NATURAL ASSET MANAGEMENT VALUATION GUIDE:
Forest and Tree Assets

AMONTario ASSET MANAGEMENT ONTARIO

Credit Valley Conservation inspired by nature

Toronto and Region Conservation Authority

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Possibility grows here.

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Table of Contents

1 INTRODUCTION

Natural assets, such as forests, grasslands, wetlands, and streams, play a vital role in supporting human well-being and providing essential services to communities (bolded terms defined in Glossary). Despite their critical importance, these **assets** are often overlooked in municipal infrastructure investment and management decisions. This oversight arises partly from the false assumption that nature will persist indefinitely, continuing to be healthy, intact, and provide the services we value, without deliberate investment. Consequently, natural assets are frequently undervalued and underprioritized in resource allocation decisions.

Natural assets fall under the broader definition of **green infrastructure**, which are natural and human-made elements that provide ecological and hydrological benefits. Other types of green infrastructure include enhanced assets (e.g., street and park trees, green roofs) and engineered assets (e.g., permeable pavement). Since this document provides guidance on both individual trees and larger forests, it captures some enhanced assets, however the term natural asset is used for simplicity.

As climate change progresses and urbanization increases, the need for proactive management of natural assets becomes more urgent. By incorporating natural assets into asset management systems, public organizations can develop long term management plans and financial strategies to protect and enhance these natural features. This includes activities such as monitoring, establishment and maintenance activities, restoration, and proactive risk management. Using asset management processes to manage natural assets also enables asset managers, such as municipal and conservation authority staff, to justify the budgets necessary for natural asset care and provides managers and decision makers with a clearer understanding of priorities, costs, risks, and alternative management scenarios. In Ontario, municipal **asset management planning** is required through ***O. Reg. 588/17:*** *Asset Management Planning for Municipal Infrastructure* regulation which explicitly includes green infrastructure assets.

1.1 PURPOSE

This report provides comprehensive guidance on the valuation of natural assets for effective management and decision-making in asset management. Specifically, it presents detailed instructions for calculating value for the following forest and tree assets:

- Street Trees
- Park Trees
- Hedges and patches (including shrubs)
- Forests (encompassing Woodlands)

These are the natural assets most commonly included in asset management plans to date, and the methods detailed in this guide have been adopted by multiple organizations. While the step-by-step guidance in this report centres on these assets, the guide also offers directions on applying the same concepts to other natural assets.

This guide is intended for municipal and conservation authority staff in Ontario, but the guidance is also relevant for asset managers across Canada and beyond. It includes detailed discussion of valuation in asset management and how natural assets can be addressed within traditional asset management processes. Step-by-step guidance and examples for forest and tree valuation using common valuation methods are also provided in this document. This serves to help practitioners understand and implement common approaches, but also to document what is being done today.

The field of natural asset management is evolving and there are currently multiple valuation methods being used for a single natural asset type. This report documents the most common methods and gives advice for choosing the best approach, while also highlighting the need to progress towards a more standardized approach. The aim is to help the field move collectively towards consistent methods that best reflect the unique characteristics of natural assets while providing comparable values that can be fully integrated into asset management systems.

2 ASSET VALUATION

The following section provides a high-level overview of how **asset value** is used and calculated within traditional asset management. It then delves into how the same approach can be applied to natural assets. It also outlines other existing methods for valuing nature and the rationale for why they should be used, and in some cases should not be used, for valuation within asset management.

2.1. ASSET VALUATION IN ASSET MANAGEMENT

2.1.1. Purpose of Asset Value

Asset valuation is a core component of reporting on the **State of Infrastructure** in asset management. Developing a State of Infrastructure is the first stage in the asset management process (see Figure 1). Asset value is used to assess an organization's level of investment (how much assets are worth) and **risk** exposure, to inform strategic decision-making, and as a communications tool. Value is recorded as an **asset attribute** within a municipality's **asset register**, which is generally either an asset management software, geospatial database, or Excel spreadsheet, and is organized by **asset hierarchy**. Financial measures, such as value and costs, also play a role in the later stages of asset management, particularly when developing lifecycle management strategies (see Figure 1). It is important to note that for treed assets, the asset value reported in the State of Infrastructure will typically not be the same as the lifecycle cost of the asset (see Section 2.1.3).

Continuous Updates and Improvements

1. State of Infrastructure	2. Levels of Service	3. Lifecycle Management	4. Financial Strategy
Inventory and Hierarchy	Customer Levels of Service	Lifecycle Activities	Available Funding Sources
Condition	Technical Levels of Service	Lifecycle Costing	Funding Scenarios
Valuation			Projected Funding
Age and Useful Life			
Risk and Criticality			

FIGURE 1. FOUR STAGES OF ASSET MANAGEMENT

The State of Infrastructure report is used to assess and communicate a variety of information including what assets an organization owns, their extent, number, size, or **asset condition**, and the organization's risk and responsibility for maintaining the **asset inventory**. Many assets in an organization have their own unit of measure. For example, pipes may be reported on per linear kilometre while traffic lights may be reported by quantity of individual lights (e.g., number of units). It can be challenging to relate these different measures and to summarize and compare across the whole asset portfolio. For instance, how does one kilometre of pipe compare to 50 traffic lights? Calculating asset value allows different assets to be rolled up and compared using a common unit of dollars ($). This financial measure can then be analyzed using other attributes, such as risk and condition, to support decision-making and guide management strategies.

2.1.2. How to Calculate Asset Value

There are two different fundamental approaches to valuing infrastructure assets, each based on a different type of accounting:

1. Financial Accounting: This type of accounting uses historical cost as the starting point. The current or book value is determined by depreciating or amortizing the historical cost according to the asset's age or condition. This is defined by the Public Sector Accounting Board (PSAB) standards and is focused on financial reporting.

2. Managerial Accounting: In contrast, this type of accounting determines current value based on replacement cost. It is more forward-looking and decision-oriented, focusing on what it would cost to replace the asset. Unlike financial accounting, it is not governed by PSAB standards.

Recognized authorities in asset management, including the Federation of Canadian Municipalities, emphasize the use of replacement cost (managerial accounting) as a preferred approach for asset valuation. In Ontario, *O. Reg. 588/17* states that asset value should be reported as the replacement cost for each asset category[a]. Therefore, replacement cost is how assets are valued in Ontario and replacement cost is calculated using a method called current replacement value.

2.1.2.1. Current Replacement Value Method

Current replacement value is a valuation method that determines an asset's value based on the total cost to replace it today. This includes considerations for:

1. Using modern and cost-effective methods and materials
2. Meeting the required **level(s) of service**[1]
3. Incorporating any updated standards or regulatory requirements

There is no standardized approach for calculating current replacement value in asset management. Exact approaches vary between municipalities, but the fundamental concept is the same. Discrepancies often arise because the full replacement value accounts for more than just the asset's purchase price, it also includes planning, delivery, installation, initial establishment and monitoring activities, and initial maintenance. This allows room for interpretation around what should be included. Another challenge relates to the cost of removing existing assets. The replacement cost may include expenses for decommissioning and disposing of old assets, but this depends on the type of asset and can vary not only between municipalities but also across different asset types within the same municipality. Some municipalities also account for contingency within their current replacement value, but there is no consistent method for how and when to do so. While this guidance is focused on natural asset valuation, traditional asset management would also benefit from moving towards a more standardized approach to valuation.

DEFINITIONS
The terms **current replacement value** and **current replacement cost** are often used interchangeably. This guide will use the term **current replacement value** to maintain consistency with most Ontario municipalities and the direction of the industry.

[1]In this instance, valuation considers levels of service with general assumptions, whereby a type of asset is expected to have average service contributions. So, a forest can be valued based on its land area and the size of its trees, which influence services and afforestation costs, without being tied to any specific service metrics. This valuation provides a basis for prioritization and communication, while current and desired levels of services are defined in later asset management stages.

2.1.3. Asset Value vs Lifecycle Costing

Within the State of Infrastructure in asset management (see Figure 1), asset valuation is the common benchmark against which decisions are considered. As outlined in the previous section, asset valuation in asset management is calculated using the current replacement value method. This method considers the full cost to replace an asset in its current operating environment. But costing is also included in a later stage of asset management when developing lifecycle management strategies (see Figure 1). It is important to note the asset value in the State of Infrastructure is generally not equivalent to the **lifecycle cost** of an asset (see Figure 2). The lifecycle cost is the total cost of an asset throughout its life, including the costs of planning, acquisition, creation and establishment, operations and maintenance, monitoring, rehabilitation, and disposal[2], less any residual value[b]. Therefore, the costs used to calculate asset value can also be used to estimate some, but not all, components of lifecycle costs.

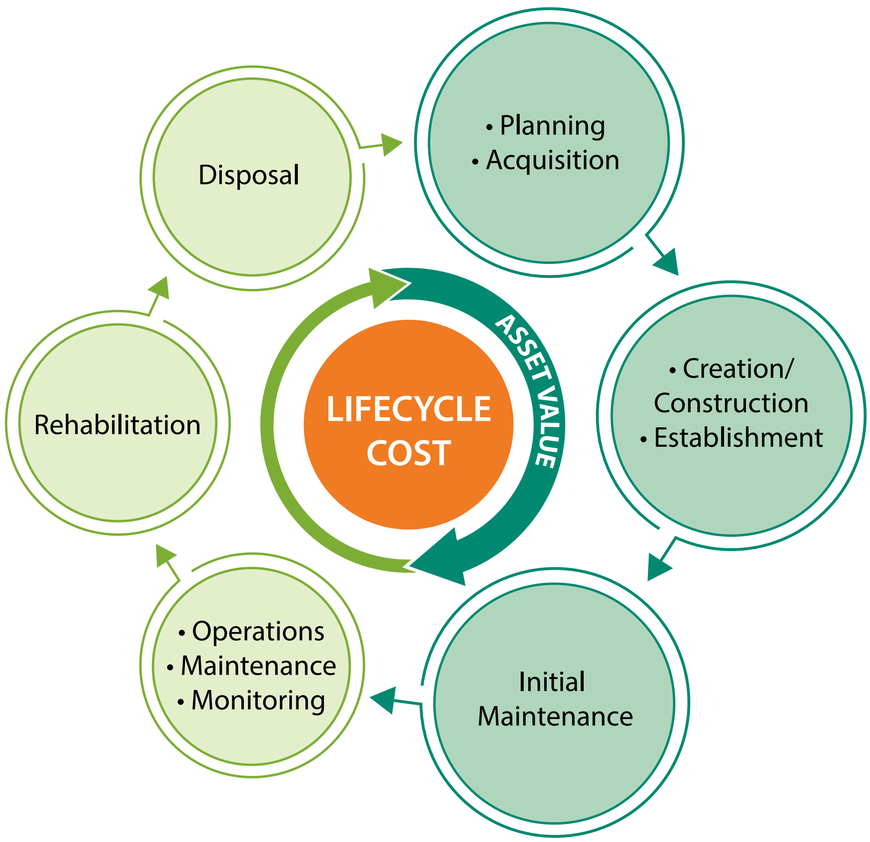

FIGURE 2. COSTS INCLUDED IN ASSET VALUE AND LIFECYCLE COSTS[2]

For example, in the lifecycle of a 100-metre bridge, the initial costs of planning and construction are only 36 percent of the lifecycle cost which includes further maintenance, monitoring, rehabilitation, and disposal (Table 1). However, if the bridge needed replacing, only the first two stages (i.e., Plan and Aquire, Create) would represent what's needed to replace the asset, therefore providing an accurate estimate of its current replacement value. Essentially, current replacement value provides a snapshot of the asset's value today if you had to replace it, while the lifecycle cost reflects the total investment needed to manage and sustain the asset over time. Please refer to Table 14 in Section 5.3 for a similar example of lifecycle costs and phases, but involving Forests as the (natural) asset.

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[2]Some municipalities include a disposal cost in their replacement value. While there is no standard approach, the recommendation is to either follow what is done for grey infrastructure assets for any given municipality or other organization, or to only include the first three stages highlighted in Figure 2 to avoid duplication of the lifecycle costs.

TABLE 1. COSTS AND PHASES ASSOCIATED WITH THE LIFECYCLE OF A 100-M BRIDGE

Lifecycle Phase	Current Replacement Value	Lifecycle Cost	Description
Plan and Acquire	$100,000	$100,000	Studies, design, project management, public engagement, planning, land acquisition (if recent)
Create	$1,000,000	$1,000,000	Bridge construction
Operate and Maintain	-	$1,225,000 ($15,000/year x 75 yrs for maintenance, $100,000 rehab once in lifespan)	Maintenance, minor rehabilitation
Monitor	-	$375,000 ($10,000/every second year for 75 yrs)	Biannual bridge inspections
Rehabilitate and Dispose	-	$350,000 ($200,000 for major rehab once in lifespan, $150,000 for final disposal)	Major rehabilitation, disposal
TOTAL	**$1,100,000**	**$3,050,000**	**-**

While asset valuation is used as a consistent comparison measure between different assets, **asset lifecycle costing** is used in financial modeling and can help staff allocate budgets and plan for establishment, maintenance, and management activities. Asset lifecycle costing can be used to help illustrate the difference between alternative management strategies. For example, if instead of implementing a strategy of performing regular proactive maintenance on an asset over its life, an alternative strategy is implemented in which maintenance activities are deferred, then the result will be a worse asset condition and potentially shorter asset lifespan or **remaining service life.** Essentially, detailed lifecycle asset costs within lifecycle management strategies can help managers consider the long-term costs associated with different management approaches. It is also integral for identifying any infrastructure funding gaps and can be used to run a wide variety of financial scenarios.

