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Ecosystem Services

Neree Pepperall (27439283)
Amit Shalev (76248666)
Joe Snodgrass (37906158)

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Abstract:

Antarctic ecosystem services have begun to be assessed formally only in recent years and they have not been quantified or otherwise calculated in a comprehensive and consistent manner. This report summarises some of what has been done in this regard, identifying tools and methods used to calculate these ecosystem services and examining approaches used for valuation as well as the explicit and implicit valuations driven by the Antarctic Treaty System. The report discusses some implications of valuation and their potential ramifications on utilisation and governance, taking the point that ecosystem services valuation should not be approached purely with market-driven methods, and that where those approaches are used, they must capture indirect costs in addition to direct costs and benefits from the get-go. The risks of doing otherwise include not just unbalanced utilisation but the potential destabilisation of the Antarctic Treaty System itself. As such, communication approaches and materials, whether originating from national Antarctic programs and researchers and aimed at the public or at governance bodies, or whether originating from governance bodies and aimed at their greater stakeholders and governments, should reflect and articulate valuation methods that consider many interdependent considerations. Further, they should shape their communications with an eye toward multidisciplinary audiences and thus avoid narrow, domain-specific perspectives.

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1 Introduction

1.1 What are ecosystem services?

Life's pursuit is led by ability of reproduction, energy synthesis and access to water and nutrients. Organisms obtain water and nutrients from their environments, either from the direct landscape itself or from other inhabitants. These organisms interrelate through ways of competition, pollination, symbiosis and by cooperation. These interactions form an ecosystem to which humans make up an essential component to the system, sometimes dominate. Whether humans are dominant or not, they rely solely on the ecosystem alike other organisms, to remain existent (Millennium Ecosystem Assessment, 2005).

Ecosystem services have been classified into four broad categories proposed by the Millennium Ecosystem Assessment (2005) (Costanza, de Groot, Braat, Kubiszewski, Fioramonti, Sutton, Farber & Grasso, 2017)(Grant, Hill, Thathan & Murphy, 2013) (Figure 1).

1. Provisioning services- these are the services that combine built, human and social capital and produce food, timber and other benefits.
2. Regulating services- these are services that include things like flood control, storm protection, water regulation, water purification, air quality maintenance, pest control and climate control.
3. Cultural services- these combines built, human and social capital to create recreation, aesthetic, scientific, cultural identity etc. these are what make the 'human experience'.
4. Supporting services- these services are through the promise that it will gradually become more conserved and valued (Costanza et al. 2013).

Scientists (Thompson and Barton, 1994 & McCauley, 2006) have argued that the idea of ecosystem services represents an 'anthropocentric', instrumental or utilitarian view of nature, that they only exists to serve the needs of humans. This is then counter argued as they believe that this simplistic view is incorrect. They imply that the concept of ecosystem services are basic ecosystem processes, for example, soil formation, primary productivity, nutrient cycling and provisioning of habitats. These all contribute indirectly to human wellbeing by maintaining the processes and functions necessary for provisioning, regulating and cultural services (Costanza, Groot, Braat, Kubiszewski, Fioramonti, Sutton, Farber & Grasso, 2017).

We must reframe the way in which we see nature as it is "essential to solving the problem of how to build a sustainable and desirable future for humanity" (Costanza, Groot, Sutton, Ploeg, Anderson, Kubiszewski, Farber & Turner, 2013). Ecosystems are fundamentally important to many aspects of human life such as survival, health, well-being and livelihoods. An ecosystem "cannot provide any benefits to people without the presence of people (human capital), their communities (social capital) and their built environment (built capital)". Research is continually growing in ecosystem services interest and it has now "entered the consciousness of mainstream media and business" which recognises that humans depend on nature for their survival and wellbeing but denote that humans are not the only thing that matters on this earth instead the whole system matters (Costanza et al., 2017).

