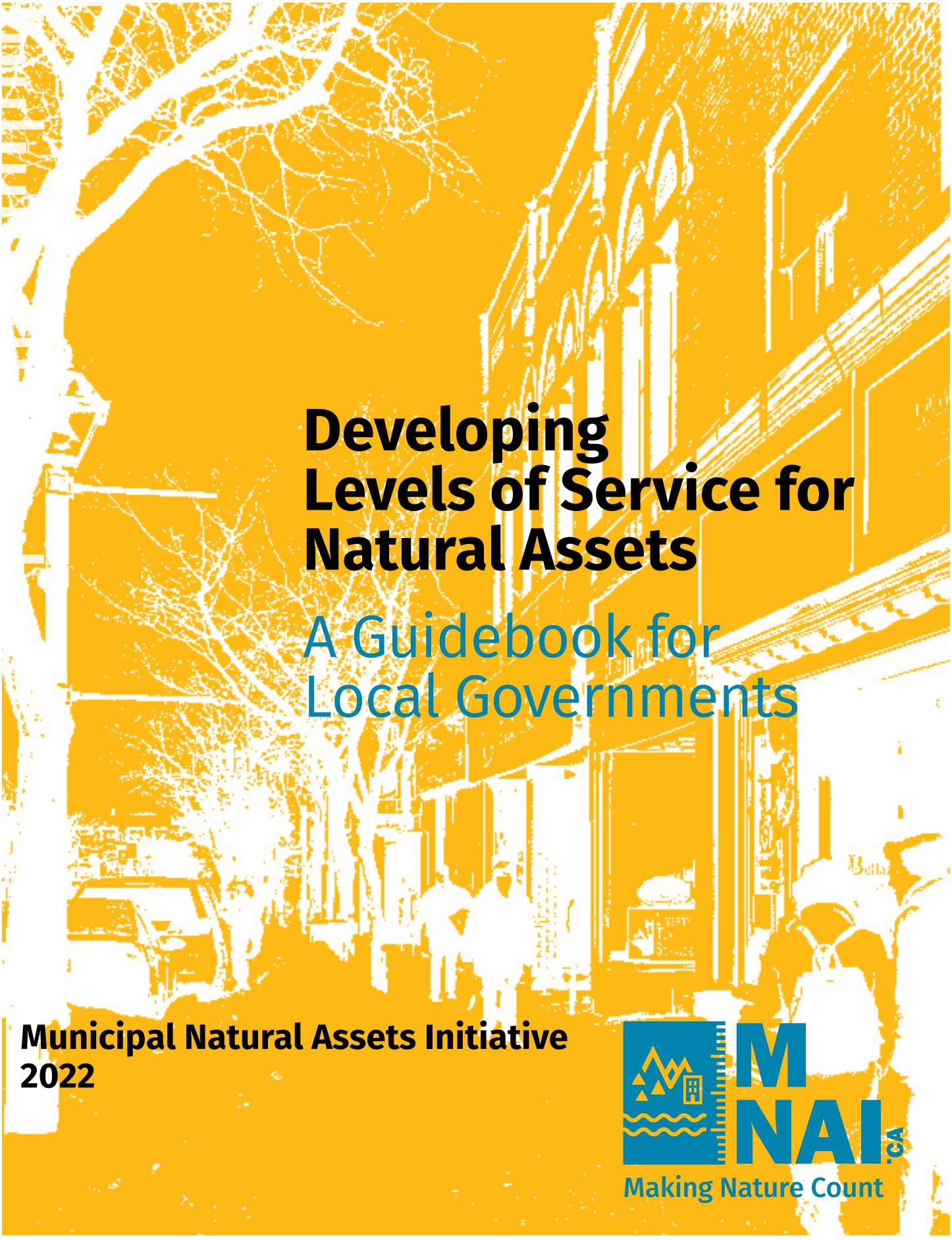


Developing Levels of Service for Natural Assets

A Guidebook for Local Governments

Municipal Natural Assets Initiative
2022

MNAI.CA
Making Nature Count

Making Nature Count

Preface

Local governments in Canada are responsible for providing their citizens and businesses with numerous services. Healthy natural systems underpin their ability to do so in a sustainable, cost-effective manner. These natural systems will become ever more critical to build local resilience to the impacts of climate change.

Many local governments are beginning to understand, account for and manage natural assets as part of their core infrastructure and have begun to develop natural asset inventories to formally document data and information about *natural assets*, as they have done for *grey infrastructure* assets. Others have begun to assess how these natural assets contribute to municipal services in their jurisdiction by studying their condition and performance across priorities including stormwater management, drinking water, carbon sequestration and storage. Some have assessed risks to natural assets and the services they provide, from factors like land use change, development pressure, overuse, forest fires, and climate change.

While many local governments have taken the steps described above, few have robust natural asset management strategies and plans to support them in proactively protecting and managing the natural systems they rely on to deliver services. Overall, Canada's municipal sector is at an early stage of using an asset management lens to integrate the management of natural assets into municipal planning and operations.

In February 2021, the Municipal Natural Assets Initiative (MNAI) engaged 19 local governments and interested organizations to identify opportunities to support progress in natural asset management. The participants identified six key opportunities:

1/ Better integrate natural asset management into asset management policies, plans and processes.

2/ Integrate natural asset management into land use plans, policies, zoning, by-laws.

3/ Make stronger linkages between natural asset management and climate change mitigation and adaptation.

4/ Build capacity of local government staff in natural asset management.

5/ Build awareness/support for natural asset management among key decision-makers.

6/ Support local governments to work with other jurisdictions, stakeholders, or levels of government to achieve natural asset management objectives.

MNAI used the findings from this engagement to develop the concept for this guidebook, *How to Develop Levels of Service for Natural Assets: A Guidebook for Local Governments*. The guidebook aims to support local governments with the first of the six identified key opportunities: to better integrate natural asset management into asset management policies, plans and programs. Defining levels of service (LOS) is a key element of this.

Local governments in Canada are at a relatively early stage of defining LOS in their overall asset management practices for all asset types. Defining LOS for any type of infrastructure assets is a notoriously challenging task, and there is no commonly recognized approach or framework for developing LOS for natural assets. This guidebook, therefore, will evolve over time as local governments make progress in this area.

Note that the instruction provided in this guidebook may also be useful to other organizations responsible for protecting and managing natural assets, including other levels of government, conservation authorities, Indigenous communities, utilities, agricultural producers or other industries that own and manage large tracts of land.

Acknowledgments

MNAI would like to thank the Neptis Foundation and the Greenbelt Foundation for their generous support for this project, without which it would not have been possible.

MNAI also thanks following organizations for their significant in-kind contribution to this guidebook:

Seven local governments and one Ontario conservation authority supported the development of this guidance using a peer learning approach. Together, MNAI and participating organizations met and shared insights in six monthly web meetings, shared municipal key documents, provided examples of levels of service and contributed thought leadership throughout the process. Contributing organizations included:

British Columbia: Town of Gibsons, City of Vancouver
Alberta: City of Edmonton
Saskatchewan: City of Saskatoon
Ontario: Town of Halton Hills, Conservation Halton
New Brunswick: Town of Florenceville-Bristol
Newfoundland: Town of Logy Bay-Middle Cove-Outer Cove

IC Infrastructure contributed in-kind support and guidance on developing customer levels of service for natural assets.

Finally, MNAI would like to thank the following peer reviewers of the guidance:

Pouyan Keshtkaran, City of Vancouver, BC
Michelle Lewis, Town of Gibsons, BC
Catherine Shier, City of Edmonton, AB
Courtney Teliske, City of Edmonton, AB
Alida Cameron, City of Edmonton, AB
Jessie Best, City of Saskatoon, SK
Dharmen Dhaliah, Town of Halton Hills, ON
Chitra Gowda, Conservation Halton, ON
Sarah Pacey, Town of Florenceville-Bristol, NB
Janine Walsh, Town of Logy Bay-Middle Cove-Outer Cove, NL
Ian Gerritsen, IC Infrastructure
Sean Shepherd, Nucleus Strategies
Amy Taylor, Green Analytics
Wally Wells, Asset Management BC

Table of Contents

Section 1 Introduction

1.1. How to Use this Guide

This guide to developing levels of service (LOS) is not prescriptive. Local governments are structured differently from one another and while many have common goals, they vary in the strategies and plans they develop. They also face unique risks and have different infrastructure priorities depending on the state of their infrastructure.

This guide shows **how** local governments might approach defining natural asset LOS, no matter what their current priorities or maturity in asset management may be. Asset management is an ongoing, non-linear process of managing infrastructure to support sustainable service delivery, as shown in Figure 1 below. The process of natural asset management is shown in the outer circle. LOS are defined (or adjusted) in the planning phase of asset management.

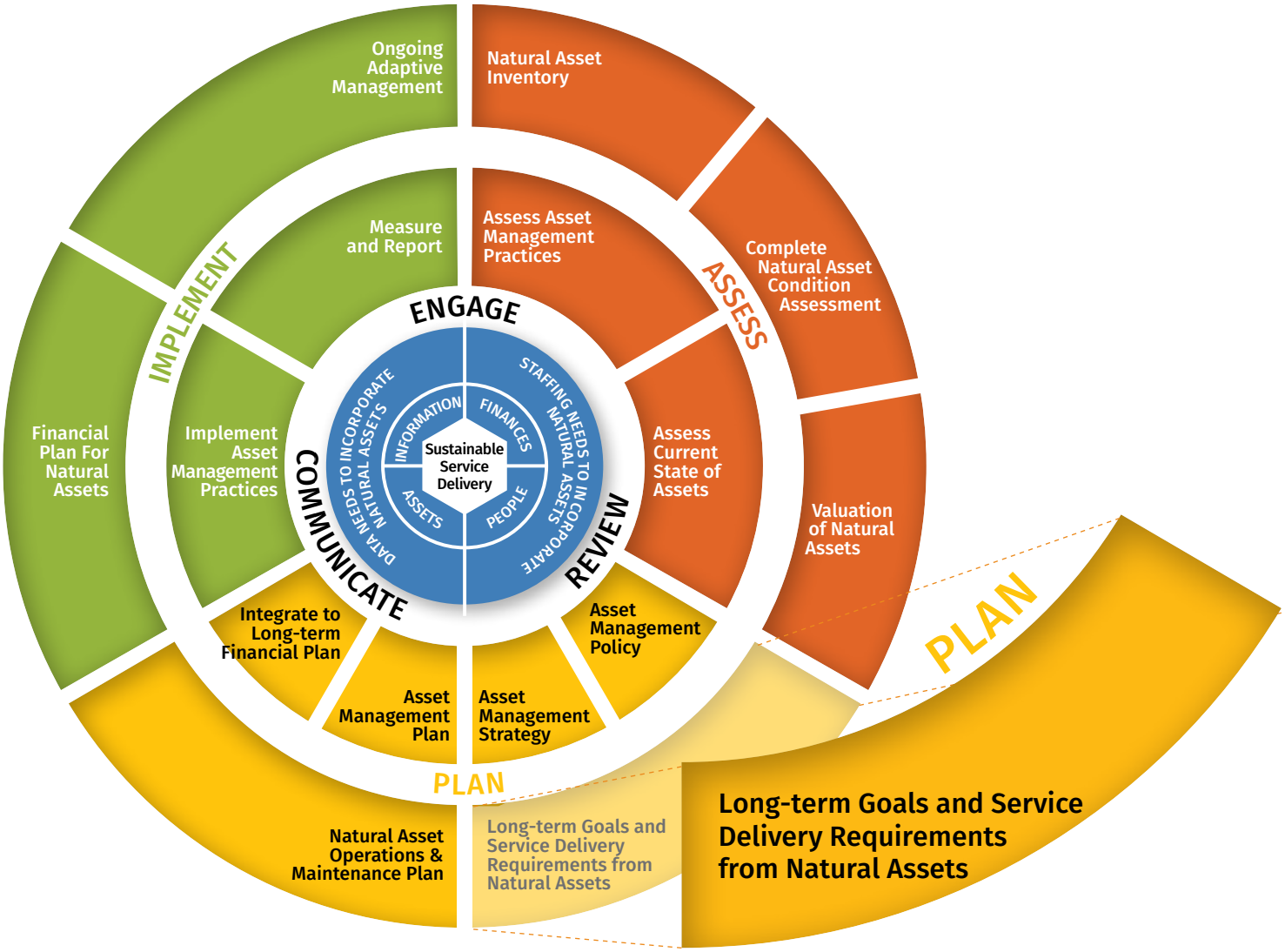


Figure 1: Natural Asset Methodology
Source: Adapted from Asset Management BC, 2014

Section 1 Introduction provides an overview of the concept of LOS and explains why natural asset inventories are a foundation for defining natural asset-related LOS.

Section 2 Considerations for Defining LOS for Natural Assets provides tips for defining LOS for natural assets based on their unique characteristics compared to grey infrastructure assets.

Section 3 Steps to Get Started in Defining LOS for Natural Assets provides a step-by-step process to support local governments in developing LOS for natural assets.

Section 4 How to Develop LOS for Natural Assets provides instruction on how to develop corporate, customer and technical LOS.

Section 5 Natural Asset Service Descriptions provides an overview of how different natural asset types contribute to service objectives of relevance to local governments. It explains the analysis needed to define LOS for service objectives and the type of data needed to define customer and technical LOS.

Section 6 Case Studies shows how the Town of Gibsons, BC, and the City of Edmonton, AB, are approaching developing LOS for natural assets.

Appendix A: Glossary of Terms explains terms of relevance for natural asset management. When a term is used for the first time in the guide, there is a hyperlink to its definition in the glossary.

Appendix B: Developing Levels of Service Using the Value Proposition Canvas Tool shows one approach that can be used to build an understanding of how natural assets provide services to a community.

Appendix C: Description of Ecosystem Services explains the four categories of ecosystem services: provisioning, regulating, habitat or supporting, and cultural.

1.2. What are Levels of Service (LOS)?

Levels of service (LOS) define the expected performance of assets and represent a commitment of a local government that will inform asset management and financial plans. Using a three-legged stool as an analogy, service represents one leg of the asset management stool and it is balanced with cost and risk, the other two legs. They are a fundamental building block of asset management.

Defining LOS enables local governments to link strategic organizational objectives with technical and operational requirements of infrastructure and is a way to steer a local government to making the best possible investments towards sustainable service delivery.

Local governments usually document service levels in *an asset management plan* (AMP). An AMP is a tactical plan that outlines the current state of infrastructure assets and how they will be managed over their lifecycle to meet service delivery objectives and strategic priorities. AMPs also document the investment required annually and over time to meet those objectives. AMPs take a long-term view of infrastructure needs and local governments update them every few years to reflect their changing contexts.

It is the responsibility of a local government's council to approve and monitor progress on LOS. Doing so enables them to be transparent and accountable for their decisions about service delivery. When councils share information about current LOS and associated costs with the public and other affected stakeholders, they are better able to communicate the social, environmental and financial impacts of improving or reducing services and engage the community on their "willingness to pay" for changes in service levels.

TYPES OF LOS MEASURES[1]

There are three main types of LOS that, taken together, show how day-to-day operational activities of infrastructure will be aligned with and support a local government's strategic objectives: corporate, customer, and technical LOS.

Corporate LOS is a strategic objective used to measure progress on service delivery and informs the development of multiple customer and technical levels of service linked to that objective.

Customer LOS is a performance measure that describes the service the community should expect to receive, expressed in terms that make sense to them.

Technical LOS is a performance measure that describes the operational requirements of infrastructure that will enable the local government to deliver the expected customer level of service. In the case of natural assets, these would be indicators to measure the ecological performance of natural assets in relation to service delivery objectives, and operational performance on activities like monitoring condition and ecological health of natural assets, maintenance activities to keep individual assets and ecosystems healthy, naturalization or restoration activities, or in some cases, disposal (e.g., street trees that have died or reached their end of life).

The graphic below shows how these types of LOS fit into the hierarchy of decision-making in a local government.[2]

1 *This section draws on guidance provided in the 2015 International Infrastructure Management Manual, Institute of Public Works and Engineering Australasia.*

2 *Graphic was adapted from the 2015 International Infrastructure Management Manual, Institute of Public Works and Engineering Australasia. The graphic includes illustrative examples of LOS measures, not an exhaustive list.*

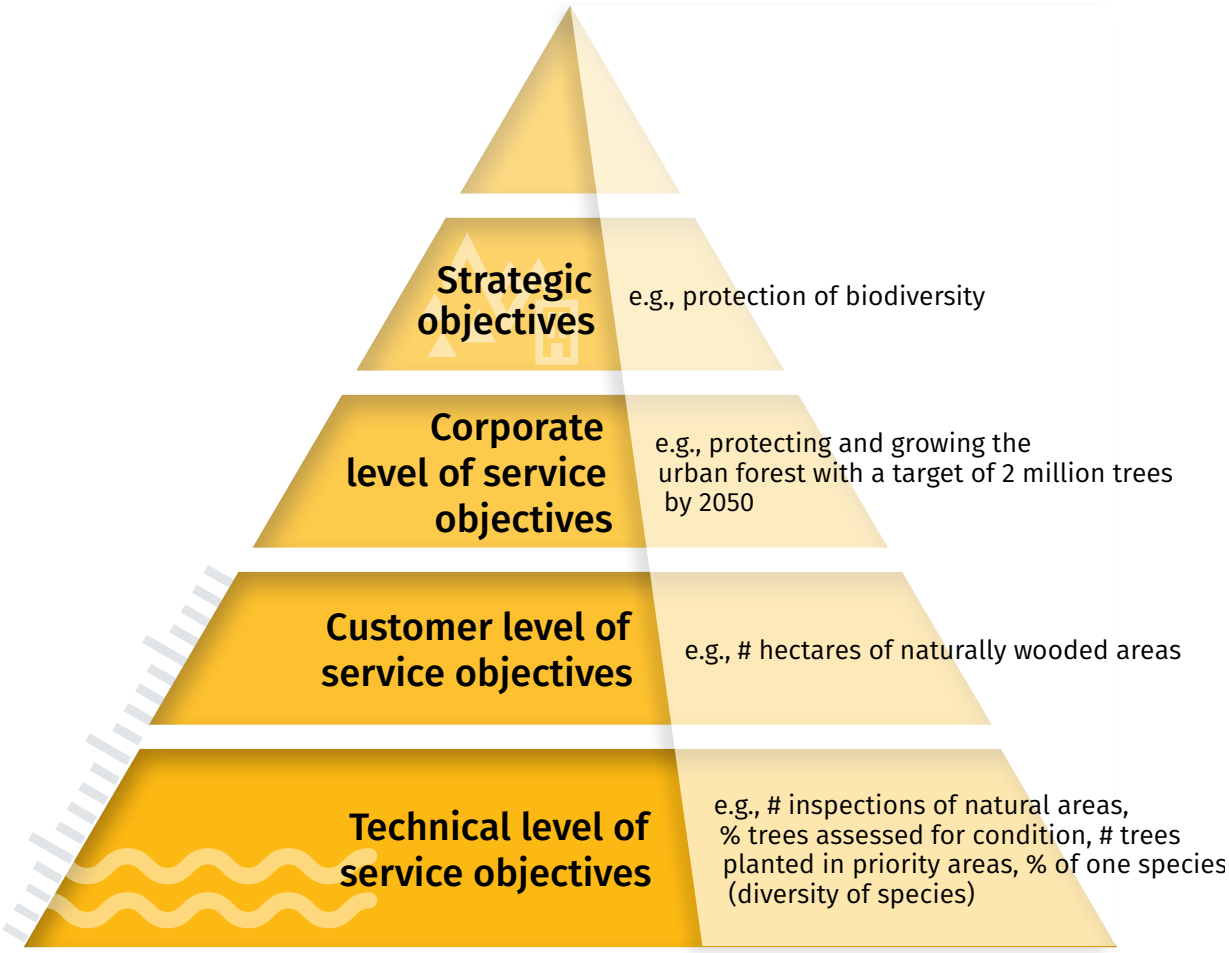


Figure 2: LOS hierarchy of decision-making

DRINKING WATER SUPPLY EXAMPLE:

Corporate LOS objective: Proactively protect and preserve the primary source of raw water. The xx River and its surrounding watershed (drainage area) is protected to ensure the local government's supply is sustainable and impact to the environment is reduced.

Customer LOS: There are no disruptions to the community's primary source of raw water.

Technical LOS: Performance measures associated with source water quality, monitoring of source water quality, monitoring ecological health of riparian areas, and other local government actions to protect source water. Examples include coverage of source water monitoring stations, frequency of monitoring, and turbidity of source water. These are specific to managing natural assets to protect source water and are different from other technical LOS the local government would have related to the quality of drinking water (i.e., tap water quality).

1.3. Why Develop Levels of Service for Natural Assets?

When local governments develop LOS for natural assets, it helps ensure:

- Natural assets' role in service delivery is recognized and there is accountability for their management.
- Lifecycle management activities for natural assets (e.g., monitoring, maintenance, restoration) make their way into budgets and long-term financial plans.
- Progress on natural management can inform continuous improvement objectives to protect and manage natural assets when strategic plans and policies, including land use plans, are updated.

1.4. What is the Difference Between a Local Government's LOS for Natural Assets and Ecosystem Services?

Knowledge about the *ecosystem services* that natural assets provide is needed to develop asset management-oriented LOS metrics. Examples of ecosystem services that natural assets provide in biophysical (or comparable) terms include degrees of heat reduction contributed by natural assets, tonnes of carbon sequestered, ability to store water or provide habitat for flora and fauna.

With an understanding of **the ecosystem services provided by natural assets** across a range of services, local governments can then define LOS measures for natural assets that represent **their commitment (through e.g., conservation and management)** to sustain or enhance these ecosystem services to achieve a desired level of service. Many local governments are now striving to enhance ecosystem services through restoration, planting or re-wilding, conservation, adaptive management, acquisition, or other activities. Local governments may need to collaborate and build partnerships with other landowners or government jurisdictions to achieve their desired level of service from natural assets as the natural assets upon which they rely may often be owned and/or under the jurisdiction of others.

Local governments will need to collect technical data about bio-physical ecosystem services to help them define LOS for certain service objectives (e.g., drinking water, stormwater, wastewater, biodiversity, climate mitigation and adaptation). *Section 5* describes the range of ecosystem services that natural assets provide and some of the data needed to determine them.

1.5. Natural Asset Inventories are a Foundation for Developing LOS for Natural Assets

Local governments must develop an understanding of the services natural assets provide to the community prior to defining LOS they will commit to sustaining over time.

Natural asset inventories are one foundational piece that local governments can put in place to assist them in developing robust and meaningful LOS for natural assets. Developing an inventory or refining it as part of continuous improvement efforts is part of the Assessment phase of the natural asset management process shown in Figure 1 on *page 3*. A basic inventory will enable local governments to begin to answer the questions:

1/ What natural assets do we (or could we) rely on for services?

2/ Where are they located?

3/ What condition are they in?

A robust natural asset inventory could also answer the questions:

4/ What is their performance on a range of services they provide to the community?

5/ What are the risks to them and the related services they provide?

Many variables can be taken into consideration when identifying data inputs for natural asset inventories; however, at a minimum, almost all start with two data sets: 1) Watershed, sub-watershed, or another catchment area boundary; and 2) detailed land cover and land use mapping of the area within the boundary to specify natural asset types, which may include[3]:

WATER	RIPARIAN AREAS	GREEN OPEN SPACES	URBAN GREEN INFRASTRUCTURE
Groundwater – aquifers Surface water – rivers Lakes	Creeks Streams	Meadows Grasslands Bushlands/shrublands	Street trees Urban parks/natural trails Bioswales Rain gardens Naturalized stormwater ponds Naturalized parks/ features Manicured lawns/ gardens Crops and pasture
WETLANDS	**FOREST ASSETS**	**COASTAL ASSETS**	
Isolated wetlands Riparian wetlands Ocean wetlands	Urban forest Urban woodlots Intact forested areas	Beach Dunes Vegetated shorelines	
SOILS			

The Canadian Standards Association will be releasing a National Standard for natural asset inventories in 2023.

For more information about natural asset inventories and examples, see MNAI's website: *Communities – MNAI | Municipal Natural Assets Initiative*.