2.2. NATURAL ASSET VALUATION IN ASSET MANAGEMENT

2.2.1. Purpose of Natural Asset Value

One of the key benefits of including natural assets in asset management is the ability to consider them alongside their **traditional (grey) infrastructure asset** counterparts, such as roads and pipes, assessing and investing in them in an equivalent manner. To achieve this equivalence, it is crucial that natural assets can be summarized and compared with all other asset types. While they may be measured in hectares or by the number of trees, using value as a common benchmark for natural assets ensures they can be effectively integrated into corporate reporting and decision-making processes.

2.2.2. How to Calculate Natural Asset Value

Various methods exist to value nature, but not all are suitable for asset management. The key consideration for natural asset value in asset management is ensuring consistency and comparability with other assets in an organization's asset portfolio. This requires using a common valuation method: current replacement value. When selecting a method for calculating this value, it is also important to keep the calculation simple, consider staff expertise and capacity for long term calculations, assess the available data (both current and future), and ensure the method can be easily explained to senior management and councillors.

Valuation within asset management meets the goal of valuing the investment an organization has made in their assets, but fails to capture the value of services provided by natural assets as well as their inherent value. Therefore, it is important to consider the need for additional valuation, such as Ecosystem Service Valuation (see Section 2.3.3.) in other plans and policies, outside of asset management. Some natural assets are also irreplaceable. These still need to be included in asset management plans to account for long-term planning and budgeting, but should be uniquely identified to facilitate their protection. This is beyond the scope of this guide, but an important area of future development (see Section 5.2).

2.2.2.1. Current Replacement Value

When applying the current replacement value method to natural assets, a key challenge is ensuring the replacement asset can deliver the required levels of service (like-for-like replacement). While built assets typically provide the required levels of service once completed, many natural assets take time to establish, sometimes even decades. During this period, their services increase, but the current service levels may not be achieved for a significant amount of time. For example, the services provided by a 50-year-old tree cannot be matched by replacing it with a young, small tree. When using current replacement value to value natural assets, four approaches exist:

1. Account for the age or size of the asset by using existing formulas or a multiplier to increase the replacement cost of mature assets (e.g., replacing a single mature tree with multiple small trees)
2. Use existing biodiversity offsetting schemes (Section 2.3.1)
3. Include all the costs of management until the ecosystem feature reaches maturity and can provide the current levels of service
4. Ignore the delay in service delivery and only factor in initial planting or afforestation costs

The first approach to account for the age or size of the asset is a commonly used and recommended method to account for the time taken to reach current service levels. It is described in detail in this guide in Sections 3.1.4 Trunk Diameter and Basal Area Replacement Methods, 3.1.5 Council of Tree and Landscape Appraisers Trunk Formula Method (CTLA TFM), and 3.3.5 Afforestation Cost with Basal Area Multiplier Method. These sections include step-by-step guidance on how to use this approach when calculating current replacement value for tree and forest assets. These methods provide strong benchmark comparisons between traditional and natural assets for strategic decision-making. This is because they provide a means of communicating levels of investment (considering all resources including time), the significance of the assets, and the potential risks of not managing them well or losing them. However, the value inflated for age or size is not the cost that should be used in the lifecycle analyses or long-term financial modeling and planning. A lifecycle cost analysis should reflect the actual costs associated with the natural asset over its entire lifecycle, including actual planting costs and longer-term management (see Credit Valley Conservation (CVC). (2025). Natural and Enhanced Asset Lifecycle and Replacement Costing report for relevant lifecycle stages for different natural asset types)[c].

The second approach to use schemes is discussed in more detail in Section 2.3.1. Biodiversity offsetting schemes are a feasible option where such schemes exist, but they are relatively rare in Canada.

The third approach to include all costs until maturity is not recommended because a tree or forest asset takes decades to mature. While nature handles much of the work after initial planting and establishment activities, these assets still require time, protection, and occasional intervention from managers. This long-term investment is difficult to quantify, especially when considering the "cost" of giving the asset time to develop.

The last approach to only factor in initial costs is also not recommended because most natural asset managers agree that ignoring the difference between a mature tree or forest compared to a newly planted one does not account for the services provided by the mature asset and the investment (both financial and time) for the asset to reach its mature stage. It is included in this guide solely because it is straightforward and requires very little data.

2.3. DISCUSSION OF OTHER VALUATION METHODS

2.3.1. Biodiversity Offsetting

Biodiversity offset guidelines can be a potentially useful source for estimating the current replacement value of natural assets, particularly if locally applicable biodiversity offset methods are standardized and published[d]. An offset is an area of land (or a tree) which has been or will be preserved, enhanced, restored, or created to compensate for the loss of biodiversity resulting from development[e]. The methods used to calculate a biodiversity offset cash-in-lieu value could also be used to estimate the current replacement value of natural assets in asset management.

However, the relationship between biodiversity offsetting and current replacement value is unidirectional as asset management's current replacement values should not be used to inform biodiversity offsetting or be interpreted as the cost to remove a particular natural asset. Published asset management plans typically report asset values rolled up to all assets within a category or service area (e.g., the value of all trees or all green infrastructure). Therefore, the values are generalized and don't represent site- or asset-specific costs or other considerations.

Toronto and Region Conservation Authority's (TRCA) Ecosystem Compensation Guideline is an example of a biodiversity offsetting scheme which could be used to assess asset value[f]. In fact, principles from the guideline are integrated into the forest valuation method outlined in this report (see Section 3.3.4). Unfortunately, local biodiversity offsetting methods are rare and will not exist as an option for many local governments. Currently, Canadian municipalities with potentially relevant offset guidelines include:

- City of Brampton's "Tableland Tree Assessment Guidelines"[g]
- City of Barrie's "Ecological Offsetting Policy"[h] and "Tree Protection Manual"[i]
- City of Edmonton's "Guidelines for Evaluation of Trees"[j] and "Natural Stand Valuation Guidelines"[k]
- City of Windsor's "Landscape Requirements for Development Manual (1996)"[l]

Credit Valley Conservation and Lake Simcoe Region Conservation Authority are other conservation authorities who have published Ecosystem Offsetting Guidelines[m] and an Ecological Offsetting Policy[n], respectively. Asset managers are encouraged to check whether their municipality or conservation authority has a guideline or policy.

2.3.2. Land Value

In asset management, land value is typically excluded from traditional asset valuation. This is primarily because of the challenge of accurately estimating it. Both market value and zoned value can vary widely, with market value being particularly volatile and influenced by factors unrelated to the management or operation of an asset. Determining an appropriate land valuation method is especially challenging for natural assets. This is because the value of land with restricted use, such as protected areas, is generally much lower than land zoned for development. Incorporating land value into natural asset valuation is not recommended because it is inconsistent with other asset types and could potentially significantly undervalue natural assets relative to their traditional infrastructure counterparts.

However, recognizing that land value is critically important to a municipality or conservation authority, they could consider adopting the City of Waterloo or Canadian City of London's approach. They valued all municipally owned land within a separate land category in their asset management plans[o,p].

It is also important to recognize that, while land value is typically excluded from the replacement cost of natural assets, there may be a compelling rationale for its inclusion in long-term financial planning. This is particularly relevant when a municipality or conservation authority anticipates acquiring land for the purpose of restoring and managing natural assets. For instance, York Region is exploring the inclusion of land value in its financial modeling, based on the assumption that continued expansion of the York Regional Forest will be necessary to sustain service levels amid increasing demand driven by population growth (J. Lane, personal communication, December 12, 2024).

2.3.3. Ecosystem Service Valuation

Natural assets provide multiple goods and services that sustain our lives, including materials (such as timber and fish), clean air, drinking water, and opportunities for recreation. All of these are examples of ecosystem services. Unlike commonly traded goods and services, most ecosystem services do not have explicit prices in the marketplace. economic valuation – assigning a value to key ecosystem services using a variety of valuation methods – is a tool that helps decision-makers understand the benefits provided by their natural assets to make a case for their protection, restoration and maintenance that will ensure those benefits flow for generations to come.

The economic ecosystem service valuation is different from the asset management valuation undertaken as part of asset management. As these two types of valuation are often confused, this section provides a brief comparison of the two valuation techniques.

Asset management valuation provides an apples-to-apples comparison measure. Asset management uses the current replacement value method to value assets; it does not involve economic valuations. For example, asset management does not involve estimating the healthcare costs saved by drinking water systems, the flood damage costs avoided by stormwater pipes, nor does it involve estimating the traffic collision costs avoided by traffic lights. Asset management aims to consider all assets strategically and facilitate holistic decision-making that considers the full lifecycle costs, risks, and services provided by assets. To be considered in parallel to traditional infrastructure assets, natural assets need to be assessed using the same measures, including valuation.

Asset management valuation focuses on the costs incurred by the owner to replace an asset. The cost perspective helps an organization directly relate its expenditures on assets to changes in their value, and it supports many asset-related decisions. The fundamental limitation of the cost perspective is its conflation of cost and value, treating them as synonyms. While the cost perspective is useful for determining how best to manage an asset, it falls short in assessing the value of assets to society.

Ecosystem service valuation is an economic valuation approach that focuses on the benefits generated by natural assets. It is often used to build a business case for protecting natural assets. It is a separate process from asset management, but can be useful for municipalities and conservation authorities, especially for communicating the value of nature to a wide variety of audiences. This type of valuation can be helpful because the cost of an asset does not provide direct insight into the economic benefits it generates. Yet, it can generally be assumed that the benefits over time are at least equal, and can greatly exceed, an asset's replacement cost. Thus, for the purposes of asset management, it is generally considered sufficient to focus on the cost of an asset, with the assumption that in doing so, an asset will inherently continue to provide benefits. Developing an ecosystem service valuation on the other hand is most useful in the context of benefit-cost analysis. The outputs of an ecosystem service valuation can be used in asset management for defining levels of service measures and indirectly for risk management, but it is not required. An emerging field within ecosystem service valuation is the creation of ecosystem markets that assign value to discrete, measurable ecosystem services generated by natural systems, such as carbon sequestration, water quality improvement, or flood attenuation. While ecosystem markets can play a complementary role in supporting conservation and restoration financing, they are generally not well suited to informing natural asset valuation within asset management plans. Ecosystem market approaches typically value individual services in isolation and do not explicitly account for the full ecological structure or replacement cost of the underlying asset.

For further details on ecosystem service valuation, including methods and examples, see Appendix A.

If a municipality or a conservation authority is uncertain whether they want to integrate natural asset valuation into asset management or whether they want to conduct an ecosystem service valuation to inform a benefit-cost analysis, there are important key advantages and limitations to consider for both (summarized below in Table 2).

TABLE 2. ADVANTAGES AND LIMITATIONS OF ASSET MANAGEMENT VALUATION VS. ECOSYSTEM SERVICE VALUATION

Method	Advantages	Disadvantages
Asset Management Valuation	• Integrates natural assets into traditional asset decision-making processes, increasing their consideration as important service providers • Provides a uniform measure for assets in asset management planning • Allows for assessment and comparison between asset investment levels among service areas/asset categories • Informs long-term asset management and financial management decisions	• Only captures replacement cost of an asset, not the benefits it provides • Based on the prescribed asset management planning framework, but can be used in other environmental policy contexts (e.g., Offsetting Guides)
Ecosystem Service Valuation	• Captures value of the asset to society: - Measures economic value of multiple services - Provides more holistic perspective on the total value of the asset (including non-use values) • Can have multiple useful applications: - Building a business case for protecting assets /securing investment for management - Informing conservation, restoration, and management strategies - Helping to calculate return-on-investment for natural assets - Informing levels of service development in asset management plans • Can be used at different scales and in different management contexts	• Can be resource-and time-consuming and often involves technical modeling expertise • Potential for greater under- or over-valuation based on assumptions and biases • Has no direct connection to and is not part of the asset management planning valuation process

However, if there is the capacity to complete both an ecosystem service valuation and a natural asset management plan, the inclusion of ecosystem service valuations as an additional chapter or appendix can be useful to avoid undervaluing natural assets and the benefits they provide to society.

3 STEP-BY-STEP GUIDANCE ON COMMON VALUATION METHODS

3.1. STREET AND PARK TREES

3.1.1. What is a Street or Park Tree?

Street and park trees are woody perennial plants typically having one stem or trunk, that are either planted (e.g., evidenced by mulch, planting context) or naturally seeded along road rights-of-way, road allowances or in parks. They exist in both urban and rural environments. Size criteria can be used to stipulate the minimum size requirements of a street or park tree for inclusion in an asset inventory (e.g., minimum height and minimum **diameter at breast height**). Trees planted in hedgerows – strips of planted trees forming a border or fence – should also be assessed individually.

Street and park trees improve the livability of urban and rural environments, providing numerous environmental, social, and economic benefits such as carbon storage and sequestration, shade, and reduced stormwater runoff volumes. Street and park trees are more isolated than trees in larger, connected vegetated communities like a forest and often require more intensive management and maintenance. This is particularly true in urbanized settings, where they are exposed to stressors such as air pollution, physical damage, and road salt. Due to these factors, street and park trees are sometimes classified as "enhanced" green infrastructure instead of "natural" green infrastructure. They are included in this guide because they are frequently included in natural asset management plans, are living assets, and are commonly found within municipalities.