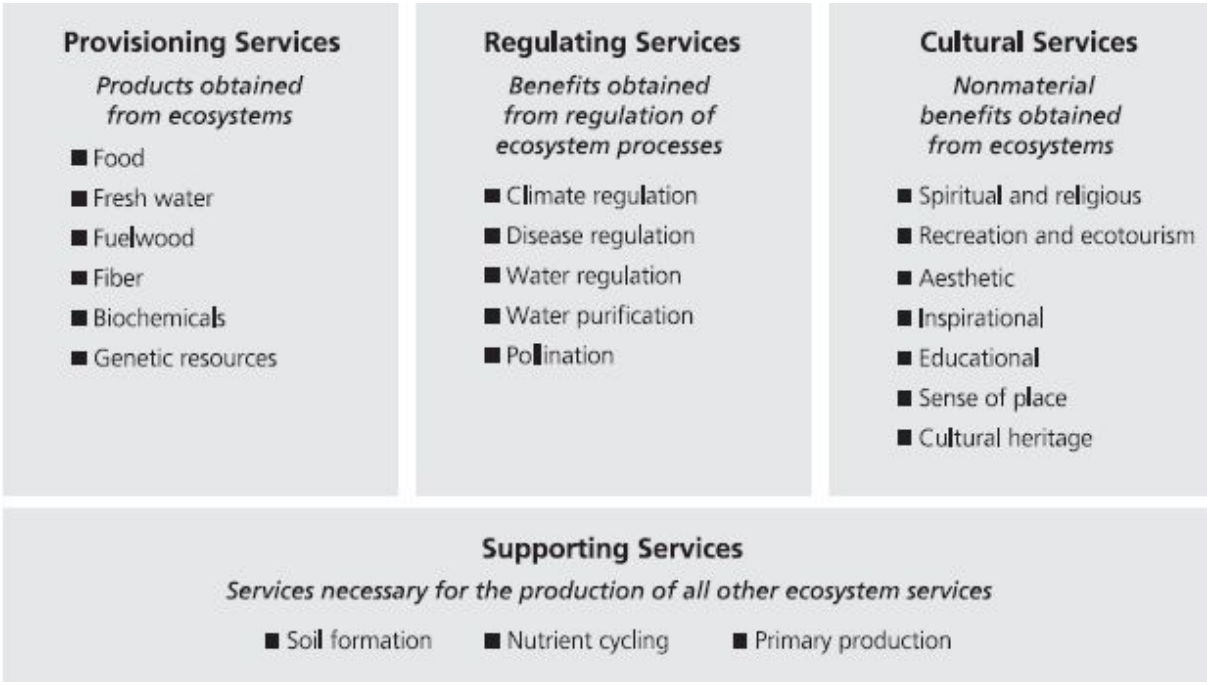

Figure 1: The four categories of services. (Atkins, Banks, Burdon, Greenhill, Hastings & Potts, 2013)

1.2 Antarctic ecosystem services: knowns and unknowns

In 1991, an environmental protection regime known as the Protocol on Environmental Protection to the Antarctic treaty was created (Rothwell, 2000). This acknowledged Antarctica's intrinsic value including its value of wilderness and spectacular aesthetics. Here decisions were made upon the management of human activity and the conservation of the environment and the species that inhabit it (Grant, Hill, Trathan, & Murphy, 2013). When discussing the valuation and awareness of the services in which the Antarctic provides, one must consider the protection that encompasses Antarctica and how much humans can withdraw from it.

Like the Arctic, Antarctica is composed of a unique ecosystem of both marine and terrestrial environments which provide a collection of services to populations globally (O'Garra, 2017) but unlike the Arctic, there is little research and gaps in our knowledge as to how far these ecosystem services travel and how they are truly valued. The state of awareness of Antarctic ES is not as common as the Arctic. There may be several reasons why, but there is insufficient evidence.

ES all over the world are categorised by the four different services and this is also true for the ES that are derived from Antarctica. The Weddell sea in Antarctica is an example of an ecosystem that provides many services to which humans benefit. Provisioning services such as fisheries products for example an abundance of toothfish and krill, fresh water, photosynthesis and nutrient uptake by phytoplankton to provide a food source for the higher trophic level species and medical resources. Weddell sea regulating services include climate and air quality regulation, waste treatment by the activity of microorganisms and nutrient cycling aiding in plant production. Supporting services include habitats, required for the conservation and biological processes of marine fauna and flora and the cultural and spiritual value found within those who have or haven't visited this extreme environment and tourism and recreation as the region is a tourism hotspot for humans to see the aesthetic properties of this environment (Deininger, Koellner, Brey & Teschke, 2016).

In Antarctica, ecosystem services have only recently become a focus for research work on the continent. Studies identifying the ecosystem services of the Southern ocean have been carried out but remain focused on individual components of the complete system. Grant et al (2013) have collated existing research on identifying ecosystem services of the Southern Ocean, but still recommend a formal ecosystem assessment to fully value ecosystem services and their interactions as a system.

A formal ecosystem assessment of the Antarctic and the Southern Ocean would require a massive breadth and depth of data, made difficult by the global spread and diversity of affected markets and their distance from the continent (Nicol et al, 2012). A complete ecosystem assessment would be required to estimate complete value of the Antarctic ecosystem services in the global context and has not been completed. This report identifies the potential for informing policy and practice from valuing Antarctic ecosystem services and implications from doing so.

2 Antarctic ecosystem services overview

2.1 Components

Antarctica has a collection of land and marine ecosystems spread from inland glaciers, to sea-ice, to coastal areas to the surrounding seas and beyond. Ecosystem Services are benefits humans derive from ecosystems, and those provided by Antarctic ecosystems fit within the four main ES categories: supporting services, provisioning services, regulating services, and cultural services.

Identification and value assessment of Antarctic ecosystem services has evolved over the decades and taken on greater depth in parallel with a growing understanding of the Antarctic ecosystems themselves. However, while there exists the general understanding that Antarctic ecosystem services arise from those same aspects in an ecosystem that typically yield services elsewhere - e.g. we generally know that supportive services derive from nutrient cycles in the biota, for example, and that these are present in Antarctica, and thus we are aware that Antarctica provides supportive services - there still has not been a comprehensive identification and categorization of the specific ecosystem services derived, or a detailed view of all the underlying ecosystem facets they are derived across the board.

Identification and study has so far mostly focused on a limited range of ecosystem services:

- Cultural: scientific research and subsequent framework of international peaceful cooperation, tourism, heritage preservation, education, and art;
- Regulating: climate regulation through ocean circulation, high albedo, etc, and carbon sequestration in ocean water;
- Provisioning: fishing and other marine harvesting, biodiversity;
- Supporting: habitat provision.

