Natural Asset Inventory & Valuation for Parkland County

FINAL REPORT

Prepared for:
Parkland County

Project #2407

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Background

Municipalities rely on engineered assets to deliver public services. While engineered assets are essential to the safe and efficient operation of a municipality, there is increasing awareness and recognition that municipal assets extend beyond engineered structures to include natural assets such as forests, lakes, and wetlands. Like engineered assets, natural assets provide important services to citizens; for example, wetlands store water, improve water quality, and moderate climate through carbon storage and sequestration, while vegetation such as forests regulate local microclimates and reduce urban heat island effects, thereby improving physical health.

Despite the significant contribution that ecosystems make to the health, well-being, and sustainability of communities the ecological, social, and economic value of natural assets is rarely assessed or captured in municipal asset management systems. This is because most municipalities lack a natural asset inventory and reliable economic data for assigning monetary values to the ecosystem services provided by those assets. Consequently, the true environmental, social, and economic costs of losing a natural asset during the land development process is rarely considered at the planning stage. As a result, natural assets are lost and converted to other land uses despite the considerable environmental, social, and economic benefits of natural habitats.

Study Purpose

Parkland County has a Municipal Development Plan (2025) that emphasizes stewardship and protection of the natural environment, preservation of rural lifestyles, and sustainable development as key pillars of planning, development, and management. This natural asset inventory can be used to identify natural assets that provide essential ecosystem services to County residents, thereby helping to identify key areas for conservation or protection. Additionally, the inventory can help to identify management practices that may need to be modified to maintain or improve the existing flow of ecosystem services and benefits that currently exist within the County.

Methodological Approach

This project followed a stepwise approach to inventorying natural assets and assessing the value of ecosystem services associated with those assets. First, the purpose and focus of the assessment was defined through consultation and workshops with internal and external stakeholders. Through this process, a list of priority ecosystem services was identified and included: Control of Soil Erosion, Water Flow Regulation, Water Quality Regulation, Atmospheric Regulation, Temperature Regulation, and Nature-based Recreation. Next, existing land cover products were extensively updated and processed to create the inventory of features. Then, the relative condition of natural assets was assessed in a GIS using available spatial datasets. The delivery of ecosystem functions and services were then assessed using the modelling software InVEST, which provided relative scores for assets for the various ecosystem services of interest. Finally, monetary values for priority ecosystem services were calculated, where possible, and the natural asset inventory was attributed with this information.

Study Findings

A total of 9,473 unique natural assets were identified in Parkland County, covering 107,900 ha (1,079 km^2) or roughly 39% of the County. Assets range in size from 0.01 ha to 7,890 ha (78.9 km^2). Most (87%) of the natural assets in the County are <10 ha in size, with almost half (3,903) being 1 ha or smaller. There are also over 1,000 assets larger than 10 ha in size, representing large habitat patches that serve as core wildlife habitat at the local and regional scale. Less than half (45%) of assets were rated as having a relative condition score of Good (6%) or Fair (39%), with most assets (51%) being rated as Poor. An additional 5% of assets were rated as having a relative condition score of Critical. Woody cover was the predominant cover type within natural assets at over 48%, although wetland cover was also substantial at just under 33%.

The total estimated value of the ecosystem services that were evaluated in Parkland County is approximately **$4.0 billion** ($2023).[1]

Atmospheric regulation was the highest value service, with an estimated value of $2.9 billion. This captures the value of carbon sequestration and the estimated damages from various climate change impacts including, but not limited to changes in net agricultural productivity, human health effects, property damage from increased flood risk, disruption of energy systems, and the value of ecosystem services (Government of Canada 2024). Nature-based recreation was also estimated as a relatively high-valued service in the County, totalling approximately $1 billion for County residents.

ESTIMATE OF ECOSYSTEM SERVICE VALUES IN PARKLAND COUNTY

Ecosystem Service	Monetary Estimate ($2023)	Confidence in Estimate
Control of Soil Erosion	$12 million	● (orange)
Water Flow Regulation	*Captured in Atmospheric Regulation Service*	-
Water Quality Regulation	$60 million	● (orange)
Atmospheric Regulation	$2.9 billion	● (orange)
Temperature Regulation	*Captured in Atmospheric Regulation Service*	--
Nature-based Recreation	$1 billion	● (orange)
Total Quantified Monetary Estimate	**$4.0 billion**	

Notes:

- ● (green) Some assumptions or estimation was used to derive estimate, but the value is considered uncontroversial.
- ● (orange) Some assumptions or estimation was used to derive estimate, which may be open to question. Accuracy of estimate is better than +/- 50%.
- ● (red) Estimates are in the right order of magnitude. Order of magnitude implies that for an estimate of 5 the real value is within the range of 0.5 to 50.
- -- A value that is in the right order of magnitude cannot be estimated. This is due to the unquantifiable uncertainty in the science, valuation, or the relationship between them. What is understood can only be discussed qualitatively.

[1] This value was calculated as a present value over a 50-year period at a 3% discount rate. All values are CAD $2023 unless otherwise stated.

Limitations & Uncertainties

Collecting primary data for ecosystem service valuation was outside the scope of this study. Instead, economic estimates from other studies were used to determine ecosystem service values, and these estimates may not be entirely representative of the ecosystem service values in the County. Furthermore, like market goods, the values of non-market ecosystem services are not necessarily static in nature. For example, as a natural or semi-natural asset becomes scarcer, the value of the asset will likely increase. Additionally, welfare estimates are known to change across income levels (those with higher incomes may be willing to pay more for natural assets than those with lower incomes). Given these limitations, the monetary values provided should be considered estimates only, with an acknowledgement that there are gaps in our knowledge of and ability to assess the monetary value of ecosystem services.

Next Steps

Parkland County has completed an important step in recognizing the value and benefits that natural assets provide to its citizens. The next steps involve defining policies, strategies, and plans that will ensure the successful integration of the natural asset inventory into an asset management system and the implementation of policies and plans that will ensure natural assets are considered in land development and management decisions.

List of Terms

Acronyms

ECCC: Environment and Climate Change Canada

ES: Ecosystem Service(s)

GIS: Geographic Information System

PV: Present Value

SCC: Social Cost of Carbon

WTP: Willingness to Pay

Glossary

Benefit Transfer (BT): a valuation approach that allows for the value of ecosystem services to be established through a review of published studies that contain estimates of values for comparable ecosystem services in similar jurisdictions.

Discounting: the process of calculating the present value of a future stream of costs or benefits.

Ecosystem function(s): intermediate between ecosystem processes and services and can be defined as the capacity of ecosystems to provide goods and services that satisfy human needs, directly and indirectly.

Ecosystem process(es): changes or reactions occurring in ecosystems; either physical, chemical, or biological; including decomposition, production, nutrient cycling and fluxes of nutrients and energy.

Ecosystem service(s): contributions of ecosystem structure and function—in combination with other inputs—to human well-being

Ecosystem service demand: the sum of all ecosystem goods and services currently consumed or used in a particular area over a given time period.

Ecosystem service supply: the capacity of a particular area to provide a specific bundle of ecosystem goods and services within a given time period.

Ecosystem structures: biophysical architecture of ecosystems; species composition making up the architecture may vary.

Final ecosystem services: direct contributions to human well-being. Depending on their degree of connection to human welfare, ecosystem services can be considered as intermediate or as final services.

Intermediate ecosystem services: biological, chemical, and physical interactions between ecosystem components. E.g., ecosystem functions and processes are not end-products; they are intermediate to the production of final ecosystem services.

Natural asset: naturally-occurring habitats or ecosystems that contribute to the provision of one or more services required for the health, well-being, and long-term sustainability of a community and its residents. In this study, natural assets were defined as areas that were predominately covered by native vegetation (trees, shrubs, grasses, and forbs), as well as water bodies such as lakes, wetlands, streams, and rivers.

Land cover: the surface cover on the ground, whether vegetation, urban infrastructure, water, bare soil or other cover types, that are mapped in a Geographic Information System (GIS). This type of mapping allows for the quantification of the location and distribution of land cover types at a single point in time, as well as a comparison across multiple time steps to assess how the amount and distribution may be changing. Land cover mapping is essential component of many land management practices, including ecosystem service mapping and assessment.

Present Value: today's value of an expected future stream of costs or benefits.

Semi-natural Asset: naturally-occurring habitats that have been substantially modified or native/non-native vegetation cover that has been planted and is actively managed that contribute to the provision of one or more services required for the health, well-being, and long-term sustainability of a community and its residents.

Willingness To Pay (WTP): the maximum amount someone is willing to pay for the provision of a product or service.

1.0 Introduction

1.1. Background & Purpose

Municipalities are at the forefront of creating safe and healthy communities. Traditionally, municipalities have relied on engineered solutions to deliver many of the public services that residents rely on, such as floodways, stormwater detention ponds, and water treatment plants. Further, because engineered assets are tangible and the costs associated with their construction and maintenance are relatively easy to express in monetary terms, most municipalities have asset management systems that allow for the financial assessment, monitoring, and replacement of infrastructure.