Several methods have been used to assess the current replacement value of street and park trees in asset management (Table 3). Most approaches account for the size or age of the tree but differ in how they calculate the number of trees to include in the replacement. There are currently three methods that factor in the size or age of a tree:

- Trunk Diameter Method
- Trunk Basal Area Method
- Council of Tree and Landscape Appraisers (CTLA) Trunk Formula Method

There is also one method that does not account for the size or age of a tree:

- One-to-One Replacement Method

Where data is available, the Trunk Basal Area Method is recommended as it balances fairly simple calculations with accurately accounting for the exponentially larger benefits of older or larger trees and mirrors the recommended approach for forests. However, all of the options provided have been successfully used by municipalities and the iterative process of asset management planning allows for changes and improvements to valuation methods over time. Therefore, each municipality or conservation authority should consider the advantages and disadvantages below as it relates to their data, capacity, and similarity to other asset valuations.

3.1.2. Street Tree Valuation Methods Comparison Table

TABLE 3. TREE VALUATION METHOD COMPARISON

Method	Description	Data Required	Advantages	Disadvantages
Trunk Diameter	Assumes one tree is 'replaced' by several caliper-sized trees which together have the same trunk diameter as the tree being assessed	• Tree diameter at breast height (DBH) • Unit cost per caliper tree	• Simple to calculate • Accounts for increased services of larger trees	• Underestimates the true size and results in a lower value per tree in comparison to the Trunk Basal Area and CTLA Trunk Formula methods
Trunk Basal Area	Assumes one tree is 'replaced' by several caliper-sized trees which together have the same basal area as the tree being assessed	• Tree diameter at breast height (DBH) • Unit cost per caliper tree	• Fairly simple to calculate, involves a basic equation • Accounts for the exponentially larger service level of bigger trees	• Can result in very high valuation for large trees
CTLA Trunk Formula	Assumes one tree is 'replaced' by several trees which together have the same basal area but then depreciates the value of the tree based on its location, functionality, and condition	• Tree diameter at breast height (DBH) • Unit cost per tree • Condition • Functional limitations • External limitations	• Accounts for the exponentially larger service level of bigger trees • An internationally recognized tree replacement cost valuation method	• Manual is proprietary and purchasing the manual has an associated cost • Data intensive • Complicated to calculate, high risk of miscalculation errors • Very specific to each tree, whereas asset management valuation attempts to use general/average costs • Depreciation not included for other traditional assets • Considers tree condition, which is not included in valuation of traditional assets
One-to-One Replacement	Assumes a single tree of any size and age is replaced by one small caliper-sized tree	• Unit cost per tree	• Simple to calculate	• Does not reflect that larger trees provide more services than smaller trees

3.1.3. Unit Cost Per Tree

Every street and park tree valuation method requires information on the unit cost per tree. A standard unit cost per tree is determined based on all the costs needed to acquire, install, and establish a tree. Ideally local tender documents are used to obtain the prices for the unit cost. This is a very important step in the valuation process because the unit cost has a significant impact on the overall valuation.

Unit Cost ($ per tree) = Average Tree Price + Installation Cost + Establishment Cost (3 years)

The average **tree price** is the average nursery cost for the plant (a caliper-sized tree). The tree price should reflect local market prices of nursery stock and should be obtained from internal tender or contract documents where possible. If tenders or contracts do not exist, the prices could be obtained from a neighbouring municipality. If none of those sources are available, cost can be obtained from the International Society of Arboriculture Ontario's (ISAO) "Ontario Supplement" (the Supplement) cost table[3]. This table was developed to provide a quick reference for the costs of individual tree species to support the completion of consistent appraisals. In the Supplement, the average wholesale prices of different commonly planted and occurring tree species have been compiled from different Ontario wholesale nurseries based on 2021 catalogue prices. These prices should be then inflated to the current year.

A municipality or conservation authority can be specific or general when estimating tree price. A tree price can be calculated based on the proportion of different species within the tree inventory or based on a tree price by species. For example, in Table 4, a municipality could include all typically planted species and then use the average price ($363) for all trees. This is a simple approach to integrate into Excel and asset management software, where a wide variety of unit costs per asset type might not be feasible. Another option is to use a tree price based on a weighted average that accounts for the proportion of individual species planted by a municipality or conservation authority. More commonly planted species would be weighted heavier in the average. This approach involves more detailed calculations but more accurately reflects the species composition in the tree price. An alternative approach would be to include the tree price per species. In Table 4, all Freeman maple assets would have a tree price of $429 and all white cedar assets would have a tree price of $282. This approach requires more detailed calculations and assumes the same species would be planted going forwards, which is not always the case.

TABLE 4. AVERAGE TREE PRICES FOR TEN COMMON TREE SPECIES IN SOUTHERN ONTARIO[4]
(Soured from ISA cost table, inflated from 2021 to 2025 CAD using a rate of 15.88%)

Botanical Name	Common Name	Number of Nurseries with Prices	Rounded Average Caliper (mm)	Average Tree Price (inflated to 2025 costs)
Acer x freemanii	Freeman maple	2	90	$429
Celtis occidentalis	Hackberry	5	80	$370
Ginkgo biloba	Maidenhair tree	5	70	$406
Gleditsia triacanthos	Honeylocust	1	80	$272
Picea glauca	White spruce	5	100	$363
Picea pungens	Colorado spruce	5	90	$341
Pinus nigra	Austrian pine	4	80	$288
Quercus alba	White oak	4	90	$527
Syringa reticulata	Ivory silk tree lilac	5	80	$356
Thuja occidentalis	White cedar	5	90	$282
TOTAL AVERAGE		**4**	**85**	**$363**

[3]See: https://www.isaontario.com/wp-content/uploads/2022/07/ISAO-CTLA-Supplement-10th-Edition_FINAL_05JUL2022.pdf

[4] Note: while the list includes the most common species found in Ontario, planting and replacing non-native species with native or near-native species is recommended.

Installation cost includes the planting labour, transportation, any basic design fees, and/or shipping expenses of a tree.

Establishment costs include the costs for tree establishment, including initial mulching and watering (for a 2-year warranty period), and mulching and watering for at least one additional year. It should be based on local practices and prices from previous tender costs from contracts. It is important to note that 3 years is a recommended minimum, and some municipalities may choose more based on what practices are used to increase young tree survival.

Inflation needs to be accounted for if the costs are obtained from a tender or other source from a previous year. The costs should be converted to their current-year equivalent. This involves using the inflation rate between the source year and the current year. For example, if a white oak cost $455 in 2021and the inflation rate between 2021 and 2025 is 15.88 percent, then the equivalent cost of a white oak in 2025 would be $527. The inflation rate can be obtained from the Bank of Canada Inflation Calculator[5] or price indexes from Statistics Canada. It is important to note the Inflation Calculator is updated monthly, so all values should be converted in the same month to maintain consistency.

3.1.3.1. Asset Removal and Contingency

The inclusion of removal costs in calculating an asset's current replacement value is not consistent across asset types. This report excludes these costs to simplify the calculation and remain aligned with the most common guidance sources in Ontario (see Appendix B). However, it is recommended to consider including them if they are accounted for in other asset values within the municipality or conservation authority. If a replacement value method is selected that applies a multiplier to account for tree size, it is important to note that the tree removal and stump removal costs would not be included in the unit cost, as these are incurred only once per asset. Although removal costs increase for larger trees, the increase is not substantial enough to warrant applying a multiplication factor to these costs. They would be added to the replacement value after the multiplication factor is applied.

Some asset managers include a contingency cost in their current replacement value valuation. This involves adding a standard percent to the calculated replacement cost to account for uncertainties. Like with asset removal, this has not been included in this guide, but it should be considered if it is accounted for with other assets in the municipality or conservation authority.

DEFINITIONS

Tree removal includes the costs associated with removing an existing tree from the planting location. This process removes the tree, but the stump remains.

Stump removal includes the cost associated with removing the tree stump from the ground.

[5] See: https://www.bankofcanada.ca/rates/related/inflation-calculator/

3.1.4. Trunk Diameter and Basal Area Replacement Methods

In asset management, the current replacement value method involves replacing the asset using modern and cost-effective methods that create an asset that provides the required level of service. To do this, it is helpful to assign a higher value to larger trees, recognizing that the services they provide would not be matched by replacing with a single caliper-sized tree. The common approach is to assume that a single large tree is worth multiple small trees and thus the value of the larger tree can be estimated by calculating the cost of planting multiple smaller caliper trees.

The **Trunk Diameter Replacement Method** assumes one tree is 'replaced' by several caliper-sized trees which together have the same trunk diameter as the tree being assessed. The **Trunk Basal Area Replacement Method** requires the number of replacement trees to sum to an equivalent trunk basal area. For example, a tree with a diameter at breast height (DBH) of 20 cm would theoretically be replaced by four 5 cm caliper-sized trees using the Trunk Diameter Method and 16 trees using the Trunk Basal Area Method (see Figure 3).

A 5 cm caliper-sized tree is used because it is the typical size of a small caliper tree planted on streets and in parks in Ontario. This number could be adapted if smaller or bigger trees are typically planted within a municipality or conservation authority.

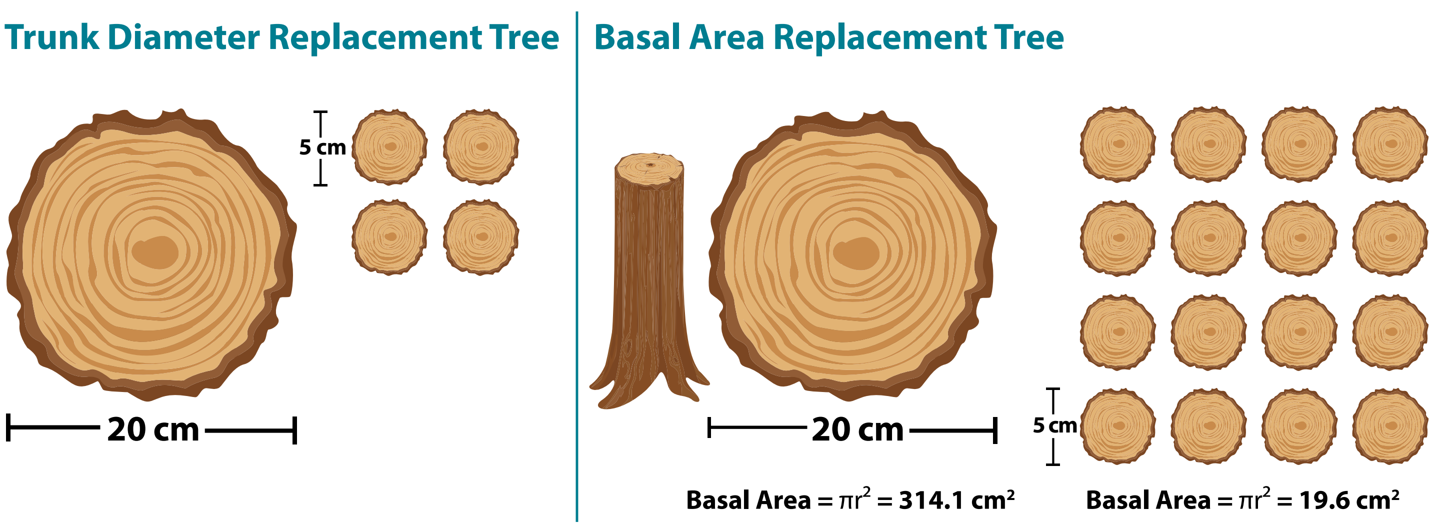


FIGURE 3. NUMBER OF REPLACEMENT TREES USING DIFFERENT TREE REPLACEMENT CALCULATION METHODS

In both approaches, the replacement cost per tree is calculated by multiplying the standard unit cost per tree by the quantity of caliper-sized replacement trees needed to equal the same trunk diameter/basal area as the tree being assessed.

In the example above, the Trunk Basal Area Method results in significantly more trees being "replaced" than the Trunk Diameter Method and therefore has a higher replacement value. The difference between methods increases as the basal area of the replacement tree increases, since basal area increases exponentially by diameter. The Trunk Diameter Method involves one less calculation step (it is not necessary to calculate the basal area from trunk diameter), however, basal area is better correlated with the quantity of many services provided by a tree, which also increase exponentially with tree size. Some municipalities may prefer the more conservative value provided by the Trunk Diameter Method. The CTLA Trunk Formula Method (discussed next) also assumes that the basal area is replaced, however, it also considers other factors such as condition and functionality.

3.1.4.1. Example Calculations

TRUNK DIAMETER REPLACEMENT

FORMULA

Replacement Cost per Tree = Unit Cost * Quantity of Replacement Trees

Unit Cost ($ per tree) = Average Tree Price + Installation Cost + Establishment Cost (3 years)

Quantity of Replacement Trees = Tree DBH / 5 cm caliper tree

Note: if a tree is smaller than 5 cm DBH, assume one-to-one replacement

SAMPLE CALCULATION

The replacement cost of a 30 cm DBH tree using the Trunk Diameter Method would be calculated as follows:

The average tree price $300, installation is $400, establishment cost is $300.

Replacement Cost per Tree = ($300 + $400 + $300) * (30 cm / 5 cm)

= $1,000 * 6 replacement trees

= $6,000

Therefore, the replacement cost of the 30 cm DBH tree would equal $6,000.

TRUNK BASAL AREA REPLACEMENT

FORMULAS

Replacement Cost per Tree = Unit Cost * Quantity of Replacement Trees

Unit Cost ($ per tree) = Average Tree Price + Installation Cost + Establishment Cost (3 years)

$$\text{Quantity of Replacement Trees} = \pi\left(\frac{\text{diameter}}{2}\right)^2 / \ \pi\left(\frac{5}{2}\right)$$

$$= \left(\frac{\text{diameter}}{2}\right)^2 / \left(\frac{5}{2}\right)^2$$

Note, if a tree is smaller than 5 cm DBH, assume one-to-one replacement

SAMPLE CALCULATION

The replacement cost of a 30 cm DBH tree using the Trunk Basal Area Method would be calculated as follows:

The average tree price $300, installation is $400, establishment cost is $300.