It is useful to look at other ecosystems that have some similarity to or direct relation with the Antarctic, and which have better understood ecosystem services, for further cues pointing to what ES Antarctica may provide. As such, we can look to ecosystems in that other polar environment, the Arctic, and we can look to those in the Southern Ocean.

The Arctic's changing climate and its effects on ES can also provide hints on how ecosystem services evolve with climate change and how those changes are recognised and used. For example, as Arctic permafrost melts, oil, gas and mineral exploitation becomes more accessible, modifying the

approach to ES there and casting them as a growing tool for increasing GDP (Declercq, 2016)(Macias-Fauria & Kettunen, 2015).

Looking at the Antarctic ecosystems across the board, a more specific picture of past, current, and potential future ecosystem services begins to form:

Supporting services:

- Habitat provision for native microorganisms (plankton and zooplankton, microbes), ocean/sea-ice biota (copepods, salps, fish, krill), mammals (seals, whales), and birds (penguins, migratory birds), supporting the Antarctic food cycle and its keystone species.
- Primary production
- Nutrient cycling

Provisioning services:

- Food – krill and finfish fisheries;
- Raw materials derived from fish & krill;
- Genetic resources via bioprospecting (dependent on biodiversity) - not currently utilised but hypothetically could be one day.
- Biogenic minerals and other materials (such as coal) - not currently mined but which hypothetically could be one day.
- In the past, ornamental use of whale and seal byproducts (scrimshaw, baleen, etc).
- Medicinal, as implicit through bioprospecting new microorganisms (bacteria, etc) - not currently utilised but which could be one day.
- Water, utilised locally.

Regulating services:

- Climate regulation through different mechanisms such as reflection of austral sunlight outward due to high albedo, and processes contributing to oceanic current circulation;
- Carbon sequestration through absorption in the oceans;
- Flood control, in the sense that much of the world's freshwater supply is locked in the Antarctic ice sheet, which would cause a rise in sea levels if melted.

Cultural services:

- Scientific research & education/discovery;
- Technology development and testing (in the 20th century Antarctica was used to test technologies as a sort of extreme lab and the practice continues);
- Art & media exploration, from early paintings and illustrations, to modern novels and poetry;
- Inspiration through art, storytelling, education and heritage outreach;
- Cultural – supporting economies and infrastructure in gateway cities, including those with interrelated educational and heritage services (as as Christchurch's Antarctic Centre and Canterbury Museum);
- Heritage preservation as valued through tourism and education;
- Recreational – tourism, and as part of that, limited outdoors sports & recreation.

2.2 Tools and methods for calculating Antarctic ecosystem services

The Millennium Ecosystem Assessment (MA) aims to analyse and quantify the importance of ecosystems to human wellbeing so that they are able to make better decisions about the management of ecosystem services and their sustainable use. Initiated in 2001 with the objective to "assess the consequences of ecosystem change for human well-being and the scientific basis for action to enhance the conservation and sustainable use of those systems and their contribution to human well-being" the MA hopes to "contribute to improved decision making concerning ecosystem management and human wellbeing" whilst building "capacity for scientific assessments" (MA, 2005). In order to assess and understand the impact of management decisions for an ecosystem, a common metric must be used, services must be comparable to one another but assigning common value for apples and oranges, proves not to be simple although seemingly advancing in recent years (MA, 2005). Although these tools and methods are put into place, they all possess limitations which inevitability may affect the valuation of the ecosystem and its services.

The Utilitarian Approach

The utilitarian approach is centred around the concept that a human gains benefit from an ecosystem and the service it provides, either directly or indirectly and either in the present or in the future. There are two aspects of this approach that must be considered. Firstly, individual's motivations may determine the type of use that is derived from an ecosystem, this may be down to personal preference and therefore will base it's perception of value on the attempt to measure a specific usefulness that an individual member of society gains from the service, then will combine all individual's values to weigh them all equally. Secondly, value cannot be calculated directly and because of this the unitarian approach attempts to measure the services of an ecosystem as a common unit. The approach aims to use well recognised units as convenience and to facilitate comparison amongst utilities to provide value (MA, 2005).

Economic Valuation

There are three main motives for valuing ecosystems:

1. To measure the total contribution of ecosystems for social and economic well-being
2. To recognise how and why financial actors use ecosystems the way they do
3. To calculate the comparative impact of alternative actions to enable guidance in decision making.

Ecosystems provide wealth and benefits to the whole nation, but their services are not traded hence values are not confined by the conventional style of accounts for income. Due to this implication, its value is generally not appreciated and accounted for. This then leads to an incorrect indication of the state of wellbeing, creating misrepresented policy actions and misadvised social decisions (MA, 2005). Correctly valuing ecosystem services can lead to improved changes in both wealth and well-being for the environment as well as human beings although it does not provide certainty that it will be conserved, it will certainly result in less of a loss of ecosystem services than if not.

Understanding why humans do what they do is a cause for evaluating ecosystem services. Why deforestation occurs, why we deplete solid or why we pollute water sources, all provide questions and possible valuations humans place on these services. Whether these behaviours are private or

social, they tend to be underpriced or not priced at all, leading to the unsustainable use of these resources. This thought process provides implications but once understood, we may then be able to help expose policy and institutional failures to provide constructive information on alternative options for markets or incentives (MA, 2005).

