UBC Social Ecological Economic Development Studies (SEEDS) Sustainability Program

Student Research Report

Integrated Valuation of Biodiversity

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University of British Columbia

RES 510

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1. Executive Summary

This project was mandated by SEEDS UBC, and was to be completed as part of our final project for RES 510 (Socio-ecological systems).

As the University of British Columbia is growing, it wants to expand and revive its infrastructure. In the past, this might have been done at the expense of other non-economic capital that still holds value for many of the stakeholders present on the campus. Currently, UBC Vancouver does not have a framework to support decisions that can integrate the ecological, social, and cultural values of the biodiversity (and resulting ecosystem services) present on campus. With this project, we aimed to review different biodiversity valuation frameworks to reflect on how they can be applied in the UBC context and to propose a toolbox as a starting point for decision-makers. Ultimately, we hope that our work can contribute to lay the foundation of a future biodiversity policy at UBC.

The first sections of the report focus on working definitions and the problem context, followed by an in-depth literature review. For the literature review, we approached the problem of valuation of biodiversity from four different perspectives: (1) landscape ecosystem relations, preferences and implications, (2) cultural and social dimensions of biodiversity, (3) urban system's role in biodiversity and ecosystem services, and (4) economic valuation of biodiversity. For each section in the literature review, we present case studies that can illustrate how the frameworks can be used to assess the ecological, social and cultural values of natural assets. Then, we present how the valuation of biodiversity fits within the UBC branding. We also discuss and review the different plans and policies that already exist at UBC and how a framework for biodiversity valuation could fit within those or add value. Finally, we make recommendations to apply the different frameworks in the UBC context.

Regarding our recommendations, for the valuation of social and cultural biodiversity at UBC, we suggest a mixed-method approach by using surveys or questionnaires to gather information from a large number of community members and focus groups to collect more nuanced data. Additionally, we also recommend that the role of biodiversity in the ecosystem structure be made central to bring multi-stakeholders to common decisions. Moreover, to put a monetary value on biodiversity and to understand opportunity cost, we propose the completion of a large scale discrete choice experiment survey that would reveal the UBC community's willingness to pay for biodiversity.

2. Introduction: Background and Definitions

2.1. What is Biodiversity?

Throughout this report, we will be relying on the definition of biodiversity as outlined by the UN Convention of Biological Diversity: "'Biological diversity' means the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems." (Convention on Biological Diversity, 1992, p. 3)

2.2. What is Ecosystem Services?

This report will apply the Millennium Ecosystem Assessments definition of Ecosystem Services: "Ecosystem services are the benefits people obtain from ecosystems. These include provisioning, regulating, and cultural services that directly affect people and supporting services needed to maintain the other services." (Alcamo et al., 2003, p. 49)

Biodiversity may underpin or regulate ecosystem services, or be an ecosystem service itself, but the two are not interchangeable (Seddon et al., 2016).

2.3. Why Valuation?

Why is it important and necessary to integrate the value of biodiversity into decision-making? According to Seddon et al. (2016), systems with higher levels of biodiversity are more stable and resilient to changes, enabling them to continue to provide the various values and services that societies depend on. Evidence continues to suggest that biodiversity is important for achieving sustainable development and for providing critical services and conditions necessary for human well-being (Seddon et al., 2016).

Decision-making tends to leave out biodiversity completely, partly because it is so complex to measure and value. There is no universal or standard approach to integrating biodiversity into decision-making processes, but rather a framework that integrates a diversity of valuation approaches may be better suited to encompass the range of services that biodiversity can be valued for.

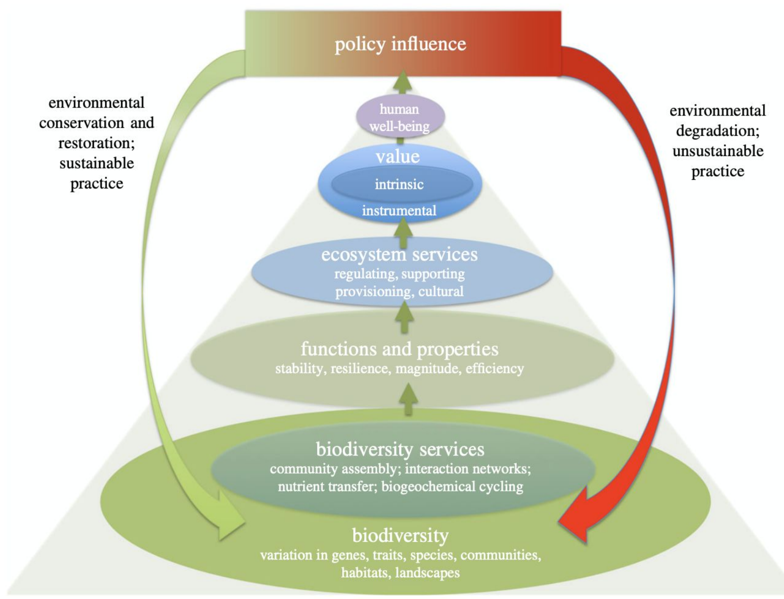


Figure 1: The value of biodiversity to human wellbeing is subject to policy influence (source: Seddon et al., 2016, p. 3)

The following report will present an overview of the diverse methods and approaches that have been used to value biodiversity and recommend a few approaches that UBC Vancouver can integrate into its future decision-making.

3. Problem Context

Currently, values surrounding biodiversity and ecosystem services are not well represented in decision-making at UBC Vancouver in regard to sustainable urban design and development. This is resulting in natural assets that are largely unrecognized, both for today and for the future.

3.1. Vision

A framework that can provide entry points for diverse disciplines/parties to engage in existing techniques/practices of biodiversity valuation and enable the integration of biodiversity valuation into decision-making processes surrounding future development at UBC.

3.2. Scope and Scale

We acknowledge that the University of British Columbia Point Grey campus is on the traditional, ancestral and unceded land of the xʷməθkʷəy̓əm Musqueam People. Valuation of biodiversity through the indigenous lens of the Musqueam People is outside the scope of this project.

This project will specifically consider valuation frameworks that are applicable to UBC Vancouver. This includes the university campus but does not include the University Endowment Lands.

3.3. Project Approach

We have undertaken a literature review of different economic and non-economic valuation methods for biodiversity, analyze the different strengths and limitations of different valuation methods, a project for UBC's biodiversity and make recommendations for action, data gaps, potential partnerships, and for future research to inform decision-making around sustainable urban design and development.

4. Literature Reviews

We have conducted a literature review comprising the state of knowledge in the academic and grey literature. This section details our findings in four reinforcing avenues in the valuation of biodiversity, presented here in the following order: Landscape and Ecosystem, Social and Cultural Dimensions, Urban Systems, and Economic Valuation.

4.1. Landscape and Ecosystem Relations, Preferences and Implications

Examining the socio-economic, biological, and cultural aspects of landscapes is inherently subject to the perspectives and lenses of the beholder. In an effort to properly contextualize the strategic landscape, scholars, conservationists, forest resource managers, and urban planners have repeatedly demonstrated the importance and benefits of examining user relations and preferences to landscapes (Cáceres et al., 2015; Clement & Cheng, 2011; Dearinger, 1979; García-Llorente et al., 2012; Herzog et al., 2000; Kaltenborn & Bjerke, 2002)

For the purposes of valuation, the same outcome has been demonstrated. By contextualizing the actor/user strategic landscape, decision-makers have been able to gain critical insight into actor-landscape dynamics, what drives user preferences, and areas of relational/preferential overlap and/or contention (Clement & Cheng, 2011; Kaltenborn & Bjerke, 2002). The emphasis being examining and eliciting perspectives that would not otherwise occur within conventional decision making groups (Wilkinson et al., 2007).