Quantity of Replacement Trees = $(30 / 2)^2 / (5 / 2)^2$

= 225 / 6.25

= 36 replacement trees

Replacement Cost per Tree = ($300 + $400 + $300) * 36 replacement trees

= $1,000 * 36 replacement trees

= $36,000

Therefore, the replacement cost of the 30 cm DBH tree would equal $36,000.

3.1.5. Council of Tree and Landscape Appraisers Trunk Formula Method (CTLA TFM)

An alternative valuation method that considers the size of street and park trees is the **Council of Tree and Landscape Appraisers (CTLA) Trunk Formula Method (TFM)**. The CTLA developed this tree valuation method for a variety of purposes including calculating a compensation value for trees. It is widely adopted in North America and around the world and can be applied to asset management.

The CTLA TFM can be applied using their reproduction cost method to replicate or duplicate the tree being appraised. This method estimates a surrogate replacement cost based on the number of caliper-sized trees needed to achieve an equivalent cross-sectional area (tree basal area) of the tree being appraised. This is similar to the Trunk Basal Area Method in Section 3.1.4, but the CTLA TFM also considers tree condition, a functional limitations factor (dependent on location and species), and an external limitations factor (which accounts for outside factors that influence plant success such as invasive pests or diseases) to decrease the replacement value. In other words, if the tree is in poor condition or has low functionality its value is depreciated. Additional costs such as installation price, establishment activities, maintenance, and fees associated with design and/or implementation of the planting project are also applied to the entire replacement cost of the tree. It is also important to note that when using this method, the unit cost has to be calculated for each tree.

The depreciation calculation makes this approach less ideal for asset management valuation because the current replacement value method for traditional assets does not depreciate asset value based on asset age, condition, or function. For many applications of the CTLA TFM (e.g., compensation) it makes sense to include a condition factor, but for asset management, condition is considered separate from value. Traditional assets do not consider condition in their valuation and it is important to utilize valuation methods that are comparable. One significant advantage of this method is it is an internationally recognized approach for calculating tree compensation value that comprehensively encompasses the size of the tree into calculations.

The CTLA Guide for Plant Appraisal, 10th Edition, Revised is proprietary and the full manual must be purchased through the International Society of Arboriculture to effectively apply this approach. An online fillable form[6] is publically available which can be used to help calculate the CTLA TFM of a tree. Example valuation results using this method are available in Table 5 in Section 3.1.8.

[6] See Reproduction Method Trunk Formula Technique from the Council of Tree & Landscape Appraisers (2019): https://www.isa-arbor.com/store/productfiles/GuideforPlantAppraisal10thEditionRevised-2180-02_GPA.pdf /

3.1.6. One-to-One Replacement Method

The **One-to-One Replacement Method** assumes a single tree of any size and age is replaced by one small caliper-sized tree. In this method, all trees effectively have the same value irrespective of their size.

ONE-TO-ONE REPLACEMENT

FORMULA

Replacement Cost per Tree = Unit Cost

Unit Cost ($ per tree) = Average Tree Price + Installation Cost + Establishment Cost (3 years)

SAMPLE CALCULATION

The replacement cost of a 30 cm DBH tree using the One-to-One Replacement Method would be calculated as follows:

The average tree price is $300, installation is $400, establishment cost is $300.

Replacement Cost Per Tree = $300 + $400 + $300
= $1,000

Therefore, the replacement cost of the 30 cm DBH tree would equal $1,000.

While the One-to-One Replacement Method is the most straightforward method outlined, it is not recommended because it does not account for the size/age of a tree, and it does not provide a like-for-like replacement of the services provided.

3.1.7. Dead Trees

Standing dead trees are often captured in a tree inventory, and they should be recognized as assets in the State of Infrastructure and factored into the overall asset valuation. Within asset management, standing dead trees will typically fail the condition assessment, and their condition will be noted in any analysis. However, their presence should be accounted for, including in valuation, to ensure a comprehensive understanding of the state of street tree assets. This is similar to grey infrastructure, for example, when a broken pipe is identified, it is repaired or replaced. Similarly, for a dead tree, ideally it should be removed and replaced.

3.1.8. Street Tree Valuation Results Comparison

The size and health of a tree greatly impacts the benefits it provides. A tree's crown area (canopy) is directly related to many of the important services a tree provides. Given good growing conditions, a young tree will grow exponentially, followed by a period of steady linear growth. Once it reaches maturity, a tree's growth slows as energy is diverted to reproduction and maintaining health. A tree's rapid "early" growth can occur over 30-40 years and generally represents an exponential increase in some of the services provided by that tree (see Figure 4 and Table 5).

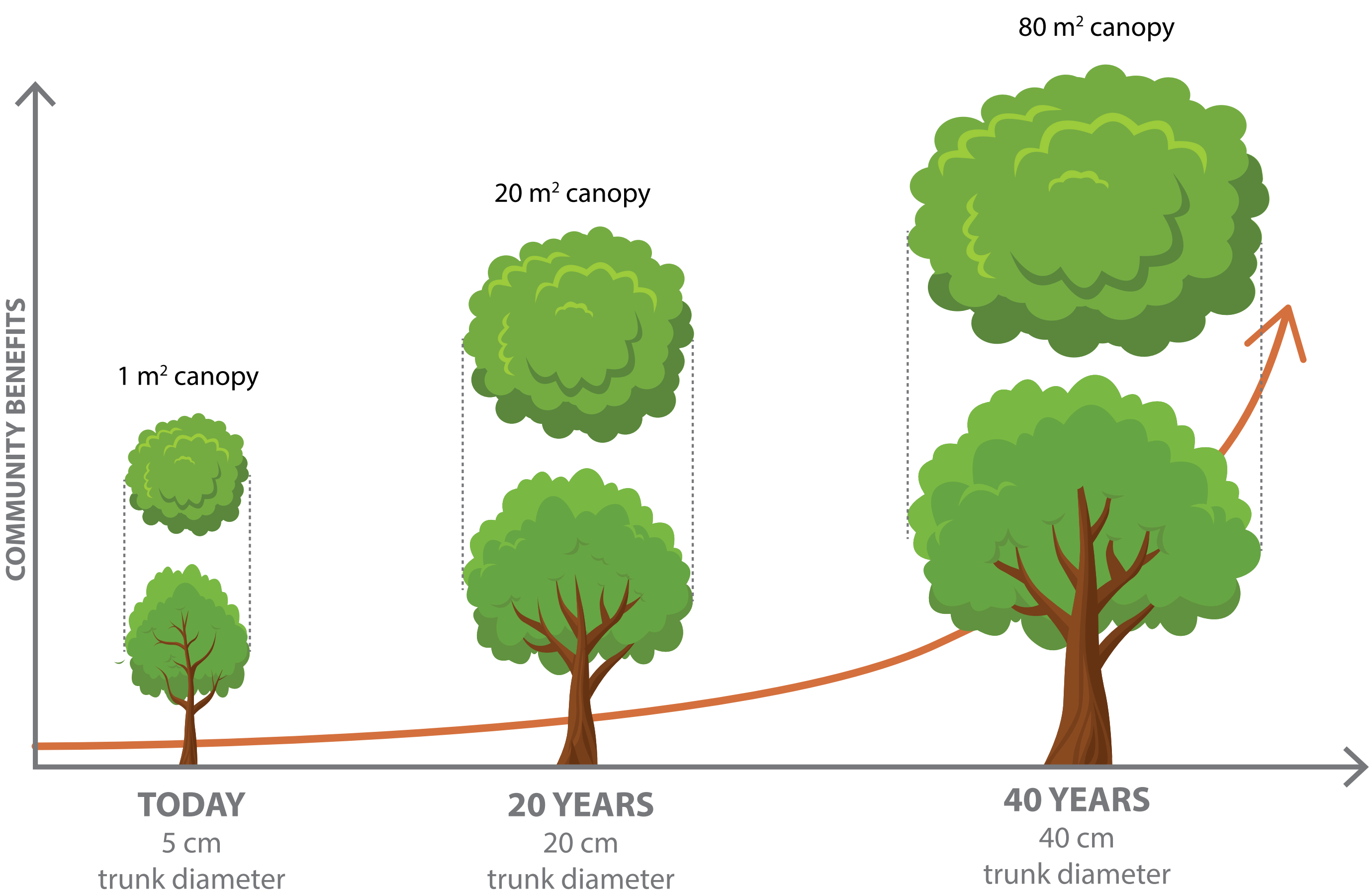
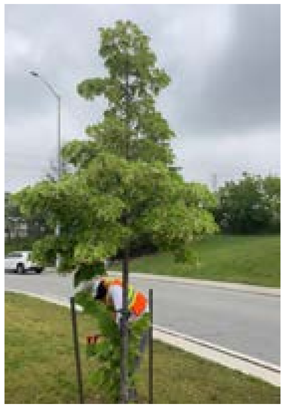
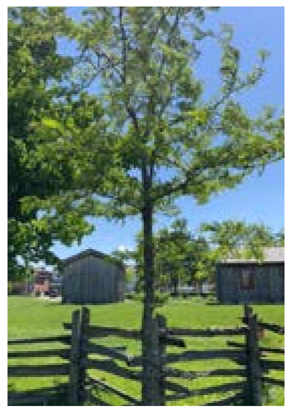
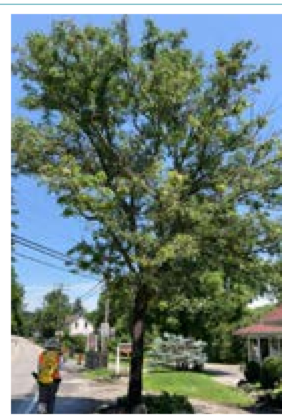
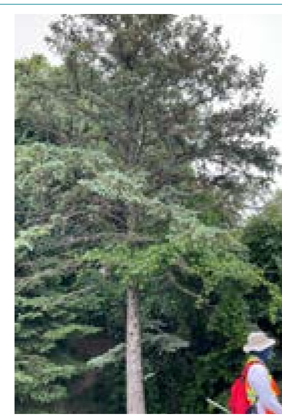
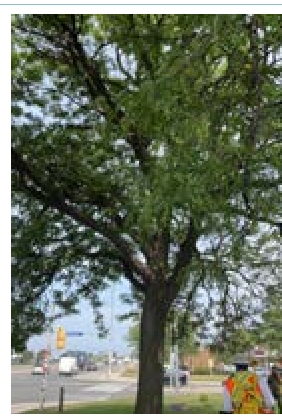


FIGURE 4. EXPONENTIAL INCREASE IN TREE CANOPY (Adapted from the York Region State of the Forest Report)

TABLE 5. TREES OF VARIOUS SIZES AND SPECIES

Tree DBH	Littleleaf Linden *(Tilia cordata)*	Honeylocust *(Gleditsia triacanthos)*	Colorado Spruce *(Picea pungens)*
5 cm			
10 cm			
30 cm			
50 cm			

This non-linear tree growth should be considered when valuing a tree. Both the Trunk Basal Area and CTLA TFM methods account for it. However, there are also other factors to consider when selecting a valuation method, including the expertise and capacity of staff to conduct calculations in the long-term, the data available (now and in the future), and the ease with which a particular method can be explained to senior management and councillors. Table 6 provides a summary of the valuation of different-sized trees using the four valuation methods detailed in this section.

TABLE 6. METHOD COMPARISON BY TREE SIZE

METHOD	VALUATION			
Tree DBH*	**5 cm**	**10 cm**	**30 cm**	**50 cm**
Trunk Diameter	$1,000	$2,000	$6,000	$10,000
Trunk Basal Area	$1,000	$4,000	$36,000	$100,000
CTLA TFM	$1,219	$1,875	$8,873	$22,870
One-to-One Replacement	$1,000	$1,000	$1,000	$1,000

*Assumes all trees are in excellent condition

The CTLA TFM is unique in that it does not yield the same value for a small tree compared to other methods. While both the Trunk Diameter and One-to-One Replacement methods fail to account for the exponential growth of trees, the Trunk Diameter Method does increase a tree's value as its size increases. As discussed previously, the Trunk Basal Area and CTLA TFM methods are both better reflections of the larger value of large trees, especially because they account for the exponential increase in services. The CTLA TFM valuations are lower than the Trunk Basal Area valuations because they are depreciated based on condition, functionality, and location factors (see Appendix C for more details on the impacts of these depreciation factors). The Trunk Basal Area Method strikes a good balance by accounting for tree growth rates while keeping the calculations relatively straightforward and data required minimal. However, this method also leads to the highest valuations for trees with a DBH larger than 5 cm.

3.2. HEDGES AND PATCHES

3.2.1. What is Included in Hedges and Patches?

Natural and planted groupings of trees and shrubs such as hedges, patches within an open natural community (e.g., cultural meadow), manicured open space, landscaped gardens, sound walls, and privacy barriers can be assessed as a single asset. Trees and shrubs densely planted or growing in hedges or patches will often be managed as a unit, so the alteration of one component of the asset would affect the rest of the asset. Treating hedges and patches as a single asset can also improve efficiencies when undertaking an asset inventory so that every stem does not need to be measured. The asset value of hedges and patches can be calculated using an area-based method. It is important to note the difference between hedgerows and hedges because trees in hedgerows should be treated as individual assets while shrubs (and very occasionally trees) in hedges should be valued as a group (see Table 7).

