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THE MEEWASIN NORTHEAST SWALE: USING NATURAL CAPITAL ASSET VALUATION TO VALUE SASKATOON'S NATURAL RESOURCES

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Abstract: The Meewasin Northeast Swale (Swale) is a 26-kilometre long, 2,800-hectare span of ancient prairie, riparian, forest, and wetland located partly in northeastern Saskatoon, Saskatchewan. Ancient grasslands and wetlands are endangered ecosystems and home to a wealth of biodiversity, yet this geologically & ecologically unique ecosystem is threatened by urban development including encroaching subdivisions and bisecting roadways. Despite these threats to the Swale's health, there has been no substantial environmental impact monitoring of this area. Additionally, the full value of the Swale – in terms of economic, sociocultural, and environmental value – has not been fully accounted for. There are two major objectives being addressed in this research. The first is to identify the three to five key ecosystem services provided by the Swale. The second is to estimate the monetary value provided by these key ecosystem services using a natural capital asset valuation (NCAV). Currently, we found that the Swale is 310 ha and dominated by wetlands 44% (138 ha) and grasslands 39% (122 ha) with limited areas for woodlands 6% (7.1 ha) and croplands 2% (19.8 ha). Overall, the ecosystem service valuation database (ESVD) data used for this study included 36 data points from 21 data sources that were used to determine 12 ecosystem service values. In total, the Swale's ecosystem services are valued at an estimated \$1.6 million per year and are dominated by wetland ecosystems and the ecosystem services of water regulation (\$1.03 M per year) and water purification and treatment (\$447 K per year).

1 INTRODUCTION

The consideration of trade-offs is an integral part of environmental management decision making. Every day trade-offs are made, in Canada and worldwide, that can lead to the sacrifice of natural environmental health for the sake of manufactured capital gain. Every environmental management decision implicitly places a value on the natural environmental "capital" being managed, yet the full value of this natural capital – in terms of economic, sociocultural, and environmental value – is often misunderstood. This deficit of understanding leads to a lack of incentives to preserve natural capital – especially in urban areas where manufactured capital is highly valuable and natural capital is most threatened due to the lack of true assessment of its economic value. Natural capital should be accounted for, and evaluated to, support enlightened, environmentally-conscious decision making based on the services that ecosystems provide to humans. The Northeast Swale, an urban, data-scarce green space in Saskatoon, Saskatchewan – given its location within the City and the ongoing expansion of the City around this green space – is an ideal area to pilot an accessible method of natural capital asset valuation (NCAV) based on ecosystem services.

Ecosystem services are defined as the contribution's that ecosystems make to human wellbeing (TEEB 2010). This is differentiated from general ecosystem functions (the natural processes of an ecosystem) by

the concept of adding the additional requirement of consideration of the direct benefit to humans. Ecosystem services are commonly divided into four categories:

- **Provisioning:** The bestowment of goods, such as food, water, and energy. Since many of these goods are exchanged through a market, the valuation of provisioning services may often follow neoclassical market-based approaches (Farber et al. 2002).
- **Regulating:** Services which improve physical goods such as air and water purification, mitigate damage such as water regulation, or support productivity such as pollination.
- **Cultural:** The intangible benefits of ecosystems, such as contributing to sense of place, education, recreation, etc.
- **Supporting:** Services which serve to support the previous three categories, such as nutrient cycling and photosynthesis.

The term *ecosystem services* was first coined in 1981 (Gómez-Baggethun et al. 2010, Ehrlich and Ehrlich 1981), however, the general concept had been alluded to in the 1950s and possibly earlier. As indicated by the categories above, ecosystem services include both goods and services provided by ecosystems. Although the term started as a utilitarian concept used to point out that ecosystems have value, there has been an increasing shift towards the mapping, quantification, and NCAV of ecosystem services. This shift presents a challenge as determining the financial value of these services is not a straightforward process and will vary widely amongst different ecosystems.