While engineered assets are essential to the safe and efficient operation of a municipality, there is increasing awareness and recognition that municipal assets extend beyond engineered structures to also include natural assets such as forests, grasslands, and wetlands. Like engineered assets, natural assets provide important services to citizens. For example, wetlands store water, improve water quality, and moderate climate through carbon storage and sequestration, while vegetation helps to control erosion and supports healthy insect populations that pollinate food crops. Notably, many natural assets provide the same or similar services as engineered assets and can often do so at reduced cost because the capital and operating costs are often lower, and natural assets are generally more resilient to the effects of climate change than engineered assets (Brown et al. 2019).

Unlike engineered assets, however, very few municipalities have a comprehensive inventory of their natural assets, nor do they calculate the economic value of the services that flow from those assets. As a result, the true cost of removing versus maintaining natural assets in terms of their value is rarely factored into land development decisions, putting natural habitats at risk of being lost or converted in favor of other land uses. There is a growing awareness that integrating natural assets into land use planning and managing these assets alongside engineered assets results in economic, environmental, and social benefits. As such, municipalities across Canada are beginning to acknowledge that accounting for and actively managing natural assets as critical components of municipal infrastructure will create more livable and resilient communities.

Parkland County (hereafter the County) has clearly acknowledged in several of their high-level planning documents, including their Municipal Development Plan (2025), that natural assets are important to the well-being of their residents. To properly account for the benefits of natural assets, this study was initiated to identify and map natural areas within the County, and where possible, provide an estimate of the monetary value of key ecosystem services that flow from those assets. Further, this inventory will serve as a foundation for tracking the condition and status of these natural assets, which will allow for more objective and informed decision-making with respect to land management in the County going forward.

1.2. What are Natural Assets & Ecosystem Services?

A natural asset is a naturally occurring feature, habitat, or ecosystem that contributes to the provision of one or more services required for the health, well-being, and long-term sustainability of a community and its residents. A key component of definition is the linkage between a natural asset and the provision of ecosystem services. The concept of natural capital and ecosystem services first began to emerge in the 1990s (e.g., Costanza & Daly 1992; Costanza et al. 1997), and over the last two decades the terms, definitions, and frameworks for classifying and assessing ecosystem services have changed and evolved through time. Early definitions described ecosystem services as the direct and indirect benefits or contributions to human well-being derived or obtained from natural habitats (Millennium Ecosystem Assessment 2005; TEEB 2010; de Groot et al. 2010). More recent definitions are more specific with respect to recognizing and describing how ecosystem structure and function contribute to human well-being (Burkhard et al. 2012; Burkhard & Maes 2017).

In terms of understanding what ecosystem services are, and how they relate to ecosystem function and benefits, the "cascade model" has become a commonly used heuristic for communicating the linkage between the biophysical structure and function of an ecosystem or natural asset, and how these produce services that directly or indirectly benefit society (Figure 1) (Potschin & Haines-Young 2017). Within this model, ecosystem services are at the interface between the environment (i.e., biophysical structure/process and ecological function) and people (i.e., social and economic systems). The "environment" is typically represented by a habitat or natural asset (e.g., wetland), and the ecosystem functions are the characteristics or properties of that habitat that are potentially useful to individuals or communities (e.g., water storage, filtration). In turn, ecosystem services are derived from ecosystem functions and represent the realized flow of services for which there is a demand (e.g., flood protection, water treatment) (de Groot et al. 2010; Maes et al. 2016; Potschin & Haines-Young 2017).

Importantly, an ecosystem service only has value if it creates a benefit that is experienced by an individual or a community; thus, clearly understanding the beneficiary of an ecosystem service is an important consideration in any assessment. In many cases, there is a desire or interest in quantifying the value of ecosystem benefits, and because people benefit from ecosystem goods and services across a range of different dimensions (Summers et al. 2012), valuation can be determined using monetary or non-monetary valuation approaches. The cascade model also acknowledges that the supply of ecosystem services can be impacted or regulated by external pressure or policy action, and that land management decisions can positively or negatively impact ecosystem structure and function, which in turn affect the amount and quality of the final service, as well as the benefits and values derived from that service.

Given the relationship between ecosystem function, ecosystem service supply, and benefit provision a natural asset inventory and valuation exercise must track and measure indicators across the entire ecosystem service pathway (Figure 1). This is essential for understanding the supply and demand of services, and how human activities and land management interventions impact the quality and supply of these services.

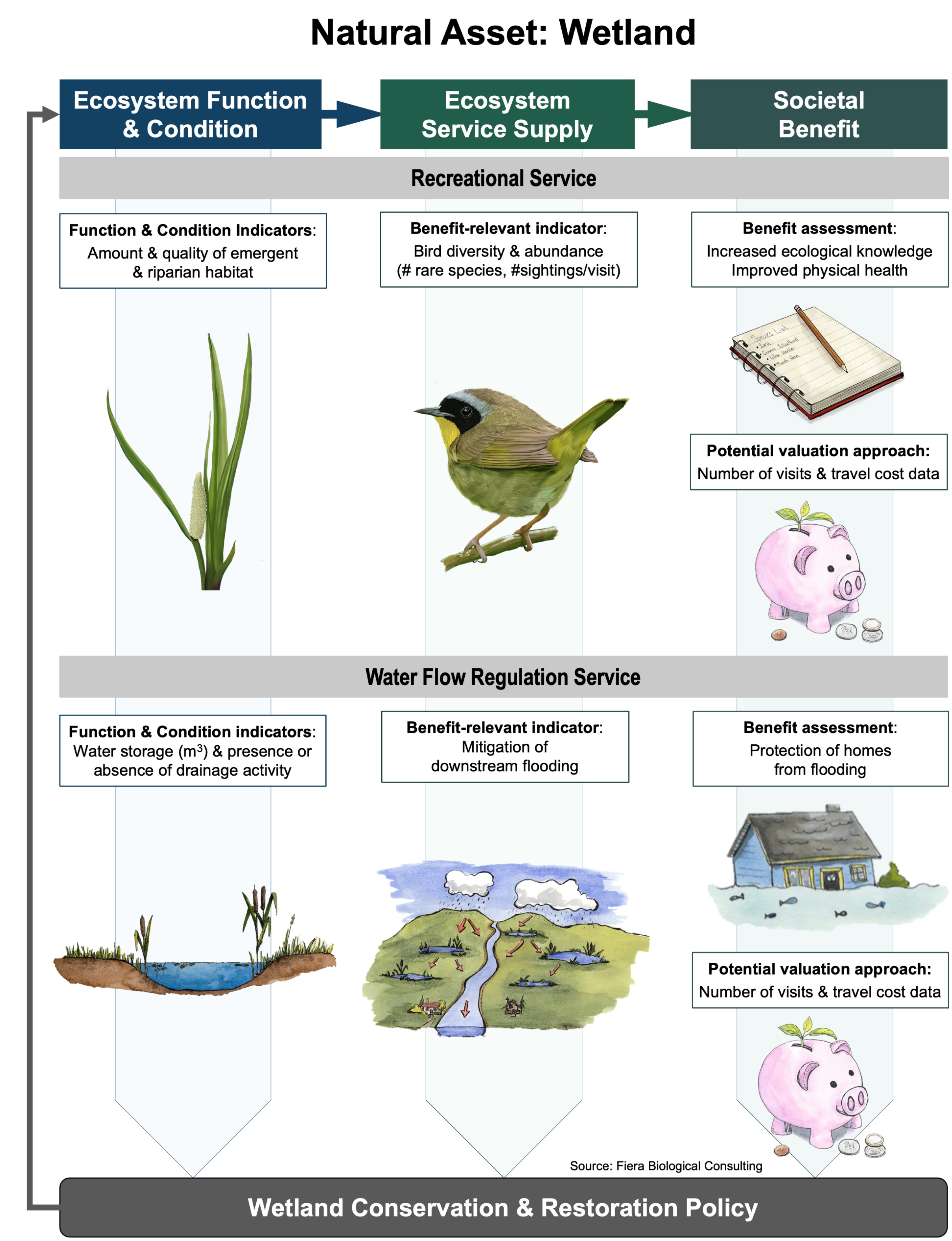


Figure 1. The ecosystem service pathway, illustrating the relationship between ecosystem function, ecosystem service supply, and societal benefit. In this example, the different ecosystem functions of the wetland give rise to multiple ecosystem services and benefits. The supply of the ecosystem services and benefits is influenced by land management practices, such as wetland drainage, which can be managed by municipalities through wetland conservation or restoration policies (adapted from Potchin and Haines-Young 2017).