TABLE 7. DIFFERENCES BETWEEN HEDGEROWS AND HEDGES

HEDGEROW EXAMPLES	HEDGE EXAMPLES
Trees planted in strips forming a border or fence: these trees should be assessed individually. Hedgerows are less densely spaced than hedges	Densely planted shrubs or trees (most often cedars) that are managed as unit
	
	
	
	

3.2.2. Area-Based Method

An **Area-Based Method** can be applied to quantify the value of hedges and patches and assumes full replacement of the asset. It is applied by first obtaining the prices for the species of plants growing in the asset or an average price of common shrub species planted in hedges and patches either from previous contracts or nurseries. Next, the typical planting density of a hedgerow, patch, or planting bed must be defined and applied to the area of the asset to estimate the number of shrubs in the asset. This value can be found using local planting plans and/or industry standards. The cost per plant is then multiplied by the estimated number of shrubs in the hedgerow or patch. Finally, the installation and establishment costs (sourced from standard operating costs, tenders, etc.) for a hedgerow or patch is added to get the total replacement cost of the asset.

3.2.2.1. Cost per Shrub

The cost per shrub should reflect local market prices of nursery stock and should be obtained from internal tender or contract documents where possible (see Table 8). If tenders or contracts do not exist, the prices can be sourced from a neighbouring municipality or local nursery catalogues.

TABLE 8. AVERAGE SHRUB PRICES FOR TEN COMMON SHRUB SPECIES PLANTED IN SOUTHERN ONTARIO[7]
(Sourced from four nurseries in Greater Toronto Area, inflated from 2024 to 2025 CAD using a rate of 1.73%)

Botanical Name	Common Name	Number of Nurseries with Prices	Average Shrub Price
Amelanchier canadensis	Canadian serviceberry	2	$27
Aronia melanocarpa	Black chokeberry	4	$22
Berberis thunbergii	Japanese barberry	4	$26
Buxus sempervirens	Boxwood	2	$41
Cornus sericea	Red osier dogwood	4	$20
Juniperus virginiana	Eastern red cedar	1	$47
Rhus typhina	Staghorn sumac	4	$18
Sambucus canadensis	American elder	4	$18
Thuja occidentalis	Eastern white cedar	1	$41
Viburnum lentago	Nannyberry	4	$23
TOTAL AVERAGE		**3**	**$28**

[7] Note: while the list includes common shrub species found in Ontario, planting and replacing non-native species with native or near-native species is recommended.

3.2.2.2. Example Calculations

AREA-BASED METHOD

FORMULA

Replacement Cost per Hedge or Patch = (Number of Shrubs * Cost per Shrub (Current Year Nursery Costs)) + Installation/Establishment per Hedge or Patch

The number of trees/shrubs are estimated based on the total area of the hedge or patch and the typical planting density for trees and shrubs.

Number of Shrubs = Hedge or Patch Area (m^2) / Planting Density (area in m^2 per shrub)

SAMPLE CALCULATION

The replacement cost of a shrub patch that has an area of 14 m^2 using the Area-Based Method would be calculated as follows:

The average cost per shrub is $28, the price of installation/establishment is $120, planting density is one plant every 2 m^2.

Number of Shrubs = (14 m^2 / 2 m^2) = 7 shrubs

Replacement Cost per Hedge or Patch = (7 * $28) + $120
= $316

Therefore, the replacement cost of the 14 m^2 shrub patch would equal $316.

3.3. FORESTS

3.3.1. What are Forests?

Forests are types of tree communities which, when narrowly defined, are distinguishable by their canopy cover percentages. Various terminology can be used to refer to different types of tree communities. For the purposes of this Guide, however, the term forest is used broadly to refer to and encompass the following categories and definitions[q]:

- A treed community: A community containing substantial tree cover where canopy cover is greater than 25 percent and can occur in terrestrial or wetland ecosystems such as savannahs or treed swamps
- Woodland: A terrestrial tree community where canopy cover is greater than 35 percent and less than or equal to 60 percent
- Forest: A terrestrial tree community where canopy cover is greater than 60 percent

The afforestation cost valuation methods described in the following sections are focused on forests (both natural and planted) but could be applied to all treed communities. However, the approach with the basal area multiplier method presented in Section 3.3.5. incorporates basal area measurements into the valuation and will only impact the replacement cost where treed communities have a basal area greater than five square metres per hectare of land.

3.3.2. Comparison of Forest Valuation Methods

The current replacement value of forests can be calculated using an average afforestation cost or restoration cost per hectare multiplied by the area of the forest asset (see the restoration vs. afforestation box below). The **Afforestation Cost Method** assumes a forest is being created through **afforestation** by planting trees on non-forested sites, e.g., abandoned agricultural fields, while the **Restoration Cost Method** uses the cost of enhancing the condition of an existing treed site.

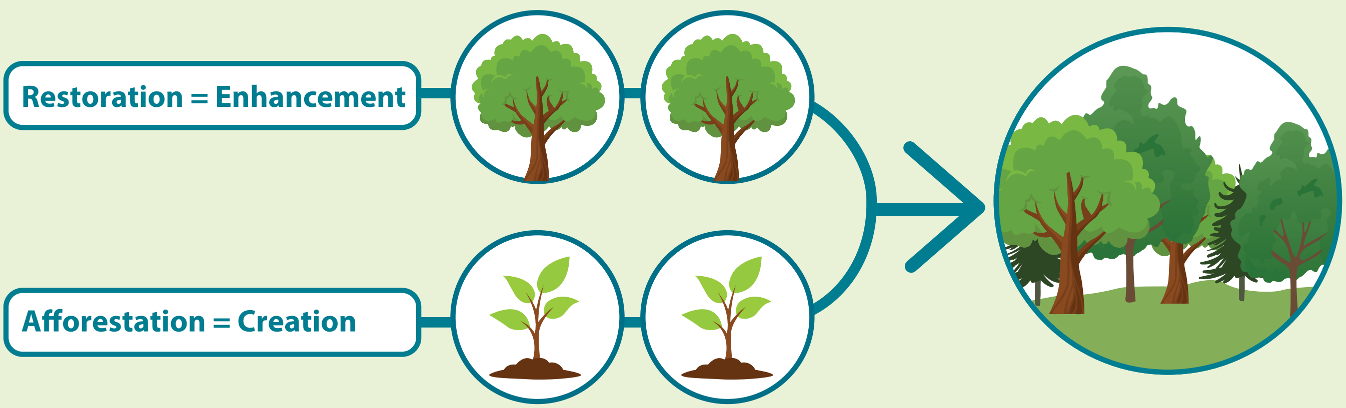
DEFINITIONS

Restoration vs. Afforestation

Restoration is commonly used as an umbrella term for management approaches that aim to recover disturbed ecosystems. This usually includes both enhancing ecosystems that are degraded and re-creating ecosystems that have been destroyed.

For clarity, this guide uses a more scoped definition of restoration, where:

- The restoration cost method only refers to enhancement activities
- The creation cost method applies to the creation of new ecosystems, where **Afforestation** specifically refers to the creation of a new forest.



Section 3 focuses on the Afforestation Cost Method because it is most consistent with the approach used for the valuation of individual trees and traditional assets. However, the Restoration Cost Method, which uses the cost of enhancing the condition of an existing natural asset, can be useful for non-forested assets, like rivers and certain types of wetlands (see Section 4), and could potentially be applied if relevant afforestation costs are not available.

When applying the Afforestation Cost Method, it is important to consider whether the length of time it takes for a forest to achieve its current levels of service can be incorporated into the valuation. Table 9 outlines the advantages and disadvantages of using the Afforestation Cost Method with and without a basal area multiplier to account for forest age. Where data is available, the basal area multiplier is recommended to account for the time lag before a young forest is able to provide the same benefits as an older forest.

TABLE 9. FOREST VALUATION METHOD COMPARISON

Method	Description	Data Required	Advantages
Afforestation Cost Method	A per unit area afforestation cost rate is estimated and applied to the area of the asset to obtain a total replacement cost	• Forest area (hectares) • Afforestation cost rate	• A standard approach applicable to all natural asset types (e.g., forests, meadows, wetlands) • Simple to calculate • The replacement cost represents the cost of creating an asset of the same size or enhancing an existing asset
			Disadvantages
			• All forests are given the same replacement cost: a new afforestation area, a 30-year-old, and a 100-year-old forest • For older forests, the "replaced" asset will not achieve the same structure and function as the actual asset for decades or more (if ever)
Afforestation Cost with Basal Area Multiplier	The Afforestation Cost Method is used to calculate a base replacement cost. This value is appreciated by applying a multiplier which takes into account the stand basal area of the asset, where basal area is used as an indicator of the structure and function of the forest	• Forest area (hectares) • Afforestation cost rate • Stand basal area	**Advantages**
			• The use of a multiplier is an approach used in biodiversity offsetting • Partially accounts for the maturity of a forest • The benchmark afforestation cost rate and base replacement cost can still be used for lifecycle costing as needed • Stand basal area can be assessed objectively, quickly and cost-effectively using a wedge prism, widely used by foresters
			Disadvantages
			• More steps to apply • Basal area data is often not available • Basal area is an imperfect indicator of forest structure and function • The quality of the species comprising the basal area are not directly accounted for, however, they can be through the use of different base afforestation costs • Thinning can result in a sudden drop in basal area

3.3.3. Afforestation Cost Method

A major consideration when using the Afforestation Cost Method is the importance of carefully determining the appropriate afforestation cost to use. Afforestation costs can vary significantly based on the location, afforestation targets, methods used, site conditions, and financial limitations and opportunities. These factors will also inform how much time it will take to achieve afforestation objectives[r].

Although this method is straightforward in concept, some important decisions must be made, including:

1. Choosing the most suitable afforestation approach
2. Identifying which activities and costs to include
3. Determining how many years of costs to include

The sections below provide details on what to consider for each of these important decisions. Forest managers and asset managers are encouraged to discuss these questions together to arrive at a mutual agreement. Ultimately, it will be necessary to make assumptions to estimate a useful replacement cost value. Those assumptions should be reasonable, based on data and existing practices, and be well-documented.

3.3.3.1. How to Choose an Afforestation Approach

To determine the appropriate afforestation approach, it is helpful to understand which services are important, and what ecosystem structures and functions are required to produce those services. These choices will determine how much effort would be required to create an asset. A significant driver of differing afforestation costs is whether the aim is to convert sites to forest (from an abandoned field, for example) as quickly and cheaply as possible or to achieve holistic afforestation objectives. An example of a holistic afforestation objective would be to create a forest so that it has "a characteristic assemblage of indigenous species, representation of all functional groups necessary for the development and/or stability of the ecosystem, and a physical environment capable of sustaining reproducing populations of the species necessary for continued stability or development"[r]. The latter approach has higher costs than the former.

A common afforestation approach for quickly converting sites to a forest is to use **traditional afforestation techniques**. This involves using a tractor to machine-plant coniferous species over a large area. This technique does not aim to create a natural forest in the short term, but rather to establish forest conditions such as shade, soil health, and wind protection by planting fast-growing conifers. The traditional afforestation technique is inexpensive, quick to start, and does not require as much site preparation or care after the initial afforestation work, but it takes longer to start providing the same levels of service as a mature natural forest and the initial low-diversity planting can be more susceptible to disease and pests. However, once trees are old enough, more desirable native species are encouraged to grow by the selective removal of rows of individual trees. It can take 50 to 100 years before this type of forest transitions to more natural conditions.

Achieving holistic afforestation objectives, on the other hand, involves using **enhanced afforestation techniques**. This involves planting characteristic desired species from the beginning. This often requires planting a greater diversity of species by hand, in varying densities and patterns, and adding habitat features. Enhanced afforestation techniques are expensive but produce naturalized forests that provide a variety of services in a shorter amount of time and the diverse planting can be more resilient to disease and pests which can save on maintenance and management costs.

Enhanced afforestation uses a series of techniques to provide the site with the best start to begin producing ecological functions as soon as possible, including:

- Site preparation including hydrological restoration (e.g., breaking old farm tiles with heavy machinery)
- Soil testing and improvements, including grading where appropriate for wet pocket creation
- Planting a higher diversity of larger trees and shrubs (requiring more labour and mulch)
- Installing deer exclusion fencing
- Monitoring of flora and fauna
- Creating habitat structure such as log piles, bird boxes, and perching poles

In general, it is best to choose the afforestation approach that matches the type of forest present or the approach that would likely be used to replace it if necessary. In other words, if the forest being evaluated is a plantation (most commonly coniferous), then a traditional afforestation approach would be suitable, whereas an enhanced afforestation approach would be more suitable for a natural forest.

Determining afforestation costs requires that the municipality or conservation authority define appropriate replacement goals for the asset type and identify the actions that would be needed to achieve them. Next, it is necessary to determine locally applicable costs for the afforestation activities. Financial values should ideally be obtained from local, current afforestation projects to ensure accuracy (see example in Section 3.3.4.1).

3.3.3.2. How to Identify Which Activities and Costs to Include in the Afforestation Cost Rate

It is recommended practice to include all the costs directly associated with preparing the asset for its use as part of the current replacement value. This includes materials, labour, purchase/construction, installation and assembly, initial delivery, site preparation, testing, professional fees, internal design and inspection fees, administrative and planning costs, and all other costs associated with replacing the asset under normal conditions. Overhead is excluded. Whichever afforestation approach is chosen, it is recommended that a municipality or conservation authority consider including all the costs in Table 10 below. For each of the categories listed below, the cost of machinery, equipment, and labour should be included as well as professional and other fees.