The Meewasin Northeast Swale (Swale) is a natural area of geological and ecological significance in Saskatchewan, Canada. Urban development surrounding the Swale threatens this environmental feature, yet no substantive explorations of the impacts of this development have been conducted. The value – in terms of economic, sociocultural, and environmental value – of this natural capital is not fully accounted for. There are two major objectives being addressed in this research. The first is to identify the three to five key ecosystem services provided by the Swale. The second is to estimate the monetary value provided by these key ecosystem services. Although the estimated value of the Swale will only account for a minority of the services which contribute to the Swale's overall value, valuing only the key services is an accessible way to determine whether it is worthwhile to conduct the intensive work necessary for a more accurate valuation. This research will provide the first step in the creation of a methodology for NCAV for natural areas of the City of Saskatoon, and beyond. This NCAV will assist in the implementation of a triple bottom line (TBL) approach to development that includes financial, social, and environmental impacts and values in the decision-making process.

2 METHODS

2.1 The City of Saskatoon and the Northeast Swale Study Area

The Swale is a channel scar covering 2,800 hectares and spanning 26 km from Peturrson's Ravine in northeastern Saskatoon to the Rural Municipality of Aberdeen (Figure 1). The Swale was formed as a drainage passage during the last glacial retreat, 15,000 years ago. This span of unbroken prairie, riparian, woodland, and wetland is a geologically and ecologically unique area – not only in the scope of Saskatoon, but within the Greater Prairie Region (Meewasin 2015). Native grasslands are regarded as one of the most endangered ecosystems on the planet (Gauthier and Riemer 2003) and over 50% of wetlands in the Prairie Pothole Region have been drained (US EPA 2018). The Swale not only hosts these endangered ecosystems, but also a diverse range of over 200 plant species, over 100 bird species, mammals, amphibians, reptiles, and insects (Meewasin 2017). These flora and fauna include several rare, endangered, or culturally significant species, including (Meewasin 2017):

- **Plants:** crowfoot violet; western red lily; narrow-leaved water plantain; and sweet grass.
- **Birds:** Sprague's pipit; barn swallow; loggerhead shrike; horned grebe; short-eared owl; common nighthawk; and sharp tailed grouse.
- **Amphibians:** northern leopard frog.