3 *Note: This classification is broad and encompasses major natural asset types generally found in a natural asset inventory. Note there is no universal classification system for natural assets and depending on an organization's needs, they may wish to add specificity, for example by breaking down forested assets into species types.*

Section 2 Considerations for Defining LOS for Natural Assets

Grey infrastructure assets normally have only one main purpose. *Natural assets*, by contrast, are "multi-taskers" that provide many services and benefits to humans and all life. Local governments need to build a holistic understanding of the services natural assets provide to their community to ensure their full value informs decisions about land use and infrastructure management.

The following are some tips to keep in mind when defining LOS for natural assets.

TIP 1

Pay Attention to the Big Picture

LOS for natural assets can be defined in different types of asset management plans, including those focussed on a service (e.g., stormwater service or drinking water) or specific natural asset types (e.g., a natural areas management plan or an urban forest management plan).

Developing LOS for natural assets in one service area only (e.g., stormwater management) or focusing solely on one natural asset type (e.g., tree canopy) risks under-estimating and under-valuing the services nature provides. This can lead to sub-optimal land-use decisions that undermine both ecological integrity and healthy ecosystems, and services of value to the community. Land use changes and management decisions should therefore be informed by an understanding of the full extent of services that would be affected if natural assets were enhanced, compromised or lost entirely.

Example: If a marsh in the centre of a city is only considered for its aesthetic features and the land faces development pressure, it may be more likely to be filled and converted to housing than if a wide range of services the marsh provides were determined and valued, including its ability to store water now and in a future climate scenario, its ability to sequester carbon, provide habitat, access to green space, and regulate the urban heat island effect.

To avoid perverse outcomes from a decision, LOS for natural assets will need to reflect multiple service areas and objectives. Understanding the full value of services that natural assets bring to the community helps build the business case for their protection. Often this leads to more elaborate, qualitative valuations of its full range of benefits than is possible for grey infrastructure projects. This understanding will support local governments in determining the trade-offs associated with their decisions and will help support the prioritization of infrastructure decisions. See *Section 4.1* for more information about valuation approaches for natural assets.

Local governments that have a robust natural asset inventory and understanding of the services nature provides to their community may be in a good position to develop a specific asset management plan that encompasses all natural assets and the priority services they deliver to the community.[4]

For example, the City of Edmonton is presenting the Urban Forest Asset Management Plan (UFAMP) to council in 2022. It includes LOS measures for its natural and *enhanced* tree assets but it excludes some key natural asset types such as wetlands, even though they are an important part of the City's Green Network[5]. The City may move to develop a broader natural asset management plan that encompasses all natural asset types in their jurisdiction in the future. See case study of the City of Edmonton's Urban Forest on *page 66*.

TIP 2

Low Carbon Resilience is a Big Picture Goal

Natural asset management should be a consideration in most local government plans because of nature's ability to "multi-task" and support sustainable service delivery. Wherever possible, LOS for natural assets should seek to align with broad organizational policy objectives and strategies around climate action and *biodiversity* protection, which are urgent priorities for many local governments across Canada.

Low carbon resilience (LCR) is a planning approach that focuses on developing integrated strategies that reduce both greenhouse gas emissions (climate mitigation) and vulnerability to climate change impacts (climate adaptation).

Local governments should be very cautious of management decisions for natural assets that have a positive climate mitigation impact while undermining biodiversity and ecosystem integrity. An example might be a tree-planting program that focuses on planting a mono-culture forest to sequester carbon, but that undermines biodiversity and healthy ecological functioning, which could in turn undermine climate adaptation efforts.

4 *Some local governments only have one asset management plan that encompasses all assets and services. In those cases, natural asset management considerations may be incorporated into the overarching plan.*

5 *The City of Edmonton's Green Network comprises three interrelated networks: its ecological network, its wellness network and its celebration network. In many open spaces these networks do overlap; in others (such as paved gathering spaces with no vegetation), they do not. See the Glossary for the term Ecological Network.*

What Is a Low Carbon Resilience Planning Approach?[6]

A low carbon resilience approach encourages decision-makers to pursue integrated strategies and investments that climate-proof their communities while strengthening overall sustainability. It embeds three key questions in all decision processes relating to:

1/ **Risk:** Does the investment or action minimize community vulnerability to projected climate impacts such as flooding, wildfire, heat, and other extreme events?

2/ **Emissions:** Does the investment or action measurably reduce corporate and/or community emissions and help advance carbon-reduction goals?

3/ **Co-benefits:** Does the investment or action advance community sustainability goals such as health, equity, biodiversity, and economic savings and development?

TIP 3 Pay Attention to Scale and Jurisdiction

Watershed-scale planning is essential to define LOS for some services natural assets provide, particularly for water and climate-related services. Hydrological functioning is typically bound by watersheds and sub-watersheds and many local governments rely on services from watersheds outside their jurisdictional boundary. It is recommended that natural asset inventories are created at the watershed scale to ensure that all natural assets providing services to local governments are accounted for. See the stormwater and drinking water service descriptions in *Section 5* for more information.

Local governments may need to find ways to protect (or enhance) the services of natural assets in a watershed outside their official jurisdiction. This will likely require collaboration and partnerships with neighbouring local governments and/or with higher levels of government during assessment, planning and implementation stages of the natural asset management cycle (see Figure 1 on *page 3* for a diagram of the asset management cycle). Similarly, collaboration will be required for natural assets they do not own (see Tip 4 below). LOS measures can be developed to track progress (see the stormwater example on *page 13*).

Example: Conservation Halton and the cities of Burlington and Hamilton in Ontario collaborated to develop a natural asset management initiative for the Grindstone Creek watershed, including developing an inventory, determining the role of natural assets in managing stormwater, now and in a future climate scenario and identifying, based on the foregoing, options for long-term management. Grindstone Creek is an important watershed in Conservation Halton's jurisdiction that provides multiple services to both cities. The City of Hamilton is upstream from the City of Burlington, so protection and management of natural assets in Hamilton may support Burlington to manage stormwater, mitigate flood risk and manage risks to water quality and biodiversity at the mouth of Grindstone Creek.

6 *Shaw, Alison, Harford, Deborah and Tolsma, Kacia (2021). LCR Tool, LCR: Advancing the Co-Benefits of Climate Action, a publication of the Integrated Climate Action for BC Communities Initiative of Simon Fraser University, page 4.*

Build on the Knowledge of Organizations with Natural Asset Management Expertise

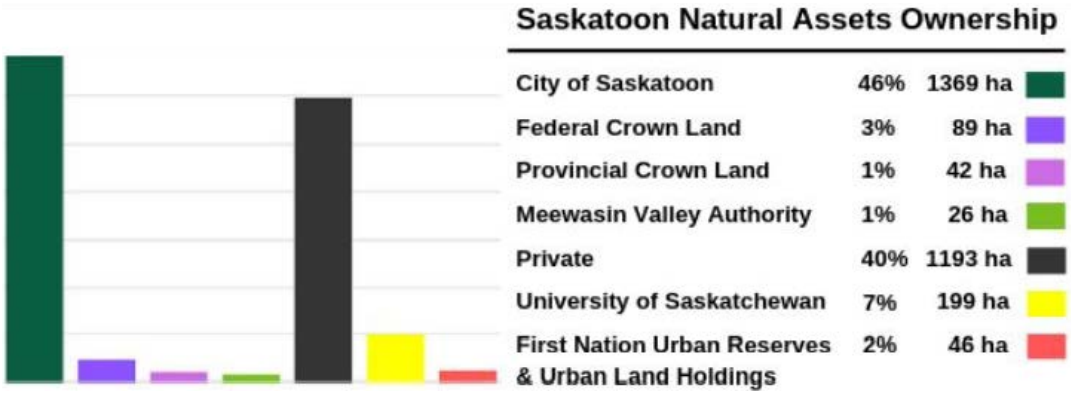
Local governments will benefit from collaborating with the multiple organizations in and outside their jurisdiction that are able to provide expertise and support on natural asset management and that are managing natural assets in their region. For example, in Ontario, the watershed-based conservation authorities play a critical role in protecting, conserving and managing natural assets and are important partners of local governments.

TIP 4

Pay Attention to Ownership of Natural Assets

Local governments should include details on ownership of natural assets in their inventory because they often rely on natural assets they do not own to deliver services, even when those natural assets are located in their jurisdiction. These could be large tracts of land owned by farmers, forestry companies, utilities, airport authorities, Crown land, First Nations Urban Reserves or Land Holdings, or smaller properties owned by residents. Many small actions can lead to substantial cumulative impacts over time.

Example: The graphic below shows the breakdown of ownership of natural assets that exist within the jurisdiction of the City of Saskatoon.



Source: *Saskatoon's Green Infrastructure Strategy: Towards an Interconnected Green Network, p. 54.*

Knowledge about ownership will help local governments define LOS measures that track progress in achieving community-wide service objectives for natural assets not directly under their control. The diagram below shows some possible actions local governments can take to achieve community-wide outcomes for natural assets, and how that might translate into defining LOS for natural assets.

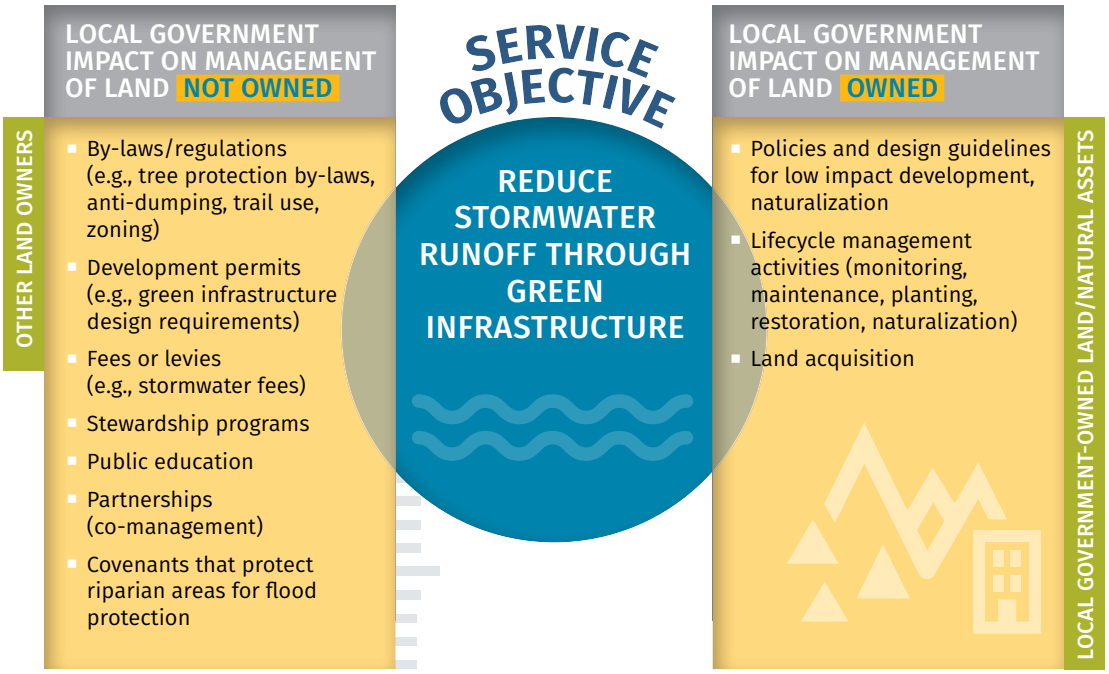


***Figure 4**: Stormwater management example*

Using the stormwater management example in the graphic above, examples of LOS measures to track progress on natural assets owned by the local government might include:

- Technical LOS: **# low impact development projects implemented**
- Technical LOS: **# boulevards naturalized**
- Technical LOS: **% tree canopy on local government-owned land**

LOS measures to track progress on natural assets not owned by the local government might include:

- Customer LOS: **# hectares of natural areas restored or protected through stewardship programs**
- Customer LOS: **# of stewardship programs and # volunteers**
- Customer LOS: **# joint natural asset management plans or programs with other jurisdictions**
- Technical LOS: **% change in impervious surface on privately-owned land**

TIP 5 Natural Asset Management is a Cross-Cutting Theme

In every built-up community, *green infrastructure* exists alongside *grey infrastructure* and can support local governments in delivering services cost-effectively and in minimizing risks associated with climate change and biodiversity loss. Green infrastructure also provides many other services to communities, including public health, recreation, and local economic development. Local governments are beginning to put more attention towards integrating green infrastructure with grey infrastructure to support service delivery objectives. The diagram below shows infrastructure types ranging

from that made with grey, engineered assets (exclusively made from concrete, steel or other non-living materials) to a spectrum of green infrastructure that includes engineered *green infrastructure assets* that combine grey and natural assets, *enhanced natural assets* that have been constructed and natural infrastructure that is compromised of intact natural ecosystems. All types contribute to local service delivery.

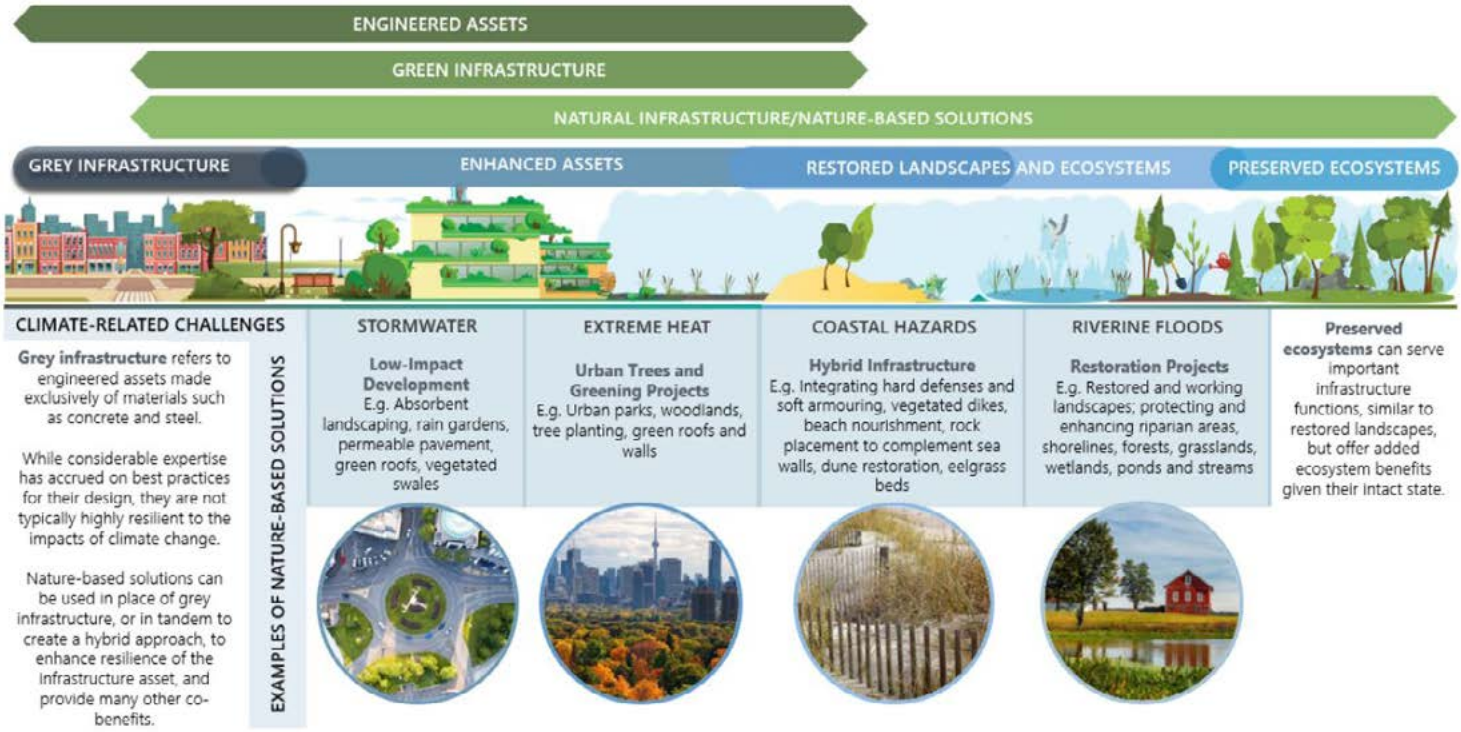


***Figure 5**: Interdependence of grey and green infrastructure*

***Source**: Canadian Council of Ministers of the Environment, Natural Infrastructure Framework: Key Concepts, Definitions and Terms, 2021, p. 5.*

To support integration of green and grey infrastructure in the built environment, LOS for natural assets will need to be defined to support service delivery in areas that have typically been confined to tracking progress on grey infrastructure (e.g., water, wastewater, transportation, parks). To do this effectively, multiple departments and services of a local government must play a role in natural asset management planning, even if they are not directly responsible for managing the natural assets themselves.

Inter-departmental coordination is required to support holistic approaches that prioritize ecological integrity of natural systems and to ensure that a local government protects and manages natural assets optimally alongside grey infrastructure. Staff with responsibilities for managing natural assets can be included on the local government's cross-functional asset management team where one exists to ensure that natural asset management considerations are fully integrated in infrastructure planning and decision-making.

Example: The City of Vancouver's Parks Board is responsible for managing natural assets in the City's parks and open spaces. The City's Engineering department is responsible for managing stormwater and has begun to implement low-impact development projects across the City, along transportation corridors, or in areas prone to flooding. For example, a study is underway on how to use natural infrastructure solutions to build resilience to climate impacts in the False Creek neigbourhood. In some cases, the Engineering department implements natural infrastructure solutions to manage stormwater in the parks themselves. In those cases, there is coordination with the Vancouver Parks Board, which must give permission for the work to occur.

Why Is it Important to Distinguish Between Different Types of Green Infrastructure?

There are different implications for service delivery between engineered or enhanced green infrastructure assets and natural assets. Natural assets (e.g., forest stands with a biodiverse understory, wetlands, ravines) are complex natural ecosystems that have greater ecosystem service potential and resilience than enhanced assets (e.g., isolated urban trees, semi-natural parks with a low diversity of species that are often non-native and more susceptible to pests) or engineered assets (e.g., green roofs, permeable pavement, rain gardens).

In addition, there are typically more maintenance activities required for engineered green infrastructure than for enhanced or natural assets and local governments will need to define LOS differently for these different types of assets. Investment needs and management activities will differ between them. The ecosystem service value and co-benefits are generally greatest for intact natural assets. For example, in the City of Edmonton's experience, natural areas are among the lowest cost maintenance sites in its municipal open space network, while assets like permeable pavement and rain barrels are not self-sustaining and require replacement over time.

Section 3 Steps To Get Started in Defining LOS for Natural Assets

Local governments across Canada differ in their service delivery responsibilities, in how they are built (e.g., how densely populated and urbanized they are) and in their geographic context (e.g., coastal, inland, forested, prairie). But natural asset management is a cross-cutting theme across services areas for all local governments.

There could be several entry points for integrating LOS for natural assets. The following steps are meant to support local governments in finding an appropriate entry point to get started and make progress.

STEP 1 Map the Relevant Natural Asset and Service Combinations

An important first step is to develop a "big picture" understanding of the local government's natural asset and service delivery context. Specifically, it can be beneficial to map and prioritize the natural asset and service combinations that are relevant to the local government. As mentioned in *section 1.3*, a natural asset inventory provides a good data foundation for this exercise, but even without one, staff likely have some understanding of the significant natural assets that exist and are providing services to the community in their jurisdiction, even if they do not yet have technical information about the ecosystem services they are providing.

Consider the natural assets that deliver services to the community. Note whether the local government has direct control over the management of the natural assets providing the service or could influence their management in other ways (e.g., by-laws, partnerships, stewardship programs).

The table below provides a snapshot of some possible asset and service combinations that local governments may want to consider. Local governments that do not yet have detailed technical information about natural assets can focus on identifying significant natural assets or natural areas that are important to the community, and note where data and information gaps exist.

Remember: Even without a lot of technical insight into services that some natural assets may be providing, those services likely do exist and strengthening data and information about them should be part of continuous improvement efforts. *Section 5* provides an overview of how the natural asset types shown below contribute to each of the service areas described.

Natural Asset Type/ Service Objective	Water (Surface, Groundwater	Riparian Areas	Forest Assets	Green Open Spaces	Wetlands	Coastal Assets	Soils	Urban Green Infrastructure
Stormwater management	■	■	■	■	■		■	■
Drinking water	■	■	■	■			■	■
Wastewater		■			■			■
Transportation			■	■				
Recreation	■	■	■	■	■	■		■
Public Health	■	■	■	■	■	■	■	■
Biodiversity	■	■	■	■	■	■	■	■
Climate mitigation or adaptation	■	■	■	■	■	■	■	■
Local Economic Development	■	■	■	■	■	■	■	■
Culture and Heritage	■	■	■	■	■	■	■	■
Other?								

STEP 2 Identify Key Risks

Once local governments have developed a big picture analysis of the natural assets providing services to the community, consider the risks to the community that can be mitigated with a natural asset management solution. Climate risks such as extreme heat, drought, flooding, sea level rise and extreme weather pose risks to engineered infrastructure, to people, and to the natural assets themselves. Other risks that natural asset management can help mitigate include poor air quality, erosion, and pollutant-loading of source water. A high-level risk identification exercise will help prioritize objectives for natural asset management, and LOS can be defined to support those objectives.

Example: The Town of Gibsons, BC, began proactively protecting and managing its aquifer, which provides pristine drinking water to the community with minimal treatment requirements. The Town recognized that the aquifer is a critical natural asset that supports cost-effective service delivery and developed a monitoring and maintenance regime to ensure it is protected. The Town then moved on to manage other natural assets to support stormwater management and other services. It also developed an organization-wide eco-assets strategy that sets higher-level corporate service objectives for natural assets.

See the case study of the Town of Gibsons on *page 63* for potential LOS measures the Town might use to measure progress on managing the aquifer. The Town has not yet formalized LOS for natural assets.

STEP 3 Identify Relevant Strategic Objectives

Identify where the local government has already defined strategic objectives for natural assets in high-level documents such as climate action plans or resilience strategies, biodiversity strategies, official plans or other strategic plans. Local governments should seek to define corporate, customer and technical LOS for natural assets that flow from their strategic objectives. This can help ensure that best-laid plans do not simply "sit on the shelf."

Example: The City of Edmonton's City Plan and its Connect Edmonton Plan both include a strategic objective of having 2 million trees for 2 million people. The City then defined LOS measures in its UFAMP, a tactical plan, to help achieve that objective by 2050, which is the assumed date the population will reach 2 million. The LOS measures are important because they help justify and guide the investments in tree planting, lifecycle management of the urban forest and other programs outlined in the Plan. See the Edmonton case study on *page 66*.

STEP 4 Find an Entry Point

At an advanced stage of natural asset management, local governments will have a comprehensive understanding of how natural assets are contributing to all services and will be in a good position to optimize investments to support their management and protection across all service areas, while ensuring ecological integrity of natural systems. Their LOS for natural assets could be defined in a natural asset management plan that encompasses all assets across all services, or in an overarching asset management plan if the local government only has one plan.

The reality is that most local governments still have limited knowledge about natural assets and are just beginning to learn about what natural assets they have and what ecosystem services they provide. They may have limited data and information about the condition and performance of natural assets in and around their jurisdiction. While they are managing natural assets to some extent and taking some measures to protect significant natural assets that provide vital services to communities, few local governments are doing it proactively through asset management planning. Investments tend to be ad hoc rather than made through a structured asset investment planning approach that considers long-term needs, and few local governments have valued the services natural assets provide across multiple service areas. Generally, more progress has been made in urban forest management than in other areas.[7]

7 *Based on MNAI's findings from conducting asset management readiness assessments with a focus on natural asset management with 30 local governments across Canada, including large metropolitan regions and very small communities.*

Although most local governments still have work to do to assess their natural assets, this should not be a major limitation in defining measures to track progress on natural asset management in asset management plans. The advantage of asset management planning is that it enables local governments to manage infrastructure (including natural assets) with a long-term perspective and continuous improvement in mind. Performance measures can still be developed to track progress based on an understanding of what services the community expects to receive from natural assets and the steps the local government will take to get there.