2.0 Methodological Approach

2.1. Natural Asset Inventory & Assessment Framework

There are a number of different frameworks that describe how to inventory natural assets and undertake an ecosystem service assessment (e.g., Millennium Ecosystem Assessment 2003; Government of Alberta 2011; Everard & Waters 2013; Crossman et al. 2013; European Environment Agency 2016; Value of Nature to Canadians Study Taskforce 2017; Maes et al. 2018; Burkhard et al. 2018; von Haaren et al. 2019). Generally, these frameworks include the following major steps:

1) Define the purpose of the study and identify the natural asset(s) and/or ecosystem services that are the target of the assessment
2) Map the extent and location of target natural asset(s)
3) Assess the condition of the target natural asset(s)
4) Quantify ecosystem service supply associated with the target natural asset(s)
5) Assess the value and/or benefits of the ecosystem services

Once natural assets have been identified, mapped, and assessed the following steps are recommended:

6) Disseminate results and formulate a management and/or policy response
7) Monitor and assess outcomes

The scope of this study included steps one through five. The methods used in each of these steps is provided below.

2.2. Defining the Purpose of the Assessment

Clearly defining the purpose of the assessment is an essential first step in any natural asset inventory, as this ensures that the information generated is both relevant and usable. To this end, the Study Team met with personnel from Parkland County and other external stakeholders in the spring of 2024 during a series of workshops and meetings to gather information and insights that were used to inform the focus of inventory as well as the methods and approach that were used to map and value natural assets.

The first step of defining the purpose of the assessment included a half day workshop with Parkland County personnel in March 2024. The workshop was led by the Study Team and was attended by County personnel with expertise in planning, environmental management, agricultural services, geospatial services, engineering, finance, County land management, and asset management. A primary focus of the workshop was to define *how* the County would use the inventory. Specifically, the County was asked to provide information on the types of land management and policy decisions they wanted to address with the inventory, as well as to provide information on how they envisioned operationalizing information from the inventory in their land use and land management decisions. Additionally, participants were asked to provide input into what type of assets and ecosystem services they considered to be highest priority for management within the County.

The initial meeting with the County was followed by a series of workshops with external stakeholders that occurred in May and June 2024. The May workshop included representatives from a variety of regional municipalities, ENGOs, and watershed groups. The June workshop included public members of Parkland County's Community Sustainability Committee, the Economic Diversification Committee, the ALUS Partnership Advisory Committee, and the Agricultural Service Board. The purpose of these workshops was to describe the project, discuss the County's natural assets and their value to external stakeholders, and gather feedback on the variety of ways the inventory may be leveraged by stakeholders to inform local and regional land use management decisions.

Information and feedback gathered during the workshops with the County and external stakeholders informed the approach and methods used in this study. This included the final list of ecosystem services that were the focus of the benefit and valuation assessment (Table 1). It is important to note that this is not a comprehensive list of the ecosystem services delivered by the natural assets in the County. Rather, this is the list ecosystem services that could be feasibly assessed as part of this study given the available resources and data.

Table 1. Key ecosystem services (ES) provided by natural assets in Parkland County that were assessed as part of this natural asset inventory and valuation study.

ES Category	Ecosystem Service	Example of Ecosystem Good/Benefit to End-Users
Regulation & Maintenance (Biotic)	Control of Soil Erosion	Reduction of damage (and associated costs) of sediment input to water courses and waterbodies
	Water Flow Regulation	Mitigation of damage because of reduced magnitude and frequency of flood/storm events
	Water Quality Regulation	Reduced damage costs of nutrient (phosphorus and nitrogen) runoff
	Atmospheric Regulation	Capture, removal, and storage of carbon in soil and vegetation resulting in avoided damage costs of carbon emissions
	Temperature Regulation	Increased thermal comfort for people, decreased heat stress for crops and other vegetation
Cultural (Biotic)	Nature-based Recreation	Bird watching, cycling, walking and hiking, water-related activities (e.g., boating, fishing, etc.)

2.3. Mapping & Assessing Natural Assets

2.3.1. Identification & Mapping of Natural Assets

Natural assets were identified and mapped using a multi-step process that leveraged existing datasets (Table 2) alongside manual editing. This resulted in a unique land cover map that was created specifically for use in this project. The steps that were used to create the natural asset inventory are described in detail below and are illustrated in Figure 2.

Step 1 – Creation of Draft Natural Asset Inventory

Existing land cover layers (17 classes, 6 m resolution) were used as the basis for the creation of the natural asset inventory for Parkland County (Table 2). The land cover layers were merged and clipped using a 5 km buffer applied to the boundary of the County. Areas located within the boundaries of Paul First Nation, or Enoch Cree Nation, Spruce Grove, and Stony Plain were excluded from the mapping. All natural classes from the land cover were selected and dissolved, resulting in over 60,000 individual natural asset boundaries ranging in size from 36 m^2 to 128,741,471 m^2. To remove fragments and very small assets, a minimum mapping unit (MMU) threshold was applied at two different scales. Based on consultation with Parkland County, the MMU for natural assets located within quarter sections overlapping a County designated Environmentally Significant Area (ESA) was 5,000 m^2 (~0.5 ha), while the MMU for natural assets not overlapping an ESAs was 10,000 m^2 (~1 ha). However, at this initial stage, a lower MMU was applied (within ESA = 0.35 ha; outside ESA = 0.8 ha). This resulted in a "draft" inventory that included roughly 7,200 assets that were the focus of more detailed editing.

Table 2. Description of the spatial data use in the mapping and assessment of natural assets in Parkland County.

Data Layer	Year	Source	Usage
North Saskatchewan & Battle River Watersheds Land Cover	2016	Fiera Biological 2021	Land cover for editing/asset creation
Pembina River Watershed Land Cover	2016	Fiera Biological 2000	Land cover for editing/asset creation
ESRI Basemaps	~2022	ESRI	Reference images for land cover editing
Google Earth Imagery	~2022	Google	Reference images for land cover editing

Step 2 – Detailed Editing

The land cover within each of the assets identified in the draft inventory was manually edited using ArcGIS basemaps and Google Earth imagery that was current to 2022 throughout most of the County. Because the input land cover layers were created using imagery from 2016, the editing tasks were focused on removing natural areas that were no longer present (i.e., had been disturbed or removed between 2016 and 2022). Additionally, land cover class label errors were corrected (e.g., mix-up between grassland and marsh), obvious boundary errors were adjusted, and missing natural features (such as small wetlands) were manually added. Time and budget constraints limited the amount of detailed editing that could be performed in areas dominated by country residential development. This is because these areas are characterized by small lots where the natural cover is highly fragmented by driveways, fences, yards, and small man-made clearings. In these areas, it was not possible to manually edit all the very small natural features, and instead, the editing was focused on capturing larger, contiguous areas of natural cover.

Step 3 –Cover Type Reattribution and Natural Asset Creation

Once the manual editing of the land cover classes was complete, more detailed land cover classes were dissolved and generalized into simplified natural asset cover types. Coniferous, Deciduous, and Shrub classes were reclassified into a “Woody” cover type, and Marsh, Swamp, Graminoid Fen, Woody Fen, and Bog classes were reclassified into a “Wetland” cover type, resulting in five major natural asset cover types (Table 3). The final step in creating the natural asset inventory was to delineate the boundary of individual assets. This was done by dissolving contiguous, singlepart cover type polygons to create a larger natural asset feature that contained all adjacent (touching) cover types. There were two exceptions to the creation of an individual asset. This included named lakes and the North Saskatchewan and Pembina River polygons identified in the provincial hydrography layer. These features were identified using the provincial boundary data and were identified as individual assets in the natural asset inventory. This resulted in a total of 9,473 natural assets. The natural assets were then spatially joined back to the cover type polygons to allow for cover type summaries for the natural assets.

Table 3. Description of cover types associated with natural assets identified in Parkland County.

Cover Type	General Description	Land Cover Classes	Land Cover Description
Woody	Areas dominated by woody vegetation primarily composed of native species	Coniferous	Coniferous trees (needle-leaf) cover greater than 75% of treed area.
		Deciduous	Broadleaf trees cover greater than 75% of treed area.
		Shrub	Areas dominated by woody vegetation typically <2 m in height.
Grassland	Areas dominated by non-woody vegetation primarily composed of native species	Grassland	Areas dominated by naturally occurring or minimally managed grasses and/or forbs. Does not include lawns or lands used as pasture.
Wetland	Areas dominated by shallow water and/or predominately native vegetation that is tolerant of wet or moist soil conditions	Marsh	Depressional areas dominated by emergent or graminoid vegetation.
		Swamp	Depressional areas dominated by deciduous tree or shrub cover.
		Graminoid Fen	Depressional areas dominated by graminoid vegetation where surface water flow is apparent.
		Woody Fen	Depressional areas dominated by woody vegetation where surface water flow is apparent.
		Bog	Areas dominated by black spruce cover where no water flow is apparent.
Natural Bare Ground	Ground naturally void of vegetation cover, including sand, soil, or rock	Natural Bare Ground	Naturally occurring bare soil, sand, sediment, banks, and beaches.
Open Water	Areas dominated by deep (typically >2m) open water	Open Water	Open water (lakes, permanent wetlands, standing water) and flowing water.