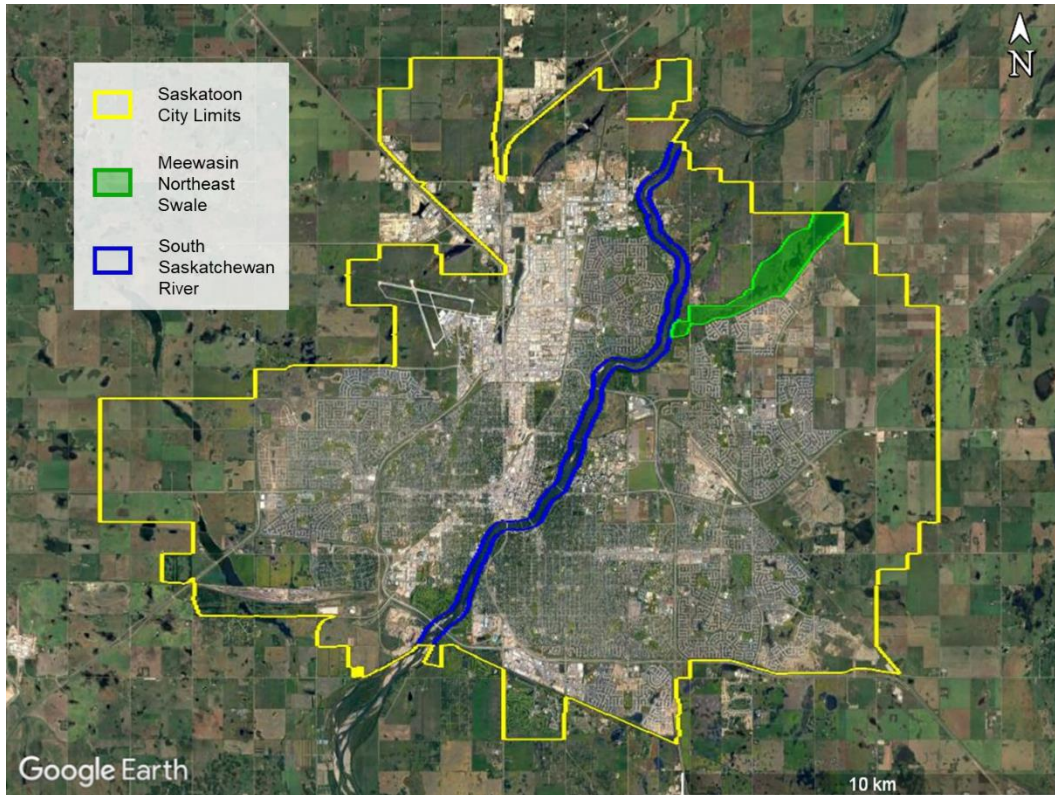


Figure 1: The delineation of the City of Saskatoon (yellow), the Meewasin Northeast Swale (green), and the South Saskatchewan River (blue) (52°08'N, 106°41'W)

A portion of the Swale – about 5 km long and 300 hectares in area, as shown in Figure 1 – lies within the City of Saskatoon city limits and the Meewasin Valley Conservation Area (Meewasin 2015). As this area is entirely owned by the City of Saskatoon, and managed by Meewasin, it serves as the current study area for this research. The remaining area of the Swale is under the jurisdiction of the Rural Municipalities of Corman Park and Aberdeen (Meewasin 2015). Incorporating the area outside of Meewasin’s jurisdiction into this study area would be a great way to expand upon this project in the future but would be contingent on stakeholder engagement. Thus, the scope of this current natural capital asset valuation (NCAV) will be limited to the City of Saskatoon section of the Swale

2.2 Mapping of the Northeast Swale

As for many natural green areas in urban environments, the Swale is composed of a variety of different ecosystems and human manufactured ‘features’ that each contribute to (or take away from) the value of the area through different ecosystem services (discussed in the following section). For the current analysis, the Swale was divided into its component ecosystems through satellite imagery interpretation of the Swale landscape. This delineation was adapted from Stantec’s (2012) wetland classification of the Swale, while including the addition of new roadways and engineered stormwater management (SWM) areas that did not exist in the previous 2012 mapping. As ecosystems do not have objective boundaries, such a delineation is not intended to be perfect. Rather, this delineation is intended to provide an estimate of the percentage of the overall area of the Swale taken up by each ecosystem for use in the current ecosystem service valuation. As well, the boundaries change markedly over time (for example, with urban expansion) and need to be assessed frequently. Thus, future work for this research area will include up-to-date unmanned aerial vehicle (UAV or drone) imagery that will further refine the Swale delineation. This work is anticipated to commence in summer of 2019.

2.3 Identification of Key Ecosystem Services and NCAV

The valuation of the Swale was conducted using the benefit transfer method (Johnston et al. 2015, Richardson et al 2015). Benefit transfer is a method of taking other, similar existing ecosystem valuation data and applying it to an area it was not originally collected for. This benefit transfer allows for the implementation of existing data to areas, such as the Swale, where sufficient data is not readily available. Currently, the required previous study data were gathered from an existing ecosystem service valuation database (ESVD) (Van der Ploeg and de Groot 2010). The ESVD is a publicly available database of previous ecosystem valuation studies, consisting of 1,310 values from over 300 case studies, put together as part of the Economics of Ecosystems and Biodiversity (TEEB) initiative (Van der Ploeg et al. 2010).

The ESVD allows for the convenient sorting and filtering of ecosystem valuation data by ecosystem type, service, valuation method, study location, among others. Currently, values from benefit transfers were avoided, although were transferred in cases where no other suitable studies were available. Avoided cost was favoured for climate regulation and water regulation, while both avoided cost and replacement cost were used for water treatment & purification. Contingent valuation was favoured for recreation, tourism, & lifestyle, although travel cost was also included as a method for the transferred values. Additionally, only values reported as a currency per unit area per year (e.g., USD\$/ha/y) were used as these allowed for easy extrapolation to the current study areas. Values taken were corrected for inflation (based on 2018 dollar values) and standardised to Canadian currency given the Swale location. Each of the selected studies was individually reviewed to ensure it was an appropriate analogue for the Swale; only studies deemed appropriate were then included in the analysis. This evaluation was inherently subjective but informed by present knowledge of the Swale ecosystem. For ecosystem service combinations with multiple available studies, the average value was used (CAD\$/ha/y). Finally, the values were multiplied by their calculated areas within the Swale, resulting in a value in CAD\$/y. These values for each service and ecosystem and service were summed to determine an overall value for the study area.