At an early stage of natural asset management, it will be important to find entry points to begin integrating LOS for natural asset management into asset management plans. Local governments can use the information gathered in the first three steps above to determine where the best point of integration might be. Consider asset management plans (AMPs) that are scheduled to be developed or updated, such as parks and recreation AMPs, urban forest AMPs, stormwater management AMPs, and water services AMPs. Based on that, local governments can determine the scope of natural assets to focus on to define LOS.

Considerations may include:

- A focus on natural assets at a watershed scale may be required if stormwater management and flood risk mitigation is a priority;
- Natural assets in parks and open spaces in the local government's jurisdiction may be an appropriate scope for a parks asset management plan; or
- A focus on one critical natural asset may be appropriate, for example an aquifer, because drinking water supply and protection are priorities; the foreshore of a coastline, because the local government has identified a priority to manage risks to property from sea level rise; or the urban forest, because AMPs are in progress or require updating.

Example: The Town of Halton Hills, Ontario began its natural asset management journey using a phased approach. In Phase 1 the Town completed a full inventory of its natural assets and a valuation of the services they provide. In Phase 2, it selected two study areas for which it updated the natural asset inventory, assessed the condition of the natural assets and the risks associated with them, and then developed LOS measures for those areas. The Town developed different risk scenarios (including climate change) and evaluated the impacts on those LOS. This approach will help the Town to decide on investments required to manage natural assets and maintain their LOS. In Phase 3 the Town plans to replicate this approach for its whole jurisdiction.

The next section provides guidance on how to develop LOS for natural assets for any scope or priority your local government has identified.

Section 4 How to Develop LOS for Natural Assets

This section outlines how to develop LOS for natural assets based on a local government's hierarchy of objectives, with strategic objectives at the top flowing down to operational objectives at the bottom (refer back to the graphic on *page 6* of Section 1.2 for an example of what this hierarchy looks like). Measuring performance on corporate, customer and technical LOS helps to track and report on progress.

Local governments should use the same general process for defining LOS for natural assets as they do for any asset class they are managing, with two added considerations:

- Avoid developing service levels for natural assets that conflict with each other (e.g., human use of natural assets for recreation at a level of service that will undermine essential services natural assets provide, such as clean drinking water and biodiversity); and
- Seek to protect the underlying ecological health, integrity and biodiversity of natural assets and create connected *ecological networks*.

4.1. How does Valuation of the Services Natural Assets Provide Guide the Development of LOS?

Natural assets are not considered tangible capital assets by the Public Sector Accounting Board and therefore their value is not officially included in local government financial reporting. However, it is common knowledge that nature and natural assets are the foundation of our well-being and that our entire social and economic systems are dependent on nature. As a global society, we have failed to properly account for the value of natural assets and this limitation has led to a context in which we are seeing unprecedented biodiversity loss and degraded natural systems, a threat now seen as the twin challenge of the climate crisis. Local governments should begin to account for the value of nature in service delivery.

One key difference between valuation of natural assets and valuation of grey infrastructure is that grey infrastructure depreciates and eventually needs to be decommissioned and replaced with other assets that will support service delivery, based on the needs defined at the time. Natural assets do not depreciate in the same way, but in the face of risks (e.g., overuse, dumping, invasive species, encroachment, wildfire) and without some degree of management, natural assets (especially those in urban settings) will degrade and hence depreciate over time. Conversely, their service value may appreciate over time when they are restored, especially because of the central role they play in buffering the impacts of climate change.

No price tag can be put on nature, but environmental economists have spearheaded the thinking on how to measure the value of ecosystem services and these approaches can be helpful in the context of asset management planning.

4.1.1. Valuation of the Services Natural Assets Provide Supports Cost/Benefit Analysis of Infrastructure Decisions

Some local governments are doing comprehensive valuations of the services provided by natural assets to build an understanding of the full value of the services they deliver to communities. A comprehensive valuation is needed to assess the full costs of losing natural assets and the full benefits of protecting them and is important when local governments are contemplating any significant land-use change that may affect natural assets. A full valuation brings clarity and transparency to the process of analyzing trade-offs of infrastructure projects and it avoids the risk of under-valuing natural assets' role in service delivery.

Example 1: The City of Toronto and Toronto Region Conservation Authority 2018 report, *Ecosystem Service Values of the City of Toronto's Ravine System*[8], determined that the ravine system provides a total of $822 million annually in ecosystem services related to recreation, physical health, mental health, air quality, carbon sequestration, food provision, aesthetic appreciation, and habitat. The report helps build the case for investments in its management, enhancement and protection.

Example 2: Within its city limits, the City of Saskatoon contains more than 1,400 wetlands (1,207 ha), a portion of the South Saskatchewan River (388 ha), grasslands (1,285 ha), and forest/shrublands (577 ha). In 2019, the City implemented the Natural Capital Asset Valuation (NCAV) Pilot Project[9] as an initial step toward evaluating key ecosystem services of Saskatoon's natural assets, including supporting services (habitat), regulating services (carbon sequestration and storage, moderation of extreme weather, wastewater treatment, pollination, biological control, air quality) cultural services (recreation, mental and physical health, aesthetic appreciation and inspiration for art, culture and design, increased property values, heritage) and forage production (livestock). While only two pilot areas were studied in-depth, the City was able to extrapolate that the service value of aquatic natural assets, grassland and forest shrubland was more than $48 million annually.

8 *City of Toronto and Toronto Region Conservation Authority, 2018, Ecosystem Service Values of the City of Toronto Ravine System, filestream.ashx (escribemeetings.com).*

9 *City of Saskatoon (2019), Natural Capital Asset Valuation Pilot Project, Saskatoon's Green Infrastructure Strategy: Towards an Interconnected Green Network.*

There are common valuation approaches that local governments use to determine the value of services natural assets provide, sometimes used in combination. They include:

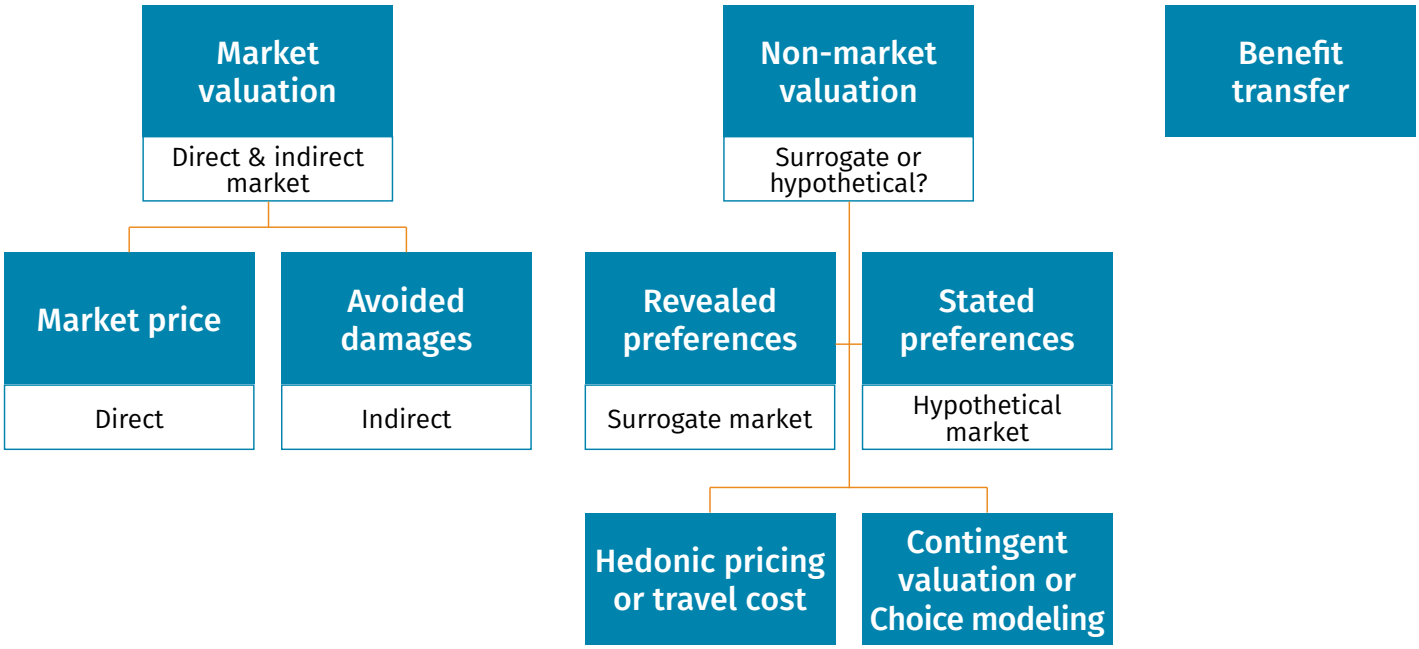


Figure 6: Valuation methods

Market valuation approaches: Only a subset of ecosystem services – things like agricultural products - is recognized in markets directly but many more are not. When ecosystem services are not directly captured in markets, indirect proxies can be used, such as avoided cost and replacement cost. The avoided cost method of ecosystem service valuation assumes that the value of ecosystem services can be measured by calculating the damages that would occur if the ecosystem service was lost. It is frequently used to value the flood mitigation service of natural assets. The replacement cost approach determines the value of a service based on the costs to deliver an equivalent service using grey infrastructure instead. This approach is commonly used to assess the value of stormwater services.

Revealed preference approaches: If market information is unavailable, there is another set of valuation approaches which rely on parallel market transactions that relate indirectly to the ecosystem service being valued. These are known as revealed preference methods, the most important of which are hedonic pricing and the travel cost method. The hedonic pricing method measures the value of ecosystem services that should be reflected in market prices of nearby goods due to proximity to those services. This method is most commonly used to value ecosystem services that impact the price of housing real estate. The travel cost method assumes that the value of an ecosystem service can be measured by the amount people are willing to spend to access it. Thus, the value of changes in the quality of a recreation site can be measured by the change in demand for people to travel to the site. This method is useful for measuring the recreational value of a forest or lake.

Stated preference approaches: If neither direct nor indirect market information is available for an ecosystem service, a hypothetical market must be used. The methods that take this approach are known as stated preference methods and they are based on survey responses which try to estimate individuals' willingness to pay for a good or service. This method is commonly used to assess cultural values.

Benefits transfer: The last approach to mention is the benefit transfer method. This involves applying values derived in previous analyses to the same ecosystem service in a different area. This method is fairly common, particularly given it requires less time and resources. It can be quite effective depending on the type of ecosystem service. This approach yields the most useful insights when adjustments to the transferred value are made based on differences between the original site and the study site. Because it is based on existing studies in other locations, it is best to regard the results as order-of-magnitude estimates. The City of Saskatoon used the benefit transfer approach for its natural capital valuation.

MNAI emphasises the valuation of services, which do not translate into the value of natural assets themselves. Although every attempt is made to recognize a range of service values, such valuations will always be, at best, minimum valuations since some values cannot be captured in monetary terms. For example, if an area is the ancestral and current home of a First Nation it would not be possible to put a dollar value on their identity with the land, water and resources.

When completing valuations, MNAI considers (i) the perspective of the audience seeking the valuation and (ii) how the valuation will be used. MNAI values services from the perspective of local governments, so understanding avoided infrastructure costs is relevant to this audience. The same service can be valued very differently by different groups. For example, 250 metres of a remnant stream provided Oakville with $1.2 - $1.4 million dollars of services, but community members may value it at much less if is degraded and not capable of supporting significant recreation. Secondly, the valuation approach is driven by how the results will be used. If the value estimates are being factored into asset management, the avoided cost or replacement cost is important. If the service lies outside of local mandates and doesn't require a high level of rigour, a benefit transfer approach may be preferable. As such, MNAI typically recommends or conducts detailed modelling for core services such that direct comparisons can be made with the performance of grey engineered assets; and combines valuations for core services with more qualitative valuations for co-benefits to provide a "composite" valuation of nature's services.

4.1.2. Financial Planning for Natural Asset Management

A comprehensive valuation of ecosystem services provided by natural assets is beneficial to build the case for investments in natural asset management because it allows local governments to develop a robust understanding of the trade-offs associated with land-use decisions and infrastructure options. This could include a valuation of core services to the local government, or these plus other benefits to the community.

Once that case is made, local governments also need to have information about the cost of conservation and lifecycle management activities for natural assets to inform financial planning for the necessary investments. LOS will be determined by estimating the costs of lifecycle management activities such as monitoring the condition and performance of natural assets, maintaining them, restoring them (e.g., planting, re-wilding, naturalization), acquiring them, or working in partnership with other organizations to manage and protect them. While it is the role of staff to define LOS and estimate the investments required, it is the local government council's responsibility to approve them in plans and budgets.

Developing LOS is a Team Effort

Local governments develop LOS during the process of developing their asset management plans. Usually this is in an iterative process that considers financial, risk, and level of service trade-offs. This typically involves discussion or debate about funding constraints and implications of LOS measures until there is agreement around what LOS is both desirable and feasible. Staff will be best placed to defend LOS measures when they are well informed about the needs of the community and all stakeholders and their willingness to pay for the services.

4.2. Build an Understanding of Stakeholder Needs and Interests

Both corporate and customer LOS need to be defined based on an understanding of the expectations of the community in relation to the services natural assets provide. Local governments defining LOS for natural assets for the first time will likely have some information about this and may also need to state some assumptions around which the measures are based.

Example: When the City of Edmonton developed its 2022 UFAMP, it engaged a cross-functional group of staff in two workshops. They defined relevant stakeholders and their interests using a set of stakeholder groups that the City considers when developing LOS in all services areas.

The table on the next page shows the included stakeholder groups.

STAKEHOLDER GROUP	NATURAL ASSETS EXAMPLE
Recipients: use the municipal services supported by assets	Pedestrians shaded by boulevard trees
Rightsholders: have Indigenous rights to the assets to practise traditional activities	Harvesting, hunting, fishing rights
Other service providers: require the municipal service/assets to provide their own services	Organizations offering recreational programs in natural areas.
Regulatory agencies: set standards, compliance regulations or other legislation that govern service delivery	Ministry of Environment and Parks
Wider community: wish to influence decision-making but may or may not be users of the service	Taxpayers funding services they may not use, City staff
Neighbouring municipalities: Adjacent communities affected by or have an interest in City services	Leduc County (adjacent to Edmonton)

The City then defined urban forest-related services of interest to the stakeholders based on results of previous engagement exercises and staff knowledge. The City also ensured that the service objectives were consistent with objectives contained in existing strategic documents. See the case study of Edmonton on *page 66* for details.

When possible, local governments should validate assumptions about service delivery and document new information about stakeholder interests as it becomes available. Asset management plans should always be considered living documents that are updated when key assumptions, strategies or budget decisions change, and council may need to adjust LOS accordingly.

One useful tool that can support development of LOS is called a value proposition canvas (VPC). The VPC can be used to identify and clarify the value of the services natural assets provide to the community's various stakeholders, which can build an understanding of the ways a local government can positively influence services and prioritize service level indicators for a given asset type. The process helps determine corporate and customer LOS. *Appendix B* provides an example of the results of this exercise for the hypothetical example of the value of natural spaces to a community. The exercise was done by the organizations that contributed to the development of this guidebook.[10]

10 *MNAI thanks IC Infrastructure for leading participating organizations through this exercise.*

4.3. Developing Corporate LOS for Natural Assets

Natural systems underpin a community's quality of life. Local governments likely already have some insight into the value of nature and healthy ecosystems to the community from the following sources:

- Engagement they have done in planning exercises.
- Information gathered through surveys, feedback or direct observation of how natural assets are being used and accessed.
- Council priorities that reflect interests of their constituents.
- Research that demonstrates how natural assets and healthy ecosystems contribute to service delivery and overall quality of life.

Local governments can use these insights to establish strategic objectives for natural assets and healthy ecosystems, even when the data and information they have about their natural assets is limited. Strategic objectives should be used as a basis for developing corporate levels of service objectives in specific service areas or for specific natural asset types. The corporate level of service outcome is needed to support the development of more granular customer and technical levels of service used to measure progress in implementing asset management plans.

Strategic objectives may be articulated as a vision or set of goals and policy objectives. They do not necessarily have to be tied to specific scientific data and information about natural assets. For example, the City of Edmonton's target of 2 million trees for 2 million people was not set based on scientific knowledge of the number of trees needed to optimize a whole range of services. Rather, it was set based on research demonstrating the value of trees for quality of life, building resiliency to climate change and community interests. As the City builds its knowledge of the biophysical services provided by its urban forest it could adjust its target as part of continuous improvement efforts.

The choice of corporate LOS measures will depend on how local governments have chosen to focus efforts on natural asset management. The table below provides examples.

EXAMPLES OF STRATEGIC OBJECTIVES AND CORPORATE LOS FOR NATURAL ASSETS

LOCAL GOVERNMENT	STRATEGIC OBJECTIVE(S)	RELATED CORPORATE LOS
Edmonton, AB	Connect Edmonton City Plan: articulates the choices the City will make to become a healthy, urban and climate-resilient city of 2 million people that supports a prosperous region; directions include: 2 million "net new trees" will be planted "throughout our nodes and corridors, parks, private and public realm" by the time the city reaches a population of 2 million	Multiple Service Objectives in its UFAMP, examples include: ■ Provide natural areas for gathering, enjoying, relaxing, recreation and mental health ■ Provide a forest with diverse native species to improve resilience to climate change

Vancouver, BC	Biodiversity Strategy 2015 Goal: Increase the amount and ecological quality of natural areas including forests, wetlands, streams, shorelines, and meadows to support biodiversity.	VanPlay, Vancouver Parks Master Plan: ■ Restore Vancouver's wild spaces and vital biodiversity. Target: Restore or enhance 25 hectares by 2020. 2010 Baseline: 847 hectares
Halton Hills, ON	The Climate Adaptation Plan has 5 key goals, one of which is: Halton Hills is Resilient to the Impacts of Higher Temperatures and More Frequent Heat Waves. It has a related objective: Halton Hills has a resilient, protected tree canopy.	Recreation and Parks leads: Encourage tree diversity (best species for a changing climate) as part of planting programs and in new developments
Gibsons, BC	Official Plan Goal: Protect the Gibsons Aquifer, as a source of high-quality drinking water for the Town.	Provide untreated drinking water from the Gibsons aquifer to the entire population of the Town

No local government asset management plan is based on perfect data, and particularly for natural assets, most local governments in Canada still have limited data and information about the services natural assets provide.

Local governments may be leery of setting corporate LOS targets in the face of uncertainty over whether approved budgets will be sufficient to achieve their objectives or if they do not have baseline data related to current LOS. In those cases, asset management plans can indicate risks associated with implementation of their plans that may limit them in achieving targets.

Another option is for local governments to define an LOS measure without a target and determine the baseline as a first step. Targets can be set in future AMPs. Local governments may also wish to consider identifying LOS targets that represent "no regret" scenarios that are known to have positive social, environmental or resiliency benefits with little or no added cost. Ultimately it is council's role to approve corporate LOS measures, to monitor progress in achieving them, and to adjust them in the face of changing local government circumstances.

Asset management is a process of continuous improvement and as local governments build knowledge about the state of their natural assets and the dynamic services they provide, their LOS measures will improve.

4.4. Developing Customer and Technical LOS for Natural Assets

Once corporate service objectives have been defined, local governments will be able to develop customer and technical LOS to guide implementation of natural asset management to achieve them. To ensure that all important aspects of service delivery are accounted for and tracked, several customer and technical LOS are generally developed to measure performance on a single corporate LOS objective.

Customer LOS are the publicly facing performance measures that represent the service the community is receiving, in terms that are meaningful and relevant to them. Technical LOS are more granular performance measures local governments use internally that define the required ecosystem performance of natural assets and operational performance required to achieve those customer service levels (monitoring, maintenance, restoration of natural assets). Together, customer and technical LOS provide insight into the progress local governments are making towards achieving their corporate LOS.

The number of customer and technical LOS measures that local governments track needs to be realistic and will be influenced by factors such as a local government's size and complexity, its regulatory framework, community priorities and expectations for services that rely on healthy natural systems, and capacity (budget and human resources). Examples of corporate, customer and technical LOS are in the case studies in *Section 6*.

The general rule-of-thumb for developing good performance measures is that they adhere to the following "SMARTER" principles[11]:

S: Specific, meaning they define results to be accomplished for a specific aspect of the service objective

M: Measurable, meaning they define a quantity, cost or quality.

A: Achievable, meaning the target should be realistic (not a stretch target or easy target)

R: Relevant, meaning it supports an organizational goal and provides a clear picture of whether the service is being provided. A customer LOS should also be relevant and meaningful to the community.

T: Timebound, meaning the measure specifies the frequency of action or a due date. Long-term targets should be stated along with annual or short-term targets that measure progress to be achieved over time.

E: Evaluation, meaning that there will be ongoing evaluation of the appropriateness of the measure/target.

R: Re-assess, meaning that LOS will be reviewed and updated to reflect the changing business environment.

Local governments can use the principles above to define LOS based on the following key service attributes (generally considered universal values of service delivery): [12]

Safety: the service is delivered safely and risks are managed

Regulatory: the service meets all regulatory requirements

Reliability: the service is reliable

Accessibility: the service is accessible (and affordable)

Quality: the service is satisfactory to those who use it or benefit from it

11 *Source: International Infrastructure Management Manual (2015), Institute of Public Works Engineering Australasia.*

12 *Source: International Infrastructure Management Manual (2015), Institute of Public Works Engineering Australasia.*

Sustainability: the service is sustainable (social, environmental and financial sustainability)

Cost/affordability: the service is affordable

Customer service: the local government is responsive to questions or concerns about the service[13]

The next section provides examples of corporate, customer and technical LOS for natural assets across service areas of interest to local governments.

13 *Note that this service attribute is used by some local governments but is not included in the International Infrastructure Management Manual (2015).*

Section 5 The Contribution of Natural Assets to Service Delivery

This section describes how different natural asset types contribute to a range of local government service objectives and provides examples of corporate, customer and technical LOS. Local government service areas included are:

- Stormwater management
- Wastewater management
- Drinking water management
- Biodiversity
- Climate resilience
- Transportation
- Public health
- Recreation
- Culture and heritage
- Local economic development

Each description shows at a high level the type of ecosystem services natural assets may provide and the type of data and information needed to define meaningful LOS. The ecosystem services are grouped into four main types: provisioning services, regulating services, habitat/supporting services and cultural services.[14] These ecosystem categories are described in more detail in *Appendix C:* Description of Ecosystem Services.

The LOS examples included in this section were developed through expert input, academic literature and local government sources (e.g., local government strategies and asset management plans). These examples are not exhaustive and local governments will need to develop LOS measures based on their priorities and capacity.

5.1. Stormwater Services

Natural assets can play an important role in stormwater management, sometimes at a lower cost than grey infrastructure solutions. They can be very effective in storing water, controlling peak flows, supporting groundwater recharge and controlling erosion, for example. By reducing stormwater runoff in urbanized areas, natural assets also contribute to the protection of source water and overall ecosystem health.