When assessing the economic value of something one must always look at the value effect for different groups for example different generations. By looking at this human-nature relationship through ecosystem services it is easy to see how these services are distributed amongst different stakeholders or groups within a society. This then can be used as an advantage to provide equity amongst the groups and guard against unintended negative consequences for the more vulnerable members of the community (Gren et al, 2015).

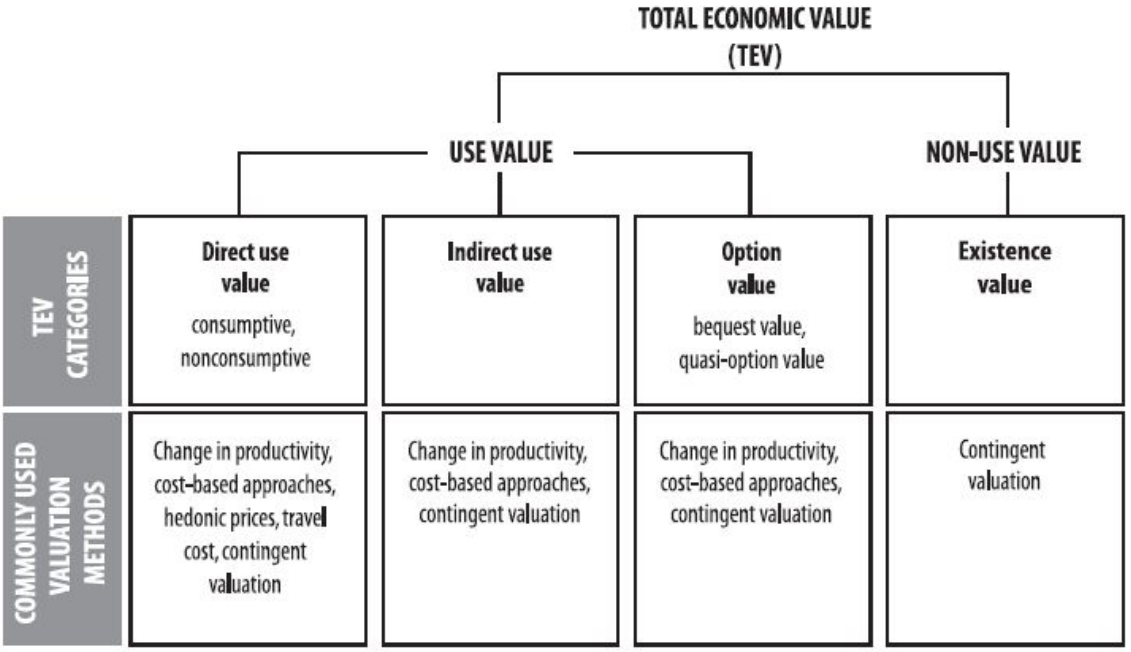

Figure 2: Framework of the Total Economic Value (*MA, 2005).*

Total Economic Value

Total economic value (TEV) is a framework widely used for assessing the utilitarian ecosystem value. Here two categories of values are implemented: use values and non-use values. Here the term value refers to the direct value a human obtains from the ecosystem and includes the services that are being used either directly or indirectly and currently or potentially in the future (MA, 2005, Grant et al., 2013).

> *Direct use values:* can either be used for consumptive or non-consumptive purposes. Food products from harvesting or timber for construction pose examples of consumptive use as wildlife or birdwatching or water sports comprise non-consumptive services. The values that make up the direct use values are in relation to the MA explanation of provisioning and cultural services.

Indirect values: these values encompass a wide range of intermediate contributions for production of the final goods and services enjoyed by humans. These include services such as water, pollination and soil nutrients for production of food and water purification and other regulating services which aid in human health benefits. This category responds to the MA notion of regulatory and supporting services.

Option values: these are values that may not be currently in use but do still provide value that could be used in the future. This is categorised as provisioning, regulating and cultural services with the intent that they may be used in the future (MA, 2005).

Ecosystem Services Valuation

Ecosystem Services Valuation (ESV) provides a tool to increase the ability of decision makers to estimate the trade-offs of the alternate ecosystem management regime, sequentially meeting a set of goals at a sustainable level with rational distribution and reasonable allocation. It is the practice of calculating the influence of ecosystem services in achieving this set of goals (Lui, Costanza, Farber, & Troy, 2010).

ESV is implemented for the use of multiple policy purposes. Such include:

1. Providing associations of the natural capital to the physical and human capital concerning their influences for human well being.

2. Monitoring the capacity of natural capital over time with appreciating the contribution it has on human welfare.

3. Providing an assessment of schemes that recommend changing either enhancing or degrading the natural capital (Lui et al, 2010).

Lui et. al. (2010) discussed three significant implications of this tool being: ethical and philosophical implications, political implications and methodological and technical implications. Lui et. al. (2010) states that ESV is exclusively based upon individual's preference in decision making, thus providing a very objective view that may be biased. Political implications arise by the "objectiveness and virtue of ESV" This tool provides clear and sometimes "unattractive" issues to the public to which there are some whom may be reluctant introducing the tool into political debates. Lastly ESV is criticised for its methodologies, with some stating that "it can only be used to evaluate changes in the values of ecosystem services".