TABLE 10. ACTIVITIES/COSTS TO INCLUDE IN THE UNIT AFFORESTATION COST

Activities/Costs	Traditional Afforestation	Enhanced Afforestation
Project Management	• Includes project initiation, planning, execution, control, and closing	• Includes project initiation, planning, execution, control, and closing
Planning and Design	• Includes site assessment, species selection, development of a planting plan	• Includes site assessment, species selection, development of a planting plan
Site Preparation	• Includes soil preparation, site grading and hydrological restoration, and removal of vegetation as needed	• Includes soil preparation, site grading and hydrological restoration, and removal of vegetation as needed
Planting	• Seedlings; mostly conifers	• Seedlings and larger trees and shrubs including deciduous species • Installation of habitat features
Monitoring	• Monitoring of vegetation for at least 3 - 5 years (survival assessments 1- and 2-years following planting and a free-to-grow assessment at year 5) • Optional fauna monitoring	• Monitoring of vegetation for at least 3 - 5 years (survival assessments 1- and 2-years following planting and a free-to-grow assessment at year 5) • Optional fauna monitoring
Establishment Activities	• Including follow-up infill planting, and competition control	• Including follow-up infill planting, competition control, and invasive species removal for a few years

3.3.3.3. How to Determine How Many Years of Costs to Include

When deciding how many years of costs to include in the afforestation unit cost rate, the ideal approach would be to include all the activities and their associated costs needed until the forest is said to be established, or free to grow (i.e., self sustaining but not necessarily mature). In this scenario all activities and costs needed to establish the asset to a satisfactory level of ecosystem function should be included in the replacement cost rate. This would include any necessary initial establishment and monitoring activities. This is similar to an individual tree replacement cost, where the replacement cost of a street tree includes the cost of planting and establishment activities (weeding, mulching, watering, and trimming) for a minimum of three years after planting to achieve a desired survival rate. This should ideally be based on actual practices that would be or are followed by the organization.

An alternative approach would be to include all establishment and maintenance costs within an agreed-upon planning time frame, for example 10 years. This method is less preferred because it is defined by an arbitrary planning time frame instead of ecosystem health and maturity characteristics.

3.3.4. Afforestation Unit Cost Rate

Both methods used to calculate forest values require an afforestation unit cost per hectare. A standard unit cost must take into consideration all the factors outlined in the previous section. Where possible, the unit costs for the creation of new forested habitat, not the improvement of degraded forest habitat, should be used for valuation (see Table 11). Enhancing or restoring an existing forest asset could be an appropriate cost for the lifecycle management costing.

TABLE 11. EXAMPLE OF TRADITIONAL AND ENHANCED AFFORESTATION UNIT COSTS PER HECTARE

Activities[8,9]	Traditional Coniferous Afforestation (1 ha)	Enhanced Afforestation Planting (1 ha)
Project Management *(including planning)*	$5,000	$5,000
Site Preparation	$2,000	$17,000
Deer Fence	$0	$38,000
Planting	$10,000	$65,000
Plant Replacement *(25% replacement of material)*	$2,500	$18,000
Habitat Installation *(e.g., bird boxes, logs)*	$0	$26,000
Monitoring/Site Assessment	$5,000	$5,000
TOTAL	**$24,500**	**$174,000**

[8] The inclusion of activities in the afforestation costs should depend on the standard practices and protocols of your organization.

[9] These costs are modified from TRCA's typical restoration costs (2024).

3.3.4.1. Example Calculations

AFFORESTATION COST METHOD

FORMULA

Forest Replacement Cost = Afforestation Cost per Hectare * Forest Area (Hectares)

SAMPLE CALCULATIONS

The replacement cost of a 30-hectare mature mixedwood forest would be calculated as follows:

The average cost of enhanced afforestation is $174,000/hectare.

Forest Replacement Cost = $174,000/hectare * 30 hectares
= $5,220,000

Therefore, the replacement cost of the 30-hectare mature mixedwood forest would equal $5,220,000.

The replacement cost of a 30-hectare young coniferous plantation forest would be calculated as follows:

The average cost of traditional coniferous afforestation is $24,500/hectare.

Forest Replacement Cost = $24,500/hectare * 30 hectares
= $735,000

Therefore, the replacement cost of the 30-hectare young coniferous plantation forest would equal $735,000.

3.3.5. Afforestation Cost with Basal Area Multiplier Method

When determining the current replacement value for a forest, a key consideration is the length of time it takes for a forest to achieve its current levels of service. Ten years after planting, even with enhanced afforestation techniques, a forest will not provide the same services (types and quantity) as an 80-year-old forest. While asset management valuation is not calculating the value of ecosystem services, as explained in Section 2.3.3, it is still important to consider replacing like-for-like. The replacement forest structure needs to replace the expected or current levels of service(s) provided by the existing forest. One option to account for this time lag until services are restored, and thereby getting closer to a true reflection of the replacement cost, is the use of a multiplier that compensates for the basal area of the standing forest similar to those for individual trees. In this scenario, mature forests are assumed to have a larger basal area than younger forests.

TRCA's Guideline for Ecosystem Compensation (the Guideline) recommends the use of a compensation ratio to determine how much additional land would be needed to create an equivalent stand basal area to a forest within ten years[f]. In this approach, the Afforestation Cost Method described in Section 3.3.3 still forms the basis of the value. However, the lag time until the existing structure and levels of service are achieved is accounted for by using a multiplier.

3.3.5.1. Principle of the Multiplier

The use of a multiplier is based on the principle of a compensation ratio outlined in TRCA's Guideline for Ecosystem Compensation[f]. The Guideline was developed to specify a method for replacing ecosystem features that would be lost at a site due to development and infrastructure projects. The goal is to replace the lost ecosystem structure and function within ten years of beginning the project. However, because ten years is an insufficient time to replace structure and function of older treed ecosystems, the guideline recommends afforesting a larger area than the impacted site. Basal area[10] is used as an indicator of forest structure[11] and it is used to establish a compensation ratio between the area to be afforested and the impacted site. The Guideline specifies that the area to be afforested must achieve the same total basal area as the forest at the impacted site as this, "helps, in part, to ensure that the same level of some ecosystem functions is maintained." Not only is basal area correlated with ecosystem functions, it also provides a consistent, objective, and widely used measure that is cost-effective to obtain.

Therefore, compensatory afforestation projects are intended to achieve the same total stand basal area of the impacted site within ten years. Based on TRCA's restoration data, it is typical to achieve a stand basal area[12] of 5 m^2/ha within ten years of afforestation. Therefore, forests on impacted sites that have stand basal area of more than 5 m^2/ha, would require a larger area of land to ensure that the total basal area is equivalent in ten years. The area to be afforested can be calculated by using the ratio of the stand basal area of the lost forest to 5 m^2/ha (stand basal area after 10 years). This is known as the compensation ratio. For example, if the area to be lost had an average basal area of 25 m^2/ha, then it would be necessary to afforest five times as much forest area (a ratio of 25 to 5). The Guideline uses basal area classes (see Table 12) rather than a continuous ratio for this calculation.

TABLE 12. COMPENSATION RATIOS BASED ON BASAL AREA OF AN IMPACTED SITE FROM TRCA'S GUIDELINE FOR DETERMINING ECOSYSTEM COMPENSATION (2023)

Basal area range (m^2/ha)	Average basal area (m^2/ha)	Lag time factor— Basal area of 10-year-old restoration site (m^2/ha)	Compensation Ratio (ha:ha)
0-5	5	5	1:1
5.1-10	10	5	2:1
10.1-15	15	5	3:1
15.1-20	20	5	4:1
20.1-25+	25	5	5:1

For the purposes of asset management, a continuous value can be applied to avoid large jumps in value as basal area increases with increasing forest age. Calculating a continuous value involves dividing the actual stand basal area by 5. For example, a stand basal area of 14 would have a multiplicative factor of 2 based on the Guideline, but would be 2.8 (=14 / 5) using a continuous calculation for asset management.

[10] Basal area is the cross-sectional area occupied by stems.

[11] More mature forests will have a greater basal area and aboveground biomass than younger ecosystems. Aboveground biomass tends to correlate with some of the ecosystem functions that a treed ecosystem provides. While biomass is difficult to measure, basal area can be used as a surrogate for biomass.

[12] Stand basal area is the cross-sectional area of all stems in an ecosystem measured at breast height (1.3 m) and expressed as a unit of land area (m^2/ha). It provides a measure of stand density and helps assess forest health, competition, and potential for thinning.

3.3.5.2. Using a Multiplier to Calculate Replacement Cost

To calculate the replacement cost of a forest stand using this method, the first step is to calculate the base afforestation cost and then apply a multiplier. The multiplier is the ratio of the asset's stand basal area to 5 m^2/ha. However, young forest stands with a basal area of less than 5 m^2/ha would have a minimum ratio of one and would remain at the base value. In other words, the multiplier cannot be used to reduce the replacement cost below the base value.

While the multiplier does not address the "quality" of the basal area (i.e., the species composition of the forest) the use of different afforestation costs for different forest types can help factor this in, e.g., using the enhanced afforestation cost rate for a natural deciduous forest compared to the traditional afforestation rate for a conifer plantation.

One limitation of this approach is that it is based on basal area and not forest age directly. Basal area is a good, but imperfect, measure of the services provided by mature forests. Additionally, it is important to note that plantations are sometimes stocked to a very high density resulting in an artificially high basal area until they are thinned.

3.3.5.3. Example Calculations

RESTORATION COST WITH BASAL AREA MULTIPLIER METHOD

FORMULA

Forest Replacement Cost = Afforestation Unit Cost per Hectare * Forest Area (Hectares) * Multiplier

$$\text{Multiplier} = \frac{\text{Stand Basal Area}}{5\ m^2/ha}$$

SAMPLE CALCULATIONS

The replacement cost of a 30-hectare mature mixedwood forest with a stand basal area of 50 m^2/ha would be calculated as follows:

The average cost of enhanced afforestation is $174,000/hectare.

Multiplier = 50 m^2/ha / 5 m^2/ha
= 10

Forest Replacement Cost = $174,000/hectare * 30 hectares * Multiplier
= $5,220,000 * 10
= $52,200,000

Therefore, the replacement cost of the 30-hectare mature mixedwood forest would equal $52,200,000.

The replacement cost of a 30-hectare young coniferous plantation forest with a stand basal area of 4 m^2/ha would be calculated as follows:

The average cost of traditional coniferous afforestation is $24,500/hectare.

Multiplier = 4 m^2/ha / 5 m^2/ha = 0.8

= 1 (multiplier cannot be less than 1)

Forest Replacement Cost = $24,500/hectare * 30 hectares * Multiplier
= $735,000 * 1

Therefore, the replacement cost of the 30-hectare young coniferous plantation forest would equal $735,000.

4 OTHER NATURAL ASSETS

This guide focuses on the valuation of forest and tree assets, including street and park trees, hedgerows, and forests. It is expected, however, that many municipalities and conservation authorities would want to include all natural assets they own and/or manage in their asset management plans.

Calculating current replacement value of non-forested natural assets, such as wetlands, meadows and streams can use the same principles as those used for treed natural assets. It involves using an average asset creation cost or restoration cost if creation costs are unavailable or not relevant (e.g., when the asset cannot be fully created or creating an asset is not ecologically or economically feasible, like many stream assets). This creation or restoration cost is determined per hectare or linear metre (for streams) then multiplied by the area of the natural asset (or per linear metre multiplied by length for stream assets), though it may require certain adjustments depending on the type of asset. For instance, the forest valuation approach using a multiplier based on the stand basal area would not be applicable to non-treed natural assets. This would necessitate developing another way to account for the asset age and/or any time required for the asset to provide the required levels of service.

Like with forests, estimating the current replacement value for any natural asset requires identifying the restoration goal (in this case, restoration includes both enhancement and creation) and key activities, including existing and desirable site conditions and characteristics as shown in the example in Table 13[c]. Credit Valley Conservation's report, Natural and Enhanced Asset Lifecycle and Replacement Costing[c], details potential restoration goals and associated costs for more natural asset types, including: stream corridor restoration and erosion control, cultural meadow creation and enhancement, thicket swamp enhancement, and cultural meadow creation and enhancement.

[c] CVC will update their lifecycle costs for aquatic and near-aquatic assets in 2026.

TABLE 13. EXAMPLE NATURAL ASSET RESTORATION GOALS

Asset Type/Subtype	Initial Site Conditions	Size of Feature	Restoration Goals *(target community or form)*	Assumptions
Wetland - Meadow Marsh (creation)	• Relatively open area requiring some vegetation removal where the existing or created hydrology can support wetland creation	1 ha	• An isolated or palustrine meadow marsh wetland portions of which are seasonally or permanently inundated; generally dominated by native wet-tolerant grasses, sedges and/or forbs	• Assumes the entire 1 ha will be wetland (meadow marsh) habitat • Excludes management in adjacent buffers or other adjacent habitats
Cultural Meadow (creation)	• An existing lawn or cropped field that requires removal of existing herbaceous vegetation, tilling, seeding and planting with native upland grasses and forbs	1 ha	• An open upland meadow characterized by mix of native and non-native, non-invasive grasses, sedge and forbs	• Assumes entire 1 ha is managed following features establishment (to prevent woody species from establishing) by mowing • Excludes any management in adjacent buffers or other adjacent habitats

Once the restoration goal and activities have been identified, the same approach to costing afforestation as described in Section 3.3.3.2 can be applied here. This includes either setting targets at which point the asset is said to be established and including all the costs up to establishment or including all establishment and maintenance costs within the planning time frame (e.g., 10 years).