By and large, this has been accomplished using survey techniques and engaging diverse actor groups in decision making. Participatory, collaborative methods such as public meetings, symposiums, solicitation of written or verbal comments were used to acquire intimate knowledge on specific areas and issues from participating in actor groups (Clement & Cheng, 2011; Dearinger, 1979). However, Clement & Cheng (2011) outlined that this approach did not address the perceptions, preferences, and relations of the silent majority and the resulting information is highly subjective to the participating groups and study structure (Hermans et al., 2008). Multiple studies included large random sample surveys to assess overall population preferences and relations in addition to participatory methods (Clement & Cheng, 2011; Kaltenborn & Bjerke, 2002). Various groups conducted adaptive, deliberative processes where information was gathered and then reviewed/exchanged among groups to critically re-examine perspectives and understandings. Which provided situated and evolving feedback from either selected groups or the general population (depending on methodology) (García-Llorente et al., 2012, Hermans et al., 2008). However, with either design, the deliberative process was subject to the same drawbacks of its root methodology (random/selective) that authors either acknowledged or aimed to minimize through additional, complementary methods.

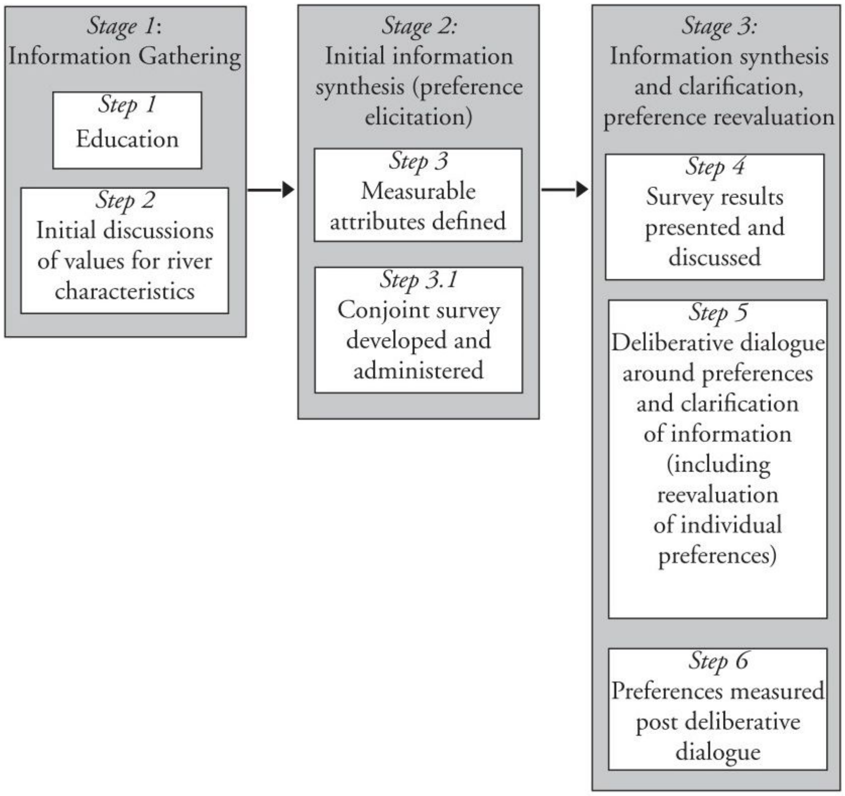


Figure 2: Methodology of deliberative process design for evaluation of preferences for river management. Adapted from Hermans et al., 2008.

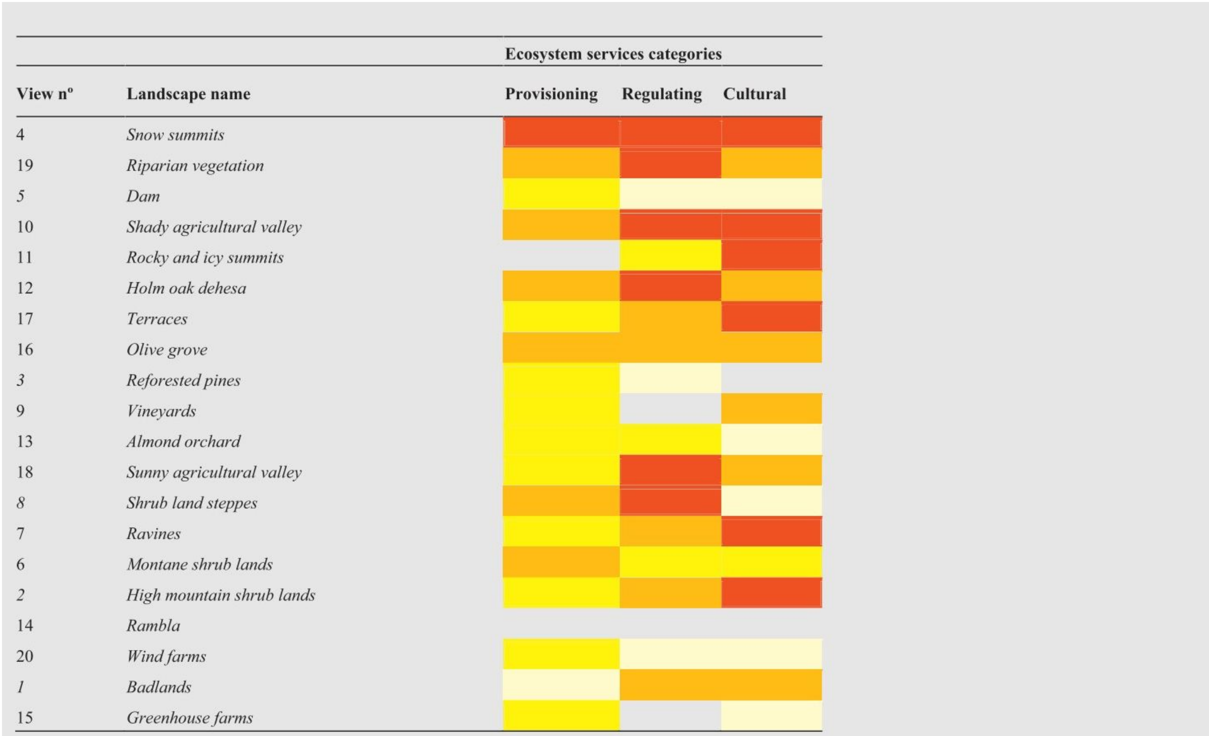
Structured interviews examining both preferences and user traits concluded that landscape preferences can be correlated to user's familiarity, their occupation, and lifestyle (Dearinger, 1979); with strong positive effect between respondent's place attachment and level of support for landscape conservation (García-Llorente et al., 2012). Groups were largely in agreeance on the polar extremes of what was deemed "very attractive" and "very ugly" but were ultimately divided on the in-between (Dearinger, 1979). Despite this, there was an overall trend of what the features of landscapes deemed attractive were between and among groups (Kaltenborn & Bjerke, 2002).

The score of "attractiveness" was not evaluated as what looks good to an individual or group (see Figure 2 above, dam ranked 3rd). Attractiveness was highly contextual, where multi-functional landscapes scored higher in terms of "attractiveness" with clear associations between landscapes that provided multiple ecosystem services and preferred landscape views (García-Llorente et al., 2012). However, it should be pointed out that although overall scores were higher for multifunctional landscapes, specifically which landscapes were higher, depended on the landscape relationships of the individual or group (García-Llorente et al., 2012; Herzog et al., 2000).

Studies examining relationships found that geography and socio-demography of social actors were indicative of relational and preferential discrepancies between actor groups (Kaltenborn & Bjerke, 2002). This finding prompts key considerations of equity and (mis)representation surrounding decision making (Takeda & Røpke, 2010). Evaluation of these discrepancies suggested "hotspots" where value orientations, preferences, and land relations indicate potential conflicts among and between groups (Clement & Cheng, 2011). The presence of which suggested points of intervention where participatory and collaborative methods across vertical and horizontal strata could ameliorate unrealized conflict and disproportionate effects (Clement & Cheng, 2011).

