benefits (benefits to Country and benefits to people) similar to one in our findings. In addition, those services "from Country to Country" are conceptually similar to what is in SEEA-EA classification referred to as "intermediate services".

For both types of ecosystem services, and indeed, all flows recorded in the revisited conceptual model in Figure 2, Nywaigi have introduced a concept of dis-services (red arrows in Figure 2). Part of this concept is similar to the Western conceptualisation of "threats" (such as in Pressures/threats accounts of SEEA-EA). This part is related to ecosystem dis-services from Country to Country and includes presence of pests and weeds in the ecosystems, that create dis-benefits to the ecosystem itself. The other part of the concept of dis-services goes beyond this threat to the ecosystem and relates to dis-services flowing from Country to people: presence of tilapia makes people sad and frustrated. The awareness by Nywaigi Traditional Owners that wetlands are not maintained in the condition required by their roles as traditional custodians creates feelings that Nywaigi are not appropriately fulfilling their cultural responsibility for Caring for Country, to ancestors and to future Nywaigi. Presence of

pests and weeds is thus directly providing a spiritual disservice to the Nywaigi Traditional Owners.

The idea of ecosystem dis-service (EDS) as such is not new (Anderson et al., 2025), particularly in invasion science (Shackleton et al., 2019). Literature reports on cultural dis-services due to the presence of invasive species that include loss of sense of place, loss of aesthetic values and reduced cultural value (de Wit et al., 2001; Le Maitre et al., 2011; Shackleton et al., 2007). However, concept of ecosystem dis-services is not addressed in SEEA-EA framework beyond Pressures/treats accounts. Nywaigi conceptualisation of dis-services is closely aligned with the Cultural and aesthetic ecosystem dis-services (EDS) classification by Vaz et al. (2017), which include negative perception of nature on people's fulfilment of cultural traditions, anxiety, fears, as well as unpleasantness due to beliefs.

Further, similar to Nywaigi, Vaz et al (2017) link dis-services to social-ecological management. They thus suggest first identifying and evaluating both potential ES and EDS, then promoting management actions that protect and maximise ES and avoid and minimise EDS while restoring ES, and finally, compensating for loss of wellbeing due to remaining EDSs. It can be noted in Figure 2 that red arrows can also flow from People to Country, in cases where there is insufficient capacity to care for country as desired by Nywaigi. Conceptual spiral of connection between people and the Country over time, presented in Figure 3, also includes red shading representing EDS and the social ills that are happening now, but are wished to decrease and then disappear into the future. Benefits to people are thus maximised when ES are increased, and EDS are reduces. Conversely, dis-benefits increase when EDS are maximised and ES are reduced (Vaz et al., 2017). We concur with Zimmermann Teixeira et al. (2017) that for more consistent ES valuations, recording of both ES and EDS is required. We also argue that the costs of management and mitigation for reducing or removing EDS, should be included in valuation exercises such as SEEA-EA. We

encourage further research into circular interdependent conceptualisations of the nature-people systems, including research on incorporation of cultural ecological dis-services into valuation systems.

Flow of services, be it ES from Country to people or Stewardship services from People to Country, are impacted by the outside influences, such as (lack of) legal right to access the country, built capital (roads, boat ramps) or capacity of people (technical, financial) to conduct stewardship activities (arrows at the left and the right hand side of the Figure 2). This conceptualisation of important impacts of influences outside of the nature-people system, is aligned with the recent Western literature highlighting that many ES are co-produced, being the product of natural capital and other inputs/capitals (Jones et al., 2016; Costanza et al., 2017; Raymond et al., 2017). Sustaining and enhancing human wellbeing thus requires a balanced portfolio of individual people, society, the built economy, and ecosystems, with goods and services created from different combinations of these capitals (Costanza et al., 2021). Costanza et al. (2014) note that, as ES do not flow directly from natural capital to human wellbeing, rather, the flow occurs in interaction with the other forms of capital; the key challenge in ES valuation is assessment of the relative contribution of the natural capital versus other forms of capital. Importantly, different cultures will have different 'forms of capital' available to them (Larson et al., in press) - for example, boat and fishing gear to catch the fish, before the provisioning ecosystem service can be realised. Hence co-designing ES flow accounts with the Traditional Owners of the area being accounted for, is likely to result in interactions, interdependencies and co-production of flows that are context-specific. SEEA-EA, as an international statistical standard with specific guidelines on how to compile a coherent set of interrelated accounts, is set to record sections of the national economic activity related to the interactions between humans and nature, with a focus on making visible the contributions of nature to the economy and people (UN et al., 2021). As such, it is

413 primarily interested in accounting for changes in natural capital (extent and condition) and
414 resulting changes in flows of services from the natural capital (Carnell et al., 2023), and as
415 such does not account for the co-contribution of co-creation of values with other forms of
416 capital.