3 RESULTS & DISCUSSION

3.1 Northeast Swale Mapping

The Swale was delineated following the mapping completed by Stantec (2012) with the inclusion of the “features” of roadways and engineered stormwater management (SWM) areas. In addition, the Swale has been separated into ecosystems including cropland, forest, grassland, and wetlands. These features and ecosystems are shown in Figure 2 with additional area information provided in Table 1.

Overall, the Swale area is 310 ha which is dominated by wetlands and grasslands at 44% (138 ha) and 39% (122 ha), respectively (Table 1). The remaining ecosystems have more limited areas in the Swale at 6% (7.1 ha) and 2% (19.8 ha) for woodlands and croplands, respectively. Interspersed prairie wetland and grassland provide numerous ecosystem services, including water regulation, carbon sequestration, and serve as an important breeding ground for North American waterfowl (Gascoigne et al. 2011). Although the value of woodland may most commonly be associated with timber provisioning, watershed protection and erosion regulation are perhaps the most important woodland services (Croitoru 2007). Cropland is land that has been cultivated to focus on the provisioning of food, but certain agricultural practices – such as the overapplication of fertilizers – are a risk to downstream ecosystems. Yet, cropland is not the only type of cultivated land impacting the Swale.

Manufactured features comprise of approximately 8% of the Swale area. These features include about equal areas of roadways and SWM with 4% (12.4 ha) and 4% (12.2 ha), respectively (Table 1). Roadways are necessary for the interconnectivity of the growing municipality of Saskatoon. However, roadways are problematic because they can prevent the natural migration of wildlife, interrupt ecosystem processes, and are potential sources of pollutant contamination (Stantec 2012). SWM takes the form of engineered wet and dry ponds within the Swale, intended to regulate and purify water from surrounding neighbourhoods during storm events and spring melt. SWM is a valuable feature within the Swale, but the influx of stormwater into the Swale from these neighbourhoods threatens the natural hydrological conditions of the Swale and the unique plant communities that are dependent on these natural conditions (Stantec 2012).