The literature concludes that the above approaches to the contextualization of social-ecological systems create pathways to balance ecological, socio-economic, and cultural aspects of landscapes and their respective ecosystem services (García-Llorente et al., 2012). Although no technique is all informative and multiple techniques and methodologies are required to paint a broader picture of both the ecological and strategic landscapes.

Case Study 1: The role of multi-functionality in social preferences toward semi-arid rural landscapes: An ecosystem service approach (García-Llorente et al., 2012)
Authors aimed to analyze the relationship between landscape preferences and landscape multifunctionality. Data were collected in three phases: first was the identification and categorization of landscape units from existing research, wherein 20 photos were selected each to represent a unit. The second was the assessment of preferences through random population sampling to cover a wide range of backgrounds and interests, using both use and non-use preferences (using the willingness to pay). Lastly, deliberative and participative processes were created to engage an expert focus group from different disciplines in identifying ecosystem services that are provided for each ecosystem. Ecosystem services were distinguished into provisioning, regulating, and cultural services, as well as each landscape, assigned a value on a land-use intensity gradient. Respondents' preferences were then analyzed and compared with expert's consensus on landscape functionality. Clear associations were noted between favourite landscapes and ecosystems that had diversified ecosystem services. Results showed very specific, detailed information on the preferences of a general populace (Figure 3) whilst providing managers with useful information on use/non-use preferences, ecosystem services, and land-use intensity.



Color	Relationship	Relationships description
White	Non-existing relation	Landscape views with no evidence of a relationship between the ecosystems represented and the ecosystem services categories
Pale yellow	Weak relation and non-diversified	Landscape views with a weak relationship between the ecosystems represented and the ecosystem services category, and where just one or two services were particularly associated
Yellow	Strong relation and non-diversified	Landscape views with a strong relationship between the ecosystems represented and the ecosystem services category and where just one or two services were particularly associated
Orange	Strong relation and partially diversified	Landscape views with a strong relationship between the ecosystems represented and the ecosystem services category, and where three or four services were particularly associated
Red	Strong relation and highly diversified	Landscape views with a strong relationship between the ecosystems represented and the ecosystem services category, and where at least five services were particularly associated

Figure 3: Demonstrates user relations based on focus groups with various landscapes and their respective ecosystem service categories. Landscape preferences are ordered from highly preferred (top) to least preferred (bottom). Adapted from (García-Llorente et al., 2012).

4.2. Cultural and Social Dimensions of Biodiversity

As scholars and practitioners in the Social-Ecological Systems field have emphasized, nature and people are not dichotomous systems; rather, social and ecological systems are intrinsically linked (Fabinyi et al., 2014; Folke et al., 2005; Holling, 1987;). Just as people have the potential to influence biodiversity within an ecosystem, the losses and gains of biodiversity can also significantly impact people, both positively and negatively (Griffiths et al., 2020). It is insufficient to attempt to assess and manage environmental resources using only biological or economic information, as it would ignore an important element of the system. Therefore, the cultural and social dimensions of biodiversity are critical components to include within a biodiversity valuation approach (Laurila-Pant et al., 2015). Despite this, socio-cultural perspectives are often overlooked within environmental decision-making and management processes (Hausmann et al., 2016).

In order to understand and measure the cultural and social dimensions of biodiversity, an ecosystem services framework is commonly used. Scholars have used ecosystem services as a bridge to integrating social values and dimensions into ecological understandings, assessments, and management (Chan et al., 2012; Diaz et al., 2011; Cáceres et al., 2015). While there are flaws in using an ecosystems services framework, notably its historic inability to account for socio-cultural values that are intangible and/or non-material such as spiritual or sense of place values (Fraser et al., 2016; Hausmann et al., 2016), it is challenging to find examples in the literature that assesses the socio-cultural values of biodiversity without some application of an ecosystems services framework (for exceptions, see Griffiths et al., 2020).

Challenging though it may be, several studies have attempted to provide frameworks and approaches to guide the assessment of cultural and social dimensions of biodiversity. Quantitative and qualitative tools have been used, although the conservation literature has noted that a mixed-method approach that applies both interpretivist, as well as positivist tools, is more effective in understanding the socio-cultural valuation of biodiversity (Fraser et al., 2016). Some of the most common methods used within the literature include (in no particular order) focus groups, semi-structured interviews, surveys/questionnaires, value-based indexes, photography and social media, and geospatial mapping. Studies that have applied these methods are summarized in Table 1, along with specific notes for applying each method in the UBC Vancouver context. Note that the majority of studies did not only apply one method but instead used a combination of two or more.

Table 1: Summary of methods to measure the social and cultural dimensions of biodiversity

Method	Sample usage	Notes for UBC Vancouver
Focus groups	(Cáceres et al., 2015) (Fraser et al., 2016) (Asah & Blahna, 2019) (Griffiths et al., 2020)	• Focus groups could be separated by different social actors, including could be students, faculty, staff, etc. • A very common way in the literature to identify social/cultural values - often, values are revealed through social interaction. • Enables the participation of more stakeholders and social actors than interviews, and more nuanced data than questionnaires.

Method (cont'd)	Sample usage	Notes for UBC Vancouver
Interviews	(Cáceres et al., 2015) (Fraser et al., 2016)	● Offers more in-depth and personal information than focus-groups for questionnaires. ● How to select participants to interview would be a challenge - time-consuming, and need to limit the number of participants.
Surveys or Questionnaires	(Asah & Blahna, 2019) (Griffiths et al., 2020) (Gkargkavouzi, Halkos, & Matsiori, 2019)	● A questionnaire that is co-designed with stakeholders is one way to elicit a wider response than only using focus groups or interviews.
Value-based Indexes	(Fraser et al., 2016) (Sun et al., 2019) (Gkargkavouzi, Halkos, & Matsiori, 2019) (Sherrouse et al., 2011)	● Useful for putting metrics and numbers on social/cultural valuation.
Photography and Social Media	(Oteros-Rozas et al., 2018) (Sun et al., 2019)	● An interesting way to involve participants in the research process: get students to take photos of the landscapes or parts of UBC they value most.
Geospatial Mapping tools	(Cáceres et al., 2015) (Sun et al., 2019) (Fraser et al., 2016) (Sherrouse et al., 2011)	● So much geospatial data that is readily available at UBC - opportunity to leverage that data. ● Method to visualize social/cultural valuation, and align with existing development strategies/tools.

The following two boxes outline specific case studies that use unique tools to measure social and cultural values of biodiversity and ecosystem services.

Case Study 2: Using Photography to Understand Residents' Social Values in an Urban Park

In this study by Sun et al. (2019), the authors used photography and GIS to strengthen their understanding of the social values of urban ecosystem services that are provided by a wetland park in Shanghai. The participants were instructed to take photos at the park of anything that positively affected their experience. Participants also filled out a post-experience survey that incorporated several social value types: aesthetic, educational, recreational, historic, life-sustaining, and therapeutic. The authors then analyzed the photos and used the Social Values for Ecosystem Services (SolVES) mapping tool to calculate a spatially-orientated value index (see Case Study 3 for more information about SolVES).

The results showed that the park successfully provides aesthetic, biodiversity, and life-sustaining values, but does not provide strong educational or historic values by visitors. The use of photographs enabled the authors to effectively document the real-time perceptions and on-site experiences of the participants, in comparison to asking participants to think back to their experience by responding to questionnaires or engaging in interviews or focus groups after they experience the park. This is an interesting exploration of a somewhat more unconventional valuation method.