417 Linking from the co-creation discussion above, some ES are recognised to flow "more
418 directly", while other require greater co-creation. Importantly, this co-creation does not
419 always happen in the same time period. Several ecosystem service flows recorded by
420 Nywaigi Traditional Owners require improvements to the current condition, before they can
421 be co-created (as presented in Figure 1 panel B and Figure 3). Also, some of the ES flows
422 identified by Nywaigi are "more distant" from nature so would not be recognised as ES but
423 rather benefits in SEEA-EA – they require more of other capitals and less of natural capital:
424 however, part of the benefit is still contingent on natural capital and flow of ES. For example,
425 when discussing building a keeping place (a museum), Nywaigi envisage moneys for this
426 activity to come from income realised from tourism (recreational ecosystem service), with the
427 increased numbers of tourists visiting Mungalla Homestead after wetland restoration. So
428 income is not the final benefit, it is what that income is used for that is important. But also
429 then there is a feed-back into increasing the tourism income as now there is a wetland and a
430 museum, co-creating greater future benefit. Relative contribution of natural capital to overall
431 wellbeing thus might even decrease over time, as other forms of capitals available to Nywaigi
432 improve and increase.

433 Another concept discussed by Nywaigi Traditional Owners is that of timelines. Temporal
434 dimensions of Indigenous conceptualisations, considerably longer than those commonly
435 considered by Western scientists, has been reported in literature (Awasis, 2020, Reid et al.,
436 2020; Stoeckl et al., 2021; Larson et al., 2023). The present is seen as a component of the past
437 (preserving and honouring culture) and the future (with aspirations for future) (Stoeckl et al.,

438 2021). Our findings support this conceptualisation, with temporal dimension – of current
439 being a bridge from past to the better future – being a strong feature of Nywaigi concept. As
440 reported in Figure 3, flow of benefits from nature to people, and from people to nature, is
441 seen as a continuous spiral evolving through time. Nywaigi aspire for this spiral to be an
442 upwards one, a vision of the improving connection between people and the Country over
443 time, with management and restoration activities improving the condition and extent of the
444 Country (Figure 3).

445 We propose that findings of our study have a stronger meaning applicable beyond Nywaigi
446 Traditional Owners and other First Nations, one that can also inform discussions on
447 'relational turn' paradigm (West et al., 2020; Gould et al., 2023). Our empirical study
448 presents an example of practice that could support more pluralistic policymaking (Pérez-
449 Hämmerle et al., 2025; West et al., 2020). We agree that existing ES approaches, including
450 SEEA-EA, risk encouraging utilitarian and inflexible views on complex system of linkages
451 between nature and people (Boswell et al., 2023). However, our explorations indicate that
452 crosswalks between Indigenous and the Western conceptualisation of flows of services from
453 nature to people and from people to nature are possible, building up on similarities rather than
454 pointing at differences.

455 **5. Conclusions**

456 In this paper we build on the previous work that explores relations between Indigenous
457 people and the Western conceptualisation of flows of services from nature to people, and
458 specifically, SEEA-EA accounting framework. We did this in partnership with the Nywaigi
459 Traditional Owners from North Queensland Australia. Our crosswalk from the Indigenous to
460 the SEEA-EA conceptualisation indicates that some of the concepts are very similar between
461 the two. Key findings are confirmation of importance to Nywaigi Traditional Owners of
462 circular and interconnected conceptualisation of the nature-people-nature system; concept of

not only flows of services from nature to people and of people to nature, but also important flows of services from nature to nature; category of dis-services – explicit recognition that ecosystem flows can be beneficial but also detrimental for human wellbeing, both physical and mental/spiritual; important role of outside influences (capitals other than natural capital) in determining the actual use of what ecosystem services might be supplying; and need for recognition of importance of longer timelines when considering impacts or evaluating benefits and co-benefits in nature-people system. We propose that conceptualisations reported in this paper are applicable beyond Nywaigi Traditional Owners and other Australian First Nations, and are of relevance to international audiences.

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