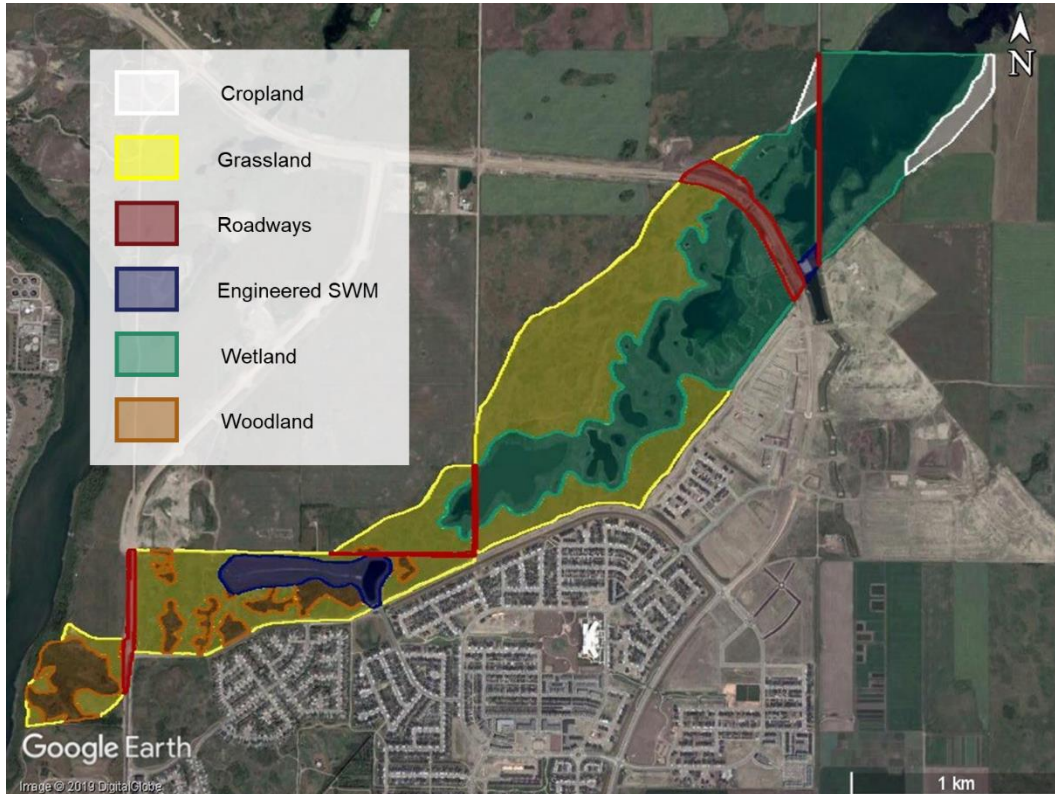


Figure 2: Swale ecosystems and manufactured features (52°10'N, 106°34'W)

3.2 Key Ecosystem Services of the Northeast Swale

As shown in Figure 3, the Swale enjoys a wide range of ecosystem services, adapted from Raymond et al. (2009). This full array of ecosystem services was narrowed to the four key ecosystem services that describe the unique quality of the Swale and are expected to most prominently contribute to its value. These four services – highlighted in green in figure 3 – include climate regulation; water regulation; water purification & treatment; and recreation, tourism, & lifestyle. Each of these key ecosystem services benefit human society in a different way, as conceptually displayed in figure 4 and discussed throughout this section.

3.2.1 Climate Regulation

Climate regulation, as shown in Figure 4(a), describes the Swale's ability to benefit society through the sequestration and cycling of carbon dioxide and other greenhouse gasses. Wetlands are well established as effective "carbon sinks", with an understood biogeochemical sequestration process, allowing for the measurement of sequestration value (Villa and Bernal 2018). This service is beneficial to society as it counteracts the accumulation of greenhouse gasses which contribute to climate change impacts. Climate regulation may also describe the ability of an ecosystem to regulate temperature in an area, but this aspect was not specifically addressed in any of the studies utilized for this valuation.

3.2.2 Water Regulation

Water regulation, as shown in Figure 4(c), describes the Swale's ability to regulate water flow, helping to mitigate flood and drought events. Water enters the Swale naturally from the northeast and from stormwater and snow melt from adjacent neighbourhoods before flowing into the South Saskatchewan River (Stantec 2012). Floods and droughts can result in significant damages and loss in productivity. The value of an ecosystem's water regulation, through avoided cost, is a function of decrease in risk of a damaging flood or drought event and the cost of such an event (Farber et al. 2002).