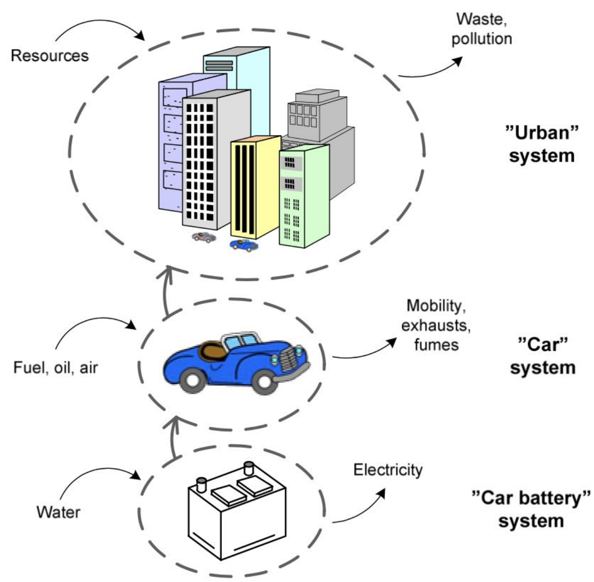
Case Study 3: Social Values for Ecosystem Services (SolVES)

Social Values for Ecosystem Services (SolVES, http://solves.cr.usgs.gov) was developed by the United States Geological Survey (USGS) in 2011 (Sherrouse et al., 2011). SolVES helps to assess, map, and quantify the perceived social values of ecosystem services, including cultural values, by calculating a quantitative, 10-point, value metric (a "Value Index") using both non-spatial and spatial responses to public value and preference surveys.

SolVES works with ArcGIS (and soon, QGIS), is free to download and use, and can be combined and layered with environmental spatial data. Index values can be compared within and between survey subgroups, facilitating the reflection of differing interests and needs across social actor groups. It is an interesting and useful tool to quantify the social values of ecosystem services in a non-monetary frame and to visualize how social values exist and change across a landscape. Since its development in 2011, it has been used to map the social values of ecosystem services of national parks, watersheds, and other landscapes in the United States, Australia, Peru, China, Japan, and Korea.

4.3. Urban System's Role in Biodiversity/ Ecosystem Services

This section explores the link between the built environment and biodiversity. The built environment includes all man-made structures and cultural landscapes that made up a society consisting of the physical, natural, economic, social and cultural capital (Hollnagel, 2014). The urbanization process has destroyed and fragmented the natural ecosystem, creating a functionally distinctive built environment ecosystem made up of both native and non-native biodiversity components (Müller et al., 2013). Conserving biodiversity is not simply setting aside undeveloped land, the interaction between the natural and built environment is dynamic and requires whole system thinking (Hostetler et al., 2011).



In the discussion between the 'built environment' and natural environment, the relational definition of 'built environment' will more precisely be understood as a *system*. For clarity, the 'built environment' is discussed as an urban system. An urban system can be conceptualized as of a city (Figure 4) where energy and resource are converted to produce waste and pollution, in which it also consists of multilevel subsystems, ie. a traffic system in the city consists of cars (subsystem) that consumes fuel and produce mobility, whereby a car also consists of a battery system (subsystem component) within itself which uses water for electricity output (Haraldsson, 2004).

Figure 4: A car battery is a subsystem of a vehicle, and vehicles are a subsystem of the city traffic. (source: Haraldsson, 2004, p. 15)

To have an efficient system analysis, it is important to recognize that most of the decision-making process is taking place within the urban system (Hollnagel, 2014) because it is how the urban system works that will influence the performance of the ecosystems. Urban systems handle and process resources and produce products, services, and wastes. The way urban systems work made cities the agglomeration of complex interactions between internal and external systems as well as their cumulative effects (Sassen, 2009). Humans as a population in the urban system are the consumers of the ecosystem services is also the biodiversity that supports the provision of ecosystem services, ie. landscape design that provides cultural services, which can be contributed by the ethnic diversity of the population. That to say, altering the way an urban system works could optimize the sustainability of biodiversity that supports it (Opoku, 2019).

We have established earlier that the health and abundance of biodiversity (subsystem component) will support the provision of ecosystem services to sustain human wellbeing (Seddon et al., 2016). Unfortunately, the effect of the expansion of the urban system often contributes to the loss of biodiversity (Forester & Machlist, 1996), while the relationship between land-use change and biodiversity losses is hardly understood empirically (de Chazal & Rounsevell, 2009).

Although the appreciation of biodiversity is broadly accepted, it is undermined, for instance, the indirect health value lost in economic valuation, ie. the therapeutic effects of urban trees, or the outbreak of infectious disease due to alteration in biodiversity equilibria (Brown & Grant, 2005; Grifo & Rosenthal, 1997). Recognizing the importance of biodiversity does not lead to an urban system decision on conserving biodiversity more apparent if its valuation fails to consolidate into mainstream accounting framework. In the decision context for ecosystem valuations, the monetary values for awareness-raising, economic accounting, priority-setting, incentive design, and litigation are often foregrounded against the underlying values (Barton et al., 2012, pp. 108–109).

The valuation of biodiversity in relation to the urban system is limited which many current studies are based on the valuation of the ecosystem services instead. Many ecosystem services valuation used for urban governance increasingly demands spatiotemporally rich and multiscalar analysis, which can be also costly to produce (Gómez-Baggethun et al., 2013). Some of the mainstream monetary methods used for urban ecosystem services valuations include hedonic pricing, travel cost, avoided cost (production or damage functions), replacement cost and stated preference (Gómez-Baggethun & Barton, 2013). *(More economic valuation see next section of this report)*. Reviews of hundreds of studies on urban systems markedly concluded with anticipated incomprehension, especially the knowledge gap in biological and cultural complexity (Botzat et al., 2016; Gómez-Baggethun & Barton, 2013; Hubacek & Kronenberg, 2013).

Case Study 4: Valuation of urban ecosystem services differs by stakeholders perspective

It is worth noting the valuation of the urban ecosystem services differs in methods depending on the stakeholder's perspective. Hubacek and Kronenberg (2013) synthesize 463 works of literature on urban systems into five broad categories: modelling studies, governance, tools, economics and social. With different perspectives and focuses on assessing urban ecosystem services for decision making yields a myriad of values, a direct correlation between different valuation is almost impossible, ie. pathway oriented policy instrument versus cost-benefit analysis. The following chart examines the Living Melbourne: Urban Forest Strategy through the lens of Hubacek and Kronenberg (2013)'s five perspectives to show the obvious mismatch in valuation metrics.

Category	Modelling studies	Governance	Tools	Economics	Social
Perspective	Environmental Science	Ecosystem Management	Urban Planning Support	Economic	Social Science
Focus/ Methods	Ecosystem components, types, interactions	Institutional structure, policy instruments, analytical tools	A physical tool, modelling tools, spatial and analytical framework	Valuation studies, cost-benefit analyses, economic consequences	Social behaviour, perception and norms
Living Melbourne Strategy - biodiversity metrics	Canopy mapping and bird species habitat likelihood modelling	Percentage of tree canopy cover target, species diversity	Ecological connectivity guild planning	The market value of honey production from bees, revenue from park tourists	Access to nature for physical and mental health

Figure 5: Analyzing Living Melbourne: Urban Forest Strategy valuation metrics (The Nature Conservancy & Resilient Melbourne, 2019) using the typology adapted from Hubacek and Kronenberg (2013)'s five perspectives of urban ecosystem services.

One of the critical missing connections in valuing ecosystem services is the *"scant knowledge on how they are produced, maintained, and affected by a system or abiotic changes and how they are related to levels of biodiversity"* (de Groot et al., 2010, p. 12). It is highly cautioned that targeting a specific ecosystem service value would neglect its other attributes in the underpinning biodiversity structure and functioning in the ecosystem, thus it is better to embed biodiversity in the core of all interacting ecosystem components that connect a collection of values (Cavanagh et al., 2016).

Case Study 5: Mapping ecosystem services capacity, flow and demand

One way to integrate ecological and cultural values in land use planning is the use of ecosystem services mapping that incorporated capacity, flow and demand. This ecosystem services spatial study analyzes the values for outdoor recreation and air purification to inform urban planning policy in Barcelona (Baró et al., 2016). This spatial modelling tool presents a comprehensive picture of the ecosystem services delivery that encompasses social and ecological dimensions for meaningful policy consideration.