Trade-offs

Human activities put pressure on the natural systems and obtaining one benefit from an ecosystem may impact its ability to provide other benefits for example continued biodiversity. There must then be trade-offs made and considered to address these imbalances (Grant et al, 2013). Tools when estimating the economic value for ecosystem services rely heavily on these informed trade-offs. These are relative values and measured in several units in terms of weight and cost for example depending on the context. The economic value must not be confused with monetary value and their importance must be emphasised (Sommerkorn and Nilsson, 2015).

Ecosystem Approach

The ecosystem approach is a policy that integrates management and encourages both conservation and sustainability of land, water and living resources. It integrates scientific methodologies that focus on levels of biological organisation, incorporating structures, processes, functions and interactions amongst organisms and their environment. It in turn recognises humans integral function within the ecosystem (MA, 2005). The ecosystem approach considers the critical relationships between the biodiversity and services as well as understands the structure and functioning of the ecosystem. This enables an entire recognition of the value that the ecosystem holds and can contribute to the management and conservation of Antarctica's ecosystem (Cavanagh, Broszeit, Pilling, Grant, Murphy, Austen, 2016). There are limitations to this approach in that this tool focuses on the management of the human activity in the ecosystem instead of the ecosystem itself (Atkins, Banks, Burdon, Greenhill, Hastings, & Potts, 2013). The danger in doing so is that the ecosystem as the core provider of the services is forgotten about and only cared for in the purpose human intentions.

3 Value of ecosystem services

3.1 Meaning of ecosystem services to humans

Humans are a major component of all ecosystems in the world, relying on them for their provisions in the form of food, water and materials, their regulation of climate, disease and natural processes and support through nutrient cycles (Millennium Ecosystem Assessment, 2005). These ecosystem services are the "functions or processes that directly or indirectly contribute to human wellbeing-that benefit people"(Costanza et al., 2017). In relying on these services we impact the ecosystem as all other organisms do. These global earth ecosystems and their services are what allowed our development as a species and our survival is directly linked to these services. Fundamentally, they are our reason for existence and survival (TEEB, 2010).

Economics services are important economically through the provision and gathering of commodities. The primary industry and tourism sectors require these services to function, creating sources of employment as well as driving secondary industries and global markets by supplying goods and materials. Countries are reliant on natural resources and without ecosystem services costs of goods would greatly increase.

Different cultures' philosophies place different meanings on the environment, often related to their environmental identity: their sense of place within the nonhuman environment (Clayton, 2003). With greater environmental identity comes stronger connection, attachment and ultimately value on the surrounding environmental processes and what they provide (Mayer & Frantz, 2004). The surrounding environment serves as a source of inspiration, connection to cultural traditions and spiritual connection to cultural figures or ancestors. Antarctica does not have native peoples, making it more difficult to be able to gauge value from many aspects of the environment, specifically these cultural values (Gren et al, 2015).

Environmental identity and connection to the environment are linked with pleasure and appreciation from interacting with the natural world and learning from it. Many people interact with the natural ecosystem through recreational activity locally and globally through tourism. Recreation provides economic benefits for communities alongside many health and wellbeing values to individual and community health. These can include (Clough, 2013):

- Increased community productivity and health with a more active workforce, and fewer obesity-related health costs.
- Cultural capital through increased social interaction and shared common interests
- Greater education and discovery of the natural world allowing greater contribution to the scientific and environmental understanding of the ecosystems. This also includes the opportunity to learn new skills.
- Inspiration for creative, scientific or personal pursuits through engaging with ecosystem scenery, fauna and flora.

Recreational activities provide passion and meaning to many people and their value is supported willingness of individuals and groups to spend time and resources pursuing them. Ecosystem services provide the setting for the activity through maintaining ecosystem biodiversity and regulatory services such as shelter in trees and water quality and flow. Harvesting activities (fishing or hunting) additionally rely on provisioning ES to provide healthy stock.

3.2 Different ways of valuing ecosystem services

Since ecosystems provide services to people, communities and organisations in a way that benefits them, it stands that there is some value associated with these services. The range of services the ecosystem provides likewise requires a range of methods to calculate their value in a context relevant to informing policy, generally divided into two categories, economic and non-economic.

As such, ecosystem services are extremely difficult to value (Cooley, Kite-Powell & Doney, 2009). Costanza et al (2017) state that there is “no right way to assess and value ecosystem services”.

Nevertheless, explicit or implicit valuation is inherently unavoidable in any decision-making or policy around ecosystem services, as those often involve trade-offs which require evaluating some kind of value proposition (Costanza et al, 2013).

Economic valuation works to define a public value for ecosystems in monetary value within the TEV process. The two main methods of economic valuation are Revealed preference methods and Stated Preference methods. This section outlines the different data sources of human value able to be collected, but in all studies complex statistical regression analysis is required to quantify value from an array of demographics, willingness to pay, other ecosystem services, as well as market prices, supply and demand (TEEB, 2010).

Revealed preference methods (Defra, 2007)(TEEB, 2010) rely on data to reveal users preferences for marketable goods reliant on ecosystem services, using real markets to calculate the value. However, ES are not fully captured and reflected in commercial markets, or quantified in enough detail so they can be used comparably to known market instruments, and their influence on policy decisions can be diminished (Verbitsky, 2018).