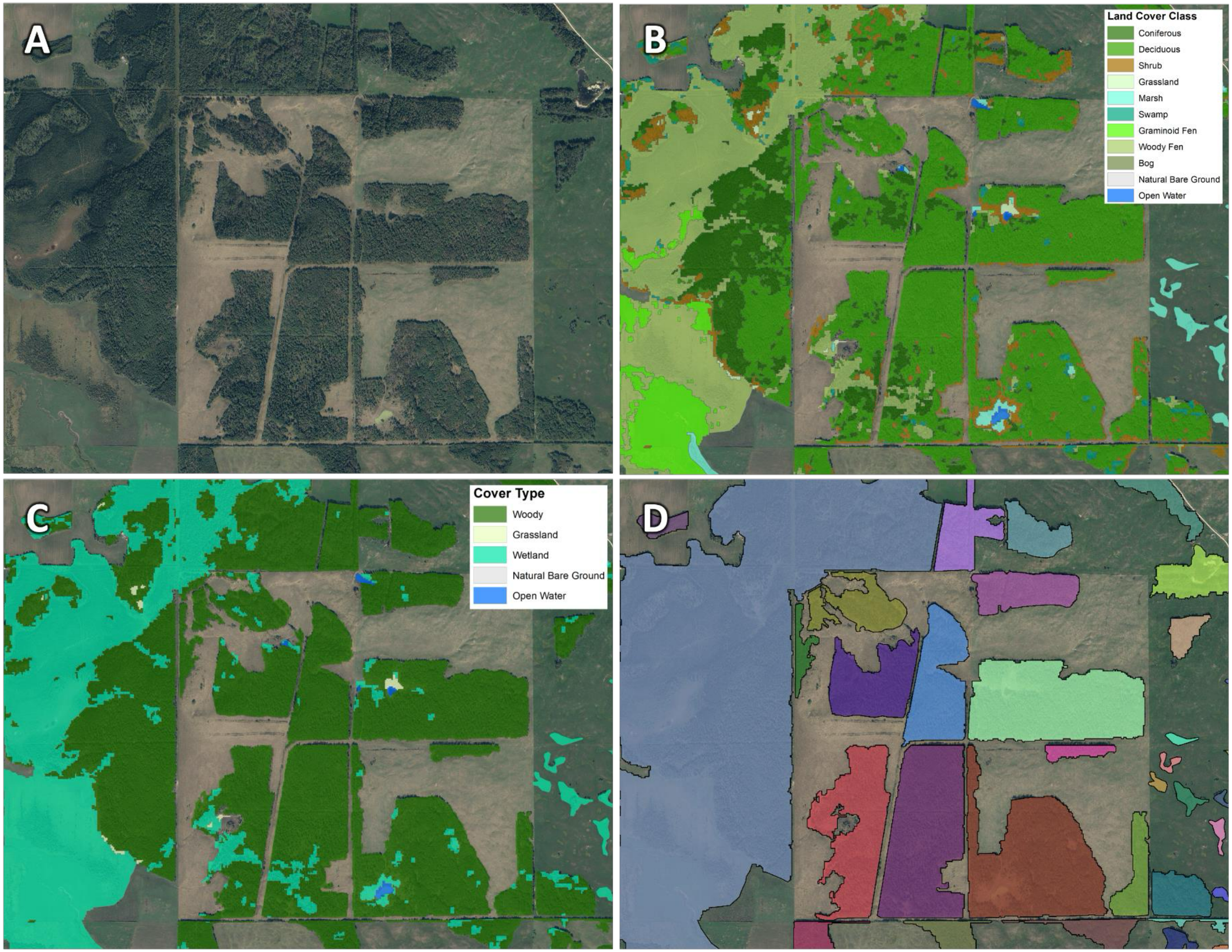


Figure 2. An example of how (A) natural cover in Parkland County was captured and mapped through the creation of a land cover layer (B) that was simplified into five main cover types (C), which were then used to identify and map individual natural assets (D).

2.3.2. Relative Condition Assessment

Generally, assets and their underlying habitats need to be in good condition to provide ecosystem services, and drivers of change can have both positive (e.g., restoration) and negative (e.g., land use pressure) impacts on condition (Maes et al. 2018; Vihervaara et al. 2019). As a result, pressure and condition are both linked to the supply of ecosystem services, as condition is likely to be good with correspondingly high function and supply of services if pressures are absent. Consequently, pressure can be used as a proxy for assessing condition in absence of information or data that allows for the direct measurement of habitat condition, quality, or biodiversity (European Environment Agency 2016). While direct measures of condition are often preferred, the existence of data that is of sufficient quantity or coverage is often lacking, and the collection of such data is typically cost-prohibitive (Maes et al. 2018; Vihervaara et al. 2019). As a result, indictors or proxies of condition are often used, and these can be measured indirectly or through modelling (European Environment Agency 2016; Maes et al. 2018).

Given that direct measures of condition from field data were not available for every asset identified in the Parkland County inventory, a combination of indicators that evaluate surrounding land use pressures, as well as general indicators of habitat quality and biodiversity status were selected to describe the relative condition of each natural asset within the county (Table 4). These indicators were selected because they account for a variety of ecological characteristics that are generally correlated with condition and there was suitable data available to use in the assessment.

For indicators that provided a continuous range of scores, the ranges were converted to categories and each asset was given a score that ranged from 1 to 5, with assets scoring a 1 being in relatively poor condition compared to assets with a score of 5 (relatively good condition). For indicators that reflected a spatial relationship with other ecological layers and provided a yes/no assessment, a binary value of 1 (yes) or 0 (no) was assigned. The approach used to score each metric is described in more detail in Table 4. To calculate a final condition score, metrics were aggregated together and the sum was divided by the total possible number of points. This value was then multiplied by 100 to give a final score ranging between 0 and 100 percent, with higher scores representing assets predicted to be in better condition. In order to visualize the data, assets were binned into four condition categories using the following scoring cut-off vlaues: Good (>75), Fari (51-75), Poor (26-50), and Critical (<25).

Importantly, this analysis reflects a predicted condition score and field validation of condition should be performed before relying on this attribute for decision-making.

2.3.3. Identification of Natural Assets of Special Interest

Given the large number of natural assets that were identified in Parkalnd County, assets that may be of particular interest for prioritization were identified. This includes assets associated with public land (municipal or provincial), those that intersect areas that have been identified by Parkland County as being high priority landscapes or primary recreation areas, as well as those assocaited with streams and open water (Table 6). All special interest indicators are binary and receive a score of 1 (yes) or 0 (no). Indicator scores for each asset were summed and divided by the total possible number of points. This output was then multiplied by 100 to give a final score ranging between 0 and 100 percent, with higher scores representing assets considered to be of relatively higher interest. The final score was classified into four interest categories by applying natural breaks: Very High (60 – 100); High (30 – 60); Moderate (10 – 30); and Low (0 – 10).

Notably, this analysis uses a limited number of indicators and may not reflect all of the values considered to be essential in identifying natural assets of special interest. Additionally, this analysis made the simple assumption that all of the selected indicators contribute equally in determining the relative importance of a particular asset. As such, additional consideration should be given to the limitations of this analysis before using it to inform decision-making.

Table 4. Indicators and the methods used to estimate relative condition scores for each natural asset in Parkland County.

Indicator	Description & Methods for Quantification	Data Used to Quantify Indicator
Intensity of Surrounding Land Use	An updated land cover layer was created for the County, plus a 1 km buffer, using existing land cover data. Natural assets were buffered by 1 km and the proportional cover of each land use class was calculated within the buffer. The proportional area of each land use class was then multiplied by the intensity value for each class (see Table 5), and a land use intensity value for each asset was calculated by summing the output values together. The area-weighted land use intensity values were then standardized to values between 0 and 100. Values were binned (<10; 10-20; 20-30; 30-50; >50) and each bin was assigned a land use intensity score ranging between 1-5, with 1 representing high intensity (i.e., assets with a value >50) and 5 representing low intensity (i.e., assets with a value <10).	Land Cover layer
Linear Density Surrounding the Asset	Natural assets were buffered by 1 km and the density of linear features (roads, trails, seismic lines, pipelines, transmission lines, railways) within the buffer was calculated. The range of linear density values ranged between 0.01 and 13.5 km/km^2. A threshold of 6.0 km/km^2 was used to assign a maximum cut-off for linear density values (Mace et al. 1996) and this value was used to normalize the range of values between 0 and 100. All natural assets with a value of ≥6.0 km/km^2 automatically receive a normalized score of 100. Values were binned (<25; 25-50; 50-75; 75-99; 100) and each bin was assigned a linear density score ranging between 1-5, with 1 representing high density of linear features (assets with a value of 100) and 5 representing low density (i.e., assets with a value <25).	Alberta Base Features Road, Cutline, Railway, and Powerline layers; ABMI 2021 Human Footprint Pipeline layer
County ESA	Natural assets that intersected a County ESA were assigned a 1 and all other assets were assigned a 0.	Parkland County ESA layer
Provincial ESA	Natural assets that intersected a Provincial ESA were assigned a 1 and all other assets were assigned a 0.	Provincial ESA layer
Riparian Intactness	Natural assets that intersected with riparian areas assessed as “High Intactness” or “Moderate Intactness” were assigned a 1, and those that intersected with riparian areas assessed as “Low Intactness” or “Very Low Intactness” were assigned a 0. All other assets were assigned no score for this metric.	Riparian Intactness layer
Regional Biodiversity	A regional biodiversity layer was created by merging multiple datasets that identify important locations that support local and regional biodiversity. This included key wildlife and biodiversity zones mapped by the provincial government, areas designated by Bird Studies Canada as Important Bird Areas (IBAs), and areas identified by the Alberta Biodiversity Monitoring Institute (ABMI) as having high (threshold value ≥90) species uniqueness and richness for birds and mammals. Natural assets that intersected with the layer were assigned a 1 and all other assets were assigned a 0.	Provincial Key Wildlife and Biodiversity Zones layer; CanIBA key biodiversity areas; ABMI bird and mammal Uniqueness and Richness layers

Table 5. Land cover classes and associated land use intensity values used to assess the intensity of surrounding land use indicator

Land Use Class	Intensity Value
Human Built, Roads	100
Cropland, Disturbed Vegetation	30
Pasture	10
Natural Cover	0

Table 6. Indicators, methods, and data used to identify and categorize natural assets of special interest in Parkland County.