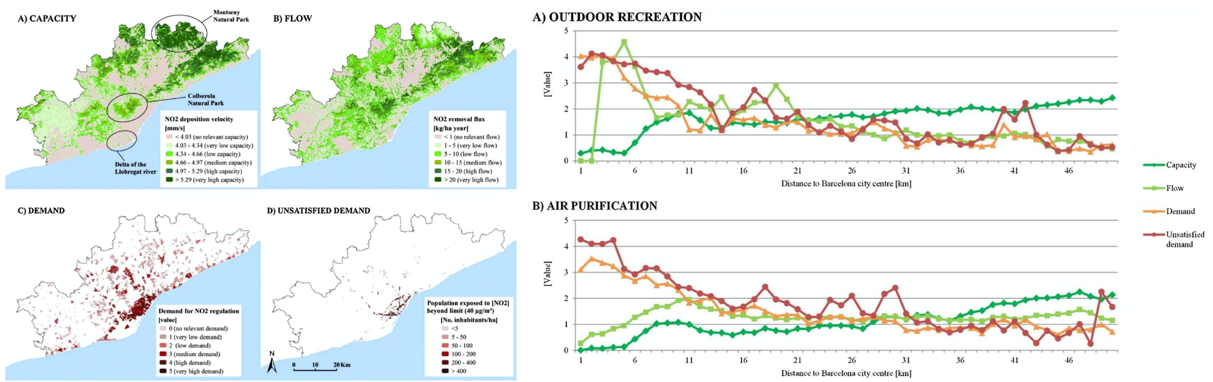


Figure 6: Capacity, flow, demand and unsatisfied demand maps; urban-rural gradients chart for air purification and outdoor recreation relative to and from the urban core (source: Baró et al., 2016, pp. 412-413)

Instead of a linear valuation, alternative approaches for effective urban biodiversity conservation are often advocated, here are three examples:

1. No single ranking of environmental goals using public derived values (economic, cultural, and aesthetic) will be adequate to protect biodiversity, a hierarchical approach can prevent a policy gridlock (Norton & Ulanowicz, 1996) (Refer to case study 6).

2. Recognizing the neoclassical economists' failure to measure ecological scarcity in natural stocks, Sassen (2020) proposes the ecological-economic model whereby humans must live on natural income produced by the remaining natural capital.

3. For co-beneficial pursuit, valuation on the potential health benefits from investment in natural capital could attract funding contributions from otherwise unlikely sources. For instance, linking the benefit of tree planting to health benefits to secure funding from health sectors for promoting a healthier environment (Refer to case study 7).

Case Study 6: Hierarchy of legislation and pathway to decision-making approach.

The State of Victoria's Marine and Coastal Policy uses a pathway approach to make biodiversity conservation protected by the legislation from harmful development planning.

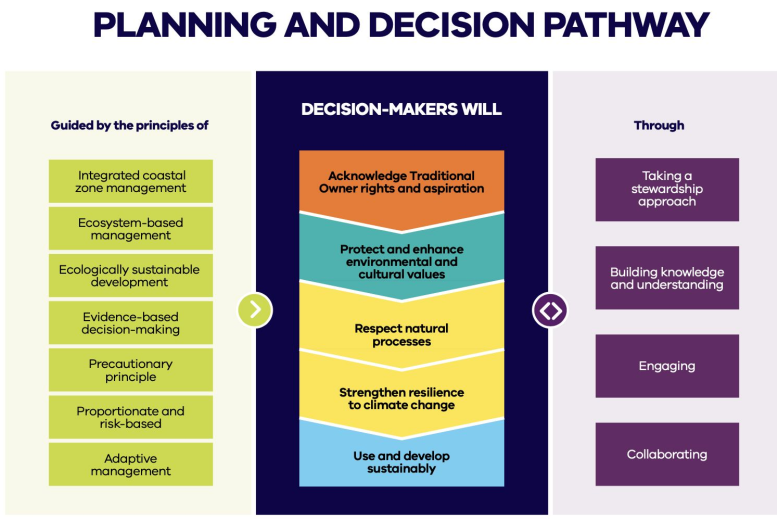


Figure 7: Planning and decision pathway developed to prioritize environment protection from harmful development. (source: The state of Victoria, 2019)

Case Study 7: Linking co-beneficial pursuit for innovative funding streams

Linking the benefit of increased urban forestry to the overall health outcome to secure funding from health sectors for promoting a healthier environment, an example from the Living Melbourne Urban Forest Strategy. Valuing the potential benefit transfer could secure funding from otherwise unlikely stakeholders.

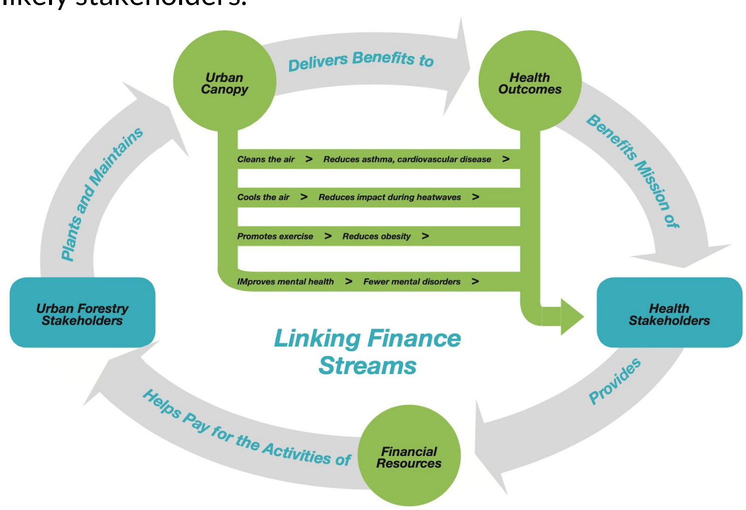


Figure 8: Innovative funding streams in the Living Melbourne Urban Forest Strategy (source: The Nature Conservancy & Resilient Melbourne, 2019, p. 131)

4.4. Economic Valuation of Biodiversity

It is unarguable that natural capital and ecosystem services hold an enormous economic value; a value that can even be said to be infinite (Costanza, 1997). In their seminal paper, Costanza et al. (1997) estimated the annual value of the world ecosystem services at US$33 trillion (in 1994 US$).

4.4.1. Why should we do economic valuation?

The valuation of ecosystem services can be thought of as undesirable because it feels crass to put a price on such “intangibles” concepts or because conservation of ecosystems should be purely moral (Costanza, 1997). That being said, Costanza (1997) argued that moral and economic arguments are not mutually exclusive and that we can reflect on both in parallel. Therefore, dismissing the economic valuation of biodiversity on moral high ground is not recommended. Both the frameworks discussed above and economic frameworks can be considered simultaneously.

Here are a few concrete reasons as to why we should use economic valuation (Pascual et al., 2010):

1. Create markets for natural assets and address market failures.
2. Understand and appreciate the opportunity cost.
3. May be useful for governments to design biodiversity and conservation policies.

In brief, the economic valuation of biodiversity is desirable for an institution like UBC because it can allow decision-makers to compare the value of change in biodiversity with the value of alternative options (e.g. investment projects) (Nunes & van den Bergh, 2001).

4.4.2. Valuation Techniques

The goal of economic valuation is to explicitly state trade-offs (Bartkowski, 2017) and to convey information to society about the scarcity of resources (Pascual et al., 2010). Ecosystems are scarce in economic terms because their conservation carries an opportunity cost (Pascual et al., 2010). That being said, economic valuation of ecosystems is undeniably an anthropocentric approach since ecosystems are viewed as tools to improve human well-being (Bartkowski, 2017). Through economic valuation, we can measure the value of marginal changes in the supply of environmental goods and services (Pascual et al., 2010; Bartkowski, 2017).