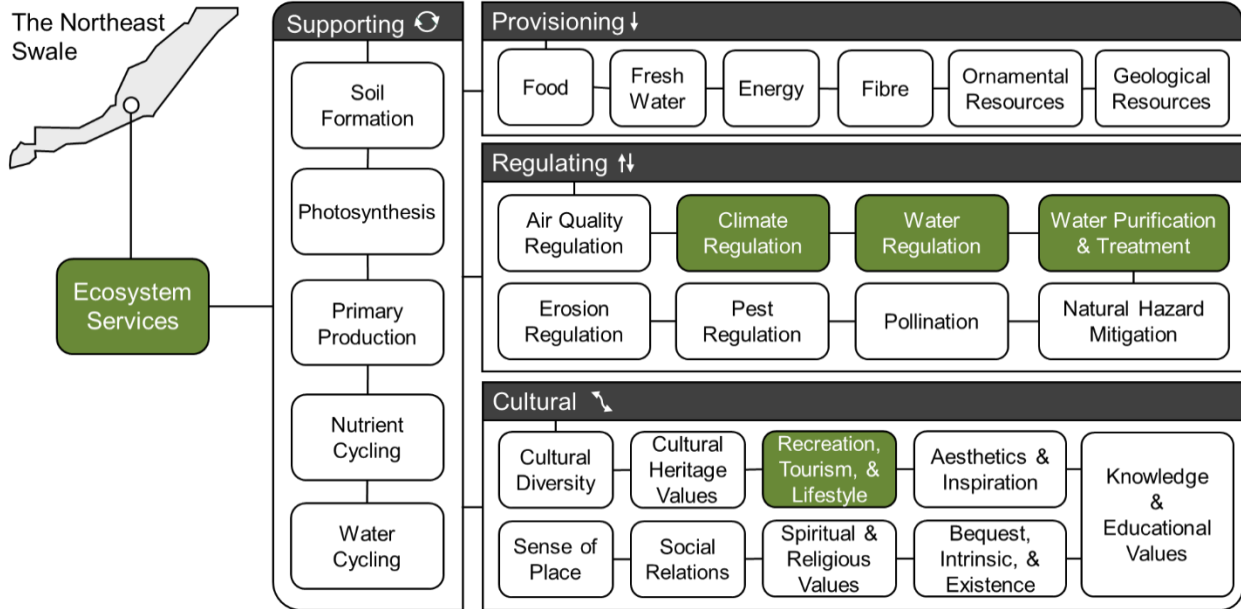


Figure 3: Typography of all potential ecosystem services of the Swale with selected key ecosystem services highlighted in green

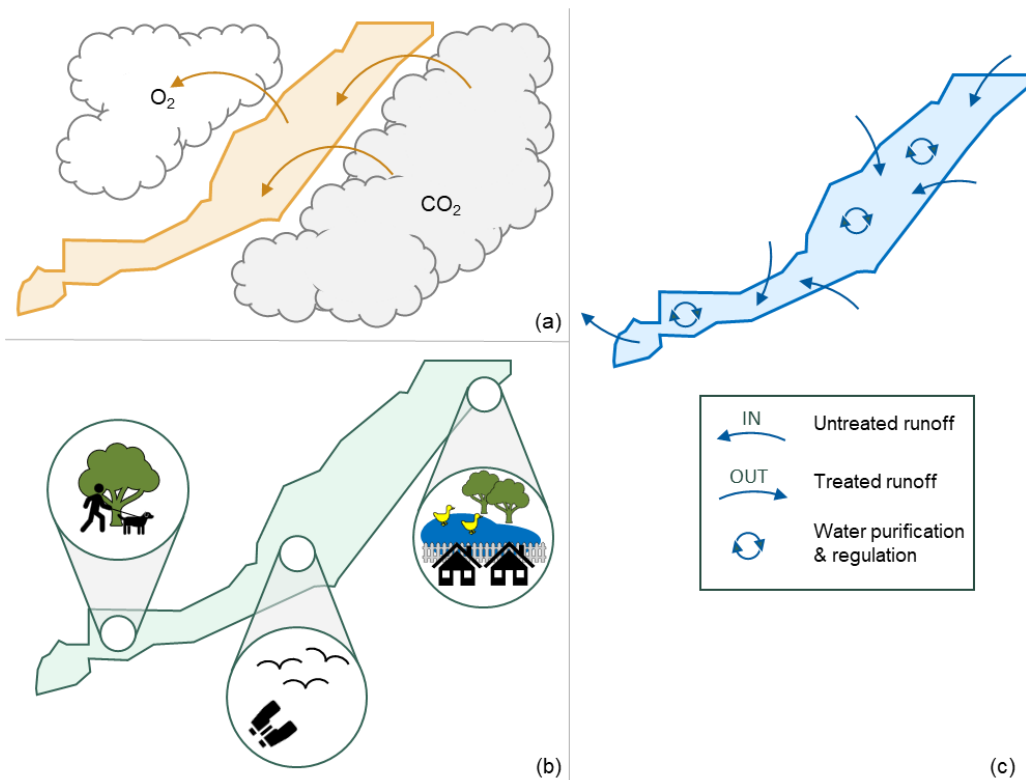


Figure 4: Conceptual model of swale key ecosystem services; (a) climate regulation (temperature regulation not pictured); (b) recreation, tourism, & lifestyle; (c) water regulation and water purification & treatment