Indicator	Description & Methods for Quantification	Data Used to Quantify Indicator
County Land	Natural assets that intersected with the County Lands layer were assigned a 1, and all others assigned a 0.	County Land layer
Crown Land	Natural assets that intersected with Crown Lands were assigned a 1, and all others assigned a 0.	Crown Land layer
High Priority Landscapes	Natural assets that intersected with the High Priority Landscapes layer were assigned a 1, and all others assigned a 0.	High Priority Landscapes, Parkland County MDP Bylaw 2017-14
Prime Recreation	Natural assets that intersected with the Prime Recreation layer were assigned a 1, and all other assigned a 0.	Prime Recreation & Tourism Areas, Parkland County MDP Bylaw 2017-14
Stream Association	The Provincial hydroline network was used to determine which natural assets were associated with a stream. A buffer of 10 m around streams was applied to adjust for stream width and potential boundary errors. Natural assets that intersected streams were assigned a 1, and those that did not were assigned a 0.	Provincial hyrdoline layer
Natural Open Water Association	The Provincial hydropoly layer was used to determine which natural assets were associated with natural permanent or semi-permanent open water areas. All features except dugouts, lagoons, quarries, and reservoirs were selected, and a buffer of 10 m was applied to adjust for potential boundary errors. Natural assets that intersected open water areas were assigned a 1, and those that did not were assigned a 0.	Provincial hydropolygon layer

2.4. Quantifying Ecosystem Service Supply

For each of the primary ecosystem services, indicators linked to the production and/or consumption of the service were selected and quantified to allow for an assignment of monetary value. Notably, the supply of several of the priority ecosystem services could not be measured, either because the data for doing so were not readily available, or because of time and resource limitations. A description of how the supply of each service was quantified is provided below. For all measures, raw outputs were converted to relative scores since field validation of model outputs could not be performed. These relative scores are sufficient for comparing potential ecosystem service delivery among natural assets within the County.

Ecosystem service supply in Parkland County was assessed using a combination of different qualitative and quantitative approaches (Table 7). Most of the ecosystem services evaluated were quantified using InVEST® (https://naturalcapitalproject.stanford.edu/software/invest) (Natural Capital Project 2025), a free open-source software developed by Stanford University that has been used to model ecosystem services worldwide. A description of the methods used to assess each ecosystem service in Parkland County is described in more detail below. Specifics related to the input datasets, values, and parameters used in each of the InVEST models is provided in the Appendix A.

Table 7. List of ecosystem services and associated methods that were used to quantify or describe the supply of services within Parkland County for this study.

ES Category	Ecosystem Service	Methods Used to Quantify ES Supply
Regulation & Maintenance (Biotic)	Control of Soil Erosion	InVEST Sediment Delivery Ratio (SDR) model
	Water Flow Regulation	InVEST Urban Flood Risk Mitigation model
	Water Quality Regulation	InVEST Nutrient Delivery Ratio (NDR) model
	Atmospheric Regulation	InVEST Carbon Storage model; Sequestration values based on literature review and landcover types
	Temperature Regulation	Landsat image analysis
Cultural (Biotic)	Nature-based Recreation	Qualitative description of nature-based recreational opportunities available in Parkland County

2.4.1. Control of Soil Erosion

The InVEST Sediment Delivery Ratio (SDR) model was used to model overland sediment generation and delivery to streams, which allows for an evaluation of the contribution of natural assets in preventing erosion (i.e., avoided erosion), as well as reducing erosion by trapping or retaining sediment (i.e., avoided export). Limitations of the model are that it relies on the Universal Soil Loss Equation (USLE; Renard et al., 1997), which is widely used but does not account for gully, stream bank, or mass erosion.

The model relies on terrain, land cover, and stream data inputs, as well as a number of parameter values. A full list and description of data sources and parameter values used in this model is provided in Appendix A. Normally, the model derives a stream layer from the input terrain data, but to more accurately represent the drainage network a stream/drainage raster layer was created using the Provincial stream network data and the County's Overland Drainage data. The outputs from the SDR model include the following spatial layers:

- Avoided Erosion: the quantification of the contribution of each land cover type (e.g., grassland) in preventing soil erosion, measured in tons/pixel/year.
- Avoided Export: the quantification of the contribution of each land cover type (e.g., grassland) in trapping or retaining erosion from entering a stream, measured in tons/pixel/year. This measure combines local/pixel level sediment retention with trapping of erosion from upslope of the pixel.

For each natural asset, the total avoided erosion (tons/yr) and avoided export (tons/yr) was calculated by summing the raster values for all pixels located within the boundary of an asset. An area weighted average was then calculated by dividing the total avoided erosion and total avoided export values by the asset area. The relative contribution of each natural asset to preventing erosion and trapping sediment in Parkland County was determined by classifying assets on a scale between 1 and 10, where 1 indicates assets with the lowest avoided erosion or avoided export per unit area and 10 the highest avoided erosion or avoided export per unit area.

2.4.2. Water Flow Regulation

The InVEST Urban Flood Risk Mitigation model estimates the runoff reduction, which is the amount of runoff retained per pixel compared to a defined storm volume. This provides a measure of how natural features can mitigate flood hazards. The model is limited in that it uses a simple approach (curve numbers), which can introduce high uncertainties; however, the ranking between land cover types is typically well captured by this approach, which means that the effect of natural infrastructure in mitigating flood impacts is well represented qualitatively.

The model relies on land cover and soil data inputs, as well as several parameter values. A full list and description of data sources and parameter values used in this model is provided in Appendix A.

The model output includes a raster layer with per pixel estimates of runoff retention values measured in m^3. The total amount of runoff retained by each natural asset was calculated by summing the raster values within the boundary of each asset. An area weighted average was calculated by dividing the total retained runoff value by the asset area. The relative contribution of each natural asset to regulating water flow was determined by classifying assets on a scale between 1 and 10, where 1 indicates assets with the lowest runoff retention per unit area and 10 the highest runoff retention per unit area.

2.4.3. Water Quality Regulation

The InVEST Nutrient Delivery Ratio (NDR) model maps nutrient sources (nitrogen and phosphorous) and their transport to streams using a mass balance approach. This allows for the assessment of how natural assets retain nutrients, thereby regulating water quality. Sources of nutrients across the landscape, also called nutrient loads, are determined based on a land cover map and associated loading rates. A major limitation of this model is that it has a small number of parameters; consequently, outputs generally show a high sensitivity to input values. Additionally, in stream processes are not well captured in the model.

The NDR model relies on terrain, land cover, and precipitation data inputs, as well as several parameter values, including nutrient load values for N and P for each land cover type. A full list and description of data sources and parameter values used in this model is provided in Appendix A.

For both nitrogen (N) and phosphorus (P), the model output includes a raster layer with predictions of nutrient loading (kg/yr) and nutrient retention (kg/yr) for each pixel. For each natural asset, the total amount of nitrogen and phosphorous retained was calculated by summing the raster values within the boundary of each asset. An area weighted average was then calculated by dividing the total amount of N or P retained by the total area of the asset. The relative contribution of each natural asset to retaining nutrients and improving water quality in Parkland County was determined by classifying assets on a scale between 1 and 10, where 1 indicates assets with the lowest nutrient or phosphorous retention per unit area and 10 the highest nutrient or phosphorous retention per unit area.

2.4.4. Atmospheric Regulation

The InVEST Carbon Storage model estimates the total amount of carbon stored within a given area based on estimates of the total amount of carbon present within four different carbon pools: aboveground biomass, belowground biomass, soil, and dead organic matter. This approach is limited in that it uses a simplified model of the carbon cycle that assumes carbon pools are static, and that each land cover type can be sufficiently represented by a single carbon pool value (i.e., it does not vary within the cover type).

The Carbon Storage model relies on land cover and soil data inputs, as well a carbon storage value (t/ha) for each land cover type and carbon pool. A full list and description of data sources and parameter values used in this model is provided in Appendix A.