Although not the only valuation paradigm, most economic valuation of ecosystems are based on the total economic valuation framework concept (TEV) (Randall 1987), which is defined as the sum of the values of all service flows generated by natural capital now and in the future (Pascual et al. 2010). The idea that ecosystems have use value and non-use value that stems from their existence for future generations dates back to Krutilla’s paper called Conservation reconsidered (1967). Conceptually, the total economic value attributed to an ecosystem can be seen in Figure 9. Meta-analyses have shown that indirect use-value is the most economically valuable aspect of biodiversity (Costanza et al., 1997) due to its impact on ecosystem services (Farnsworth et al., 2015). For more details, the fifth chapter of The Economics of Ecosystems and Biodiversity (TEEB) (Kumar, 2010) gives examples for each of these use and non-use values.

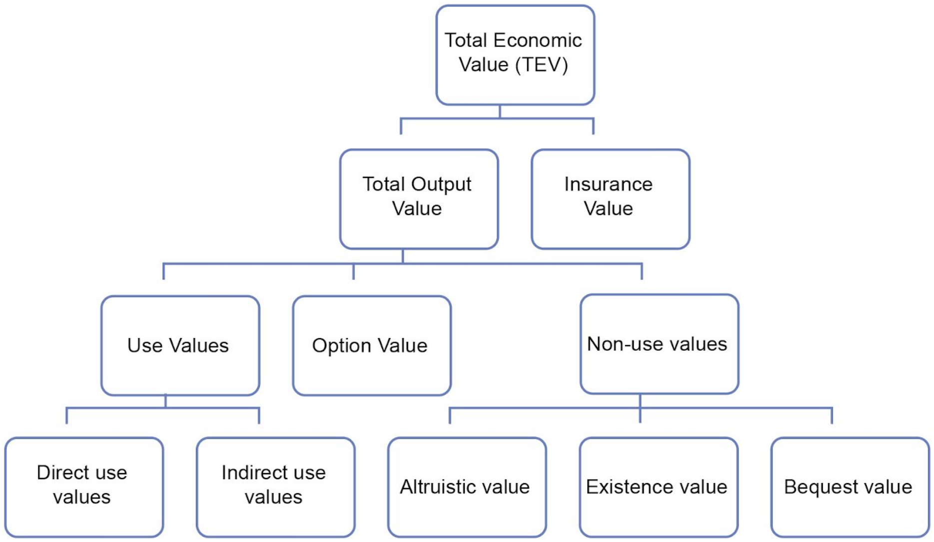


Figure 9. Total Economic Value framework for ecosystems and biodiversity. Adapted from Pascual et al. (2010) and Bartkowski (2017).

We will focus on economic valuation through stated preference approaches that have the potential to capture both use and non-use values (Pascual et al., 2010). The goal of these methods is to simulate a market and demand for ecosystem services through surveys on theoretical changes in the provision of ecosystem services (Pascual et al., 2010). Values are attributed to natural assets through people's willingness to pay (WTP) for the services that emerge from the assets (Pascual et al., 2010). Economic values are however not definitive (Bartkowski, 2017) but rather heterogeneous in space and time and dependent on socio-economic contexts (Barbier et al., 2009).

The most used types of stated preference surveys for the valuation of biodiversity and ecosystem services are:

- **Contingent Valuation (CV)**: Respondents are asked through questionnaires how much they would be willing to pay to increase the provision of ecosystem service (Pascual et al., 2010).
- **Discrete Choice Experiment (CE)**: Respondents are presented with a list of multiple mutually exclusive choices associated with a value and they have to state their preference among the choices (Hoyos, 2010). There is a trade-off between each choice (ibid.)

Biodiversity is a multi-level concept (organisms, taxonomic, community) that can be measured in various ways (e.g. structural diversity, functional diversity) (Farnsworth et al., 2015). The role of biodiversity in the ecosystem service framework is still unclear (Atkinson et al., 2012), and more generally, most people do not have a grasp on the meaning of the biodiversity concept. Therefore, some scholars think that the value of biodiversity can only be captured through proxies (Bartkowski et al., 2015). Bartkowski et al. (2015) classified biodiversity proxies within six attribute categories: numbers, species, genetics, functions, habitats and abstract. They found that the two most satisfactory approaches were functions (emphasizing the roles rather than the components) and genetics (carrier of the option value, future utility).

In their response article to Bartkowski et al. (2015), Farnsworth et al. (2015) disagreed with the conclusion on proxies and stated the importance of valuing biodiversity and not just valuing the preservation of perceived biodiversity attributes (called naturalness). This is to say that scientists from different backgrounds do not necessarily agree on how to accurately quantify the value of biodiversity. In their closing remarks, Farnsworth et al. (2015) concluded that more research on the relationship between ecosystem services and biodiversity is needed to ultimately improve valuation techniques.

Here are some case studies that could be valuable in the UBC context in terms of valuing biodiversity and green spaces more generally.

Case Study 8: The value of green walls to urban biodiversity
Collins et al. (2017) conducted a study in Southampton City in the U.K. attempting to capture the value of green walls for the population. This was done as a case study in partnership with the city council following their interest in the implementation of green walls in this densely populated city. The authors used a choice experiment survey with four different policies described in simple terms. The policies included two green walls choices, one living wall choice, and one status quo choice. For each choice, the only attributes described were the impact on urban biodiversity and the cost of the project per household per year. When answering the survey, respondents were given visual aids of the proposed projects and a section explained the impacts of green walls on biodiversity and subsequent benefits. The results showed that people were willing to pay around £27 to £35 for a green wall and around £38 for a living wall per household per year. When aggregating these scenarios for the entire region, it represented an aggregated annual WTP of £5.2 million for a living wall that would increase biodiversity and £4.8 million for a green wall. Finally, an interesting finding from this research was that people who knew what biodiversity represented prior to the survey were significantly more likely to choose the living wall option.

Case Study 9: A generic marginal value function for natural areas
Koetse et al. (2017) used a choice experiment survey to create a model using multiple variables that would assign a generic value to natural areas in the Netherlands. Their incentive to generate this marginal value function was to give policymakers a tool to acknowledge the trade-offs against the cost of conservation. They designed their survey in a way that did not refer to a specific site or area. The attributes used included the size and type of the area, the distance to the natural area as well as the accessibility for recreational use. The annual municipal tax increase associated with a project was also an attribute. The attributes were described in detail to the respondents and pictures were used to represent the natural areas.

The results showed that there were strong decreasing returns to size, which meant that a bigger area had a lower per hectare value than smaller areas. Also, the authors found that inaccessible areas had no value for consumers at all.
Equation 1 is the model that can be used to calculate the WTP for natural areas in the Netherlands based on the survey results. The I(*) are equal to 1 when the natural areas have the characteristics described in the brackets.

Equation 1. Willingness to Pay in Euro per household per year for natural areas.

$$
\begin{aligned}
&\mathrm{WTP}_{(\text{in Euro per household per year})} = \\
&\mathbf{I}(\text{grass}) \times €0 + \mathbf{I}\ (\text{water})\ \times €23 + \mathbf{I}(\text{forest}) \times €70 + \\
&\mathbf{I}(2 < \text{size}\ \leq 6\ \text{km}^2) \times (€6.7 \times\ (\text{size in km}^2 - 2)) + \\
&\mathbf{I}(\text{size} > 6\ \text{km}^2) \times (€27 + €1 \times (\text{size in km}^2 - 6)) + \\
&\mathbf{I}(\text{distance}\ > 5\ \text{km}) \times (-€3.8 \times (\text{distance in km}\ - 5)) + \\
&\mathbf{I}(\text{fragmentation urban sprawl: high}) \times -€30 + \\
&\mathbf{I}(\text{fragmentation infrastructure: medium}) \times -€17 + \\
&\mathbf{I}(\text{fragmentation infrastructure: high}) \times -€57 + \\
&\mathbf{I}(\text{area not accessible})\ \times -€73.
\end{aligned}
$$

Other notable findings included a higher willingness to pay for people with higher education. Finally, people that do not recreate in natural areas were not sensitive to the differences in type and size of the areas, but more sensitive to tax increases.