14 *As described in TEEB – The Economics of Ecosystems and Biodiversity (2011). TEEB Manual for Cities: Ecosystem Services in Urban Management, www.teebweb.org.*

NATURAL ASSET TYPE	POTENTIAL ECOSYSTEM SERVICES PROVIDED	FACTORS INFLUENCING THE SERVICES PROVIDED
Water		
Groundwater - aquifers	Regulating: • Water storage	Sustainability of groundwater supply is dependent on the recharge rate. Water regulation services are provided when the rate of groundwater withdrawal does not exceed the natural renewal rate. Recharge rates are determined by integrated hydrologic and/or hydraulic modeling. Net recharge is a function of many variables. It varies temporally and spatially by season, storm water intensity, stream stage, soil type, vegetation type and cover, elevation, slope, temperature, solar radiation, and other factors, including the presence of buildings, paved surfaces, and drainage culverts.
Surface water – rivers, creeks, streams	Regulating: • Conveyance of water and attenuation of peak flows • Groundwater recharge • Water storage	Factors negatively impacting stormwater services include: • Development in floodplains • Channelized streambeds • Over-extraction of water / unsustainable water extraction rates • Damage to headwater streams • Any of the above factors could be exacerbated by climate change Factors positively impacting stormwater services include: Watershed-scale stormwater management planning that sets policies or targets around imperviousness over the watershed and minimum widths of riparian buffers Note: Services provided when hydrological, geological, and biological components of stream networks are intact.
Snowpack	Regulating • Water storage	Factors negatively impacting water storage via snowpack include: • Loss of canopy cover at high elevations (could be exacerbated by climate change
Riparian areas / floodplains	Regulating: • Flood & drought mitigation • Groundwater recharge • Erosion control / bank stability	The width needed for a riparian buffer to be effective depends on multiple factors, but in general, the wider the buffer, the greater the benefits delivered. This is particularly true for headwater streams. • Flood & drought mitigation provided with buffer widths of 20 – 150m. Forested buffers are more effective than grass buffers. • Groundwater infiltration provided with buffer widths of 5-30m. • Erosion control and bank stability provided with buffer widths of 10-30m

NATURAL ASSET TYPE	POTENTIAL ECOSYSTEM SERVICES PROVIDED	FACTORS INFLUENCING THE SERVICES PROVIDED
Forest assets (urban forest, urban woodlots, intact forested areas)	Regulating: • Erosion mitigation • Groundwater recharge	Major factors influencing the performance of trees for stormwater management: • Tree (e.g. evergreen/deciduous; species; size/age; leaf area index; evapotranspiration rate; root structure/depth) • Atmosphere (e.g. climate zone; annual precipitation; precipitation intensity & duration; temperature) • Soil (e.g. rooting volume; water holding capacity; compaction; drainage) • Landscape (e.g. surrounding land cover; impervious services; watershed position; tree density) Factors impacting erosion mitigation include: • Vegetation establishment (e.g. planting forests on erosion-prone soils and runoff pathways to reduce & intercept sediment • Soil type (e.g. gravel less prone to surface erosion than sand) • Connectivity with adjacent ecosystems • Forest operations (e.g. cultivation, drainage, road construction, timber harvesting)
Inland green open spaces (vegetated areas, meadows, grasslands, bushlands)	Regulating: • Erosion mitigation • Flood control	Factors impacting erosion & flood control include: • Vegetation type (e.g. native species that are tolerant to local conditions) • Location (e.g. floodplain meadows should be kept intact to limit flooding) • Soil type
Coastal natural spaces (vegetated areas, beach, dunes, eelgrass & seagrass, rocky shoreline, estuaries and ocean wetlands)	**NOTE:** Coastal natural spaces are impacted by stormwater but do not contribute to managing stormwater (as it comes from upstream of these ecosystems). Sea level rise that encroaches on foreshores could limit the ability of upstream natural assets to store and transmit water.	
Wetlands (isolated palustrine, riverine)	Regulating: • Flood control • Water supply & storage	• Water level fluctuations determined by wetland-to-watershed area ratios, level of watershed development, outlet conditions, and soils • Percent imperviousness of land cover • Topography • Wetland type (isolated wetlands most effective, then palustrine wetlands, then riverine wetlands) • The balance of inflows and outflows of water through a wetland defines the water budget and determines the amount of water stored within the wetland (ibid) • Wetland type (isolated wetlands most effective, then palustrine wetlands, then riverine wetlands) • Connectivity with adjacent ecosystems

NATURAL ASSET TYPE	POTENTIAL ECOSYSTEM SERVICES PROVIDED	FACTORS INFLUENCING THE SERVICES PROVIDED
Soil	Regulating: • Water storage • Erosion control	Factors impacting delivery of services: • Hydrological soil group • Connectivity with adjacent ecosystems • Percent imperviousness of land cover
Urban green infrastructure (street trees, urban parks, urban trails, bioswales, rain gardens, naturalized stormwater ponds, lawns and gardens, green roofs and walls, crops and pasture, naturalization)	Regulating: • Flood control / water supply & storage	Factors impacting delivery of services: • How GI/LID is constructed • Changes to landscape post construction (e.g. urbanization, restoration) • Bioswales, rain gardens, naturalized stormwater ponds, green roofs and walls, naturalization effective for flood control; water supply & storage • Street trees, urban parks, urban trails, lawns & gardens, crops & pasture of moderate effectiveness for stormwater regulation

SCALE OF ANALYSIS NEEDED TO DEFINE CUSTOMER LOS

- For intact natural assets it is preferable if analysis is completed at a watershed scale as all components of ecosystem interact to manage quality and quantity of water. If this is not feasible, the scale should be catchment or drainage basin (smaller sub-basins that combine to form a larger water basin).
- For urban green infrastructure, the scale of analysis is the local government boundary and may be completed at the site level.

TYPE OF DATA AND INFORMATION NEEDED TO DEFINE LOS

- Modelling may be needed to inform LOS: Modelling: hydrologic model uses a variety of hydrologic parameters (e.g., runoff, evaporation, snowmelt) to estimate the runoff/storage/infiltration from a watershed for a given rainfall event based on a suite of physical characteristics of a given watershed (e.g., size, slope, length/width, surface cover, soil types).
  - Floodplain flood control data needs: channel geometry, flow data, digital elevation model (DEM).
  - Marsh flood control data needs: flow and water level monitoring.
  - Channel flood control data needs: water levels, groundwater, precipitation, and velocity.
- Water level monitoring: water level logger (Oct – Dec and March – July)
- Groundwater monitoring: drivepoint piezometer (to be installed in proximity to the surface water level monitoring stations). Each monitoring location had one ‘shallow’ and ‘deep’ piezometer to observe the impact of the remnant channel on the surface water groundwater interaction.

- Precipitation data: rain gauge
- For scenario analysis (CC) – Intensity-Duration-Frequency curves
  - Wetland flood control data needs: surface and groundwater levels (piezometers)
  - Water purification data needs: water quality monitoring
- Is detailed condition assessment needed?
  - Not necessarily needed for modeling (which provides technical information for LOS). A basic condition assessment provides an indication of ecosystem services provided

EXAMPLE(S) OF CORPORATE, CUSTOMER AND TECHNICAL LOS

CORPORATE LOS OBJECTIVE	**PERFORMANCE MEASURES** Customer LOS shown on white, Technical LOS shown shaded	**SERVICE VALUE** (attribute)
Protect and preserve the natural assets to reduce incidences of flooding and drought	# residents affected by flooding	Safety
	# residents affected by drought	Safety
	Length of time residents affected	Customer service
	% of wetlands, stream channels, forests restored to support drainage	Sustainability
	Up-to-date flood mapping completed, with climate scenarios incorporated	Safety
	Percentage of properties in municipality resilient to a 100-year storm.	Safety
	Percentage of the municipal stormwater management system resilient to a 5-year storm.	Safety
	No repetitive losses	Reliability
	No increases in base flood elevation due to new development	Safety
Implement low-impact development solutions	Proportion of arterial roads that adhere to low impact development design standards	Quality
	% impervious cover	Quality
	Volume of stormwater runoff from maintained trees	Sustainability
	# partnerships or programs that support low impact development investments on private property	Accessibility
	% change in impervious cover on private property	Accessibility

5.2. Drinking (potable) water services

Fresh water is essential for human survival and all local governments that provide drinking water services have an interest in protecting source water quality. The cleaner a community's source of drinking water, the more cost-effective service delivery will be through avoided costs of water treatment. Local governments also need to build an understanding of the quantity of source water available for the community and take relevant actions to protect the supply of source water. There may be natural asset management activities (e.g., forest conservation) that support aquifer recharge for communities relying on groundwater. Local governments can also implement demand management programs and policies to help conserve water.

With increased risk of drought from climate change, some local governments are looking into strategies to conserve drinking water, which has very stringent treatment requirements, and separate it from other uses such as emergency fire services and irrigation.

NATURAL ASSET TYPE	POTENTIAL ECOSYSTEM SERVICES PROVIDED	FACTORS INFLUENCING THE SERVICES PROVIDED
Water		
Groundwater - aquifers	Provisioning: • Water purification Regulating: • Water storage	• Contamination at or near surface, particularly near recharge zones (e.g., fertilizers, manure, pesticides) • Pumping (services provided when abstraction of ground water does not exceed the natural renewal rate) • Increase in impervious surfaces • Climate change
Surface water – rivers, creeks, streams	Provisioning: • Water purification Regulating: • Groundwater recharge • Water supply	• Climate change • Natural disasters (floods, droughts, earthquakes) • Agricultural activities • Sewage discharge • Timber harvesting • Industrial discharge • Channelization • Land fill sites • Increase in impervious surfaces • Climate change
Snowpack	Regulating • Water storage	• Climate change • Forest loss at high elevations • Increase in impervious surfaces

NATURAL ASSET TYPE	POTENTIAL ECOSYSTEM SERVICES PROVIDED	FACTORS INFLUENCING THE SERVICES PROVIDED
Riparian areas / floodplains	Provisioning: • Water purification Regulating: • Groundwater recharge • Erosion control / bank stability	Factors that negatively influence service provision: • Vegetation removal (predisposes site to erosion) • Stream channelization (reduces recharge capacity, increases runoff) • Streambank disturbance (by animals, people roads) • Catastrophic stream flow fluctuations (from upstream, storm drains) • Siltation, pesticides and other pollutants • Operation of heavy equipment in or near stream (destruction of soil structure and vegetation) • Diversion or impoundment of waters (disrupts flow, fisheries) • Upper watershed disruptions (e.g., logging, fire development)
Forest assets (urban forest, urban woodlots, intact forested areas)	Provisioning: • Water purification Regulating: • Erosion control	Factors that negatively influence service provision: • Timber harvesting, particularly in riparian areas • Roads and stream crossings • Climate change • Erosion and sedimentation processes • Landslides • Wildfire • Channel erosion • Geology and soil type • Catchment hydrology
Inland green open spaces (vegetated areas, meadows, grasslands, bushlands)	Provisioning: • Water purification Regulating: • Erosion mitigation	• Pollutant loading (e.g. fertilizers, manure, pesticides, industrial discharge) • Increase in impervious surfaces • Climate change • Geology and soil type • Vegetation removal • Invasive species
Coastal natural spaces (vegetated areas, beach, dunes, eelgrass & seagrass, rocky shoreline, estuaries and ocean wetlands)	**NOTE:** coastal natural spaces do not contribute to drinking water (as it comes from upstream of these ecosystems)	

NATURAL ASSET TYPE	POTENTIAL ECOSYSTEM SERVICES PROVIDED	FACTORS INFLUENCING THE SERVICES PROVIDED
Wetlands (isolated palustrine, riverine)	Provisioning: • Water purification Regulating: • Water supply & storage	• Water extraction or drainage • Climate change • Poor agricultural practices • Invasive species • Wildfire • Wetland type • Erosion • Contaminants • Loss of vegetation
Soil	Provisioning: • Water purification Regulating: • Water storage • Erosion control	• Soil type (texture and structure) • Compaction • Poor agricultural practices • Contaminants • Erosion • Increase in impervious surfaces • Climate change
Urban green infrastructure (street trees, urban parks, urban trails, bioswales, rain gardens, naturalized stormwater ponds, lawns and gardens, green roofs and walls, crops and pasture, naturalization)	Provisioning: • Water purification Regulating: • Water storage • Erosion control	• How GI/LID is constructed • Changes to landscape post construction (e.g., urbanization, restoration) • Contaminants • Climate change • Increase in impervious surfaces • Invasive species • Vegetation removal

SCALE OF ANALYSIS NEEDED TO DEFINE CUSTOMER LOS

- For intact natural assets – preferable if scale of analysis completed at watershed scale as all components of ecosystem interact to manage quality and quantity of water. If this is not feasible, scale should be catchment or drainage basin (smaller sub-basins that combine to form a larger water basin).
- For urban green infrastructure, the scale of analysis is the local government boundary and may be completed at the site level.

TYPE OF DATA AND INFORMATION NEEDED FOR TECHNICAL LOS

- Modelling may be needed to inform technical LOS: Modeling: hydrologic model uses a variety of hydrologic parameters (e.g., runoff, evaporation, snowmelt) to estimate the runoff/storage/infiltration from a watershed for a given rainfall event, based on a suite of physical characteristics of a given watershed (e.g., size, slope, length/width, surface cover, soil types).
- Water quality monitoring. Measurements may include: physical-chemical parameters (temperature, pH, alkalinity, major ions), nutrients (P, N, TSS) and metals.

- Monitoring site may include: major tributaries near confluence with river or streams, where streams/river discharge into lakes.
- Increasingly, monitoring efforts are aimed at determining the condition of entire watersheds because of an improved understanding of the impact of land-based activities on the waters that drain the land, and the interconnectedness of all types of waterbodies, including those beneath the ground.

EXAMPLE(S) OF CORPORATE, CUSTOMER AND TECHNICAL LOS

CORPORATE LOS OBJECTIVE	**PERFORMANCE MEASURES** Customer LOS shown on white, Technical LOS shown shaded	**SERVICE VALUE** attribute
Provide abundant, safe drinking water to residents	# of boil water advisories (with # residents affected)	Safety
	% of population served by municipal water	Accessibility
	# water quality complaints	Quality
	% residents satisfied with water quality	Quality
	# times water quality fails to meet provincial standards	Regulatory
Cost-effective water service delivery (minimize water treatment requirements)	# partnerships that support restoration activities	Sustainability
	# of residents/farmers engaged in best management practices	Sustainability
	% change in natural water storage capacity	Sustainability
	Proportion of floodplain reconnected with rivers	Sustainability
	# hectares of degraded water bodies restored	Sustainability

5.3. Wastewater services

While a range of natural assets play a role in water purification, the use of natural assets for wastewater treatment is generally discouraged as pollutant loads can overwhelm natural treatment capacity. Natural and constructed wetlands are an exception and have been used for water purification in different parts of the world since the 1950s, but mainly as supplementary treatment. Constructed wetlands are human-made and used to treat non-point source pollution.[15] They have emerged as a cost-effective, environmentally friendly method of treating a variety of wastewaters, particularly because they have the added benefit of being designed for optimal performance and maximum control of hydraulic and vegetation management.[16]

15 *For detailed technical information about constructed wetlands, please see the Government of Canada Fact Sheet on Constructed Wetlands, Fact sheet: Constructed wetlands — Guidance and Orientation for the Selection of Technologies — Contaminated sites — Pollution and waste management — Environment and natural resources — Canada.ca (tpsgc-pwgsc.gc.ca).*

16 *See, for example, the Federation of Canadian Municipalities case study, "Constructed wetland treats wastewater and adds green space in Loyalist Township, ON", Case study: Constructed wetland treats wastewater and adds green space in Loyalist Township, ON | Federation of Canadian Municipalities (fcm.ca)*

NATURAL ASSET TYPE	POTENTIAL ECOSYSTEM SERVICES PROVIDED	FACTORS INFLUENCING THE SERVICES PROVIDED
Water		
Groundwater - aquifers	Not applicable	
Surface water – rivers, creeks, streams	Not applicable	
Snowpack	Not applicable	
Riparian areas / floodplains	Not applicable	Although riparian buffers are well recognized for water purification properties, it is not recommended to utilize them for wastewater treatment
Forest assets (urban forest, urban woodlots, intact forested areas)	Not applicable	
Inland green open spaces (vegetated areas, meadows, grasslands, bushlands)	Not applicable	
Coastal natural spaces (vegetated areas, beach, dunes, eelgrass and seagrass, rocky shoreline, estuaries and ocean wetlands)	Not applicable	
Wetlands (isolated palustrine, riverine)	Regulating: • Removal of pollutants	• Wetland hydrological and ecological characteristics • Increased phosphorous and nitrates removal if wetland has alternating wet and dry periods • Type of wastewater • Wastewater loading rate • Addition of absorbing materials to the wetland sediment. • Distance from main rivers and streams (min recommended buffer zone of 500 and 40 m, respectively) • Sediment and plant types
Soil	Not applicable	

NATURAL ASSET TYPE	POTENTIAL ECOSYSTEM SERVICES PROVIDED	FACTORS INFLUENCING THE SERVICES PROVIDED
Urban green infrastructure (street trees, urban parks, urban trails, bioswales, rain gardens, naturalized stormwater ponds, lawns and gardens, green roofs and walls, crops and pasture, naturalization)	Regulating: • Removal of pollutants	Applicable for: naturalized stormwater management ponds, bioswales Wetland hydrological and ecological characteristics: • Increased phosphorous and nitrates removal if wetland has alternating wet and dry periods • Wastewater loading rate • Addition of absorbing materials to the wetland sediment. • Distance from main rivers and streams (min recommended buffer zone of 500 and 40 m, respectively) • Sediment and plant types

SCALE OF ANALYSIS NEEDED TO DEFINE CUSTOMER LOS

- Site-specific analysis required

TYPE OF DATA AND INFORMATION NEEDED FOR TECHNICAL LOS

- Water quality monitoring
- Wastewater volumes and loading rate as high levels may impact aquatic wildlife
- Wetland hydrological and ecological characteristics
- Map(s) and/or description of which user groups or areas of the community (e.g., residential, commercial, industrial, agricultural, institutional, mixed-use) are connected to wastewater treatment ponds/wetlands

EXAMPLE(S) OF CORPORATE, CUSTOMER AND TECHNICAL LOS

CORPORATE LOS OBJECTIVE	PERFORMANCE MEASURES Customer LOS shown on white, Technical LOS shown shaded	SERVICE VALUE attribute
Provide safe, cost-effective wastewater treatment solutions	# complaints about sewage back up, odors or other impacts	Quality
	# wastewater treatment non-compliance events	Safety
	% of properties serviced by naturalized wastewater treatment ponds or wetlands	Accessibility
	% of samples not meeting Provincial/Municipal regulatory requirements	Regulatory

5.4. Climate resilience services

Ecosystems and the natural assets contained in them are vital to the climate system through their role in the carbon cycle, the water cycle, and the maintenance of biodiversity. The IPCC's Special Report on Global Warming of 1.5°C (2018)[17] highlighted how land plays a key role in storing greenhouse gases. Within Canada, the soils of the tundra, forests, wetlands, and grasslands are of heightened importance for carbon storage. However, once ecosystems are disturbed, carbon is released to the atmosphere (IPBES, 2018)[18]. These stores of carbon may have accumulated over centuries or millennia.

Ecosystems also play an important buffering role in reducing the severity of climate change, including through services such as flood attenuation, urban heat island reduction, and storm surge protection. Maintaining, restoring, and managing ecosystems to address climatic and non-climatic stressors are key strategies for reducing their vulnerability and the vulnerability of communities in the face of climate change, by enhancing their resilience to changing conditions.

Many knowledge gaps exist about how ecosystems will respond to climate change because of their complexity. For example, feedback loops can limit, reduce, or magnify further impacts on ecosystems and people and create tipping points where ecosystems are no longer able to cope with environmental change. Future projections of ecosystem function and dynamics are built on an incomplete understanding of this complexity. Long-term monitoring and adaptative management strategies are therefore essential to managing the impacts of climate change.

17 *IPCC, 2018: Global warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [V. Masson-Delmotte, P. Zhai, H. O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J. B. R. Matthews, Y. Chen, X. Zhou, M. I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, T. Waterfield (eds.)]. In Press.*

18 *IPBES. 2018. The IPBES regional assessment report on biodiversity and ecosystem services for the Americas. Rice, J., Seixas, C. S., Zaccagnini, M. E., Bedoya-Gaitán, M., and Valderrama N. (eds.). Secretariat of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, Bonn, Germany. 656 pages.*

NATURAL ASSET TYPE	POTENTIAL ECOSYSTEM SERVICES PROVIDED	FACTORS INFLUENCING THE SERVICES PROVIDED
Water **Groundwater - aquifers** **Surface water – rivers, creeks, streams** **Snowpack** **Riparian areas / floodplains** **Forest assets** (urban forest, urban woodlots, intact forested areas) **Inland green open spaces** (vegetated areas, meadows, grasslands, bushlands) **Coastal natural spaces** (vegetated areas, beach, dunes, eelgrass and seagrass, rocky shoreline, estuaries and ocean wetlands) **Wetlands** (isolated palustrine, riverine) **Soil** **Urban green infrastructure** (street trees, urban parks, urban trails, bioswales, rain gardens, naturalized stormwater ponds, lawns and gardens, green roofs and walls, crops and pasture, naturalization)	Regulating: • carbon sequestration and storage • buffering extreme weather events through temperature regulation, flood and drought mitigation (see stormwater services)	• Ecosystem degradation and fragmentation • Over-harvesting of natural resources • Biodiversity loss/decline • Invasive species • Protect and/or restore ecosystem complexity and structure • Percentage of vegetated cover (vs % of impermeable surfaces) • Pollutants • Fresh water demand • Concentration of population in vulnerable areas (e.g., coastal zones, floodplains, deforested hillsides) • Early warning systems (to initiate restoration, for instance) • Adaptative ecosystem research/adaptative ecosystem management • Long-term monitoring

SCALE OF ANALYSIS NEEDED TO DEFINE CUSTOMER LOS

- Climate change is a global issue, implying local analysis should be informed by regional, provincial, and national trends and information.

TYPE OF DATA AND INFORMATION NEEDED FOR TECHNICAL LOS

- Data for climate mitigation (i.e. GHG sequestration & storage)[19]
  - ☐ Land use
  - ☐ Land cover
  - ☐ Land use conversion
  - ☐ Land management
  - ☐ Current weather and climate
  - ☐ Future climate projections
  - ☐ Permafrost
  - ☐ Topography
  - ☐ Topography
  - ☐ Forest data: dominant species, DBH (diameter at breast height), frost-free days, tree health, crown light exposure, canopy height, trees-per-hectare, ecozone, forest age)
  - ☐ Agriculture (soil type, soil depth, crop type)
  - ☐ Wetland (wetland type, wetland vegetation)
- Data for climate adaptation
  - ☐ Land use
  - ☐ Land cover
  - ☐ Land use conversion
  - ☐ Land management
  - ☐ Current weather and climate
  - ☐ Future climate projections
  - ☐ Topography
  - ☐ Ecosystem disturbances

EXAMPLE(S) OF CORPORATE, CUSTOMER AND TECHNICAL LOS[20]

CORPORATE LOS OBJECTIVE	**PERFORMANCE MEASURES** Customer LOS shown on white, Technical LOS shown shaded	**SERVICE VALUE** attribute
Provide a forest with diverse native species to improve resilience to climate change	% of one species (maintained trees)	Sustainability
	Native species measure	Sustainability
	Canopy coverage (distance to nearest occupied patch to measure connectivity of canopy)	Accessibility
	# hectares of natural spaces restored	Sustainability

19 *While methods to obtain local GHG estimates have been developed for forest ecosystems, limited methods are available for other ecosystem types.*

20 *These examples focus strictly on natural asset-related measures that support climate mitigation and adaptation. There are other measures related to public safety and resilience of infrastructure that local governments should define in asset management plans.*

Provide opportunities to build community awareness of and engagement in nature-based solutions that build resilience to climate impacts.	% of residents aware of how nature-based solutions build resilience to climate change	Sustainability
	# of stewardship programs in place supporting nature-based solutions to climate change	Sustainability
	# partnerships supporting nature-based solutions to climate change	Sustainability
Protect and conserve existing wetlands	# hectares wetlands protected through partnerships with private land owners	Sustainability
	# hectares wetlands acquired	Sustainability
	% of wetlands monitored for condition and ecological functioning	Quality
Prioritize protection of the most vulnerable residents.	# of deaths per year from climate-related events (e.g., extreme heat, flooding) disaggregated by neighbourhood	Safety
	# of homes experiencing municipal service disruptions due to extreme wind or rain events disaggregated by neighbourhood	Reliability
	Proportion of residents that have implemented flood protection measures through the city/town's flood protection program.	Sustainability

5.5. Biodiversity services

Biodiversity is the diversity among living organisms. It is essential to support functioning ecosystems. Changes in biodiversity can influence the supply of ecosystem services, just as changes in the quantity and condition of natural assets in an ecosystem can influence biodiversity.

The Post-2020 Global Biodiversity Framework (GBF) is a United Nations-led initiative to tackle the root causes of biodiversity loss and could have a similar impact as the United Nations Climate Change Conference Paris Agreement. Cities are a main driver of biodiversity loss, and local governments are critical to implementing solutions. The GBF includes an action agenda to:

1/ raise public awareness about the urgent need to stem biodiversity loss and restore biodiversity health for the sake of humanity and the global ecosystem.