Model outputs provide an estimate of the amount of carbon (in metric tons) stored in each pixel. For each natural asset, the total amount of carbon stored was calculated by summing the raster values within the boundary of each asset. An area weighted average was then calculated by dividing the total amount of carbon stored by the asset area. The relative contribution of each natural asset to carbon storage was determined by classifying assets on a scale between 1 and 10, where 1 indicates assets with the lowest amount of carbon stored per unit area and 10 the highest amount of carbon stored per unit area.

In addition to calculating the amount of carbon stored by each natural asset, the amount of carbon sequestered by each asset over a 50-year period was estimated. Carbon sequestration differs from carbon storage in that sequestration is the process by which atmospheric carbon dioxide is taken up by vegetation through photosynthesis and stored in another form that cannot be released (i.e., carbon storage). Carbon sequestration is an on-going process and differs from carbon storage in that once a natural asset is lost (i.e., a forest is cut down) the carbon sequestration service is no longer provided by that natural asset, but the carbon storage service may persist (e.g., if the trees are converted into lumber). For this reason, ecosystem service valuations typically use carbon sequestration, and not carbon storage, to estimate the value of atmospheric regulation services.

To allow for an estimate of the value of atmospheric regulation services provided by natural assets in Parkland County, carbon sequestration was estimated using values sourced from the literature (Table 8). For grasslands, Bork and Badiou (2017) cited a range of annual carbon sequestration rates for grasslands in the Canadian Prairies (0.8 to 5.1 tonnes of CO_2e/ha/yr), and the value at the lower end of this range was selected to remain conservative. For wetlands, a recent study by Creed (2025) suggests that wetlands in southern Ontario sequester carbon at an average rate of roughly 2.5 tonnes of CO_2e/ha/yr. For woody land cover, Bernal et al. (2018) presented carbon sequestration rates for both broadleaf and coniferous boreal forests (similar to the forest composition in the County) and an average of sequestration rates for these two forest types was taken (5.7 tonnes of CO_2/ha/yr). Finally, in a study of northern lakes, Heathcote et al. (2015) estimated an average carbon burial rate (post-1900) of 0.139 t/ha/yr, which is equivalent to 0.5 tonnes of CO_2e/ha/yr.

For each natural asset, the annual carbon sequestration rates (Table 8) were multiplied by the area of each land cover type present, and the total was summed to derive an overall estimate of carbon sequestration over a 50-year time period. An area weighted average was then calculated by dividing the total amount of carbon sequestered by the asset area. The relative contribution of each natural asset to carbon sequestration was determined by classifying assets on a scale between 1 and 10, where 1 indicates assets with the lowest amount of carbon sequestered per unit area and 10 the highest amount of carbon sequestered per unit area.

Table 8. Annual carbon sequestration rates by land cover class

Land cover class	Carbon Sequestration Rate (tonnes CO_2e/ha/year)	Source
Grassland	0.8	Bork and Badiou (2017)
Wetland	2.5	Mistry et al. (2025)
Woody	5.7	Bernal et al. (2018)
Open Water	0.5	Heathcote et al. (2015)

2.4.5. Temperature Regulation

Landsat images from June through September for the years 2014 to 2024 were used to quantify median temperature values across a 30 m grid for the County. This temperature data was then intersected with the natural asset boundaries to calculate an average temperature value for each asset. Assets were then assigned a relative “cooling” score of 1 to 5 based on the range of temperatures across the County, where 5 indicates the greatest potential cooling effect and 1 indicates the lowest potential cooling effect.

2.4.6. Nature-based Recreation

There are a range of metrics that can be used to assess nature-based recreation; however, many of these require information related to visitation or use of natural areas, and these data are typically obtained through surveys of residents and recreational users. These data do not currently exist for the County. Instead, we provide a high-level summary of the nature-based recreation opportunities available in the County, including a map showing the location of key recreational areas, which was used to inform the valuation of nature-based recreation services.

2.5. Valuing Ecosystem Services

The final step in an ecosystem service assessment is the identification of the goods and benefits provided by an ecosystem service, and the associated value of those benefits that accrue to end-users (Burkhard & Maes 2017). The extent to which people derive benefits from ecosystem services defines the relationship between human well-being and an ecosystem, and the benefits or welfare gained by the end-users from the supply of an ecosystem service is considered the asset's value. The total value of ecosystem services provided by natural assets generally consists of two sub-components (Figure 7):

- **Use values**, which include direct and indirect use values:
    - **<u>Direct use</u>** values reflect the value a person places on being able to actively use a particular natural asset. These include consumptive use values such as fishing or hunting, as well as non-consumptive use values like hiking or picnicking near a river.
    - **<u>Indirect use</u>** values reflect the value a person places on benefits derived from regulating services provided by natural assets like flood protection or climate regulation.
- **Non-use** or passive use values reflect the value a person places on certain environmental assets that is not demonstrated through observable behaviour (Adamowicz et al. 1998). These include the value of having the option to use the asset in the future (option value), the value for future generations to use the asset (bequest value), as well as the value of knowing that a particular environmental asset continues to exist, regardless of current of future use potential (existence value).

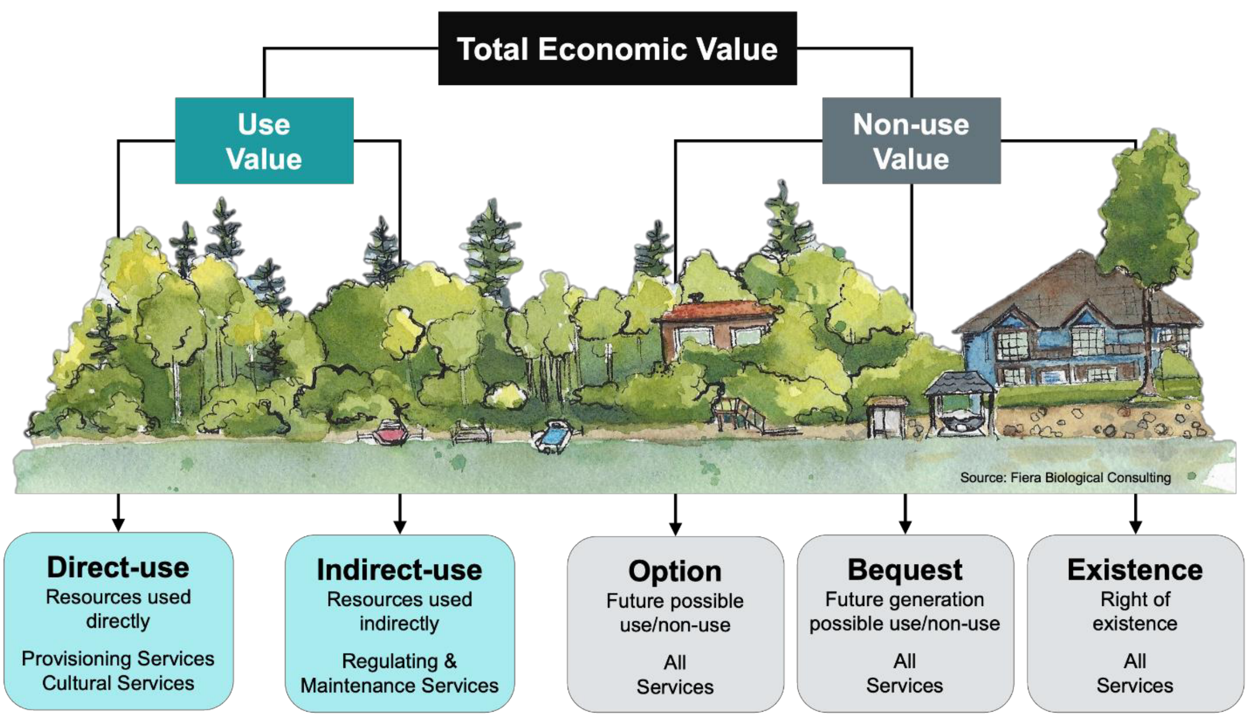


Figure 7. Use and Non-use values that make up the total economic value of an ecosystem.

Economic valuation attempts to measure the welfare derived from the use and consumption of ecosystem services and is typically expressed in monetary units. For assets that are exchanged in conventional markets, valuation is simpler as we can more easily observe consumers' willingness to pay (WTP) for a market good using available market data (e.g., prices, demand curves). For goods that are not traded in markets (non-market assets) however, other valuation techniques must be used. The economic literature outlines three generally accepted techniques to estimate end-users' WTP to determine their value:

- The **revealed preference (RP)** approach which, on a conceptual level, consists of examining transactions in a market to infer a value for an ecosystem good or service related to the transaction but not explicitly traded. For example, one can examine the costs that individuals are willing to incur (i.e., travel costs) to enjoy an activity (e.g., fishing) to provide insight into the value associated with the use of a particular ecosystem good (e.g., a lake). This approach works well for estimating use values.
- The **stated preference (SP)** approach involves designing surveys or experiments that explicitly asks what participants are willing to pay for a good or service that is not traded in a market. This approach is well-suited for estimating passive use values. For example, most Albertans have no use value for species such as woodland caribou; however, they may still have value in knowing that this species continues to exist (i.e., existence value). While this value cannot be measured through any observable behaviour, one could design a stated preference survey to directly ask participants what their WTP is for the continued existence of woodland caribou.
- The **benefit transfer (BT)** approach allows for the value of ecosystem services to be established through a review of published studies that contain estimates of values for comparable ecosystem services in similar jurisdictions. This approach is best suited for cases where primary data collection and analysis (i.e., revealed and stated preference approaches) are not practical or feasible. Published ecosystem service values are generally specific to a particular time and geography; therefore, the passage of time and difference in affected population need to be accounted for. The goal is to find values from studies with similar socio-economic conditions and cultural norms and practices. Where necessary, these values are adjusted to reflect inflation as well as differences in currency and purchasing power of key stakeholder groups.