Case Study 10: Economic valuation of green and blue nature in cities: A meta-analysis

Bockarjova et al. (2020) performed a meta-analysis of economic values of nature in cities focused on WTP estimates from stated preference studies that captured both use and non-use values. This meta-analysis included 60 studies from around the world. They built a model to estimate the dollar value (in 2016 US dollars) of a hectare of urban nature per year.

They found that the average value of 1ha of nature in the city was around US$2249 per year but US$6656 /ha/year if it was elicited through choice experiment. They also found that parks have a much higher value than other natural areas at US$12,000 per ha per year. Like in the previous case study, they found decreasing returns to the size of a natural area. Income was also significantly related to WTP. A 1% increase in income yielded around a 1.5% increase in WTP for nature. Additionally, in densely populated areas, the per ha nature value was higher than in sparsely populated areas.

Bockarjova et al. (2020) also created a Europe specific model that showed overall higher average values for nature due to the higher income. These higher values would likely be similar to values that could be calculated in a city like Vancouver.

5. Biodiversity Evaluation in the UBC context

5.1 UBC Branding

For UBC, not only does biodiversity and natural areas hold value for the ecosystem services they provide to the campus and surrounding communities, but they also have a value as a "green brand" to attract and retain students from around the world. As an example, the City of Vancouver has demonstrated the strength of having a "green city brand", which was valued at $31 billion in January 2015 (Baum, 2015). However, the key to having a successful brand is authenticity (Ryan, 2016). UBC cannot be seen as being opportunistic in its effort to promote biodiversity on campus. If the university truly cares about natural conservation issues, then the branding will come by itself.

Biodiversity and natural areas are emphasized throughout both UBC's prospective undergraduate website (you.ubc.ca) and UBC's primary website (ubc.ca). Figure 10 and 11 are two screenshots that demonstrate how UBC has integrated its landscape and focus on sustainability within its own promotional messaging:

Figure 10: Screenshot of UBC's prospective undergraduate website (you.ubc.ca), highlighting its recognition as the "#1 most beautiful university in Canada" (assessed March 23, 2020; https://you.ubc.ca/ubc-life/vancouver/)

Figure 11: Screenshot of UBC's website (ubc.ca), highlighting its recognition as the "1st in Climate Action" and "1st in Sustainable Cities and Communities" under the Times Higher Education (THE) University Impact Rankings (assessed March 23, 2020; https://www.ubc.ca/about/our-place.html)

Several of the top facilities that UBC Vancouver highlights on their website are tied to biodiversity and green spaces, including:

- The Beaty Biodiversity Museum
- The UBC Botanical Garden and Centre for Plant Research
- The UBC Farm — the only working farm in the city of Vancouver
- Nitobe Memorial Garden

Biodiversity plays a role in the retention of students as well. A recent SEEDS project found that of the various factors that influence recruitment and retention of university students, place plays a significant role at UBC Vancouver, with green spaces being of particular importance for student retention (J. Kew, personal communication, March 18th, 2020). In response to these findings, the project authors recommended that UBC Vancouver directs resources to create a greater variety of green spaces on campus, preserve and enhance perceptions and connections to these green spaces and other natural assets, and use them to enhance educational and social opportunities (J. Kew, personal communication, March 18th, 2020).

5.2 Relevant Plans and Policies

A biodiversity valuation framework would not be out of place in the UBC decision-making and planning context. In addition to an upcoming Biodiversity Plan, there are multiple plans and policies that have been published and put in place that are relevant to the biodiversity and natural areas at UBC Vancouver, and that could provide some foundational justification for the integration of a biodiversity valuation framework. These plans and policies are included and summarized in Table 2.

Table 2: UBC plans and policies relevant to the integration of biodiversity valuation.

Plan/Policy	Relevancy to Biodiversity Valuation	Evidence from text
Green Building Action Plan	The goal of this plan is to positively impact UBC's human and natural systems. The plan specifically includes biodiversity as one of its eight component areas.	"By 2035, UBC's buildings will make net positive contributions to human and natural systems." (p.7) The two-component goals under Biodiversity are: "[1] UBC will develop highly functioning landscapes at the building and site scales to contribute to biodiversity and natural ecosystem processes; [2] UBC will engage campus teaching and research opportunities to enhance biodiversity management capacity" (p. 22)
Land Use Plan	The way UBC manages its natural assets and biodiversity is grounded in its management of the land. The vision that this plan describes includes a campus that values natural spaces and integrates them into other parts of campus life. Goals centred around "Ecology" are included throughout the plan. Land Use is split into three main categories, one of which being "Green Academic", which includes open areas that support land-based teaching, research, etc. It explicitly denotes which greenspaces are to be maintained and protected from development.	The plans vision statement includes direct phrasing related to natural areas and ecology including: "The community is planned, designed, constructed and inhabited with respect for the land and its patterns- natural, cultural, and historical. The community harmonizes with its setting and its academic core. Residents, staff and students join in stewardship for the environment including Pacific Spirit Regional Park" (p. 6) "This vision is about a university community, and adjacent park, that strives to balance ecological health, economic viability, and community' (p. 6) Included within the Neighbourliness objectives are: "Inter-related land use and transportation systems will be managed to mitigate the adverse impact on adjacent areas. Linkages between open spaces and natural areas on- and off-site will be included." (p. 9)

Technical Guidelines on exterior	These guidelines outline technical instructions for how to care for and manage UBC's various exterior features, including the plants and green spaces that make up the bulk of UBC biodiversity.	Guidelines that refer to the maintenance of campus plants include: "Maintenance shall include all measures necessary to maintain plants in a vigorous, healthy, normal growing condition, providing an appearance characteristic of their species and appropriate to their surroundings. (Section 32 01 90, p. 3) "Note that use of toxic chemical pesticides for cosmetic purposes is suspended on UBC Campus" (Section 32 01 90, p. 4)
Climate Action Plan 2020	Climate action is intrinsically linked to biodiversity. Several of the goals outlined in this plan relate to the biodiversity at UBC, especially those referring to measuring carbon within trees. Climate action is also connected to UBC's brand as a sustainability leader. As noted on the Climate Action Plan website, "We commit our entire community, including our land, assets and utilities, to sustainability research, teaching and learning".	Included under the co-benefits of climate action; "Bolstering UBC's internationally recognized reputation and leadership in climate action and sustainability in operations and the academy" (p. 9) Complementary opportunities for future consideration include: "Research UBC's tree inventory and calculate the amount of carbon sequestration that they account for per year; Explore opportunities to deduct the amount of carbon that is being sequestered by trees within non-designated areas (i.e. parks) to be used as a credit towards carbon offsets." (p. 29)
Vancouver Campus Plan	UBC's Vancouver Campus Plan aligns with and falls under UBC's Land Use Plan. It includes specific goals and considerations that relate to biodiversity. One of the five strategies outlined in the plan is to "Rediscover UBC's sense of place and natural west coast beauty" (Campus Plan Synopsis, p. 6). The importance of nature and ecological goals are emphasized throughout the plan.	The plans "Rediscovered Sense of Place" goal is one of the most directly related to biodiversity. Within the Campus Plan Synopsis, this goal outlines the following objectives: "Accentuating the Natural West Coast Setting: The west coast setting of UBC's Vancouver campus will be featured by emphasizing the forest setting along with the campus' western edge and designing strong indoor-outdoor relationships between new buildings and their surroundings. Celebrated views will be captured through at-grade viewpoints and by strategically locating some social spaces on the upper floors of buildings and the mixed-use hubs." (Campus Plan Synopsis, p. 10-11) "Improving the Public Realm: UBC's Vancouver campus is well known for its landscape... As new facilities are developed and the greenways are completed, more space can be added to the network. Implementation of the Public Realm Plan capital improvements over the next 15 years will bring renewed beauty, visibility and cohesiveness to the campus." (Campus Plan Synopsis, p. 11)