2/ to inspire and help implement nature-based solutions to meet key global challenges.

3/ to catalyze cooperative initiatives across sectors and stakeholders in support of the global biodiversity goals.[21]

Canada's commitment to the United Nations Convention on Biological Diversity includes Target 4, that by 2020, biodiversity considerations are integrated into municipal planning and activities of major municipalities across Canada.

21 *See ICLEI's sub-national and local government engagement platform, Local & Subnational Government engagement platform - ICLEI*

NATURAL ASSET TYPE	POTENTIAL ECOSYSTEM SERVICES PROVIDED BY NATURAL ASSETS	FACTORS INFLUENCING THE SERVICES PROVIDED
Water		• Overfishing/over-use undermines biodiversity in aquatic systems • Pollutant loading undermines biodiversity in aquatic systems • Larger, intact forests and natural areas support greater biodiversity • Climate change will lead to changes in species types and biodiversity • Invasive species can negatively impact biodiversity • Deforestation affects the health of ecosystems and can undermine biodiversity • Urbanization/development pressure risks loss of natural assets and biodiversity • Fertilizers can negatively impact the health of agricultural soils • Road salts and other pollutants can negatively affect the condition of natural assets & biodiversity
Groundwater - aquifers		
Surface water – rivers, creeks, streams	Supporting/habitat: • Provide habitat	
Riparian areas	Supporting/habitat: • Help maintain healthy aquatic ecosystems and provide reliable sources of clean water • Provide habitat • Pollination	
Forest assets (urban forest, urban woodlots, intact forested areas)		
Inland green open spaces (vegetated areas, meadows, grasslands, bushlands)	Supporting/habitat: • Provide habitat • Pollination	
Coastal natural spaces (vegetated areas, beach, dunes, eelgrass and seagrass, rocky shoreline, estuaries and ocean wetlands)	Supporting/habitat: • Provide habitat	
Wetlands (isolated palustrine, riverine)	Supporting/habitat: • Wetlands support the lifecycles of a huge range of plants and animals, including one-third of Canada's species at risk. • Provide habitat • Pollination	
Soil	Supporting: • Nutrient cycling • Primary production	
Urban green infrastructure (street trees, urban parks, urban trails, bioswales, rain gardens, naturalized stormwater ponds, lawns and gardens, green roofs and walls, crops and pasture, naturalization)	Supporting/habitat: • Provides habitat • Pollination	

SCALE OF ANALYSIS NEEDED TO DEFINE LOS

- A watershed-scale understanding of natural assets and biodiversity is beneficial to identify protection and management actions that support ecological integrity and manage risks to biodiversity.
- Some local governments begin with an analysis of a significant natural area or areas within their jurisdiction where they have direct control or influence over how natural assets are managed.

TYPE OF DATA AND INFORMATION NEEDED TO DEFINE LOS

- Local governments require input from a range of disciplines to effectively incorporate and conserve biodiversity in and around their jurisdiction, including planners, architects, landscape architects, and urban designers because of their central role in influencing land use change; and ecologists, biologists, foresters and other scientists because of their ability to assess the health of species and ecosystem functioning.
- Local governments need to ensure their land use decisions, policies and by-laws adhere to all relevant provincial/territorial and federal regulations related to protection of biodiversity.
- The federal and provincial/territorial governments have databases of the status of wildlife and species at risk: *chm.cbd.int/database/record?documentID=241248*.
- Monitoring data related to ecosystem health, including changes in prevalence/condition of species at risk, invasive species, diversity of species (flora and fauna).
- Monitoring of ecological functioning including soil health, hydrological functioning.
- Water purification: determined through water quality monitoring or by estimating pollution removal rates based on existing literature.
- Standards and guidelines that support protection and enhancement of biodiversity (e.g., bird and wildlife-friendly design standards, tree planting and naturalization guidelines).
- Local governments may wish to refer to the City Biodiversity Index, also referred to as the Singapore Index (SI), a self-assessment tool for cities to evaluate and monitor the progress of their biodiversity conservation efforts in relation to a baseline. It comprises the "profile of the city" and 23 indicators that measure native biodiversity, ecosystem services provided by biodiversity, and government and management of biodiversity. It also includes a user's manual.[22] The cities of Ottawa and Montreal contributed to the development of the Index.

22 *Source: User's Manual on the City Biodiversity Index, www.cbd.int/authorities/doc/Singapore-Index-User-Manual-20140730-en.pdf.*

EXAMPLE(S) OF CORPORATE, CUSTOMER AND TECHNICAL LOS

CORPORATE LOS OBJECTIVE	PERFORMANCE MEASURES Customer LOS shown on white, Technical LOS shown shaded	SERVICE VALUE attribute
Increase the quantity of natural areas	% change in # hectares of natural areas	Sustainability
	# hectares natural areas acquired to be protected	Sustainability
Protect species at risk	Proportion of natural areas assessed for species at risk	Sustainability
	Change in prevalence of species at risk	Sustainability
	# legal challenges related to species at risk arising from development applications	Regulatory
Provide opportunities for biodiversity stewardship	# stewardship programs in place	Sustainability
	# community partnerships tracking species at risk or biodiversity	Sustainability
	# new developments applying wildlife and bird-friendly design guidelines	Accessibility
Increase the diversity of native trees and vegetation	# naturalization projects implemented annually	Sustainability
	% change in # of native species	Quality
	% natural areas with invasive species	Sustainability
	Diversity of age class of maintained trees (target = 40% young, 30% semi mature, 20% mature, 10% old)	Sustainability

5.6. Public health services

This service outcome area describes the services natural assets provide that promote physical and mental health.

*Note that services natural assets provide related to **drinking water quality** are addressed in the drinking water service outcome area. Services natural assets provide related to **temperature regulation** are addressed in the climate mitigation and adaptation service outcome area.*

Several studies demonstrate that when people live close to, and can access, greenspace, it can lead to improvements in physical and mental health and wellbeing, reduced mortality and reduced health care costs. A 2017 study of close to 1.3 million people, "Urban Greenness and Mortality in Canada's Largest Cities", found that being around trees and other vegetation reduced the risk of dying from several common causes of death by eight to twelve per cent.[23]

In 2020, the Greenbelt Foundation published *A Conceptual Framework for Understanding the Business Case for Ecohealth in Ontario*, which helps decision-

23 *Crouse DL, Pinault L, Balram A, Hystad P, Peters PA, Chen H, van Donkelaar A, Martin RV, Ménard R, Robichaud A, Villeneuve PJ. Urban greenness and mortality in Canada's largest cities: a national cohort study. Lancet Planet Health, October 2017.*

makers to understand the health-related business case of specific investments in greenspace to help inform policies, programs and planning decisions to enhance greenspaces. The literature review that guided the development of the framework showed that the evidence connecting greenspace investments to health outcomes was strongest for:

- Physical health improvements associated with higher levels of physical activity;
- Mental health improvements associated with spending time in nature; and
- Health improvements associated with lower levels of air pollution and specifically reduced respiratory symptoms and incidences of cardiovascular disease (page 24).

There is still no standard or policy to guide local governments on how much greenspace people need, how close to their homes, and what quality of greenspace or amenities should be provided to support positive health outcomes. Natural England created an Accessible Natural Greenspace Standard (ANGSt methodology) that states that each resident should have at least one area of accessible environmental space conforming to the following size and distance criteria: 2 ha, <= 300 m from home; 20 ha, <= 2 km from home; 100 ha, <= 5 km from home; and 500 ha, <= 10 km from home.[24]

Local governments can use resources like the Greenbelt Foundation's conceptual framework to estimate the health-related value of greenspace for their community.

A common approach to determine the value of greenspace to communities is contingent valuation. This involves the use of surveys to determine the willingness of the community to pay for the services that greenspace provides (e.g., improved air quality, reduced health risks, access to nature and recreation). Other valuation methods are explained in the Greenbelt Foundation's conceptual framework.

Example: The City of Edmonton, through its Urban Forest Asset Management Plan, did not specifically put a value on the public health-related services the urban forest provides to the community. However, it drew on several of the City's strategic documents and previous public engagement activities to define a corporate service objective for the urban forest "To provide natural areas for gathering, enjoying, relaxing, recreation and mental health." Several customer and technical LOS measures were then defined to support that objective, based on highly valued services the City had identified through public consultations, including:

24 *See Natural England website, Natural Accessible Greenspace Standard, Accessible Natural Green Space Standards in Towns and Cities: A Review and Toolkit for their Implementation - ENRR526 (naturalengland.org.uk)*

- Safe access to areas for gathering, enjoying nature, relaxation, and mental health
- Safe access to areas for recreation
- Shelter from elements including sun and wind
- Privacy and sound barriers
- Protected and connected natural areas system to promote human health and wellness

See the LOS the City defined in the case study on *page 66*.

NATURAL ASSET TYPE	POTENTIAL ECOSYSTEM SERVICES PROVIDED BY NATURAL ASSETS	FACTORS INFLUENCING THE SERVICES PROVIDED
Water		• Studies of health benefits have mainly focused on urban parks and greenspace, green corridors, trails and tree canopy. • Research has shown that duration in greenspace, level of physical activity and frequency of visits influence health outcomes, therefore factors influencing the level of service provided include: • Proximity to greenspace • Extent of greenspace • Quality of greenspace (amenities provided) • Equity issues may limit access to the benefits of natural assets among vulnerable groups
Groundwater - aquifers	Not applicable	
Surface water – rivers, creeks, streams	Cultural services: • Physical activity • Access to nature (mental health) • Reduced air pollution • Reduced noise pollution	
Riparian areas		
Forest assets (urban forest, urban woodlots, intact forested areas)		
Inland green open spaces (vegetated areas, meadows, grasslands, bushlands)		
Coastal natural spaces (vegetated areas, beach, dunes, eelgrass and seagrass, rocky shoreline, estuaries and ocean wetlands)		
Wetlands (isolated palustrine, riverine)		
Soil	Not applicable	
Urban green infrastructure (street trees, urban parks, urban trails, bioswales, rain gardens, naturalized stormwater ponds, lawns and gardens, green roofs and walls, crops and pasture, naturalization)	Cultural services: • Physical activity • Access to nature (mental health) • Reduced air pollution • Shade • Reduced noise pollution	

SCALE OF ANALYSIS NEEDED TO DEFINE LOS

- Natural assets located within the local government jurisdiction: most relevant are assets in close proximity and accessible to the community. These include urban parks and greenspace, green corridors, trails, and tree canopy. Local governments can also collaborate with nearby jurisdictions to support community access to near urban nature.

TYPE OF DATA AND INFORMATION NEEDED TO DEFINE LOS

- Research, direct observation, surveys to understand community and stakeholder needs
- Modelling Pollution Reduction Services Provided by Trees
  - Air and water pollution: For trees specifically, the Urban Forest Effects Model, available with i-Tree software (*www.itreetools.org/*), estimates the quantity of pollution that trees remove to support improved air quality and water quality. Studies have also been done that estimate the value of avoided health care costs associated with trees and shrubs.[25]
  - Noise pollution: Research that links noise pollution with health outcomes is limited but some studies have shown that vegetation belts with a width of at least 1.5 to 3 metres, especially in the form of trees, can reduce noise pollution.[26]

EXAMPLE(S) OF CORPORATE, CUSTOMER AND TECHNICAL LOS

CORPORATE LOS OBJECTIVE	**PERFORMANCE MEASURES** Customer LOS shown on white, Technical LOS shown shaded	**SERVICE VALUE** attribute
Provide a tree canopy of 30%	% neighbourhoods identified as vulnerable meeting tree canopy targets	Accessability
Provide a healthy environment for people to thrive in	# hectares natural areas restored	Sustainability
	# smog alerts	Safety
Reduce pollution with green infrastructure	# tonnes pollutants removed by trees and shrubs	Safety

25 *For example, A Conceptual Framework to Understand the Business Case for Eco-health noted a 2013 study that estimated the value of improved air quality provided by trees in the City of Toronto. Across the City, it was estimated that trees and shrubs remove 1,430 metric tonnes of air pollution valued at $20.4 million in avoided health care costs, Greenbelt Foundation, 2020, page 16.*

26 *Source: Pathak, V., Tripathi, B. D., & Mishra, V. K. (2008). Dynamics of traffic noise in a tropical city Varanasi and its abatement through vegetation. Environmental monitoring and Assessment, 146(1-3), 67-75.*

Provide greenspace for all residents to enjoy activities such as physical exercise, traditional or ceremonial uses, family outings, community gatherings, or solitude in natural settings.	% satisfied with urban parks and open space	Quality
	% residents living less than 500 metres from a park at least .5 hectares	Accessability
	# parks meeting accessibility standards and guidelines	Regulatory

5.7. Recreation services

Recreation services play a vital role in fostering healthy, engaged and socially cohesive communities and is a primary service offered by most local governments. Local governments have typically focused on built infrastructure such as facilities and park amenities in their asset management plans, although there is widespread recognition of the value of the natural assets themselves in places where people recreate.

In addition to urban parks, many types of green infrastructure such as urban and nearby forests, tree-lined streets, and other types of natural assets (e.g., a naturalized stormwater management facility), can support nature-based recreation. Accounting for all the green infrastructure that can be accessed for recreational purposes can inform natural asset management planning.[27]

27 *See for example, Cortinovis, Zulian and Genilletti (2018), "Assessing Nature-based Recreation to Support Urban Green Infrastructure Planning in Trento, Italy, www.mdpi.com/2073-445X/7/4/112/htm.*

NATURAL ASSET TYPE	POTENTIAL ECOSYSTEM SERVICES PROVIDED BY NATURAL ASSETS	FACTORS INFLUENCING THE SERVICES PROVIDED
Water		• Quality and size of natural assets and greenspace, including amenities provided • Availability of outdoor recreational programs • Accessibility of natural assets for recreational purposes • Proximity to nature and greenspace
Groundwater - aquifers	Not applicable	
Surface water – rivers, creeks, streams	Cultural services: • Access to public spaces for water recreational activities such as swimming, kayaking, canoeing, and fishing • Access to public spaces for hiking, biking, climbing, camping, geo-caching • Access to public space for activities such as nature appreciation, bird-watching	
Riparian areas		
Forest assets (urban forest, urban woodlots, intact forested areas)		
Inland green open spaces (vegetated areas, meadows, grasslands, bushlands)		
Coastal natural spaces (vegetated areas, beach, dunes, eelgrass and seagrass, rocky shoreline, estuaries and ocean wetlands)		
Wetlands (isolated palustrine, riverine)		
Soil	Not applicable	
Urban green infrastructure (street trees, urban parks, urban trails, bioswales, rain gardens, naturalized stormwater ponds, lawns and gardens, green roofs and walls, crops and pasture, naturalization)	Cultural services: • improved aesthetic value, shade and cooling in active transportation corridors and in urban parks and open space • Greenspace for field sports and athletics	

SCALE OF ANALYSIS NEEDED TO DEFINE LOS

- Natural assets located within local government jurisdiction: most relevant are assets in close proximity and accessible to the community including urban parks and greenspace, green corridors and trails.
- Local governments can collaborate with nearby jurisdictions to support community access to near urban nature for recreational purposes.

TYPE OF DATA AND INFORMATION NEEDED TO DEFINE LOS

- Direct observation of access to, and use of, natural assets to collect data on the number and type of users, the amenities they are seeking, time spent in greenspace, distance travelled, expenditures. Trail counters can provide an indication of the extent of how amenities are being used.
- Similar to public health, one common approach used to determine the value of greenspace to communities is through contingent valuation, which involves the use of surveys to determine the willingness of the community to pay for the services that greenspace provides (e.g., improved air quality, reduced health risks, access to nature and recreation). Local governments can also engage communities to inform the quality of greenspace and natural areas for recreation and features to prioritize, such as walking paths, shade, water features, lighting, birdlife, BBQs, tables and seating, dog enclosures, formal sport features, playground features, and proximity to public transit.
- For intact natural areas, local governments should build an understanding of the natural assets' capacity to absorb human activities without compromising ecosystem functioning and biodiversity. For example, some local governments have identified the overuse of trails and camping as a key risk to natural assets [28].
- Valuation of recreational services for which natural assets play a role is not common or necessary to define LOS, but some local governments may wish to do a valuation if they are building the business case for natural asset protection and management. For example, the City of Toronto did an Ecosystem Assessment of its ravine system and included the value of recreational services it provides. The assessment calculated the welfare benefit of walking and biking in the ravine system for recreational purposes.[29]

28 *See for example the key risks identified in the Comox Valley Watershed Protection Plan (2016), hwww.comoxvalleyrd.ca/sites/default/files/docs/Projects-Initiatives/2-20160603_cvrd_wpp_final.pdf*

29 *See Ecosystem Values of the City of Toronto Ravine System (2018), pub-trca.escribemeetings.com/filestream.ashx?DocumentId=5227*

EXAMPLE(S) OF CORPORATE, CUSTOMER AND TECHNICAL LOS

CORPORATE LOS OBJECTIVE	PERFORMANCE MEASURES Customer LOS shown on white, Technical LOS shown shaded	SERVICE VALUE attribute
Provide outdoor recreational programs for residents of all ages and abilities	# local government outdoor recreational programs	Accessability
	% population served by local government	Accessability
	outdoor recreational programs, broken down by age; neigbourhood; ability (special needs); other	Accessability
	programs using local parks and open spaces	Accessability
Increase the proportion of green corridors for active transportation	% of residents satisfied with green infrastructure aspects of active transportation corridors (e.g. aesthetics, shade, drainage, air quality)	Quality
	% of active transportation routes in close proximity to urban green infrastructure	Accessability
Provide greenspace for all residents to enjoy outdoor recreational activities.	% satisfied with urban parks and open space	Quality
	% of population using parks and open space	Accessability
	% residents living less than 500 metres from a park at least .5 hectares	Accessability
	% satisfied with park amenities	Quality
	# hectares greenspace within a 10 minute walk of residents by neighbourhood	Quality
	# parks meeting accessibility standards and guidelines	Regulatory
	Distribution of outdoor recreational types (e.g. open sports area, children's play area, natural park)	Sustainability
	Capacity of green infrastructure to support nature-based recreation	Sustainability
Provide safe water for swimming at the publicly-owned beaches.	# beach closures due to pollution (target = 0)	Safety
	# times e. coli levels exceed regulatory standards for swimming	Safety

5.8. Culture and heritage services

Note: This section focuses on how local governments might measure progress on nature-based culture and heritage benefits beyond those associated with recreation and public health, which may also be culturally significant and support overall well-being in communities.

Nature plays an important role in supporting community culture and heritage goals. A cultural landscape is any geographical area that has been modified, influenced, or given special cultural meaning by people:

> *"Cultural heritage honours and celebrates excellence, creativity and innovation from eras past that have shaped and inspired our present. It recognizes landmarks, sacred places and landscapes of memory."*[30]

The *UK National Ecosystem Assessment Follow-On* describes key components of cultural ecosystem services as: environmental spaces; cultural values; cultural practices; and benefits.[31] It includes a conceptual framework for understanding cultural ecosystem services, shown below.

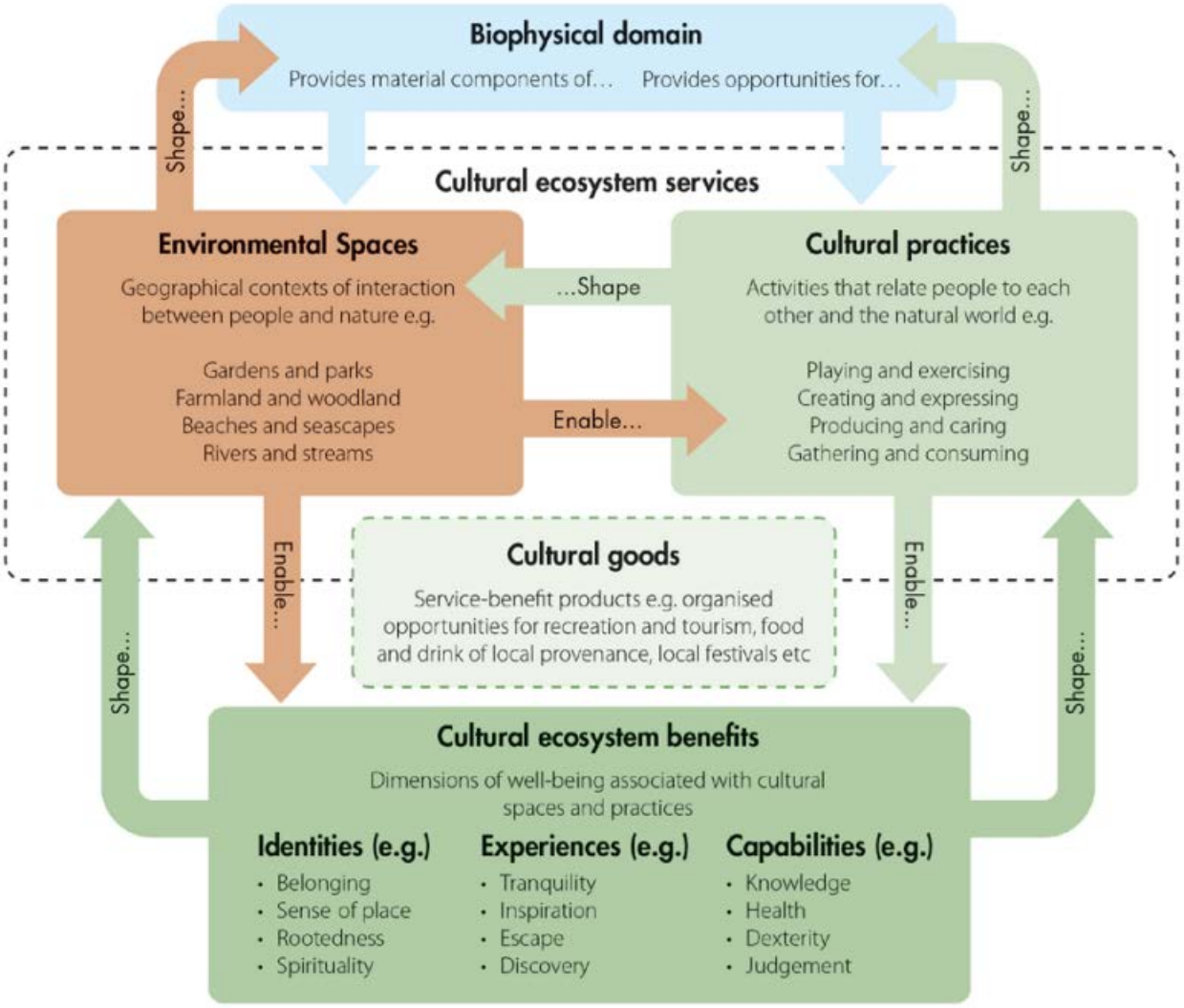


Figure 7: *Conceptual Framework (Fish and Church, 2013)*

Levels of service that are defined for natural assets in relation to culture and heritage should be based on an understanding of the needs and interests of the community in relation to how natural spaces contribute to their cultural experience and practices. An example is the City of Vancouver, which included

30 *Source: Ontario Heritage Trust (2015), Proposals for Ontario's Culture Strategy.*

31 *UK National Ecosystem Assessment Follow-On*

the principle that its biodiversity is a cultural asset in its 2015 Biodiversity Strategy. This principle has helped ensure that biodiversity is considered at a city-wide scale.

Local governments can support reconciliation with Indigenous peoples through cultural heritage goals. These goals may help prioritize protection and co-management of natural areas that are home to, for example, sacred sites, cultural practices and artifacts.