It is important to note that the most robust form of environmental valuation is elicited through either revealed or stated preference techniques, as these methods allow for the estimation of welfare values to the end-users of natural assets. Benefits transfer allows individuals who cannot undertake primary data collection to use values estimated in comparable jurisdictions through either revealed or stated preference.

It is not always feasible to acquire primary revealed or stated preference data, and these data are not always available in comparable jurisdictions to allow for the benefit transfer approach. As such, many have resorted to using other methods to estimate environmental values that are not considered to be true valuation approaches. For example, market proxies, such as replacement costs of an asset or avoided damage costs associated with the degradation or destruction of an asset, are often used as an estimate of natural asset values. Conceptually, the use of replacement or avoided damage costs is predicated on the assumption that an asset is worth at least as much as expenditures made by individuals or institutions to replace it, or the damages that would occur if it were lost; however, there are several reasons why replacement and avoided damage costs may depart significantly from true WTP estimates.

For example, consider a naturally occurring wetland that is not providing substantial benefits to end-users in the community – perhaps it is in a remote location and is not used recreationally and does not provide flood protection for any development. If that wetland were to be destroyed and replaced with a man-made wetland or alternative structure (e.g., stormwater management pond), there is no reason to believe that a linkage exists between the cost of replacement and the value of the initial asset to society. Similarly, consider a wetland that provides flood protection to a housing development. It would be incorrect to infer that a homeowner's WTP to retain the wetland is equivalent to the avoided cost of a flood, as the homeowner may be able to achieve flood protection through other means (e.g., retaining wall, dykes, culverts) with costs that can differ substantially from the flood damages.

In sum, these techniques do not represent WTP estimates of end-users since the end-users' WTP for ecosystem services may differ from the estimated avoided or replacement costs, making them an imperfect proxy for non-market values. Having said this, market proxies like avoided cost estimates can, in some instances, provide reasonable estimates of environmental value, and are more readily available for natural assets in urban settings than WTP values through revealed or stated preference techniques. As such, market proxy estimates can still be of great use to the County for municipal decision-making purposes. Our goal here is simply to provide clarity around what estimation techniques are considered to reveal robust environmental values and what represent other market proxies.[2] We provide a general confidence level (low, medium, and high) for each of the estimated monetary values provided in this study based on several factors such as the valuation technique and the geographical similarity of the data.

As described in Table 1, each ecosystem service identified for the County has an associated benefit to end-users. The specific end-users accruing benefits from the County's natural assets is variable. Indeed, virtually all ecosystem services provided by natural assets in the County also benefit those who live outside of the County (e.g., climate regulation, nature-based recreation, etc.). While we endeavour to focus the valuation of ecosystem services to County residents, depending on the valuation approach for individual ecosystem services, benefits to those living outside the County may be captured as well.

Primary data collection for the economic valuation of ecosystem services in the form of revealed or stated preference approaches were cost-prohibitive for this study. As such, the benefit transfer method, as well as market proxy methods, were relied upon to estimate the economic value of ecosystem services in the County. Data and information sources used to undertake the valuation include:

- The Environmental Valuation and Reference Inventory (EVRI), a database of empirical studies on the economic value of environmental assets;
- Academic literature; and
- Engagement with the County regarding pathways through which ecosystem services and natural assets impact the County's end-point users.

[2] For the purposes of this study, we use the term 'value' and 'monetary estimate' interchangeably, so as not to create too much confusion.

3.0 Overview of Natural Assets

In total, 9,473 unique natural assets were identified within Parkland County, covering 1,079 km^2 or roughly 39% of the County (Figure 3). Assets are between 0.01 ha and 7,890 ha (78.9 km^2), reflecting the wide range in the size of contiguous natural areas within the County. The smallest natural assets are generally isolated wetlands in agricultural fields that are primarily located in the eastern and central parts of the County. Larger assets are generally located in the western portion of the County and along the North Saskatchewan and Pembina Rivers, and are a mix of woody, wetland, and open water cover types.

Woody vegetation accounts for the greatest area (523 km^2) and proportion (48%) of cover within natural assets in the County (Figure 4). Wetlands make up the second largest proportion (33%) of cover, while open water accounts for 17% of cover. Grassland and Natural Bare Ground are rare, accounting for a combined total of less than 3% of the cover within natural assets.

Condition scores for natural assets range between 15 and 100, with an average score of 49 (Table 9). Generally, larger assets (>10 ha) have a higher relative condition score than smaller (<10 ha) assets. Less than half (45%) of the natural assets have a relative condition score of Good (6%) or Fair (39%), with most assets (51%) being rated as Poor (Table 10). An additional 5% of assets have a relative condition score of Critical. Generally, larger assets and assets in the western part of the County have higher condition scores (Figure 5). Assets with lower condition scores are typically smaller and generally located in highly fragmented areas or areas with more residential, agricultural, and/or industrial activity surrounding them.

Special interest scores for natural assets ranged between 0 and 100, with an average score of 16.9 (Table 9). Natural assets that fall into the High Special Interest category are typically larger and have a greater likelihood of being associated with County or Provincial ESAs, hydrological features, and other areas of interest (Figure 6).

Table 9. Summary of condition and special interest scores assigned to natural assets in Parkland County.

Asset Size Category	Number of Assets	Condition Score			Special Interest Score		
		Minimum	Maximum	Average	Minimum	Maximum	Average
< 10 ha	8,249	15.4	100	48.7	0	83.3	14.4
> 10 ha	1,224	15.4	100	54.8	0	100	33.8
All Assets	9,473	15.4	100	49.5	0	100	16.9

Table 10. Summary of condition scores assigned to natural assets in Parkland County.

Condition Score	Condition Category	Number of Assets	Proportion of Assets (%)
75 - 100	Good	578	6.1
50 – 75	Fair	3,667	38.7
25 – 50	Poor	4,774	50.7
0 – 25	Critical	428	4.5