Revealed preference methods:

Market based method

Food and materials have a market value that can be applied to estimate the monetary value of the ecosystem services that contribute to these commodities. The proportion of value is determined by these values and is often linked to incurred costs and increased market price with the loss of these services. For example, using market based changes and prices to determine the value of the provisioning benefits and ecosystem of a food source like commercial fishing vessels.

Hedonic value method

Is used for ecosystem services that directly affect the economic price of commodities. The most common study is the prices of residential or commercial properties and the changes with proximity to ecosystems. The change in economic value and therefore the perceived value of living in proximity to the ecosystem can be defined with analysis across the region.

Travel cost method

A value of an environment can be estimated by the cost of the user to travel to the site. The frequency of trips, opportunity cost and additional values gained from the trip apart from the ecosystem service must be considered. This method is combined with the willingness to pay for accommodation and equipment or service costs to analyse the recreational value of an ecosystem. However, the measured value will generally be lower than the true cost the user is willing to pay for the activity as the personal value of travelling must be greater than the cost. Valuing ecosystem services for tourism and recreation can be determined by estimating visitor's willingness to pay for activities that they can do whilst in the ecosystem (Marre, Thebaud, Pascoe, Jennings, Boncoeur. & Coglan, 2015).

Stated Preference method

Best suited for evaluating non-use ecosystem services (Defra, 2007)(TEEB, 2010). Specifically designed phone or physical questionnaires are used to determine individual preferences and ultimately willingness to pay for an ecosystem service, equivalent to their value of it. Questionnaires are designed for either contingent valuation (stated preference) and choice modelling to better define non-market services. Focus groups and community discussions are also used to determine collective views.

Substitute/Damage cost method

Another method for valuing ecosystem services is by estimating the cost to repair the ecosystem if it wasn't able to supply services or substitute the service manually. This must be the cheapest alternative and there must be a willingness to pay for this service to accurately represent the value placed on the ecosystem service. For the ecosystem service value to be accurately assessed substitute must be providing the equivalent magnitude of service. In some cases, particularly for these services which constitute earth's life support systems such as climate regulation this value is unlimited because the service would be irreplaceable if lost completely (Grant et al., 2013).

Benefit transfer

Where similar studies have been made, these can be employed to inform an estimate of a separate case study. Care must be made when using other studies designed particularly for that local

ecosystem and will encapsulate the value of another set of ecosystems, demographics, economic assets and settings (TEEB, 2010). Therefore using studies as similar to the new case study as possible will increase validity. A benefit transfer will only ever be as accurate as the original study and will create errors of its own but with increasing studies of ecosystem services values they will become a more accessible way of informing policy without collecting the same scope of data.

There is intrinsic value that go beyond economics; monetary quantification is only a part of the big picture. There are many things we simply do not know how to quantify in economic terms - from physical aspects like climate regulation which can drastically change humanity's future, to sociological services like cultural preservation of indigenous ways of life which are not on the market to be priced like commodities - but which are integral to the value of a system across time and independent of socio-cultural-dependent economic valuation (Declercq, 2016).

Payment for ecosystem services (PES) attempts to address the commercial market problem of comprehensive valuation by identifying that ecosystem services have a value for users are willing to pay to maintain, and that these values can be transferred through a framework using a "Beneficiary Pays Principle" or "Provider Gets Principle" to fund conservation through the market (Van Hecken and Bastiaensen, 2010). PES attempts to surpass cost-benefit analyses of the traditional ecosystem services approach, integrated the holism of ecosystems, encompassing the human-nature relationships and the full range of values for humans (including those unable to be defined by monetary value like cultural and aesthetic services). While still using an anthropocentric framework, PES tries to use the market to place value in the ecosystem beyond solely as a source of human benefit (Gillespie, 1997)." (Verbitsky, 2018)

3.3 Values arising implicitly (and explicitly) from agreements in the Antarctic Treaty System

While the approaches to ecosystem services valuation described above have been applied outside of Antarctica, not many have been applied directly to Antarctica. Valuation there is difficult because many ecosystem services do not manifest themselves in directly observable ways and require close study to fully understand, something which has begun within formal valuation approaches only in recent years. Further, because Antarctica has no indigenous people and only a small, transient population, only a relatively small group of people has observed ecosystem services directly, and while a much larger group benefits from Antarctic ecosystem services at regional and global levels (from services such climate regulation for example), the means by which they do is indirect and therefore poorly understood by those groups. Thus, limited direct access and poorly-understood indirect benefits has limited the scope of explicit application of valuation frameworks.

However, we can increase our understanding of Antarctica's ecosystem services classification and valuation by tracing explicit and implicit manifestations of such valuation through the Antarctic Treaty System and its agreements, and by noting what historical utilization of Antarctic ecosystem services motivated those agreements. The Antarctic Treaty System (ATS) can thus be seen as a type of map, pointing to specific Antarctic ecosystem services it explicitly and implicitly acknowledges, and implying their relative value in relation to one another.