3.2.3 Water Purification & Treatment

Also shown in panel Figure 4(c), water purification & treatment describes the Swale's ability to treat the water that flows through it. The flow of water through natural wetland and ground cover allows for the settling

and filtration of contaminants (Brauman et al. 2007). This treatment results in purified water from storm events flowing downstream into the South Saskatchewan River, decreasing the likelihood of adverse environmental impacts and saving downstream users treatment costs. Additionally, the Northeast Swale is used to manage stormwater from surrounding subdivisions (Stantec 2012). As more stringent stormwater regulations may be introduced in the future, the Swale will potentially need to assist in meeting water quality requirements for secondary effluent into the river. However, this assumes that the Swale is a part of the treatment process, rather than a natural green area in need of protection itself.

3.2.4 Recreation, Tourism, & Lifestyle

Recreation, tourism, & lifestyle, as shown in Figure 4(b), describes the Swale’s ability to attract visitors, facilitate recreational activity, and enhance lifestyle. This service is very broad, including facilitating walking through scenic trails, supporting birding due to its bird habitats, and increasing a sense of connectedness to nature for those who live in the vicinity. Cultural services, such as recreation, tourism, & lifestyle, may be abstract and difficult to value – as revealed preference methods are often inadequate for capturing the full value (Farber et al. 2002) – but can hold comparable value and importance as physical, market-based services (de Groot et al. 2012).

3.3. Swale Valuation

The delineation of the Swale shown in Section 3.1 above is a required step for the determination of benefit transfer that will allow the transfer of benefits for different ecosystem types to be applied to the Swale. The various ecosystems and features within in the Swale are shown in Table 1. The features within the Swale, including stormwater management and roadways, provide no ecosystem services values, thus have no database values available. In fact, these features would likely be considered as negative value services; however, the estimation of this negative value is beyond the scope of the current study. Croplands, although considered an ecosystem currently, also have no database values and are not discussed further. This valuation will focus on the remaining woodland, grassland, and wetland ecosystems.

Table 1: Ecosystem services values for the Northeast Swale based on database values (Van der Ploeg and de Groot 2010)* (Note: the monetary values are corrected for 2018)

	Ecosystem or Feature	Area		Climate Regulation	Water Regulation	Water Purification & Treatment	Recreation, Tourism, & Lifestyle	Total Value
		(%)	(ha)					
\$CAD/y	Stormwater	4	12.2	—	—	—	—	—
	Roadway	4	12.4	—	—	—	—	—
	Cropland	2	7.1	—	—	—	—	—
	Woodland	6	19.8	3,847	4	5,103	3,481	12,435
	Grassland	39	122	40,830	502	14,695	98	56,126
	Wetland	44	138	47,562	1,033,449	447,532	29,603	1,558,148
	Northeast Swale	100	310	92,240	1,033,956	467,331	33,182	1,626,710
\$CAD/ha/y	Woodland			195	<1	258	176	629
	Grassland			336	4	121	<1	462
	Wetland			346	7,515	3,254	215	11,331
	Northeast Swale			297	3,331	1,505	107	5,240

*Studies used in this analysis: Adger et al. (1994); Brenner-Guillermo (2007); Costanza et al. (1997); Cowling, Costanza and Higgins (1997); Croitoru (2007); De la Cruz and Benedicto (2009); Dubgaard et al. (2002); Emerton (2005); Gerrard (2004); Gupta and Foster (1975); Kumari (1996); Lant and Roberts (1990); Leschine, Wellman, and Green (1997); Meyerhoff and Dehnhardt (2007); New Zealand Department of Conservation (2007); Pearce and Morgan (1994); Perrot- Maitre and Davis (2001); Sala and Paruelo (1997); Secretariat of the Convention on Biological Diversity (2001); and Schuijt (2002).