NATURAL ASSET TYPE	POTENTIAL ECOSYSTEM SERVICES PROVIDED BY NATURAL ASSETS	FACTORS INFLUENCING THE SERVICES PROVIDED
Water	Cultural services: • Access to space for cultural ceremonies • Access to or protection of cultural sites of significance to the community • Access to or protection of natural heritage with cultural value to the community	• Local government priorities may affect land use and protection of cultural and natural heritage • Funding for cultural services
Groundwater - aquifers		
Surface water – rivers, creeks, streams		
Riparian areas		
Forest assets (urban forest, urban woodlots, intact forested areas)		
Inland green open spaces (vegetated areas, meadows, grasslands, bushlands)		
Coastal natural spaces (vegetated areas, beach, dunes, eelgrass and seagrass, rocky shoreline, estuaries and ocean wetlands)		
Wetlands (isolated palustrine, riverine)		
Soil		
Urban green infrastructure (street trees, urban parks, urban trails, bioswales, rain gardens, naturalized stormwater ponds, lawns and gardens, green roofs and walls, crops and pasture, naturalization)		

SCALE OF ANALYSIS NEEDED TO DEFINE LOS

- Natural assets located within the local government jurisdiction where local governments have direct control or influence.
- Local governments may wish to start with site-specific assessments of needs for culturally significant natural spaces where there are enduring qualities that make the sites special.
- Local governments can also collaborate with nearby jurisdictions to support protection and management of natural and cultural heritage of significance regionally.

TYPE OF DATA AND INFORMATION NEEDED TO DEFINE LOS

- The type of data and information that local governments can use to define culture and heritage LOS for natural assets is grounded in social science and based on an understanding of the value of nature-based cultural services that promote human well-being. The local context, nature and landscape are important factors in the assessment.
- Local governments can engage different segments of the community on the cultural attributes they associate with local natural spaces, the practices they engage in, and the types of cultural well-being benefits the natural spaces provide.

EXAMPLE(S) OF CORPORATE, CUSTOMER AND TECHNICAL LOS

CORPORATE LOS OBJECTIVE	**PERFORMANCE MEASURES** Customer LOS shown on white, Technical LOS shown shaded	**SERVICE VALUE** attribute
Protect cultural landscapes (any geographical area that has been modified, influenced, or given special cultural meaning by people)	# stewardship programs in place to protect cultural landscapes	Accessibility
	#volunteers involved in protection of cultural landscapes	Accessibility
	% of natural areas mapped and surveyed for cultural significance	Quality
	Proportion of Indigenous cultural landscapes protected or co-managed	Sustainability
Provide opportunities for religious, ceremonial and traditional cultural practices in natural areas	# cultural activities in urban parks and open spaces (could be disaggregated by segment of the community)	Accessibility
	% of population that participate in outdoor cultural activities in parks and open spaces	Accessibility

5.9. Transportation services

Natural assets do not provide transportation services directly. Instead, they tend to be associated with local government objectives to create a connected, green network that serves to enhance people's active transportation experience while walking, riding bikes, scooters or using mobility support devices like wheelchairs. Degradation of natural assets may also impede transportation services, for example through flooding of roads and tracks.

The City of Saskatoon's Active Transportation Plan found that almost half of Saskatoon residents want to walk or cycle more often for both commuting and recreation. Its Green Infrastructure Strategy notes that many of the City's existing paths and trails already traverse green spaces, and that green infrastructure could become a major component of the City's active transportation network. The City's Transportation and Construction division has identified a need to find overlap between the active transportation network, park trail systems, and the local conservation authority's trail network.

The City of Oshawa recognizes that connected green space has important social benefits for vulnerable populations, based on a significant body of research that indicates vulnerable groups such as children, seniors, and people with low income often gain the most from increased access to green spaces. Local governments can define objectives to track progress on providing green active transportation corridors in vulnerable neighbourhoods.[32]

With transportation services, and particularly road assets, local governments are increasingly recognizing the interdependency between grey and green infrastructure (adjacent green infrastructure that provides drainage, shade, aesthetic value). Low-impact development can improve drainage and build resilience to climate impacts. **See the section on stormwater services for the type of data and information needed to support development of LOS for urban green infrastructure as part of low impact development.**

32 *See MNAI case study on the City of Oshawa, City of Oshawa, Ontario – MNAI | Municipal Natural Assets Initiative*

NATURAL ASSET TYPE	POTENTIAL ECOSYSTEM SERVICES PROVIDED BY NATURAL ASSETS	FACTORS INFLUENCING THE SERVICES PROVIDED
Water		
Groundwater - aquifers	Not applicable	• Proximity to natural assets • Quality of natural assets • Extent of natural assets • Vegetation can contribute to or limit people's feeling of safety relating to lighting, sightlines and darkened/obscured areas • Trees and planters can provide protection from cars along road corridors
Surface water – rivers, creeks, streams	Not applicable	
Riparian areas	Cultural services: • Proximity of natural assets to active transportation corridors enhances user experience and promotes public health Regulating services: • temperature regulation, improved air quality, drainage	
Forest assets (urban forest, urban woodlots, intact forested areas)		
Inland green open spaces (vegetated areas, meadows, grasslands, bushlands)		
Coastal natural spaces (vegetated areas, beach, dunes, eelgrass and seagrass, rocky shoreline, estuaries and ocean wetlands)		
Wetlands (isolated palustrine, riverine)		
Soil		
Urban green infrastructure (street trees, urban parks, urban trails, bioswales, rain gardens, naturalized stormwater ponds, lawns and gardens, green roofs and walls, crops and pasture, naturalization)		

SCALE OF ANALYSIS NEEDED TO DEFINE LOS

- Natural assets located within the local government jurisdiction on local government-managed transportation corridors.

TYPE OF DATA AND INFORMATION NEEDED TO DEFINE LOS

- Goals and objectives defined in transportation master plans or active transportation master plans.
- Data tracking of use of active transportation routes/green corridors.
- Data tracking of green infrastructure and urban forestry projects implemented in transportation corridors.

EXAMPLES OF CORPORATE, CUSTOMER AND TECHNICAL LOS

CORPORATE LOS OBJECTIVE	PERFORMANCE MEASURES Customer LOS shown on white, Technical LOS shown shaded	SERVICE VALUE attribute
Provide safe and appealing corridors for vehicles and active transportation to all residents and all abilities	% residents satisfied with green infrastructure on transportation routes	Quality
	# or % of residents who use active transportation (could be disaggregated by neighbourhood, demographic, etc.)	Accessibility
	# low-impact development projects implemented along transportation corridors	Quality
	% city/town connected through a green network (active transportation corridors)	Accessibility
	Proportion of arterial roads meeting tree count targets (e.g., 1 tree every 10 metres)	Accessibility

5.10. Local economic development services

Natural assets are foundational to local economies through the provisioning services they provide for agriculture, forestry, fishing and resource extraction. An example is the high-quality soils in Ontario's Greenbelt, which contribute to food and drink production including fruit and other produce, wine, craft beer and cider, generating significant economic benefits for the region.[33]

Natural assets also contribute to local economies by providing opportunities for nature-based tourism and recreation activities. In addition, studies have shown that trees and nature located close to residential and commercial properties increase their property value.

While the use of natural assets provides many economic benefits, local governments have an important role in balancing their use with their conservation and management to ensure ecosystem services can be provided sustainably over the long-term. To determine that balance, local governments need to consider how risks like climate change, pollution and land-use change from development pressure affect natural assets and could undermine local economies.

When local governments undertake a valuation of natural assets' services in terms of their contribution to local economies, it can build a business case for their protection and restoration and influence land-use decisions. Note that if a local government or other level of government is contemplating a significant land-use change, for example through an official community plan update, they should undertake a more comprehensive analysis of all ecosystem services that could be affected (e.g., stormwater, drinking water, biodiversity, public health, recreation, local economic development, etc.). Such an analysis would build an understanding of the local economic development impact of the loss of natural

33 *See the Greenbelt Foundation website, Greenbelt Foundation*

assets such as prime agricultural land or intact forests, while also considering how the costs of service delivery for other core services could be affected.

NATURAL ASSET TYPE	POTENTIAL ECOSYSTEM SERVICES PROVIDED BY NATURAL ASSETS	FACTORS INFLUENCING THE SERVICES PROVIDED
Water		
Groundwater - aquifers		• For property value: larger parks, natural areas and mature trees close to homes generally have a greater impact on their property values; while noise, congestion and reduced privacy in urban settings can limit the benefits of nearby parks on property values • Quality of parks and natural areas linked to their size, features, amenities and accessibility affect their ability to support economic activities • Local economic development incentives can positively influence services provided • Increased property value
Surface water – rivers, creeks, streams	Cultural services: • Access to parks and natural spaces for tourism, recreation • Commercial activities that generate economic activity	
Riparian areas		
Forest assets (urban forest, urban woodlots, intact forested areas)		
Inland green open spaces (vegetated areas, meadows, grasslands, bushlands)		
Coastal natural spaces (vegetated areas, beach, dunes, eelgrass and seagrass, rocky shoreline, estuaries and ocean wetlands)		
Wetlands (isolated palustrine, riverine)		
Soil	Provisioning services: • Food production	
Urban green infrastructure (street trees, urban parks, urban trails, bioswales, rain gardens, naturalized stormwater ponds, lawns and gardens, green roofs and walls, crops and pasture, naturalization)	Provisioning services: • Local food production Cultural services: • Providing attractive places for gathering and local economic activities (activity kiosks, bike rentals, music and art festivals)	

SCALE OF ANALYSIS NEEDED TO DEFINE LOS

- Natural assets located within the local government's jurisdiction.
- Local governments can also collaborate with other jurisdictions to build an understanding of how natural assets on a regional scale contribute to local economic development, and thus support efforts for their protection and sustainable management. An example is provincial and national parks that contribute to tourism and local economic development for all nearby local governments.

TYPE OF DATA AND INFORMATION NEEDED TO DEFINE LOS

- Tracking the use of parks and natural spaces
- Tracking of local business and local government revenues generated from nature-based activities and activities in parks and natural spaces
- Local analysis of how parks and natural assets affect property values

EXAMPLES OF CORPORATE, CUSTOMER AND TECHNICAL LOS[34]

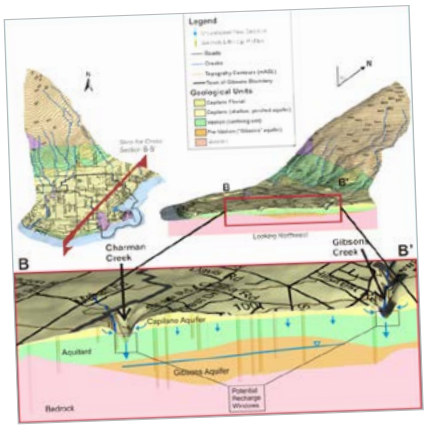
CORPORATE LOS OBJECTIVE	**PERFORMANCE MEASURES** Customer LOS shown on white, Technical LOS shown shaded	**SERVICE VALUE** attribute
Provide local economic development opportunities in parks and natural spaces	% change in revenues from economic activities in parks and natural spaces	Sustainability (financial)
	# small businesses operating in parks and natural spaces	Sustainability (financial)
	% change in tourists visiting parks and natural spaces	Quality
	% surveyed who are satisfied with revenue generating activities in parks and natural spaces	Quality
	Proportion of city/town-owned parks and natural assets that offer revenue generating activities (food, festivals)	Accessibility
Enhance the beauty of the city/town to attract visitors and increase property values	Health of naturally wooded areas, naturalized areas, and maintained trees	Quality
	Canopy cover % of city/town-owned assets	Sustainability

34 *Some LOS defined to support economic development objectives overlap and are consistent with other service outcomes related to public health and recreation.*

Section 6 Case Studies

The case studies of the Town of Gibsons, BC, and the City of Edmonton, AB, provide examples of two local governments leading the way in developing LOS for natural assets.

6.1. Town of Gibsons, BC



The Town of Gibsons, BC, embarked on a journey in 2009 to proactively manage natural assets when it realized the importance of the local aquifer in providing untreated water to three quarters of the Town's population. The Town commissioned an aquifer mapping report, published in 2013, that expanded the community's understanding of the aquifer's boundaries, hydraulic properties, and recharge and discharge.

The aquifer mapping report provided a good data and information foundation about the aquifer's water quality and quantity, flow and recharge, and included 15 recommendations for the Town on how best to manage and protect it, shown in the table below:

RECOMMENDATION	DESCRIPTION	TIMELINE/TERM
Community outreach	Ongoing-going public engagement is recommended	Short
Contaminant/Chemical inventory	Identify potential contaminant sources over the aquifer so that a comprehensive analytical program can be developed for water testing of Town wells	Short
Well maintenance	All Town supply wells need to be inspected to determine their condition and the risk of casing failure which could cause uncontrolled release of water from the Gibson Aquifer due to the artesian pressure. Town Well #1 is the oldest well and is showing signs of reduced efficiency.	Short
Site-specific investigations	Determine the source of elevated chloride, fluoride, and CFC (12) in groundwater which may include drilling near Aquatic Center and Sewage Treament Plant.	Short
Establish Groundwater Management Zone	Use aquifer mapping boundaries provided by Waterline and incorporate into groundwater management planning document	Short
Groundwater Management Plan	Town and SCRD to develop a Groundwater Management Plan with appropriate Bylaws and Policies to guide development work that can potentially affect the Gibsons Aquifer yield or quality.	Short to medium
Groundwater monitoring	Water levels, water use, and water quality in existing and new monitoring wells.	Short to long
Installation of new monitoring wells	Three new wells are required on the Gibsons waterfront in the short term to determine artesian pressure in the aquifer in Lower Gibsons to assess risk and to locate salt/fresh water interface. Additional wells are also required but may be added to network as new developments are being considered over the long term.	Short to long

RECOMMENDATION	DESCRIPTION	TIMELINE/TERM
Geotechnical and hydrogeology studies of Gibsons Aquitard	Protecting the integrity of the confining layer over the Gibsons Aquifer is imperative. Waterline recommends that geotechnical/hydrogeological investigations be completed in advance of approving new developments in order to assess the risk associated with breaching the Gibsons Aquitard. Drilling and pile driving protocols should be established to avoid creating pathways for uncontrolled artesian discharges or contaminants.	Short to long
Manage artesian flow	The Town should consider using the 275 m day that is currently being diverted to the storm sewer.	Short to long
Water conservation	Reduce waler use, manage runoff, use low volume alleralives such as low flow luilels, shower heads. Longer term objectives may consider rainwater capture and use.	Short to long
Goundwater quality targets and thresholds	Based on inventory of possible contaminants and baseline water quality data for the specified suite of water quality parameters.	Short to long
Hydrometric and climate stations	Installation of hydrometric and climate stations is recommended in order to more fully address groundwater-surface water interactions and aquifer recharge.	Short to long
Significant recharge areas	On-going process to identify and map recharge areas as new developments are being proposed.	Short to long
Conceptual and numerical model	Will require updating as new data comes available.	Long

Notes:
Short term means 1 year, medium term means 2-5 years, long term means > 5 years

The Town of Gibsons has implemented several of the recommendations in the aquifer mapping study and in 2017, updated its water supply strategy which recommended that it continue its direction of ongoing aquifer management and water quality management.

The Town continues to strengthen its knowledge of the health and capacity of the aquifer and is now proposing modelling to further build its understanding of the relationship between surface water and groundwater. The modelling will provide insight into how natural assets such as creeks and forested areas affect aquifer recharge rates, and how pumping water out of the aquifer for the Town's use could affect the quantity of water in the creeks and overall ecosystem health. Notably, a significant aquifer recharge area has been identified that lies outside of the Town's jurisdiction. Protection and management of natural assets in the recharge area will therefore require collaboration with the Sunshine Coast Regional District, the Sḵwx̱wú7mesh Úxwumixw (Squamish Nation), and the provincial government.

The Town of Gibsons has not yet defined LOS for natural assets to measure progress on water service delivery, but it plans to do so in the short-term, possibly as part of a natural asset management plan that encompasses all natural assets that deliver services to the community.

STRATEGIC OBJECTIVES FOR NATURAL ASSETS

The Town has adopted strategic objectives that guide how its aquifer and other natural assets will be managed. They should inform how corporate, customer, and technical levels of service are defined for the aquifer and other relevant natural assets:

- In 2014, Gibsons adopted a municipal asset management policy that explicitly defines and recognizes natural assets as an asset class and creates specific obligations to operate, maintain and replace natural assets alongside traditional capital assets. These obligations include having well-defined natural asset management strategies in place, as well as the financial resources to maintain them.
- One of the goals in the Town's Official Plan is to "protect the Gibsons Aquifer, as a source of high-quality drinking water for the Town." The Official Plan goes on to say "A well-managed aquifer provides clean drinking water in perpetuity and reduces the risk of liabilities for new water purification and storage infrastructure."
- The Town's eco-assets strategy includes objectives around managing risk, maintaining healthy ecosystems, and long-term financial sustainability that requires Gibsons "to retain the fewest assets possible, and to ensure that assets are natural, energy-efficient and the lowest cost possible to operate over the long-term."

Below are some examples of LOS measures that could be used to track Gibsons' performance based on current objectives and management activities related to the water services delivered by the aquifer.[35]

EXAMPLES OF POTENTIAL CORPORATE, CUSTOMER AND TECHNICAL LEVELS OF SERVICE

CORPORATE LOS OBJECTIVE	**PERFORMANCE MEASURES** Customer LOS shown on white, Technical LOS shown shaded	**SERVICE VALUE** attribute
Provide minimally treated drinking water to the whole community	% of population untreated potable water served by the aquifer; target = 100%	Accessibility
	# boil water advisories mandated by Public Health Authority; target = 0	Safety
	# times chlorination of groundwater required; target = 0	Quality
	# times groundwater quality thresholds breached; target = zero	Sustainability

35 *Developed with input from staff from the Town of Gibsons, BC. Note that these examples have been defined for illustrative purposes only and have not been endorsed by the Town of Gibsons, BC.*

Conserve Gibsons' water supply by managing demand and minimizing leaks in the system (targets TBD)	Average daily consumption of water per household (target TBD)	Sustainability
	# residents reached in public awareness programs about conservation	Sustainability
	# leaks detected	Reliability
	% water leaked	Reliability
	# water restriction advisories	Sustainability
	# development permit area infractions (y-Law)	Regulatory
Protection of the aquifer recharge area (Watershed management plan with Sunshine Regional District, Squamish Nation and Province of BC is developed and implemented)	# stewardship programs in place	Sustainability
	# hectares of natural areas in recharge areas protected	Sustainability
	Groundwater monitoring undertaken and results reported to council; target = annually	Safety (risks are managed)
	# abandoned wells decommissioned	Safety
	# new monitoring wells installed	Safety
	# actions in watershed management plan (to be developed) being implemented	Sustainability

6.2. City of Edmonton, AB

The City of Edmonton developed an Urban Forest Asset Management Plan (UFAMP) in 2021 (scheduled to be presented to council in 2022). The Plan outlines forecasted costs for activities and programs to manage the City's urban forest over the next 50 years. It describes the characteristics and condition of publicly managed urban forest assets, the levels of service expected from them, the planned actions to achieve the levels of service at the lowest possible life cycle cost, and the costs and strategies to implement the planned actions. The Plan also shows how investments in urban forest management activities contribute to the City's strategic goals: healthy city, urban places, regional prosperity, and climate resilience.

SCOPE OF THE URBAN FOREST ASSET MANAGEMENT PLAN

The natural (including enhanced) assets within the scope of the plan are both planted and naturally occurring.

INCLUDED IN THE PLAN	NATURAL ASSETS OUT OF SCOPE OF THE PLAN
Enhanced assets: • Publicly owned, maintained trees along the city's streets and open spaces • City-owned areas that have been managed back to a natural state (i.e., naturalization sites) Natural assets: • Stands of primarily native trees growing in tableland, ravine, river valley, and other city-owned natural areas	• Wetlands, • Naturally non-wooded areas (e.g., grass and shrublands) • Naturally non-vegetated areas (e.g., open water and exposed sands)

The natural assets out of scope of the plan are still considered part of the City's Green Network and should be incorporated in all-encompassing natural assets AMP as part of the City's continuous improvement efforts.

This is the City's first comprehensive asset management plan and its first effort to define Levels of Service for natural and enhanced tree assets. The City's Open Space Operations Group is ultimately responsible for developing lifecycle management strategies and operations and maintenance activities of the urban forest. That said, the LOS measures defined in the Plan have implications for several services the City delivers, including stormwater management, transportation, and parks and recreation. The LOS were defined with input from a cross-functional group that included staff from multiple service areas, including the operations, planning and climate team.

ALIGNING EDMONTON'S URBAN FOREST LOS WITH ITS STRATEGIC OBJECTIVES AND PLANS

The City of Edmonton is a large, complex organization serving a population of nearly one million people. The LOS defined in its Urban Forest Asset Management Plan had to be aligned with a range of organizational objectives found in multiple strategic planning documents and master plans. The diagram below shows how four strategic goals in the City's Strategic Plan, Connect(Ed)monton 2019-2028[36], relate to its urban forest-specific goals.

36 *Source: City of Edmonton Urban Forest Asset Management Plan, page 14.*

Strategic goals	Urban forest specific goals
HEALTHY CITY Edmonton is a neighbourly city with community and personal wellness that embodies and promotes equity for all Edmontonians.	• To promote healthy living and foster wellbeing through diverse kinds of recreation, mobility and environments • To protect native forest and tree stands
URBAN PLACES Edmonton neighbourhoods are more vibrant as density increases, where people and businesses thrive and where housing and mobility options are plentiful.	• To improve Edmonton's livability by ensuring that public green spaces are attractive and well maintained • To provide an integrated, multifunctional system of green and open spaces to every neighbourhood as the city grows
REGIONAL PROSPERITY Edmonton grows prosperity for our Metro Region by driving innovation, competitiveness and relevance for our businesses at the local and global level.	• To effectively manage and ensure the growth of the urban forest
CLIMATE RESILIENCE Edmonton is a city transitioning to a low-carbon future, has clean air and water and is adapting to a changing climate.	• To have a diverse and sustainable forest • To support and enhance the environment by sustaining healthy and resilient ecosystems

The Strategic Plan also notes the health benefits and regulating services that the urban forest assets provide, including pollutant filtration, carbon storage, water cycling, disaster protection, and mitigation of heat-island effects. The City of Edmonton depends on these services to meet its commitment to sustainability, which is a key theme underlying all corporate and strategic objectives.

There were also 15 key policy directives in Edmonton's Municipal Development Plan (the City Plan) that informed the LOS measures defined in the UFAMP. They include:

1	Protect, restore, maintain, and enhance a system of conserved natural areas within a functioning and interconnected ecological network.
2	Manage the impact of environmental stressors on people and natural systems including excessive noise, air, and light pollution.
3	Conserve, restore and reconnect natural areas and ecological networks within the built environment for ecosystem health.
4	Improve the quality and function of habitat greenways and ecological connections within the Green and Blue Network.
5	Expand and diversify Edmonton's urban tree canopy and native vegetation.
6	The community and Administration are increasingly knowledgeable about the value of natural areas, and actively involved in their stewardship.

7	Conservation of Edmonton's natural areas is increasingly achieved through partnerships.
8	Steward ecological networks and systems to ensure ongoing function, long-term sustainability and ecological connectivity within Edmonton and the region.
9	Acquire lands within the North Saskatchewan River Valley and Ravine system for natural areas protection, open space connectivity and use.
10	Edmonton protects, expands and improves access to its natural systems and open spaces in support of biodiversity and the health and enjoyment of all Edmontonians.
11	Use environmental reserve to protect land and water bodies that meet the definition of environmental reserve but are not claimed by the province in a manner that balances interests and enables contiguous and efficient urban development.
12	Design new and retrofit existing open spaces to encompass wellness, celebration and ecology at the district level.
13	Improve local open space and public amenities to support density increases.
14	Maintain the North Saskatchewan River Valley and Ravine system's key role as an environmental protection area and for open space, cultural and recreational uses.
15	Incorporate nature and natural systems into the built environment.

The City Plan also includes the direction that 2 million "net new trees" will be planted throughout its nodes and corridors, parks, private and public realm by the time the city reaches a population of 2 million people.

Finally, the UFAMP (and therefore the LOS measures) is also aligned with and builds on six other plans and strategies, including:

1/ An Urban Parks Management Plan (2006), where:

- A minimum target of 2.0 hectares of parkland/1,000 people is required for new neighbourhoods.
- A target of 70 trees per ha was identified for areas within the River Valley and Ravine Parks, City Level parks, and pocket parks.
- Minimum targets of 45 trees per ha and 55 trees per ha were identified for District Activity Parks, and School and Community Parks, respectively.
- A target of 65 trees/ha for Urban Village Parks.

2/ A city-wide Natural Areas Management Plan (2014) that identifies objectives and strategies for managing and restoring City-owned natural areas, and community stewardship strategies.