Challenges associated with valuing non-treed assets include gaps in costing knowledge and a lack of existing methods to account for the time required for the asset to deliver the required levels of service. There is significant variability in natural asset creation or restoration costs, which can vary by type of natural asset, restoration target, approaches, and site conditions. Therefore, it is slightly easier to value an asset like trees which are commonly planted and maintained. Some natural asset types (e.g., swamps) require much more effort and resources to restore and take longer to establish than others (e.g., marshes). Some natural assets cannot be created at all (e.g., bogs). In this case the current replacement value is generally assumed to be the cost of enhancing the asset to good/excellent condition, but this is a poor proxy for the value of certain irreplaceable natural assets. This topic is discussed in more detail in Section 5.2.

5 OTHER CONSIDERATIONS

5.1. THE NEED FOR STANDARD METHODS

As the field of natural asset management evolves, it is important to work towards standardized valuation methods. Standardization is crucial because it allows for the consistent and comparable valuation of natural assets with other assets within asset management. This consistency is vital for ensuring that natural assets are effectively integrated into infrastructure planning and decision-making processes. By establishing clear, evidence-based methods, municipalities and conservation authorities can make more informed and equitable decisions regarding resource allocation for managing all assets. This will help increase investment in natural assets which in turn will lead to more sustainable and resilient communities. In contrast, inconsistent methods across organizations may undermine trust in valuations, especially if they produce vastly different values for similar assets, potentially increasing reluctance to include natural assets alongside traditional ones. This guide documents existing methods and recommends some approaches over others. A next important step would be to gather experts in this field together to collectively determine the best standard methods to apply.

5.2. INTRINSIC VALUE AND INVALUABLE/IRREPLACEABLE NATURAL ASSETS

Current replacement value will never be a perfect fit for valuing natural assets. This method focuses on the cost of replacing an asset, but it fails to capture the full value of the services the asset provides as well as the intrinsic value of nature. Some would argue that there is an ethical imperative to protect these assets, recognizing that their preservation is a moral responsibility beyond service considerations. However, relying solely on ethical arguments has not been sufficient to ensure their management and protection to date. The valuation of natural assets is important to see them better integrated into practical municipal and conservation authority decision-making. But to make the most compelling case for their conservation and management, both practical and ethical perspectives should be a priority. Essentially, asset management, and valuation within it, is a useful and important tool, but it will not solve all the existing issues facing natural assets. Other strategies and policy approaches also need to be implemented.

It is also important to note that certain natural assets are truly irreplaceable. This can be due to their unique characteristics, slow formation processes, and/or the intricate role they play in an ecosystem. These assets are impossible to fully restore once lost. For example, once an aquifer is depleted or polluted, it is extremely difficult, if not impossible, to restore it to its original state. Ancient forests, once cut down, cannot be fully regenerated within a human lifetime, making their loss permanent from a planning perspective. Nevertheless, it is important to include irreplaceable natural assets in asset management systems to ensure they are considered in long-term planning and budgeting. They are essentially priceless, but they do require investment in their management. There needs to be a clearly defined approach for ensuring these assets are considered and included in asset management while allowing for their invaluable valuation within an organization's State of Infrastructure reporting. Developing such an approach will require collaboration between asset management, finance, and environmental professionals.

5.3. NATURAL ASSET VALUE VS. LIFECYCLE COSTING

Circling back to the idea that natural asset current replacement value can be estimated from lifecycle costing, Table 14 is a reproduction of Table 1 but for a forest asset. Again, the difference in the costs considered is due to current replacement value serving as a comparable measure across assets of what it would cost to replace them today, while the lifecycle cost reflects the total investment including long-term management to sustain the asset. The other key difference is that multipliers, such as basal area for forests, are not applied to the lifecycle cost. The multiplier is used in forest valuation to account for a time lag in services provided by an older forest replaced by young trees. This is a theoretical case designed to identify the value of what is currently on the land. When planning for the lifecycle of an asset, only actual/expected costs should be considered to build an accurate picture upon which a financial strategy can be developed.

TABLE 14. COSTS AND PHASES ASSOCIATED WITH THE LIFECYCLE OF A FOREST ASSET

Lifecycle Phase	Current Replacement Value	Lifecycle Cost	Description
Plan and Acquire	$50,000	$50,000	Studies, project management, public engagement, planning, land acquisition *(if recent)*
Create and Establish *(from Table 11)*	$169,000	$169,000	Site preparation, tree planting, habitat installation, and 5 years of monitoring and maintenance *(e.g., watering, invasive species control)*
Operate and Maintain	-	$2,000,000 ($40,000/year x 50 yrs)	Invasive species control, pruning, thinning, hazard tree removal
Monitor	-	$500,000 ($10,000/year x 50 yrs)	Forest health monitoring, ecological assessments
Rehabilitate or Dispose	-	$0 (not applicable or minimal)	Not typically disposed, ideally shifts to natural succession
TOTAL	$219,000	$2,719,000	-
Multiplier	$20\ m^2/ha \div 5\ m^2/ha = 4$	-	A basal area of $20m^2/ha$; lifecycle costs are not adjusted for age, they are based on actual costs
TOTAL *(Adjusted for natural asset age)*	**$876,000**	**$2,719,000**	-

6 CONCLUSIONS

As climate change and urbanization continue to place increasing pressure on natural assets, it is essential to conduct proactive management and allocate sufficient resources for their survival. Asset management serves as a valuable tool in achieving this goal. This report is a step-by-step guide for how to conduct forest and tree asset valuation for the purposes of including these assets in municipal and conservation authority asset management systems. This process helps organizations make informed decisions, allocate resources, justify budgets, and develop strategic management plans that consider the long-term benefits and risks associated with these critical resources.

This guide presents current natural asset valuation methods and aims to encourage progress towards a standardized valuation approach in Ontario. There are many factors to consider when selecting a valuation method, including the expertise and capacity of staff to conduct calculations in the long term, the data available (now and in the future), and the ease with which a particular method can be explained to senior management and councillors. All these factors should be considered when selecting the most appropriate valuation methods for an organization.

6.1 OPPORTUNITIES FOR ADVANCEMENT

This guide provides directions on conducting forest and tree asset valuation in a rapidly evolving field. In this context, the following actions are recommendation to help move the field forward and ensure that natural assets are recognized, valued, and protected in a way that is consistent, comparable, and sustainable. Key opportunities for advancing the field include:

DEVELOP STANDARDIZED GUIDELINES: Building on the report's findings, there is a need to work towards developing standardized methods for valuing forest and tree assets. A key next step would be to convene relevant stakeholders, including asset management organizations, conservation organizations, and municipalities, to discuss and collectively decide on a set of methods that can be widely adopted. This could involve creating a maturity scale to facilitate valuations for organizations with different levels of available data and expertise.

CREATE DETAILED VALUATION GUIDANCE ON OTHER NATURAL ASSET TYPES: Publish additional report(s) that provides step-by-step guidance on how to conduct natural asset valuation for other asset types, including wetlands, watercourses, meadows, and shorelines.

COLLABORATE ON AN APPROACH FOR INVALUABLE ASSETS: Develop a specialized framework for incorporating irreplaceable natural assets into asset management systems, ensuring their unique value is recognized and preserved.

DEVELOP TOOLS: Collaborate with asset management leaders to develop and refine existing tools and templates that can assist in the valuation of natural assets.

CONDUCT TRAINING: Develop training programs and workshops for municipal staff, conservation authorities, and other stakeholders. These should focus on how to incorporate natural assets into asset management systems, apply valuation methods, and use the resulting data to inform decision-making.

7 GLOSSARY

Afforestation – The process of establishing a forest in an area where there is no current or recent forest cover.

Afforestation Cost Method – A current replacement value cost-based method that assumes a forest is being created by planting trees on non-forested sites and is most consistent with the approach used for the valuation of individual trees and traditional assets.

Area-Based Method – A method to determine the current replacement value of trees or shrubs based on the total area of a hedge or patch and the typical planting density for trees and shrubs.

Asset – Defined in O.Reg. 588/17, an asset has to meet two basic thresholds: a) something that the municipality owns or reports on in its consolidated financial statements; b) provides a service.

Asset Age – The current year minus the date of installation of an asset. Age-related attributes (e.g., age, remaining useful life) can act as a proxy for condition and indicate when rehabilitation or replacement of an asset may be required.

Asset Attributes – Characteristics that enable each asset to be clearly identified, quantified, described, and evaluated. Examples include type, size, location, installation date, condition, and age (for more detail, see Asset Condition, Asset Age definitions). Collecting and tracking appropriate asset attributes enables municipalities to understand the state, extent, and relative importance of the assets they own.

Asset Condition – Defines the physical state of an asset at a point in time and supports the assessment of remaining useful life, maintenance interventions, replacements, and other asset management decisions. Condition is also used to determine whether service levels are being met or if an asset is underperforming.

Asset Hierarchy – A framework for asset information that lists and categorizes assets. The hierarchy is used to guide collection and organization of asset inventory data in asset management databases and allow reporting to rollup through parent/child relationships between asset components.

Asset Inventory – A list of assets owned and their asset attributes.

Asset Lifecycle (Costing) – Phases and costs of managing a municipal infrastructure asset over its expected or remaining service life, including planning, acquisition, creation and establishment, operations and maintenance, monitoring, rehabilitation, and disposal. Asset management planning is intended to support the management of assets across their entire lifecycle to keep costs to a minimum by making the right management interventions at the right time.

Asset Management Planning – Aims to manage municipal assets over their entire asset lifecycle to ensure sustainable service delivery, while managing risks such as asset failure, and minimizing costs. Asset management planning is an iterative process, involving continuous updates and improvements.

Asset Management Valuation – A valuation approach designed to estimate the investment in an asset based on the replacement cost necessary to recreate or restore said asset. The purpose of these values is to serve as an apples-to-apples comparison measure across assets. Asset value is calculated using the current replacement value method. This approach does not involve economic valuations (such as Ecosystem Service Valuation).

Asset Register – Repository of asset attributes organized by asset hierarchy, in an asset management software, Excel spreadsheet, or geospatial database. An asset inventory will be input into the register.

Asset Value – The dollar amount quantified using current replacement value of an asset, used for financial planning.

Council of Tree and Landscape Appraisers (CTLA) Trunk Formula Method (TFM) – Tree valuation method based on reproduction cost to replicate or duplicate the tree being appraised. This method estimates a surrogate replacement cost based on the number of caliper sized trees needed to achieve an equivalent cross-sectional area (tree basal area) of the tree being appraised, while also considering tree condition, a functional limitations factor (dependent on location and species), and an external limitations factor (which accounts for outside factors that influence plant success such as invasive pests or diseases) to decrease the replacement value. Additional costs such as installation price, establishment activities, maintenance, and design fees associated with design and/or implementation of the planting project are also applied to the entire replacement cost of the tree.

Current Replacement Value – An industry best practice for measuring the asset value of municipal infrastructure assets. Calculated as the cost of replacing an existing asset with a new asset that will provide the current required level of service in the same operating environment. It should also consider changes in technology and construction methods and materials and use the least cost option. In Ontario, *O. Reg. 588/17* requires that municipalities report replacement costs for each asset class, which is a group of assets with similar characteristics, attributes, and establishment and maintenance requirements. An asset class is the top level in an asset hierarchy framework.

Diameter at Breast Height (DBH) – A standard method of measuring the diameter of the trunk or bole of a standing tree at 1.37 metres (4.5 feet) above ground.

Ecosystem Service Valuation – An economic valuation approach that focuses on the benefits generated by natural assets (rather than the cost to replace the asset as in Asset Management Valuation).

Enhanced Afforestation Techniques – Involves the planting of characteristic desired species from the start of restoration activities to produce ecological functions as soon as possible. These techniques often require planting a greater diversity of species by hand, in varying densities and patterns, and adding in habitat features.

Establishment Cost – An operating cost for tree establishment, including costs associated with initial mulching, fertilizing, and watering (for a 2-year warranty period), and mulching and watering for at least one additional year, until the tree has established a functioning root system.

Green Infrastructure – Natural and human-made elements that provide ecological and hydrological benefits. Green infrastructure can include components such as natural heritage features and systems, parklands, stormwater management systems, urban forests, permeable surfaces, and green roofs. Green infrastructure can be subdivided into three types: Natural, Enhanced, and Engineered.

Inflation – Increase in the average price of goods and services over time.

Installation Cost – The cost of planting labour, transportation, any basic design fees, and/or shipping expenses of a tree.

Level(s) of Service (LOS) – Describe the function, capacity, and quality of services provided by a municipality or conservation authority and reflect the social, environmental, and economic outcomes that are delivered. Levels of service are integral to asset management planning decision-making and are unique for each organization because they need to be relevant for the municipality or conservation authority's specific decision-making context and needs, except where the province sets some required level of service for core assets.

Natural Asset – A type of green infrastructure comprised of natural features, such as forests, grasslands, wetlands, and streams that provide ecological and hydrological benefits.

O. Reg. 588/17 – In 2015, Ontario passed the Infrastructure for Jobs and Prosperity Act and under the Act, O. Reg. *588/17: Asset Management Planning for Municipal Infrastructure* regulation, was published on January 1, 2018, to address the issue of aging infrastructure and the need for new infrastructure. The regulation aims to improve municipal infrastructure planning to ensure sustainable service delivery and requires municipalities to finalize asset management plans, including green infrastructure assets, by 2025.

One-to-One Replacement Method – A current replacement value method that assumes a single tree of any size and age is replaced by one small caliper-sized tree.

Remaining Service Life – The number of years an asset can continue to perform at the desired levels of service. The average remaining life of an asset can be extended by implementing preventative maintenance and capital investments into renewal.