Integrated Stormwater Management Plan	This plan's objective is to manage stormwater on campus in a way that prevents flooding while also responding to ecological needs. Several of the strategies this plan outlines have been designed in a way to also consider biodiversity, and its overall goal is to manage stormwater while also improving the environment by incorporating a "natural systems approach".	Within the executive summary, the following passages are featured: "Opportunities exist and are strongly supported by the University, to take a natural systems approach for stormwater handling. Measures such as green roofs, cisterns, detention facilities, bioswales, rain gardens, etc., are considered part of the solution." (p. 3) "The purpose of this Integrated Stormwater Management Plan (ISMP) is to consider the complete rainwater cycle and outline stormwater management tactics that aim to improve the local environment, mitigate risk, and maintain wildlife and their habitats." (p. 3)
Water Action Plan	The overarching goal of this plan is to manage water use in a way that aligns with UBC's sustainability goals - this includes environmental goals, which is relevant to biodiversity. Of the five key action areas this plan identifies, one is "Landscape and irrigation". The goals and strategies outlined under this action area have implications for biodiversity management as they relate to building a more resilient landscape and vegetation systems on campus through irrigation and drought-management.	Under the "Landscape and irrigation" action area, the context provided is as follows: "With anticipated impacts of climate change, these drought periods will continue or increase, resulting in more stress on plants and potential loss of soft landscape assets. Going forward, the actions identified here can provide guidance for the transition to a landscape that is better adapted to these changing conditions and less dependent on potable water for irrigation. This trajectory will increase landscape resiliency, reduce the loss of plants due to drought stress, and reduce overall irrigation water demands. Landscapes can be classified to identify "priority" areas that will meet a higher standard of irrigation, maintenance and aesthetics, and underutilized irrigated grass areas could be retrofitted with drought-resistant landscaping." (p. 20)

6. Recommendation Toolbox

Landscape and Ecosystem Dimension

To contextualize strategic decision making with respect to human-landscape interactions, there are vast combinations of approaches and methodologies depending on social-ecological history, placement, current political climate, etc. However, a few key insights that have been common across the literature:

Ensuring the **meaningful participation** of actors and groups outside of conventional decision making whilst being cognizant of power dynamics, cross-cultural dialogue, and different epistemologies.

Utilizing both **intensive, small, focused surveys** and **broad, random, generalized surveys** to get insightful, group-specific information, whilst hearing from the silent majority and assessing general population sentiments respectively.

Who is included and the structure of surveys will have very significant results on study outcomes. Utilizing a **mixed background expert focus groups** in deliberative processes can provide background information before conducting preference and relational surveys. Again assessing context outside of the body of knowledge of decision-makers is critical for viewing the scope of the problem through alternative lenses and perspectives.

Create an **inclusive framework** for different definitions and understandings when engaging in cross-cultural/actor dialogue.

Social and Cultural Valuation

In order to ensure social and cultural values of biodiversity are integrated into UBC Vancouver's decision-making context, we recommend applying a **mixed-method approach** that combines both quantitative and qualitative methods.

Quantitative methods that we recommend include both **questionnaires/surveys** and **mapping** (e.g., using the SolVES tool). Surveys would enable a wide range and a large number of UBC community members to participate in the process and are relatively simple to circulate. Spatial mapping is visual and engaging, aligns with existing methods of planning and decision-making at UBC, and would be able to leverage the large amount of geospatial data that already exists for the UBC Vancouver campus.

As for qualitative methods, we recommend the use of **focus groups** as they offer a good combination of both nuance in data and larger sample sizes, and are useful for understanding values from a diversity of social actors (e.g., can set up focus groups for students, faculty, and staff separately).

We also recommend that UBC Vancouver pays particular attention to the **sense of place** as a key socio-cultural value to integrate into decision-making. Sense of place represents the way people perceive and interpret their environment, and a strong and positive sense of place within a community has been shown to drive tourists to visit certain locations, to increase productivity, and to strengthen social capital, among other benefits (Hausmann et al., 2016). Due to UBC

Vancouver's identity and brand as a place of learning, and the goal to attract and retain community members, the sense of place is critical to consider in any sustainable development decision. As this is explicitly recognized within UBC's Vancouver Campus plan, with "Reinforcing Sense of Place" included as a key goal (see Table 2 for more details), the groundwork required to support this focus is already in place.

Urban System Valuation

One way to solve a complex system problem is to construct a system analysis by modelling a **causal loop diagram**. Intervention using measures in modifying behaviour will lever a change in the system feedback loop to achieve the desired outcome (Haraldsson, 2004).

Mapping and spatial analysis can be effective in bringing together a myriad of perspectives (ecology, governance, planning, economic and social) for meaningful valuation beyond dominant values.

Effective biodiversity conservation at UBC relies on biodiversity as a causal variable within the ecosystem services valuation for sustainable development outcomes. **Centralizing the role of biodiversity** in the ecosystem structure and functioning valuation is pivotal in bringing commonality into multi-stakeholders decision making — see Cavanagh et al. (2016) for the conceptual diagram. For instance, the valuation of urban trees needs to take into account the biodiversity (soil health, complementary species, water and nutrient loads) that sustains them.

Leverage of policy tools such as a hierarchical approach can safeguard difficult valuation tradeoffs in monetary valuation. **Innovative funding mechanisms** like benefit transfer could favour biodiversity valuation at investment avenues.

Economic Valuation

Ultimately, finding one specific proxy to value biodiversity at UBC is not necessarily a worthwhile exercise. As Bartkowski et al. (2015) emphasize, no single proxy is perfect for biodiversity valuation. From our conversation with UBC employees, the important aspect of this valuation process is being able to put a monetary value on natural areas, even small ones, in order to show the opportunity cost of removing nature to build infrastructures.

If UBC is looking to put an economic value on biodiversity, we would, therefore, recommend having a broader approach less focused on the concept of biodiversity itself and more on natural areas in the larger sense. We suggest that UBC conduct a **large scale discrete choice experiment survey** with multiple attributes such as type of natural area, size, accessibility, and cost similar to the work of Koetse et al. (2017). Each attribute would have multiple levels. With this data, it would be possible to build a **UBC specific valuation model** that could put specific values on a range of natural areas around the UBC Vancouver Campus. With this model in hand, the opportunity cost of new infrastructure projects could be weighted by decision-makers.

7. Conclusion

The state of the literature draws into light many complex and chronic problems associated with integrating biodiversity valuation into decision-making, and while there is a diversity of possible methods to approach this task, there is no universal or standard method. This report offers insight on several methods across multiple disciplines and perspectives to valuation, including landscape and ecosystem relations, socio-cultural dimensions, urban systems, and economic approaches.

Biodiversity valuation can be conducted through ecological, social, cultural, and economic frames. In order to fully account for the value of biodiversity into decision-making, a diversity of approaches that bring in perspectives from all of these frames is required. Tradeoffs are an inherent part of decision making and land use planning, however using only a simplified numerical approach masks the complexity of the problem and distances the decision-maker with the consequences and outcomes. Diversified ecological, political, cultural, and societal landscapes at UBC Vancouver demand equally diverse approaches.

In addition to these approaches, we would suggest conducting deeper research in close collaboration with the Musqueam People to include their traditional ecological knowledge in the valuation biodiversity frameworks. Their unique perspective on biodiversity could unfortunately not be addressed within this project.

Integrating the value of biodiversity into decision-making at UBC Vancouver will therefore not be a simple task, but it is an important one. Biodiversity plays a critical role in system resiliency, underpins the ecosystem services that human wellbeing relies on, and is a necessary consideration in the pursuit of sustainable development. Additionally, both sustainability and the beautiful natural characteristics of Canada's west coast are core pillars of UBC Vancouver's branding and feature prominently throughout UBC's existing development plans and policies. The integration of biodiversity valuation into decision-making does not only align well with the institution's goals and vision for the future, but it may be necessary to maintain its identity.

This report provides a toolbox, with a selection of recommended methods and approaches, to enable the integration of biodiversity valuation within development decision-making at UBC Vancouver. It is our hope that future frameworks, initiatives, plans, and studies will find use in this synthesis to make ethical, equitable decisions as UBC continues to grow, develop, and lead.

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