Historical Utilisation

Historically, Antarctic provisioning services were highly valued starting in the 18th century. Heavy utilisation came through commercial seal hunting, primarily for fur but also for meat and other materials, which led to severe depletion of the fur seal population by the early decades of the 19th century. Another vector of provisional service utilisation was commercial whaling, which grew tremendously in Antarctic waters in the early 20th century and led to severe population depletion among multiple types of whales. While seal hunting continued through roughly the mid-20th century, albeit at decreased levels, commercial whaling continued until the late 20th century at numbers that continued to deplete whale populations faster than they were able to bounce back. (Human Impacts on Antarctica and Threats to the Environment - Whaling and Sealing, n.d.) These are examples of market forces placing high valuation on provisioning services, without a counterbalancing market calculation of sustainability and conservation. Markets typically counterbalance high demand and low supply with higher prices and call it a day, but this was not enough for preserving ES in these cases, and thus was the primary driver of the explicit conservation efforts under the ATS.

Utilisation of Antarctic ES during the Heroic Era also encompassed cultural services, inspiring exploration, art, and the imagination of people across the world, and ultimately providing the foundation for future exploration and scientific expeditions and leading to the formation of the ATS. This is an example of an ES of clearly high value, but which a market-based model would not be able to fully capture. And yet, its value held such power that it ultimately brought nations together and made a new era of Antarctic history possible.

Antarctic Treaty System

If we look at the Antarctic Treaty and observe what it extols and prioritizes, we can trace a certain approach to valuation in Articles I-III and IX, which emphasizes cultural services through:

- Scientific research for regional and global benefit;
- International scientific cooperation and sharing of information;
- Peaceful relationships;
- Preservation and conservation of living resources.

(The Antarctic Treaty, 1959)

These values were further reinforced in the Protocol on Environmental Protection to the Antarctic Treaty (PEPA, i.e. the “Madrid Protocol”) whose main focus was to :

- protect the Antarctic environment along with its dependent and associated ecosystems;
- designate Antarctica as a “natural reserve, devoted to peace and science”
- avoid degradation to areas of biological, scientific, historic, aesthetic or wilderness significance (PEPA, Article 3.2.b.i-vi), thus in essence recognizing and prioritising the value of biodiversity and habitat preservation as well as heritage preservation and beauty, in addition to the already familiar scientific research.

(Protocol on Environmental Protection to the Antarctic Treaty, 1991)

The other main parts of the ATS - Annexes under the Madrid Protocol, CCAMLR, and CCAS - all serve to reinforce variations on the above, valuing conservation, biodiversity and habitat preservation and implicitly protecting ES supporting services as part of the conservation doctrine, de facto seeking to

preserve natural processes around food webs and hence also nutrient cycling and primary production.

Furthermore CCAMLR (Convention on Conservation of Antarctic Marine Living Resources) recognises value in "rational use" of living resources and prioritises a cautionary approach that balances rational use with conservation in an attempt to "maintain existing ecological relationships" (CCAMLR: Fisheries, 2017).

In fact, in cases when the ecological variables are complex, interdependent and difficult to study (such as in Antarctica, where both access and resources for research are limited) prioritising precautionary conservation and a "do no harm" focus is a safe bet in the absence of comprehensive valuations that fully quantify impact of utilisation on ES preservation. The ATS takes this approach and therefore its valuations are made on the basis of reducing potential harm rather than calculating an explicit, quantified utilisation cost.

Finally, the ATS recognizes and explicitly acknowledges ES derived from tourism, mineral exploitation, and bioprospecting through the Antarctic Treaty Consultative Meeting (ATCM) as well as, in the case of minerals, the CRAMRA (Convention on the Regulation of Antarctic Mineral Resource Activities). It prioritizes these differently from one another however, allowing tourism under guidelines that prioritize conservation and environmental protections, allowing bioprospecting with the pointed reminder to NAPs that they should share whatever knowledge is gleaned, and disallowing mineral exploitation (ATS: Other topics, n.d.) (ATS: Tourism, n.d.).

4 Discussion

Implications of assigning values

Creating more extensive approaches to valuation carries certain benefits and risks. Valuation approaches must capture both cost and benefit to not blind people to risks while they are enamoured with benefits. Furthermore costs cannot be solely the direct costs of extracting benefits, but also the indirect but interlinked hidden costs.

Increased benefit valuation without corresponding understanding of risks to sustainability and other ecological costs can destabilize not just the ecosystem, but the ATS itself. As the ATS hinges on international cooperation, which market forces unchecked by cost assessments (which inevitably lag behind) can turn into competition (which is destabilizing by its very nature).

The goal must be to build valuation approaches that do not cause runaway market behaviors resulting in downstream devaluation. How can this be done?

Communicating value of Antarctic ecosystem services

Valuation representing non-economic benefits, or benefits which are not otherwise reflected in market-driven approaches, are not easily quantifiable and so effectively communicating their meaning is key to proper support among policymakers. If these valuations cannot be properly conveyed, they could be undervalued or even ignored when it comes time to enact policy (Grant et al, 2013).

Those approaches that do rest on economic valuation must communicate benefits alongside costs and exploitation risks in ways that don't minimize costs/risks but in fact demonstrate how their

understanding is necessary to achieve proper valuation. Furthermore the costs conveyed should take into account not just the direct cost of extracting benefits, but the indirect ones, dependent on less obvious interdependencies among variables.