3/ A Naturalization Master Plan (1999) that identifies candidate areas and criteria for naturalization areas.

4/ A Natural Connections Strategic Plan (2007) that sets out the City's conservation vision, goals and natural area system outcomes.

5/ Its Green Network strategic plan (Breathe, 2017) that sets direction for the care and expansion of the City's open space networks.

6/ A Climate Adaptation Strategy and Action Plan (2018).

DEFINING STAKEHOLDER NEEDS AND INTERESTS RELATED TO THE URBAN FOREST

The City of Edmonton follows an organization-wide approach to asset management planning and has tools and processes to guide staff in identifying stakeholder needs and interests. A cross-functional group of staff used these tools to identify the relevant stakeholder needs and interests for the urban forest during two workshops. The results were based on staff knowledge and insights from previous public engagement undertaken by the City of Edmonton, including significant engagement done during the development of its City Plan. The table below shows the stakeholders staff identified.

STAKEHOLDER GROUP	STAKEHOLDERS
Service recipients: they use the urban forest	residents, park users, transportation corridor users, visitors, tourists, recreational users, researchers, schools, adjacent landowners, environmental special interest groups, and native flora and fauna
Rights holders	Indigenous Peoples
Other service providers: they require the municipal service/assets to provide their own services	water, power, drainage, telecom, and pipeline utilities; other city departments; school boards; emergency responders
Wider community: they wish to influence decision-making but may or may not be users of the service	developers, the Edmonton Federation of Community Leagues / homeowners associations, business improvement areas, environmental stewardship and conservation organizations, Urban Development Institute, Infill Development in Edmonton Association (IDEA) and other home builder associations Neighbouring municipalities - Municipalities of Leduc, St. Albert, Fort Saskatchewan, Sherwood Park, Strathcona County, Devon; and the North Saskatchewan Watershed Alliance

The City of Edmonton then identified the services of value and interest to specific stakeholders, including[37]:

Safe access to areas for gathering, enjoying nature, relaxation, and mental health	Integration of land use within envelope (fruit-producing native species, beautification)
Safe access to areas for recreation	Privacy and sound barriers
Safe access to areas for research	Attractive city for living and working in
Safe access to their infrastructure (e.g., utilities, other City departments)	Attractive green spaces for gathering and enjoying nature

37 *The City's Urban Forest AMP provides additional detail on which services are of interest to specific stakeholders.*

Access to areas for gathering and harvesting	Shelter from elements including sun and wind
Regulations, standards, and guides for open space planning in new communities	Preservation and responsible stewardship of assets to ensure retention of property values and a desirable neighbourhood
Reduced 'red tape' around development adjacent to all urban forest assets	Landscape design and construction standards for green infrastructure
Increased property value	Safe and appealing corridors for vehicle travel and active transportation
Fast, informative and respectful customer service	Climate change adaptation
Clear sightlines along roadways and at accesses	Stormwater retention
Risks posed by the urban forest to people and infrastructure, e.g., fires, falling trees, damage by roots	Specifically for Rights Holders: Access to areas for gathering, harvesting and ceremony Potential opportunities for land-based learning in natural areas Concerns where excavation of undisturbed natural areas may result in finding items of archaeological significance, and a desire to participate in ground disturbance monitoring in these cases Connection to native species (spiritual, wellness, restorative) Ecosystem goods and services including clean fresh air and water, stormwater capture to reduce flooding and erosion, shade to reduce ambient temperatures Protected and connected natural areas system to promote human health and wellness
Risks posed by pests and disease	
Safe access to areas for responding to emergencies	
Applying Crime Prevention Through Environmental Design Principles (CPTED) to make areas safer	
Ensuring Edmonton remains a competitive and successful environment for development and economic growth	
Fiscally responsible management	
High quality habitat that is biodiverse, connected, and sustainable	
Restoring naturally wooded areas and trees disturbed by infrastructure projects to design and construction landscaping standards or above and beyond	
Preservation of areas to help ensure a connected network for fauna and flora	

LOS PERFORMANCE MEASURES INCLUDED IN THE CITY OF EDMONTON'S URBAN FOREST AMP

The City of Edmonton developed a set of corporate service objectives and customer and technical LOS that will be used to track performance on its Urban Forest AMP. These were defined based on their alignment with the City's strategic goals and policy directives and the analysis of stakeholder needs and interests. The measures selected focus on stakeholder interests that have an impact on asset lifecycle activities and asset performance[38] and address a set of universal service values the City uses to define LOS in all service areas:

38 *Levels of service have not been defined to measure progress on all stakeholder interests. Some interests will be addressed through policies, master planning and other processes outside the scope of the UFAMP.*

Accessibility: The ability for all possible customers of different abilities to access and use a service provided by the City, and to access information about it.	**Safety:** A measure of service that considers the amount of harm that could be incurred to the customer, bystanders, wildlife/pets, and the environment.
Availability/Reliability: The frequency the service is available for use by the customer (availability) and disruptions to the service (reliability).	**Sustainability:** Striving for community well-being, a sustainable environment, a prosperous economy, and smart growth and mobility choices that serves citizens today and in the future.
Quality: The level of excellence in service delivery provided by the City.	**Legislative:** Meeting standards set by legislative assemblies such as provincial or federal standards.
Customer Service: The service provided for interacting with the customer regarding the services provided.	

The table below provides a snapshot of the LOS measures included in the UFAMP.

CORPORATE LOS OBJECTIVE	**PERFORMANCE MEASURES** Customer LOS shown on white, Technical LOS shown shaded	**SERVICE VALUE** attribute	**SERVICE OUTCOME AREA**
Provide volunteer opportunities for stewardship	# volunteer programs	Accessibility	Multiple
Provide attractive areas for gathering, enjoying, relaxing, recreation and mental health	# hectares of naturally wooded areas (target = 3,200 hectares) (also included as a technical LOS measure)	Accessibility	Public health Recreation Culture & heritage
	# hectares of naturalized areas with trees or shrubs (target = 2,200 hectares)	Accessibility	
	# maintained trees (target = 796,100 by 2071) (also included as a technical LOS measure)	Accessibility	
	% users satisfied with parks and greenspace (target = 80%)	Quality	
	All formalized viewpoints have been maintained within the required timeframe, e.g., not obstructed by vegetation (target = every 5 years)	Quality	
	Frequency of inspections of naturally wooded areas and naturalization areas to identify service needs (target 12/yr)	Quality	
	# hectares of naturalization sites planted, i.e., moved to stage 2 (target = 2,100 hectares)	Accessibility	

CORPORATE LOS OBJECTIVE	PERFORMANCE MEASURES Customer LOS shown on white, Technical LOS shown shaded	SERVICE VALUE attribute	SERVICE OUTCOME AREA
Enhance the beauty of Edmonton and contribute to the well-being and quality of life of its current and future residents	Canopy cover % contributed by city owned assets (customer LOS target = 20% overall canopy coverage; technical LOS target = 11% contributed from city-owned urban forest)	Sustainability	Public health Culture and heritage Local economy Biodiversity
	Survival and health of planted trees in naturalized areas (target = 80% survival)	Quality	
	% maintained trees planted surviving after 5 years (target TBD)	Quality	
	Expected useful life of maintained trees (target TBD)	Sustainability	
Provide safe access to natural areas and provide safe roadside environments	% claims at fault (target = 0)	Safety	Climate resilience Transportation Public health Recreation Culture and heritage
	% maintained trees removed within 2 years of being marked for removal (target = 100%)	Safety	
	% stumps removed within 12 months of tree removal	Safety	
	Frequency of inspections to identify imminent safety hazards in publicly accessible spaces (target = 12/yr for naturally wooded areas in Tablelands; every 2 yrs for maintained trees, target TBD for naturalization areas)	Safety	
	Time to respond to hazards after a storm (target = 24 hours for all calls; except for significant storms)	Safety	
	% maintained trees pruned meeting the specified pruning cycles (target = 100%)	Safety	
	% naturally wooded and naturalization areas mitigated for tree risk every 10 years (target TBD)	Safety	
	% trails pruned (by length) for vegetation clearance each year (target TBD)	Safety	
Protect and preserve the urban forest to protect health and wellness of people, native flora and fauna	% of naturally wooded areas protected for biodiversity conservation (target TBD, used as both a customer and technical LOS measure)	Sustainability	Biodiversity Public health
	Connectivity measure TBD	Sustainability	
	% areas where fire risk has been reduced through vegetation management (target TBD)	Safety	
	% areas with invasive species (target TBD)	Sustainability	
	% areas where legislated weeds are controlled or eradicated (target TBD)	Sustainability	

CORPORATE LOS OBJECTIVE	PERFORMANCE MEASURES Customer LOS shown on white, Technical LOS shown shaded	SERVICE VALUE attribute	SERVICE OUTCOME AREA
Provide a forest with diverse species to improve resilience to climate change	% of one species of maintained trees (target = no more than 10% of one species, also used as a technical LOS measure)	Sustainability	Biodiversity Climate adaptation
	Native species measure for naturally wooded and naturalization areas (target TBD)	Sustainability	
	% elm or ash in replacement plantings of maintained trees (target = 15%)	Sustainability	
	Diversity of age class of maintained trees (target = 40% young, 30% semi mature, 20% mature, 10% old)	Sustainability	
	Diversity of seral stage for naturally wooded areas (target TBD)	Sustainability	
Respond to customer service requests within 5 days	% customer service requests responded to within 5 days	Customer service	Multiple
Adhere to applicable by-laws and legislation	# non-compliances issues (target = 0)	Regulatory	Multiple
Ensure cost-effective service provision	TBD		

FACTORS THAT INFLUENCED THE SELECTION OF LOS MEASURES AND TARGETS

1. Data limitations

The primary focus of the AMP is on managing tree assets. While data was available for some of the performance measures in Edmonton's Urban Forest AMP, staff identified key gaps for assessing connectivity, biodiversity including native plants, and specific canopy coverage targets for city owned assets.

City staff considered adding performance measures related to reducing stormwater runoff, tonnes of pollution removed, and tonnes of carbon sequestered by the urban forest, but did not yet have the confidence in the methods they could use to measure performance to be able to include them in the current UFAMP. In addition, there were no LOS measures defined for enhanced or engineered green infrastructure like bioswales, rain gardens and other low-impact development features that contribute to stormwater management as these types of assets were out of scope of the Plan.

The City of Edmonton will be better able to define LOS measures related to stormwater, climate and biodiversity when it builds its understanding of how the biophysical properties and dynamic relationships between all its natural assets and other urban green infrastructure contribute to these services, and has the tools to do so.

2. Assumptions

The City of Edmonton assumed that its target of 20% canopy coverage could be created through planting 421,500 new maintained trees and 1,900 ha of naturalization area with shrubs and trees, and incentivizing other property owners to create an additional 2,900 ha of new canopy. This assumption was based on limited condition data for the urban forest. Condition data was only available for 1.6% of the maintained trees and no condition data was available for naturalization or natural areas. All trees besides maintained trees were assumed by the City to have a condition rating of 70% for the purposes of valuation. The City may need to adjust its LOS targets as it builds knowledge about the health of the urban forest and the investments required.

3 Valuation of Natural and Enhanced Tree Assets and Costs of the AMP

The City of Edmonton estimated the value of its urban forest assets within the scope of the plan using two methods. The first was determining the total replacement or restoration costs at $1.1 billion, which includes:

- the cost to remove a maintained tree that has reached the end of its life and plant a new, usually smaller tree, including watering it for three years; and
- the cost to replant naturalization areas or restore naturally wooded areas plus watering for three years until the plants are established (plus occasional investment for renewal due to poor condition or outside events causing damage).

The second valuation approach recognizes the services provided by a tree or tree stand as it grows and its canopy increases. The estimated service value of the urban forest asset using this approach is $2.7 billion. For maintained trees, this value is based on the City of Edmonton's Guidelines for Evaluation of Trees - Boulevard and Open Space Trees, Open Space Operations. For naturalization and naturally wooded areas the value is based on canopy cover according to a methodology stated within the City of Edmonton's Natural Stand Valuation Guidelines.

The City of Edmonton did not do a valuation of urban forest services related to public health, recreation, local economy, biodiversity, or climate, although several LOS measures were defined to support service outcomes in those areas. It was able to define LOS for those services because of the linkages made between the services provided by the urban forest and the City's strategic objectives related to sustainability. Future valuations in these areas could be beneficial if a strong business case is needed to protect and manage urban forest assets that are threatened by potential land use changes.

The valuation of the urban forest did not influence the level of service measures; however, the targets do reflect what was considered realistic and achievable based on the estimated costs of implementing the UFAMP.

OPPORTUNITIES IDENTIFIED FOR CONTINUOUS IMPROVEMENT

The City of Edmonton identified several actions that it aims to undertake that will support its urban forest management activities. If implemented, these will also ultimately lead to refining its LOS in future plans. These included:

- Update management plans for the urban forest assets to more accurately estimate quantities of new assets and additional funding needed to achieve long-term goals for canopy coverage, number of new trees planted, and total amounts of natural and naturalized areas. The plans should also:
  - Identify primary demand factors for forecasting future quantities of urban assets.
  - Confirm assumptions underlying demand forecasts in the plan.
  - Develop a data management strategy and plan including collecting data on the attributes of the below-ground infrastructure, soil and soil volume for maintained trees and additional data on trees that are removed (e.g., age and reason for removal).
  - Develop a condition assessment approach and collect data for natural and naturalized areas.
  - Develop performance measures for ecological connectivity and diversity of native species.
  - Plan for and improve the Emergency Response Plan.
  - Prepare a risk framework for assessing and identifying unacceptable risks to infrastructure assets.
  - Work with utility companies and developers to find new ways to create and share green space (page 15 Urban Forest AMP).
- The Plan also notes the need for the urban forest operations team to work with the environmental strategies team to quantify the ecological benefits of the urban forest such as tonnes of pollution removed, carbon sequestered, and quantity of stormwater runoff retained.

Appendix A: Glossary of Terms

Governments use a range of terms in reference to the protection and management of the environment and in relation to policies and programs supporting natural infrastructure solutions. Most terms in this glossary are drawn from the 2021 publication of the Canadian Council of Ministers of the Environment (CCME), *Natural Infrastructure Framework: Key Concepts, Definitions and Terms*. In cases in which CCME is not the source, MNAI is noted as the source of the term.

Biodiversity: 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.

Blue-green infrastructure: Blue-green infrastructure describes the common elements, linkages and connected spaces formed between water and land, whether in a coastal or inland, rural or urban context. It includes such features as lakes, ponds, marine waterways, rivers and creeks, as well as engineered or built water features in developed areas.

Constructed wetlands: Green infrastructure designed to mimic the terrestrial and aquatic features of natural wetlands, and are designed to support similar ecological and hydrological functions.

Ecological Network: A network of connected natural areas that functions as a natural system. In urban areas, the network may be anchored by large patches of natural areas such as large parks, shorelines and riparian areas.

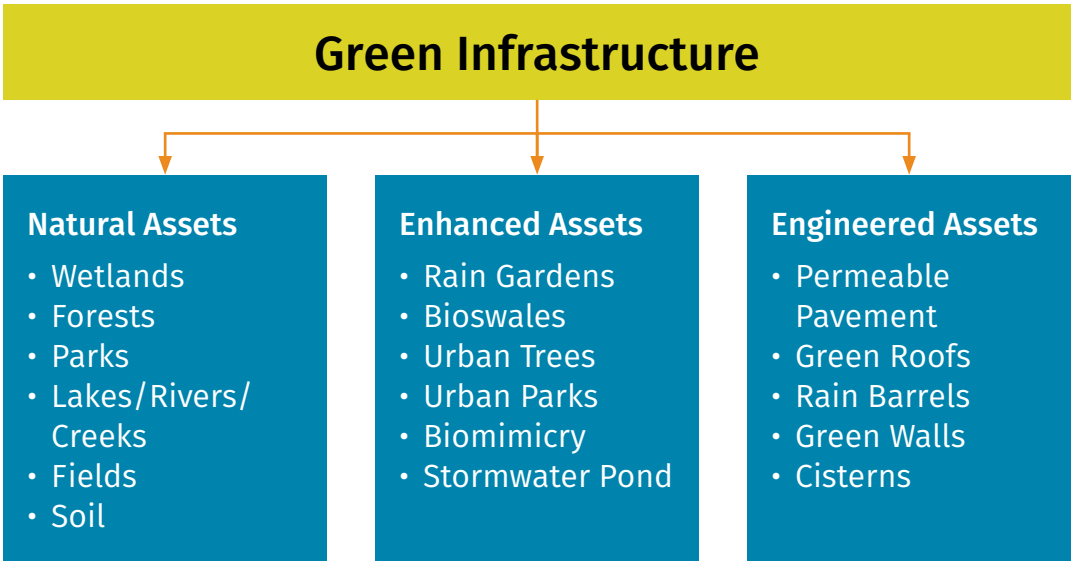
Ecosystem services: the conditions and processes through which natural ecosystems (and the species that make them up) sustain a flow of direct and/or indirect benefits to people. They include the benefits resulting from ecosystem processes (e.g., flood management, nutrient cycling, water filtration and climate regulation) as well as sociocultural benefits (e.g., recreation, aesthetics, cultural heritage and practices).

Engineered Green Infrastructure Assets: See definition of green infrastructure below.

Enhanced Green Infrastructure Assets: See definition of green infrastructure below.

Forests: Forested land may consist of either closed or open forest formations, and demonstrate the absence of other predominant (e.g., agricultural) land use.

Green infrastructure: The terms natural asset and green infrastructure are often used interchangeably, but one is broader than the other. Whereas natural assets refers to the stock of natural resources and ecosystems that yield a flow of benefits to people, green infrastructure also includes designed and engineered elements that have been created to mimic natural functions and processes in the service of human interests. See figure below for the distinction between natural assets, enhanced green infrastructure assets and engineered green infrastructure assets (Source: MNAI[1]).



Green (or natural) **open spaces:** GOSs or simply green spaces are terms used to describe city or town parks, conservation areas, ravines, woodlots, riparian areas, provincial and federal parks, playing fields, as well as schoolyards and golf courses.

Grey infrastructure: Features of the built environment made exclusively of materials such as concrete and steel, including bridges, dams, water treatment plants, culverts, concrete lined ditches and storm drains.

Habitat: A place or type of site where an organism or population naturally occurs. It is also used to refer to the environmental attributes directly or indirectly required by resident species to carry out their life processes such as reproduction, hibernation, rearing, migration and feeding.

Low impact development: LID is a broad-based urban planning approach usually used for stormwater management applications, and sometimes to wider practices of minimizing ecosystem impacts in the design and development of municipal water services in particular. Related to stormwater management, it involves strategies for reducing runoff and stormwater pollution by managing runoff as close to its source as possible.

1 *MNAI (2018). Defining and Scoping Natural Assets, mnai.ca/media/2018/02/finaldesignedsept18mnai.pdf*

Managed landscapes: Managed landscapes include livestock grazed/grazing lands, farming lands and orchards. When located on natural floodplains, these landscapes can help prevent large-scale damage and reduce the financial impact of inland floods.

Municipal natural assets: Municipal natural assets are the stock of natural resources and ecosystem elements that are (or could be) relied upon and managed by a municipality, regional district, or other form of local government for the sustainable provision of one or more municipal services. Examples include native forests, shrublands, grasslands, lakes, ravines, and open water (Source: MNAI).

Note: Indigenous communities do not typically use the term natural assets as nature is typically interpreted in a broader sense encompassing all life represented in the Earth's land, water and resources. MNAI uses the term natural assets to mirror the language of municipal asset management, while recognizing that expressing Indigenous traditional knowledge in asset management frameworks will predictably lead to better, more robust understandings of natural assets of all kinds and is thus a vital component of natural asset management.

Traditional Indigenous knowledge relies on nature-based solutions and has a key role to play in adaptation and resilience strategies at the local, national and global levels. It also builds qualitative data from a large number of variables instead of building quantitative data based on a small number of variables. When local governments interweave Indigenous knowledge, world views and perspectives into asset management and find meaningful ways to recognize Indigenous cultural and natural assets within local government processes, it can enhance respectful relationships that support reconciliation, the implementation of the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP), and the Pan-Canadian Framework which recognizes the importance of climate action that is respectful of Indigenous peoples and integrates their knowledge.(Source: MNAI[2])

Natural Assets (used interchangeably with the term natural capital**):** The stock of renewable (e.g. plants, animals, air, water, soils) and nonrenewable (e.g. minerals) resources that combine to yield a flow of benefits to people.

Natural infrastructure (NI): refers to a specific segment of nature-based solutions that uses preserved, restored or enhanced ecosystem features and materials (e.g., water, native species of vegetation, and sand and stone) to meet targeted infrastructure outcomes, while providing a range of co-benefits to the environment, the economy, community health and well-being. It can be differentiated from the related category of green infrastructure based on its composition exclusively of natural ecosystem features and materials (e.g., water, native species of vegetation, sand and stone), and from grey infrastructure

2 *From: Natural Asset Management Considerations for Engineering and Geoscientist Professionals, Municipal Natural Assets Initiative (July 2021), p. 6.*

because it provides a range of co-benefits to the environment, the economy, community health and well-being that grey infrastructure usually cannot.

Nature-based solutions (NBS): refer to nature-based measures that protect, repair and sustainably manage natural or human-modified ecosystems, with the aim of maintaining or enhancing the services provided to human communities and benefits to biodiversity.

Nature (or Green) Corridors/Greenways: Habitat connections that facilitate the movement of wildlife and ensure the overall continuity of human communities with the natural environment or ecological network.

Urban forests: Urban forests are groups of trees with placement along streets and on rooftops, in parks and woodlands within the municipal boundaries of towns and cities, rural communities and on private and public lands. They are ecosystems encompassing shrubs and other greenery, as well as the soil and water that support vegetation. Nature-based projects using urban trees include preserving, restoring or creating forested spaces, and planting and maintaining street trees, those in parks, as well as managed conservation areas within a municipal jurisdiction. Private trees and vegetation include those in private front and backyards, around apartment buildings, in parking lots, and on commercial and industrial lots.

Wetlands: Non-tidal wetlands in Canada are located on riparian lands, on the natural floodplains of drainage basins, along the margins of lakes and ponds, and in low-lying areas where groundwater contacts the soil surface (e.g., swamps, marshes, and peatlands including fens and bogs). Coastal wetlands occur inland of ecosystems that begin offshore and move inland through estuaries and salt marshes.

Appendix B: Tool: Defining Levels of Service Using a Value Proposition Canvas

A Value Proposition Canvas (VPC) is a tool that can help identify and clarify the value of the services that infrastructure assets provide to the community's various stakeholders and Indigenous rights holders. The process of developing a VPC can build an understanding of how a local government could positively influence services and prioritize service level indicators for a given asset type. The process is described below.[1]

Note that the organizations involved in the development of this guidebook participated in a workshop to develop a VPC for the natural asset category "natural spaces" in parks.[2] The outputs from their workshop are included here as Illustrative examples. A VPC could be developed for any of the major natural asset and service combinations that have been described in Section 5 of this guidebook to help inform development of relevant LOS.

STEP 1 Map the typical stakeholders for the natural asset of interest.

The relationship between the natural asset and service it provides is what helps identify stakeholders. Stakeholders and Indigenous rights holders of the natural asset include:

- People and groups that use the natural asset.
- People and groups that are affected by the services the natural asset provides.
- People and groups that manage, govern, or impact that natural asset in some way.

Stakeholders can be grouped according to their relative importance in relation to the services of interest. The example below shows **essential**, **important** and **interesting** stakeholders that may use, manage, or be affected by natural spaces in parks that were identified during a brainstorming session.