In total, the Swale’s ecosystem services are valued at an estimated \$1.6 million per year (Table 1). Most of this value can be attributed to the wetland ecosystem with the highest valuations for the water regulation (\$1.03 M per year) and water purification and treatment (\$447 K per year). The remaining ecosystems have marginal ecosystem services values at \$12 K per year for woodlands and \$56 K for grasslands. As well,

the climate regulation and recreation, tourism, and lifestyle services provide \$92 K and \$33 K per year, respectively. For better comparison between areas, and for extension of current results to future ecosystems, consideration of a value per hectare (ha) can be used (Table 1). The yearly total Swale value is \$5,240 per hectare per year with an analogous distribution of values to the totals discussed above. Overall, the yearly estimate appears to underestimate the Swale's value but serves as a useful starting point in its NCAV. A cruder estimate of the benefit transfer following de Groot et al. (2012) results in a valuation for the Swale of \$4 million per year. Clearly the wetland ecosystem and water services are the most important areas for the Swale making their protection a priority for the City of Saskatoon. However, it should be noted that a NCAV may provide a very wide range of values making the exact valuation difficult.

Overall, the ESVD data included 36 data points from 20 data sources that were used to determine the 12 ecosystem service values shown in Table 1 (Van der Ploeg and de Groot 2010). These data points were distributed between the various services with most points found in water purification (17), and similar number of points in the remaining ecosystems services with 8, 6, and 5, for climate regulation, water regulation, and recreation, tourism, and lifestyle, respectively. The ESVD database provides a reasonable starting point for valuation of similar ecosystems worldwide and serves as an excellent starting point for the City of Saskatoon and Meewasin for NCAV of the Swale, and in other green areas throughout the City.

The benefit transfer used here focussed on studies that used specific valuation methods for each service, as discussed in section 2.3. Each of these methods was important to assess to ensure the applicability of the data for benefit transfer. For example, some ecosystem services reduce the risk of damage from other processes – natural or otherwise. An example of this is water regulation which may reduce the risk of flood and drought, thus avoiding costs associated with these events. Avoided Cost (AC) is the economic valuation method used to value these types of ecosystem services (Farber et al. 2002). Alternatively, 'ecosystem services' may be provided by human manufactured infrastructure specifically to provide analogous systems to naturally occurring services. In these cases, the value of the service may be estimated through replacement cost (RC). For example, the water purification & treatment offered by many ecosystems may be replaced by expensive manufactured treatment systems. The cost of such a system of equivalent productivity may be considered the value of the ecosystem being replaced (Farber et al. 2002). Many cultural ecosystem services are not directly associated with market activity, making them difficult to assess using revealed preference valuation methods. Contingent valuation (CV) is a stated preference method of ecosystem service valuation, allowing for the valuation of these ecosystem services. CV involves surveying a group of people to elicit their willingness to pay for access to an ecosystem service, or conversely their willingness to accept for the loss of access to said ecosystem service. Future work in the consideration of AC, RC, and CV for the Swale is being planned to produce a more accurate NCAV.

Although benefit transfer has many advantages – as discussed in the section 2.3 – its limitations are numerous and important to discuss as well. The selection of data to transfer will always involve some amount of professional bias. Additionally, there are rarely perfect analogues of ecosystems that are available for transfer. Beyond that, the actual valuation methods used for the studies being transferred are imperfect and involve further bias. In addition, although the databases such as ESVD are publicly available, the peer-reviewed studies included in the database are largely inaccessible to industry and government users, potentially resulting in the misuse of this resource. Benefit transfer will likely always be an imperfect estimate, but it fills a need for monetary valuation of natural capital without requiring a prohibitive level of time and money for many applications.

4 CONCLUSIONS AND FUTURE WORK

There is a paradox between the acknowledged importance of NCAV and the difficulty in acquiring monetary valuation results with high certainty. However, as time passes and more research is undertaken, the uncertainty in NCAV will be reduced and the accuracy of such valuations will be improved. This study provides a framework for the NCAV of natural green areas within the City of Saskatoon starting with the Swale. There remains needed further work to improve the Swale's valuation that is currently being undertaken by our research team. In addition, future work will include:

- A contingent valuation in partnership with Meewasin and the City of Saskatoon to better estimate the cultural value of the Swale and other natural capital in the city.
- Detailed mapping of the Swale and its features using a UAV, allowing for the refinement of this valuation through more site-specific benefit transfer.
- Development of a monitoring plan, informed by the detailed mapping and this valuation, to monitor the Swale's key sources of natural capital.

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