There is an argument to be made that communicating through clear market-driven valuation is effective. Pavan Sukhdev says "Economic valuations, in particular, communicate the value of ecosystem services and biodiversity and their largely unpriced flows of public goods and services in the language of the world's dominant economics and political model." (TEEB, 2010)

However, since policymakers come from different disciplines, detailed economics-based arguments need to be made clearly, without burying core ideas within the fine details only specialists in the specific value chain would understand. Additionally, policymakers must communicate findings outward and build support in their greater government, so common language must be found among stakeholders and interested parties.

Similarly, increasing public understanding of non-market-driven Antarctic ES, as well as the risks of unbalanced market-driven exploitation, depends on communicating these effectively across all levels through outreach in the scientific community and national Antarctic programs, as well as conveying the clear rationales behind policies and how ES are prioritised. Where it comes to market-driven benefits, their valuation is communicated automatically through the market itself, though risks and indirect costs are not. Those could be undiscovered and poorly understood by the market, and therefore not reflected in its pricing, only finally coming to light with significant lag behind initial pricing. As such, these too must be communicated to the public and not left to the market to convey through what might turn out to be poorly mapped pricing models.

Benefits to governance bodies of Antarctic ES valuation

Proper valuation empowers decision-making, outreach and communication, as well as the creation of regulations that can manage ES and protect them. In other words, proper valuation helps governance bodies do their jobs efficiently in the following ways:

Better communication of environmental topics within policy making

In defining and calculating the ecosystem services of the Antarctic region and the Southern Ocean, their value globally to humans can be assessed and quantified in a way that can be compared to the value generated from their use or their contribution to global systems. Ecosystem services as a tool deliver the inherent value of systems in a way that is directly comparable and understandable to policymakers. Without valuing ecosystem services they are considered free in the economic and political model and will not be fully appreciated in policy decisions.

Conservation can be debated directly with exploitation and use

Antarctic management will continuously involve management of activities in the Antarctic and Southern Ocean regions. These could be scientific programme development and ventures to fishing or exploitation ventures. Ecosystem services values will help inform the cost of impacts to the natural environment when performing cost-benefit analysis of future or existing ventures or systems. Environmental assessment for all activities within Antarctica is already required as a part of the Madrid protocol, the inclusion of ecosystem services within these assessments would allow direct evaluation of impacts and benefits from a human-centric perspective. Ecosystem services would already be indirectly covered within these environmental assessments, but explicit identification of impacts on services would allow better communication of implications of impacts with policymakers

in a more relevant manner. Explicit identification would also force users to discuss impacts in terms of a human perspective closer to their own instead of a disconnected environment whose values they may not be attuned with. Valuing of the impacts should serve to inform the lasting effects on the continent with the intent to maintain ecosystem stability and therefore ecosystem services.

Increased relevance of Antarctic topics

While the concept of ecosystem service is entirely humanistic and selfish in approach, it identifies what is of value for people and relevant for their wellbeing. In doing so environmental conservation becomes significant to the individual in a way that may more directly affect them. In this sense, the use of ecosystem services can be used to better communicate and evoke a response and environmental political awareness within the ATS and the wider public although this will not promote an altruistic or intrinsic value (Bekessy et al, 2018).

Administering environmental legal judgements

If in the future, liability to environmental damages or impacts may be enforceable. Valuing and quantifying ecosystem services can inform costs of damages to these services provided to humanity and with quantification of damages to ecosystem services or capital, liability in the form of a PES may inform future environmental justice for future events in the ATS.

Enforceable liability for environmental damage would serve both as a penalty and deterrent for organisations and individuals working within the area while also providing financial support for environmental reparations to the affected systems (Phelps et al, 2015).

Responding to SCAR Horizon Scan questions as they relate to ES

The Scientific Committee on Antarctic Research's (SCAR) 1st Antarctic and Southern Ocean Horizon Scan recognised the need to assess Antarctic ecosystem services by asking "What is the value of Antarctic ecosystem services?" (The 80 most important scientific question, 2017). While the majority of the questions imply SCAR understands Antarctica primarily as a source of knowledge, and its primary value contribution to ES as being knowledge/understanding, ie scientific-contribution SCAR nevertheless recognizes the lack of comprehensive understanding of Antarctic ES valuation beyond scientific contributions/knowledge. A better understanding of valuation would directly address this obviously, and also allow SCAR to communicate this understanding to those outside the research community, fulfilling one of its goals.

5 Conclusions

New opportunities and challenges are arising in Antarctica, this creates demand for new management strategies. These need to identify, characterise and assess the cultural, social and economic changes to these ecological systems to value the whole system of processes (Gren et al, 2015).

There are major gaps in knowledge as limited information exists about the type of ecosystem services and their economic value especially for services with non-economic value. They must rely on models to predict future environmental conditions, but these have limited capacity for incorporating feedbacks such as changes to behaviours or ecosystems. (MA, 2013)

More work needs to be done on tools and valuation approaches to properly capture ecosystem service valuation. Effective communication is also needed around valuation approaches that are not market-driven, but this too requires common language and tools with which to understand non-quantifiable valuations. To use market-driven language, it is important to convey the non-obvious costs of utilisation as well as the risks to ES themselves, or else risk inaccurate cost-benefit analysis or worse, upsetting the cooperation underpinning the ATS. Ultimately, governance bodies should be quite interested in attending to these challenges as it will make their jobs easier, advancing their goals, a fact also reflected in the SCAR Horizon Scan question around ES valuation.

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