1 *Process adapted from icInfrastructure and Nucleus Strategies level of service planning framework. Value Proposition Canvas adapted from Osterwalder, A., Pigneur, Y., Bernarda, G., Smith, A. (2014) Value Proposition Design: How to Create Products and Services Customers Want, John Wiley & Sons.*

2 *The group defined both natural spaces and parks very broadly for the purpose of this exercise and did not consider specific natural assets within natural spaces or the size of a park or its amenities. The examples provided here are illustrative only.*

ESSENTIAL STAKEHOLDERS INCLUDING INDIGENOUS RIGHTS HOLDERS	IMPORTANT STAKEHOLDERS	INTERESTING STAKEHOLDERS
• Jurisdiction holders (owners of parks) • Residents • Ecosystem (e.g., flora, fauna, biodiversity) • Federal/provincial government • Local government • Indigenous rights holders • Future generations • Heritage/ancestors	• Watershed agencies • Farmers • Environmental stewardship groups • Tourists • Taxpayers • Private property owners • Vulnerable and marginalized groups • Renters • Businesses	• Developers • Utility companies • Bird watchers • Festival/event organizations • Schools • Researchers

STEP 2 Identify the services and service outcomes the asset provides to a stakeholder group.

i/ Select a stakeholder group of interest to develop a VPC for. Begin by listing all the services that stakeholder group uses, manages, is affected by, or impacts in relation to the natural asset in the Products and Services section on the left side of the VPC tool (as shown in figures 1 and 2 below). This side of the tool characterizes the services from the perspective of the organization.

ii/ Next, identify the "jobs to be done" for or by the stakeholders in relation to the natural asset and the services identified. List these on the right side of the tool, which describes the services from the perspective of the stakeholder. The "jobs" or "jobs to be done" are a way of describing the outcomes the stakeholders are trying to achieve when they use, manage, impact, or are affected by the service. These could be functional, social, or emotional tasks.

iii/ Depending on the time available for this exercise, it will be important to choose a scope that matches the local government's priorities and capacity. Refer to Section 3 of the guidebook that provides instruction on how to get started and find an entry point. Once the local government has selected the relevant natural assets and services they would like to focus on, they may wish to consider developing VPCs for as many essential stakeholders as possible for them, for a few important stakeholders, and for one or two important stakeholders.

STEP 3 Identify the stakeholder gains and pains for the asset and related service

Next, identify the gains stakeholders hope to achieve, and the pains the stakeholders want to reduce or eliminate through the "jobs" defined previously.

Gains describe the outcomes and benefits the stakeholder wants.

Pains describe the annoyances, barriers, or negative outcomes for stakeholders.

Figures 1 and 2 below[3] show the example VPCs for natural spaces in parks for two of the essential stakeholder groups that were identified: 1) residents and 2) the ecosystem.[4] It shows the suite of services provided by natural spaces for each stakeholder group, the jobs they are attempting to do, and the gains and pains experienced by the stakeholders in those attempts.

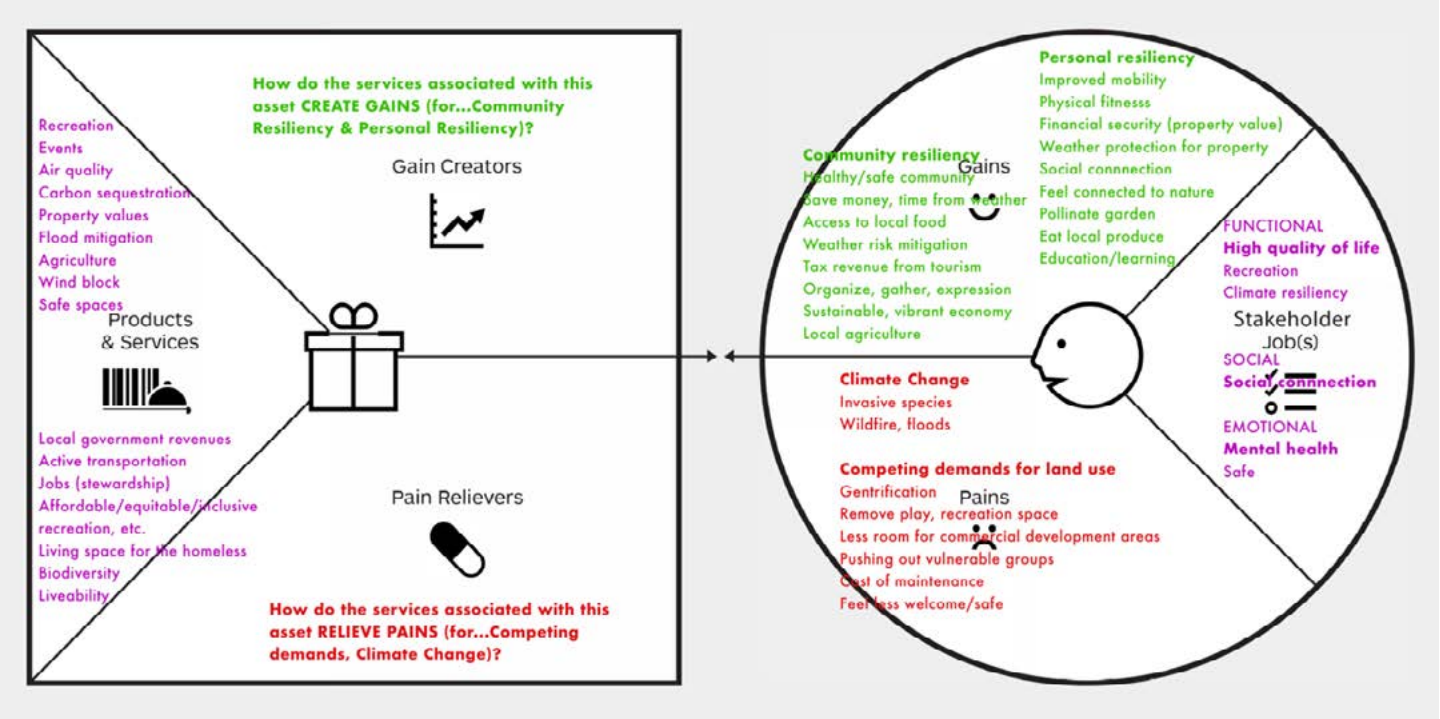


Figure 1. Stakeholder = Residents

3 *Source: Value Proposition Canvas template from Strategyzer (www.strategyzer.com/canvas).*

4 *Note that the ecosystem is not typically included by local governments as a stakeholder in its own right, but that perspective may change as some governments have begun to assign inherent rights to rivers and other living systems).*

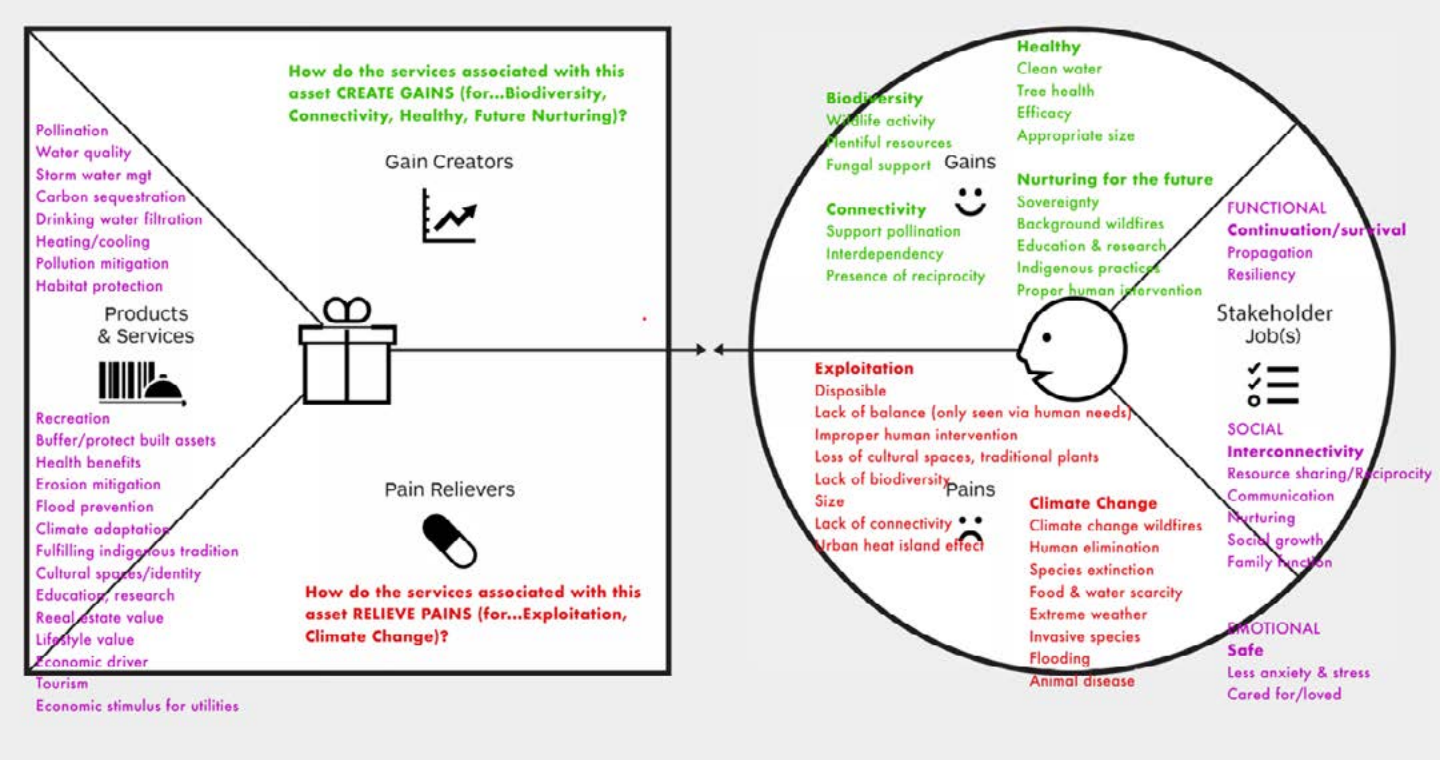


Figure 2. Stakeholder = Ecosystem

STEP 4 Identify the stakeholder gain creators and pain relievers for the asset and related service

Once the pains and gains associated with the stakeholder's "jobs to be done" are identified, identify how the local government can create gains and relieve pains with the natural asset and service. List these on the left side of the tool, again from the perspective of the organization. These are a description of the specific ways in which the services provide value to the stakeholder.

Examples:

i/ Residents stakeholder group:

- **Gain creator =** an increase in fruit trees in parks that they can harvest at no cost and enjoy as a source of healthy, local food.
- **Pain reliever =** increased shade from large trees to protect them from sun and heat while they are recreating in parks.

ii/ Ecosystem stakeholder group:

- **Gain creator =** increased coverage of pollinator trees and vegetation to support pollination and biodiversity.
- **Pain reliever =** an invasive species program that controls the spread of invasive species.

The trigger questions below[5] can be used to help identify how the services provided can create gains and relieve pains for each stakeholder.

TRIGGER QUESTIONS FOR STAKEHOLDER GAINS

The following trigger questions can be used to think through potential stakeholder gains:

1/ Which savings would make the stakeholder happy? Which savings in terms of time, money, and effort would they value?

2/ What quality levels does the stakeholder expect, and what would they wish for more or less of?

3/ How does the service provided delight the stakeholder? Which specific features do they enjoy? What performance and quality do they expect?

4/ What would make the stakeholder's job or life easier? Could there be more services, or lower costs?

5/ What positive social consequences does the stakeholder desire?

6/ What is the stakeholder looking for most? Are they searching for good design, guarantees, specific or more features?

7/ What does the stakeholder dream about? What do they aspire to achieve, or what would be a big relief to them?

8/ How does the stakeholder measure success and failure? How do they gauge performance or cost?

9/ What would increase the stakeholder's likelihood of using or benefitting from the service?

TRIGGER QUESTIONS FOR STAKEHOLDER PAIN RELIEVERS

Pain relievers describe how the natural asset and related service alleviates specific pains for that stakeholder. They explicitly outline how the organization intends to eliminate or reduce some of the pains. The following questions can be used to think through potential stakeholder pain relievers.

Could the natural asset and related service:

1/ Produce savings? In terms of time, money, or efforts?

2/ Make the stakeholder feel better? By eliminating frustrations, annoyances, and other things that cause problems for the stakeholder?

3/ Perform better? By introducing new features or enhanced quality?

4/ Put an end to difficulties and challenges the stakeholder encounters? By making things easier or eliminating obstacles?

5/ Wipe out negative social consequences the stakeholder encounters or fears?

5 *Value Proposition Canvas trigger questions from Strategyzer (https://www.strategyzer.com/canvas) have been adapted for a local government context.*

6/ Eliminate risks to the stakeholder? In terms of financial, social, technical risks, or things that could potentially go wrong?

7/ Help the stakeholder sleep better at night? By addressing significant issues, diminishing concerns, or eliminating worries?

8/ Limit or eradicate common mistakes stakeholders make? By helping them use a solution the right way?

9/ How could the natural asset and related service eliminate barriers that are keeping the stakeholder from adopting the value proposition?

STEP 5 Organize and prioritize (define the core jobs/pains/gains/relievers/creators)

For each natural asset and service of focus, the next step is to prioritize actions or interventions with the most potential to meet stakeholder needs and interests related to service delivery. Prioritize the gain creators and pain relievers. When possible, local governments should validate the services, jobs, pains, gains, pain relievers, and gain creators with actual stakeholders. See section 4.2 of this guidebook for information about the sources of information that local governments can use to validate stakeholder needs and interests.

STEP 6 Write a value proposition statement for each stakeholder group, using the following template[6].

This exercise can be done for each of the natural assets and services of focus for the local government and for each priority stakeholder group. These will form the foundation of a corporate service objective.

Substitute actual answers from the Value Proposition Canvas into the bracketed areas:

- Our (products/services)
- help (stakeholders)
- who want to (jobs to be done)
- by (verb, such as reducing, relieving) (customer pains)
- and (verb, such as increasing, enabling) (customer gains)

Example:

- Our **wastewater services**
- help **our local ecosystem**
- who want **ensure their survival, resiliency and safety**
- by **eliminating toxic substances, foreign objects, and other harmful detritus from the local water supply**
- and **increase flora and fauna diversity in and near our local water systems**

6 *Source: Value Proposition Canvas template from Strategyzer (www.strategyzer.com/canvas).*

STEP 7 Identify where there are gaps and conflicts in the current service offering for each stakeholder group.

How is the current way the service is delivered creating gains for each stakeholder group? How is it relieving pains? Local governments should seek to answer the following questions:

- Are there any core pains/gains for any essential stakeholders that are not being met by the current service offering?
- What information is missing about the understanding of service delivery or performance?
- What level of influence does the local government have in the delivery of the service?
- Are there any obvious conflicts between the value propositions of stakeholders? Local governments should focus efforts on where there are gaps or conflicts.

STEP 8 Identify potential Levels of Service (LOS) objectives and indicators

The VPC can help identify service objectives and customer LOS because it describes the specifics of the values stakeholders receive from the service, i.e., the gains created and pains relieved. It highlights those aspects of the services that are important to stakeholders and where measures can be taken to improve the services and alleviate problems in service delivery. The VPC is also useful in identifying expected customer levels of service, which are metrics that represent the LOS the stakeholders expect.

Local governments may already have metrics that represent the LOS currently being provided. They will be able to determine target LOS measures by undertaking a process of dialogue with elected officials, staff, and stakeholders to determine what service can realistically be delivered for a reasonable cost. The VPC, along with customer LOS, can be used to write out a short, simple statement that covers what the service is, what it provides, what the target service performance is, and how it will be measured.

See the City of Edmonton case study in Section 6 for examples of service objectives for its Urban Forest Asset Management Plan and related customer levels of service. The City included targets for most of its LOS measures.

Appendix C: Description of Ecosystem Services[7]

Table 1: Ecosystem categories and types relevant to cities.

Ecosystem Service	Service Icon	Service description	Example
Provisioning services: Ecosystem services that describe the material or energy outputs from ecosystems.			
Food		Ecosystems provide the conditions for growing food. Food comes principally from managed agro-ecosystems, but marine and freshwater systems, forests and urban horticulture also provide food for human consumption.	In Havana, Cuba (1996), a significant proportion of the urban population's food was produced within urban gardens, including 8,500 tons of agricultural produce, 7.5 million eggs and 3,650 tons of meat (according to a review by Altieri, 1999).
Raw materials		Ecosystems provide a great diversity of materials for construction and fuel including wood, biofuels and plant oils that are directly derived from wild and cultivated plant species.	Non-timber forest products such as rubber, latex, rattan and plant oils are very important in trade and subsistence – the annual global trade in such products is estimated to amount to US$11 billion (Roe et al. 2002).
Fresh water		Ecosystems play a vital role in providing cities with drinking water, as they ensure the flow, storage and purification of water. Vegetation and forests influence the quantity of water available locally.	Estimates of the value of the services of a South African mountain fynbos ecosystem with an area of only 4 km² indicated that water production was the biggest contributor to the total value of the system. The value was estimated to range from approximately US$4.2 million to 66.6 million in 1997, according to how well the system is managed (Higgens et al. 1997).
Medicinal resources		Biodiverse ecosystems provide many plants used as traditional medicines as well as providing raw materials for the pharmaceutical industry. All ecosystems are a potential source of medicinal resources.	80% of the world`s people are still dependent on traditional herbal medicine (WHO 2002), while the sale of medicines derived from natural materials amounts to US$57 billion per year (Kaimowitz 2005).
Regulating services: The services that ecosystems provide by regulating the quality of air and soil or providing flood and disease control, etc.			
Local climate and air quality regulation		Trees and green space lower the temperature in cities whilst forests influence rainfall and water availability both locally and regionally. Trees or other plants also play an important role in regulating air quality by removing pollutants from the atmosphere.	In Cascine Park in Florence, Italy, the urban park forest was shown to have retained its pollutant removal capability of about 72.4 kg per hectare per year (reducing by only 3.4 kg/ha to 69.0 kg/ha after 19 years, despite some losses due to cutting and extreme climate events) (Paoletti et al. 2011). Harmful pollutants removed included O_3, CO, SO_2, NO_2, and particulate pollutants as well as CO_2.
Carbon sequestration and storage		Ecosystems regulate the global climate by storing greenhouse gases. As trees and plants grow, they remove carbon dioxide from the atmosphere and effectively lock it away in their tissues; thus acting as carbon stores.	Urban trees too, are important in carbon sequestration: in the United States, their annual gross carbon sequestration amounts to 22.8 million tons of carbon per year (as calculated in 2002) (Nowak and Crane 2002). This is equivalent to the entire USA population's emissions in five days. This sequestration service is valued at US$460 million per year, and US$14,300 million in total.
Moderation of extreme events		Ecosystems and living organisms create buffers against natural disasters, thereby preventing or reducing damage from extreme weather events or natural hazards including floods, storms, tsunamis, avalanches and landslides. For example, plants stabilize slopes, while coral reefs and mangroves help protect coastlines from storm damage.	In the case of the Californian Napa City, USA, the Napa river basin was restored to its natural capacity by means of creating mudflats, marshes and wetlands around the city (TEEBcase by Almack 2010). This has effectively controlled flooding to such an extent that a significant amount of money, property, and human lives could be saved.

7 *Source: TEEB – The Economics of Ecosystems and Biodiversity (2011). TEEB Manual for Cities: Ecosystem Services in Urban Management, www.teebweb.org.*

Waste-water treatment		Ecosystems such as wetlands filter effluents. Through the biological activity of microorganisms in the soil, most waste is broken down. Thereby pathogens (disease causing microbes) are eliminated, and the level of nutrients and pollution is reduced.	In Louisiana, USA, it was found that wetlands could function as alternatives to conventional wastewater treatment, at an estimated cost saving of between US$785 to 34,700 per hectare of wetland (in 1995) (Breaux et al. 1995).
Erosion prevention and maintenance of soil fertility		Soil erosion is a key factor in the process of land degradation, desertification and hydroelectric capacity. Vegetation cover provides a vital regulating service by preventing soil erosion. Soil fertility is essential for plant growth and agriculture and well-functioning ecosystems supply soil with nutrients required to support plant growth.	A study estimated that the total required investment to slow erosion to acceptable rates in the USA would amount to US$8.4 billion, yet the damage caused by erosion amounted to US$44 billion per year. This translates into a US$5.24 saving for every US$1 invested (Pimentel et al. 1995).
Pollination		Insects and wind pollinate plants which is essential for the development of fruits, vegetables and seeds. Animal pollination is an ecosystem service mainly provided by insects but also by some birds and bats.	Some 87 out of the 115 leading global food crops depend upon animal pollination including important cash crops such as cocoa and coffee (Klein et al. 2007).
Biological control		Ecosystems are important for regulating pests and vector borne diseases that attack plants, animals and people. Ecosystems regulate pests and diseases through the activities of predators and parasites. Birds, bats, flies, wasps, frogs and fungi all act as natural controls.	Water hyacinth was brought under control in southern Benin using three natural enemies of that plant (De Groote et al. 2003). Whereas the biological control project cost only US$2.09 million in present value, its accumulated value is estimated to amount to US$260 million in present value (assuming the benefits stay constant over the following 20 years), representing a very favourable 124:1 benefit cost ratio.
Habitat or Supporting services: These services underpin almost all other services. Ecosystems provide living spaces for plants or animals: they also maintain a diversity of plants and animals.			
Habitats for species		Habitats provide everything that an individual plant or animal needs to survive: food, water, and shelter. Each ecosystem provides different habitats that can be essential for a species' lifecycle. Migratory species including birds, fish, mammals and insects all depend upon different ecosystems during their movements.	In a March 2010 article (IUCN 2010), IUCN reports that habitat loss is the single biggest threat to European butterflies, and may lead to the extinction of several species. Habitat loss was said to occur most often as a result of changes in agricultural practice, climate change, forest fires, and expansion of tourism.
Maintenance of genetic diversity		Genetic diversity (the variety of genes between, and within, species populations) distinguishes different breeds or races from each other, providing the basis for locally well-adapted cultivars and a gene pool for developing commercial crops and livestock. Some habitats have an exceptionally high number of species which makes them more genetically diverse than others and are known as 'biodiversity hotspots'.	In the Philippines, an initiative to conserve local varieties of rice aided in the development of rice strains that are better adapted to local conditions - giving greater yield, a quality seed supply, and decreasing dependence on plant breeders - at a much lower cost than that of formal plant breeding (SEARICE 2007).
Cultural services: These include the non-material benefits people obtain from contact with ecosystems. They include aesthetic, spiritual and psychological benefits.			
Recreation and mental and physical health		Walking and playing sports in green space is a good form of physical exercise and helps people to relax. The role that green space plays in maintaining mental and physical health is increasingly becoming recognized, despite difficulties of measurement.	A review article examined the monetary value of ecosystem services related to urban green space, based on 10 studies, including 9 cities from China and 1 from the USA (Elmqvist 2011). It reported that on average, 'Recreation and Amenity' and 'Health effects' contributed a value of US$5.882 and US$17.548 per hectare per year respectively to the total average of US$29.475 per hectare per year provided by the seven identified ecosystem services in the various studies.
Tourism		Ecosystems and biodiversity play an important role for many kinds of tourism which in turn provides considerable economic benefits and is a vital source of income for many countries. In 2008 global earnings from tourism summed up to US$944 billion. Cultural and eco-tourism can also educate people about the importance of biological diversity.	Based on the amounts of money people spent on travel and local expenditure in order to visit Coral reefs in Hawaii, it was estimated that the value associated with these reefs amounted to US$97 million per year (TEEBcase by van Beukering and Cesar 2010). This implies that reef tourism resulted in significant income generation for individuals, companies, and countries.
Aesthetic appreciation and inspiration for culture, art and design		Language, knowledge and the natural environment have been intimately related throughout human history. Biodiversity, ecosystems and natural landscapes have been the source of inspiration for much of our art, culture and increasingly for science.	Prehistoric rock art of southern Africa, Australia, and Europe, and other examples like them throughout the world, present evidence of how nature has inspired art and culture since very early in human history. Contemporary culture, art and design are similarly inspired by nature.
Spiritual experience and sense of place		In many parts of the world natural features such as specific forests, caves or mountains are considered sacred or have a religious meaning. Nature is a common element of all major religions and traditional knowledge, and associated customs are important for creating a sense of belonging.	In the example of the Maronite church of Lebanon, the church committed to protecting a hill in their possession, comprising rare remainders of intact Mediterranean forest, independent of scientific and legal arguments, because this was in line with Maronite culture, theology and religion (Palmer and Finlay 2003).

Municipal Natural Assets Initiative