Restoration Cost Method – A current replacement value cost-based method that uses the cost of enhancing the condition of an existing treed site.

Risk – The relationship between the likelihood of an event happening and the consequences of that event. Asset risk involves assessing the relationship between the probability of an asset failing and the consequences of the asset failing.

State of Infrastructure – The first stage of asset management planning which reports on the assets for which a municipality is responsible. This relies on the compilation and/or update of an asset inventory which records the following information for each asset category: asset types, quantity and quality, asset value, asset age, and asset condition.

Stump Removal (Cost) – The cost associated with removing the tree stump from the ground following tree removal.

Traditional Afforestation Techniques – Involves using a tractor to machine-plant coniferous species over a large area. This technique does not aim to create a natural forest in the short term, but rather to establish forest conditions such as shade, soil health, and wind protection by planting fast-growing conifers. Once trees are old enough, more desirable native species are encouraged to grow by the selective removal of rows of individual trees.

Traditional (Grey) Infrastructure Assets – Built and engineered assets that provide services to communities.

Tree Price – Nursery cost for a plant (a caliper-sized tree) that should reflect local market prices of nursery stock and should be obtained from internal tender or contract documents where possible.

Tree Removal (Cost) – The cost associated with removing an existing tree from the planting location. This process removes the tree, but the stump remains and would require further stump removal.

Trunk Basal Area (Replacement) Method – A current replacement value method that assumes one tree is 'replaced' by several caliper-sized trees which together have the same basal area as the tree being assessed.

Trunk Diameter (Replacement) Method – A current replacement value method that assumes one tree is 'replaced' by several caliper-sized trees which together have the same trunk diameter as the tree being assessed.

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APPENDIX A - Ecosystem Service Valuation

Ecosystem services are benefits provided to people by natural assets, including provisioning (e.g., food), regulating (e.g., air quality improvements), cultural (e.g., recreation), and supporting services (e.g., nutrient cycling).

A.1. ECOSYSTEM SERVICE VALUATION PROCESS

Ecosystem service valuation starts with identifying natural assets and the scope of services they provide, in order to be assessed (see Figure A1 for full valuation process). It also requires deciding on the metrics needed for the services to be quantified. The next step involves quantifying ecosystem services in biophysical units followed by the step of assigning monetary values to those services. This section focuses on the last process step, i.e., the monetary valuation of ecosystem services provided by the natural assets.

FIGURE A1. ECOSYSTEM SERVICE VALUATION PROCESS

A.2. ECOSYSTEM SERVICE VALUATION METHODS

There are several well-established methods and approaches for the economic valuation of ecosystem services. Those can be categorized into two main groups: revealed preference methods and stated preference methods. Revealed preference methods are based on actual market behaviour of users of ecosystem services, whereas stated preference methods are based on hypothetical situations. There are multiple great sources on ecosystem service valuation, including guides and methodologies (e.g., Canada's Ecosystem Services Toolkit) but their detailed overview is beyond the scope of this section. However, the summary table below provides a brief description of methods most commonly used for ecosystem service valuation. In addition, examples are provided for the cost-based (substitution/replacement cost) ecosystem service valuation method as it is often confused with the replacement cost asset management valuation method (asset management valuation methods for forests are described in more detail in Section 3).

The type of valuation technique chosen will depend on a number of factors (see Table A1), including the objectives of the valuation (e.g., building the business case for protecting or restoring a natural asset); type and number of services to be valued; geographical scope (neighbourhood, municipal, watershed, or provincial/national); data availability (e.g., access to the data on house values); and available time and financial resources.

TABLE A1. ECOSYSTEM SERVICE VALUATION METHODS

Method Category	Valuation Method	Good or Service Valued	Benefits of Method	Limitations of Method
Revealed preference methods	Market price	Those traded in markets, e.g., timber, fuelwood, other forest products	• Data availability • Based on observed data • Uses standard approaches	• Limited to market goods and services • Can underestimate true economic value of goods or services
	Cost-based (avoided damage; replacement/ substitution cost)	Mainly ecological services, e.g., stormwater management/flood control; water quality protection	• Based on real market value /costs data • Can be less data-and resource-intensive	• Potential confusion between the value of replacing the asset vs. the value of replacing the services it provides • Substitute alternatives are unlikely to provide the same types of benefits as the natural asset • Services being replaced often represent only a portion of the full range of services provided by the natural asset
	Hedonic pricing	Services contributing to a market good, e.g., impact of proximity to green space on housing values	• Based on market data	• Very data-and time-intensive and limited mainly to benefits related to property values
	Travel cost	Services related to recreation	• Based on observed behaviour	• Limited to recreation
Stated preference methods	Contingent valuation	All goods and services	• Able to capture all services	• Potential bias in response, hypothetical market, resource-intensive
	Choice experiment	All goods and services	• Able to capture all services	• Potential bias in response, hypothetical market, resource-intensive

The benefit transfer method is another popular ecosystem service valuation technique. Technically it is not a valuation method, as it only pulls values estimated in other valuation studies, which are performed for similar services and preferably in a similar context, and then transfers these values to estimate the value of services at another location. However, it typically requires less resources and time, and, therefore, is widely used for assessing multiple ecosystem services.

Example: Estimating Value of Stormwater Management (SWM) Services for 1 Hectare of Forest Using the Cost-Based (Substitution) Method

Cost-based methods, such as avoided damage cost and replacement/substitution cost are ecosystem service valuation methods that estimate values of ecosystem services based on either the costs of avoiding damages due to lost services or the cost of replacing/providing a substitute for lost services.

The replacement/substitution cost method uses the cost of providing a substitute for an ecosystem service provided by natural assets as an estimate of the value of the ecosystem service. It should be emphasised that this method focuses on replacing the ecosystem service rather than replacing the asset itself, whereas the replacement cost in asset management valuation estimates the cost of replacing the asset rather than the services it provides. To avoid confusion, it is recommended to use the term substitution cost when assessing the value of services provided by the asset and use the term replacement cost when calculating the asset replacement cost in the asset management planning process.

The ecosystem service valuation example below applies the substitution cost method to assess the value of stormwater management (SWM) services provided by one hectare of a hypothetical forested asset.
The SWM services provided by a hypothetical forest with an area of 1 hectare was estimated following methodology from Credit Valley Conservation[1A]. The study used extreme event-based modelling to quantify the SWM services provided by natural assets (i.e. rate and volume control). Stormwater retention and detention service flows were separately estimated for different groups of assets, including forests. Retention and detention values were estimated as follows, yielding results in cubic metres of stormwater retention or detention:

$$\text{SWM Retention or Detention}_A = (m \times \text{Asset Area in ha})^b$$

Where the subscript 'A' represents the asset type (forest, open space, or wetland) and 'm' and 'b' represent the retention or detention scaling coefficients. For forested natural assets these parameters were estimated as follows:

Asset Group	Retention Scaling Coefficients		Detention Scaling Coefficients	
	m	b	m	b
Forest	405	1.06	14,105	0.19

[1A] Credit Valley Conservation (CVC). (2021). Natural Asset Scaling Analysis. Prepared by EOR Consultants (internal report).

Applying this equation to the forest with the area of 1 hectare, yields the following results for the SWM capacity (in m^3):

- Retention: 580.63 m^3
- Detention: 6.14 m^3

Once the stormwater retention and detention service flows were estimated in cubic meters, the value of stormwater management services was derived (see Table A2). Per unit area monetary values ($\$/m^3$) for each asset grouping were obtained from Credit Valley Conservation[2A]. Since the per-unit area values were not annual, they required conversion to an annual value. To do so, the per unit area retention or detention values ($\$/m^3$) were amortized; that is, they were evenly distributed over the anticipated lifespan of grey infrastructure that provides equivalent stormwater retention and detention services. Retention services were assumed to be similar to those provided by bioretention facilities and infiltration chambers, while detention services were assumed to be similar to those provided by wet ponds and underground storage)[3A].

TABLE A2. STORMWATER RETENTION AND DETENTION MONETARY UNIT VALUES

Asset Group	Per Unit Area ($\$/m^3$)		Lifespan		Annual Per Unit Area ($\$/m^3$/year)	
	Retention	**Detention**	**Retention**	**Detention**	**Retention**	**Detention**
Forest	$475.75	$355.54	37.5	32.5	$12.69	$10.94

The final annual monetary value of retention and detention stormwater service provision for the 1 hectare of forest was calculated by multiplying the estimated retention or detention service flows (m^3) by the relevant annual per unit area monetary value ($\$/m^3$/year):

Annual SWM Service Value for 1 hectare of forest = (580.63*12.69) + (6.14*10.94) = **$7,703.40**

How does that compare to the replacement cost estimated for the same 1 hectare forest? As described in Section 3.3.4, the replacement cost for 1 hectare of the forest can range from $24,500 for basic traditional coniferous afforestation to over $174,000 for enhanced afforestation. It should be noted that while ecosystem service valuation estimates the value of services being provided by the asset, replacement cost estimates the cost of replacing the asset. The cost of an asset is not directly linked to the value of the services it generates. However, it is expected that the value of services over time is at least equal to or exceed the asset replacement cost. So, if we assume that 1 hectare of a healthy forest generates benefits estimated at $7,703 annually, then over 100 years it will generate $770,300 worth of benefits, which is 7 times higher than the upper range replacement cost estimate for that asset. It should also be noted that the value was only assessed for the stormwater management service. If the value of other services, such as carbon sequestration, recreation, urban heat island reduction, etc., is included, the ecosystem service valuation value of the services provided by the 1 hectare of forest will be significantly higher.

[2A] Credit Valley Conservation (CVC). (2021). Natural Asset Scaling Analysis. Prepared by EOR Consultants (internal report).

[3A] Sustainable Technologies Evaluation Program (STEP). (2019). Low Impact Development Life Cycle Costing Tool. https://sustainabletechnologies.ca/lid-lcct/

APPENDIX B - Asset Removal in Current Replacement Value Guidance

The costs of removing a previous, failing asset prior to replacement are not typically included in the calculation of current replacement value, illustrated by three guidance sources below. The exception to this recommendation would be if a municipality or conservation authority is already including removal costs when valuing other assets in their asset management plan, where therefore removal costs should be considered for natural assets to provide a standard approach and allow comparison across assets.

B.1. ONTARIO REGULATION 588/17

Direction is to include "the replacement cost of the assets in the category"[a]. This source does not mention asset removal or any specifics about what to include.

B.2. MUNICIPAL FINANCE OFFICERS ASSOCIATION

PSAB 3150 states that the historical cost of an asset should include "all costs directly attributable to the acquisition, construction or development of the tangible capital asset. This includes installing the asset at the location and in the condition necessary for its intended use. Examples of directly attributable costs include:

- Asset purchase or construction
- Site preparation costs
- Initial delivery and handling costs
- Installation and assembly costs
- Costs of testing that the asset is functioning properly prior to, or during, installation
- Professional fees (e.g., design, legal, etc.)
- Other (e.g., service continuity costs)

The term "directly attributable" is the key to determining whether a cost can be allocated to a tangible capital asset" from a historical cost perspective. While this term is related to determining the historical cost of an asset, the same guideline can be applied in determining the asset's current cost for asset management purposes"[1B].

Site preparation costs could be interpreted to include existing asset removal, but generally PSAB would be more specific if that it was intended. The costs associated with new acquisitions and disposals are generally disclosed separately.

B.3. ASSET MANAGEMENT BC

"The best determinant of replacement value is current replacement cost plus a provision for inflation. Replacement value should include all associated planning, engineering, general contractor and other administrative costs. Current replacement costs can be identified using recent contracts, labour rates and supplier pricing lists"[2B]. This source does not mention asset removal.

[1B] Municipal Finance Officers' Association of Ontario. (2018). Asset Management Framework: A Guide to Asset Management for Municipalities in Ontario. https://mfoa-amp.ca/AMF/AMF_03.html

[2B] Auditor General for Local Government. (2015). Asset Management for Local Governments. https://www2.govbc.ca/assets/gov/british-columbians-our-governments/local-governments/facts-framework/aglg/aglg_asset_management_local_governments_booklet.pdf

APPENDIX C - CTLA Depreciation Analysis

The condition of an asset is not typically used to depreciate its asset value in asset management planning, however this is a compromise in using the CTLA Trunk Formula approach for asset valuation. A comparison of the CTLA Trunk Formula method, two modified CTLA Trunk Formula applications without depreciation factors, and the Trunk Basal Area method was undertaken to more closely examine the impact of the CTLA Trunk Formula depreciation factors on the asset value of a single tree (Table C1). The comparison shows that the difference in asset value is significant across the methods. The application of the full CTLA Trunk Formula method generates the lowest asset value, particularly for assets in worse condition. When the condition depreciation factor is removed from the formula, a slightly higher asset value is generated. A further modified CTLA Trunk Formula approach with no depreciation factors generates the second highest asset value of any method. The Trunk Basal Area approach results in a significantly higher asset value than the standard CTLA TFM and the highest asset value of any approach. The impact that depreciation factors in the CTLA Trunk Formula Method have on the asset value should be taken into account when choosing the best approach to quantify the asset value of street and park trees.

TABLE C1. TRUNK BASAL AREA TREE REPLACEMENT METHOD COMPARISON

		Method			
		CTLA TFM Replacement Cost			Trunk Basal Area Replacement Cost
Tree DBH	**Condition**	**All depreciation factors**	**Modified: no condition depreciation factor**	**Modified: no depreciation factors**	-
Comparison of Costs		$	$$	$$$	$$$$
30 cm	Excellent	$8,873	$9,748	$11,800	$36,000
30 cm	Very Poor	$1,875	$9,748	$11,800	$36,000