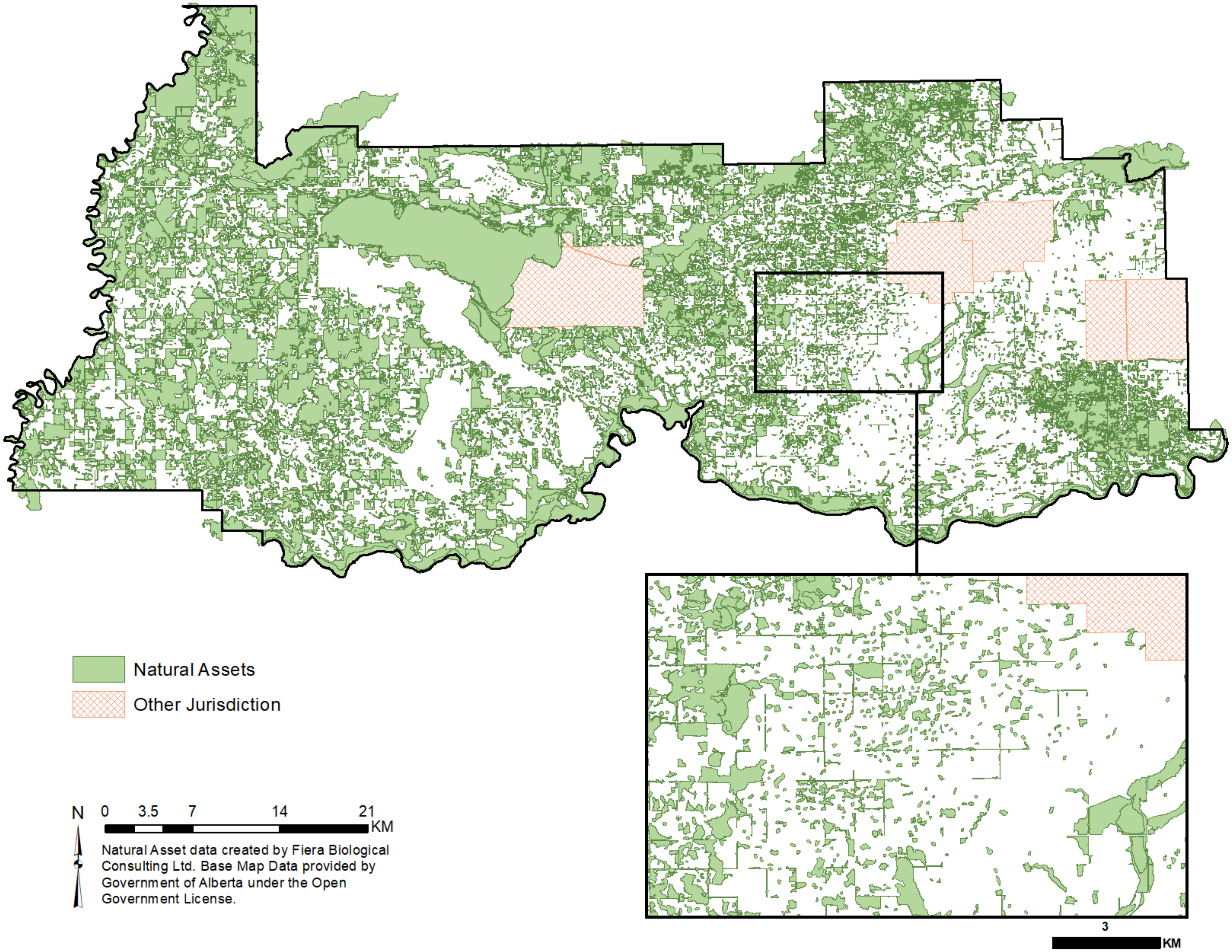


Figure 3. Natural assets identified in Parkland County.

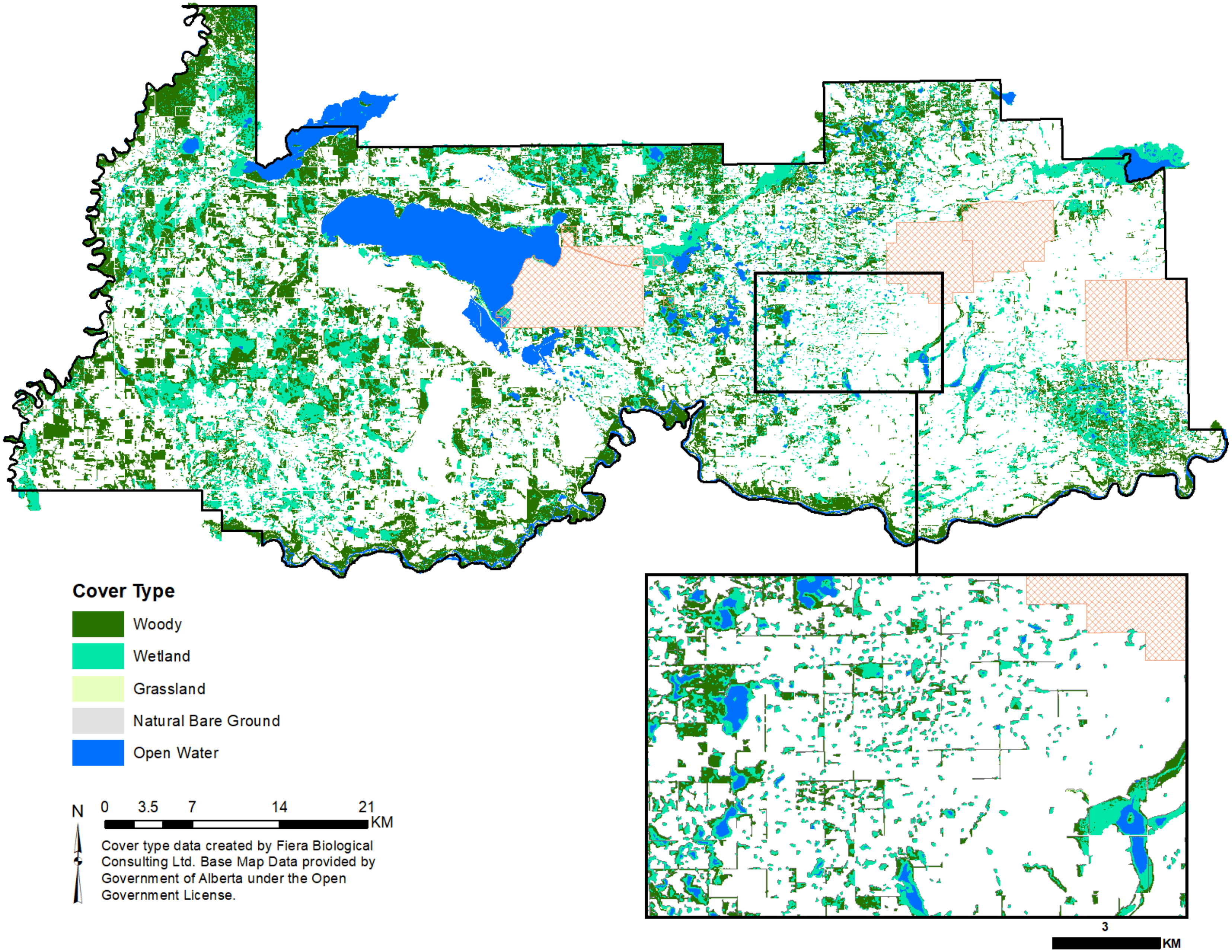


Figure 4. Major land cover types contained within the natural assets in Parkland County.

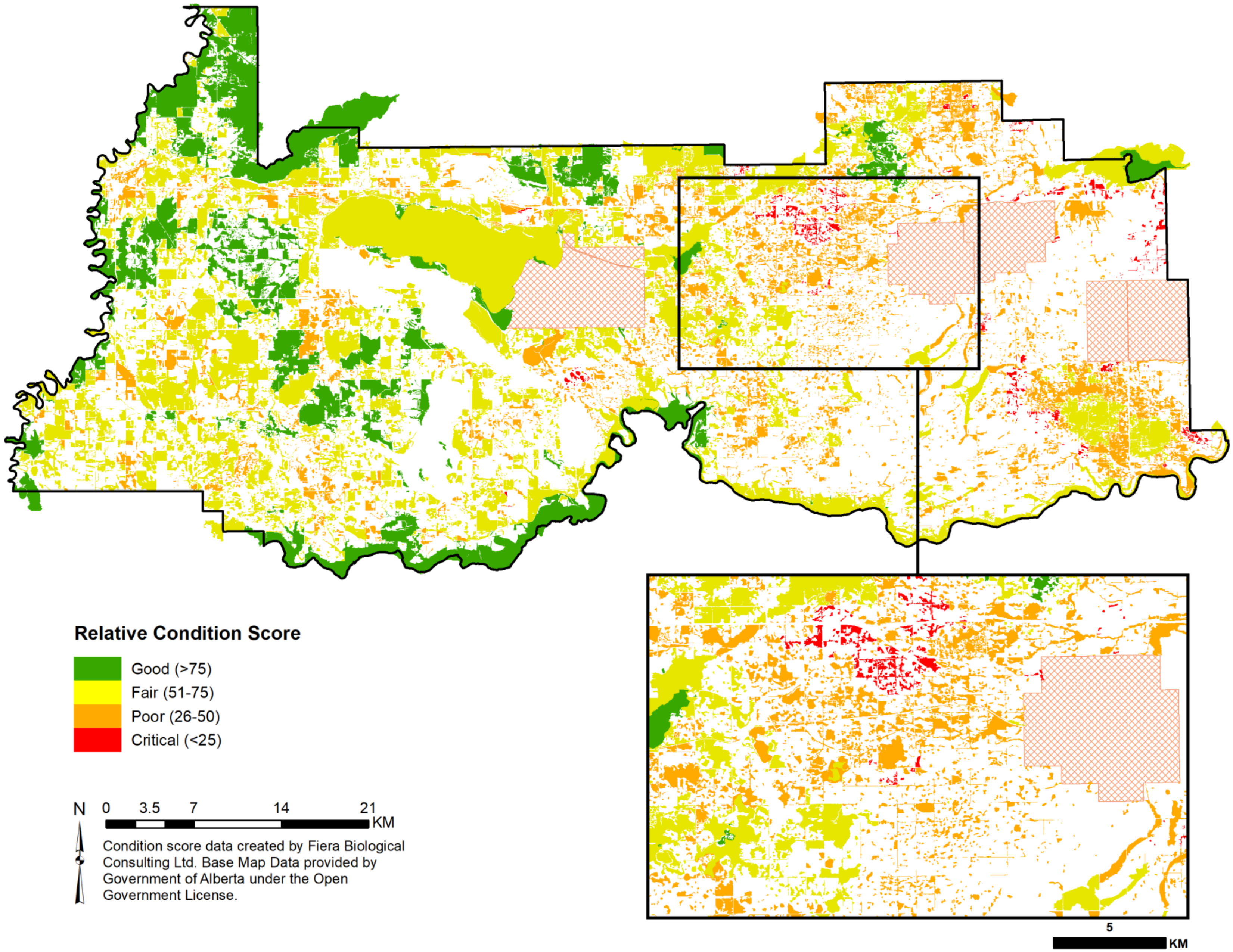


Figure 5. Relative condition scores for natural assets identified in Parkland County.

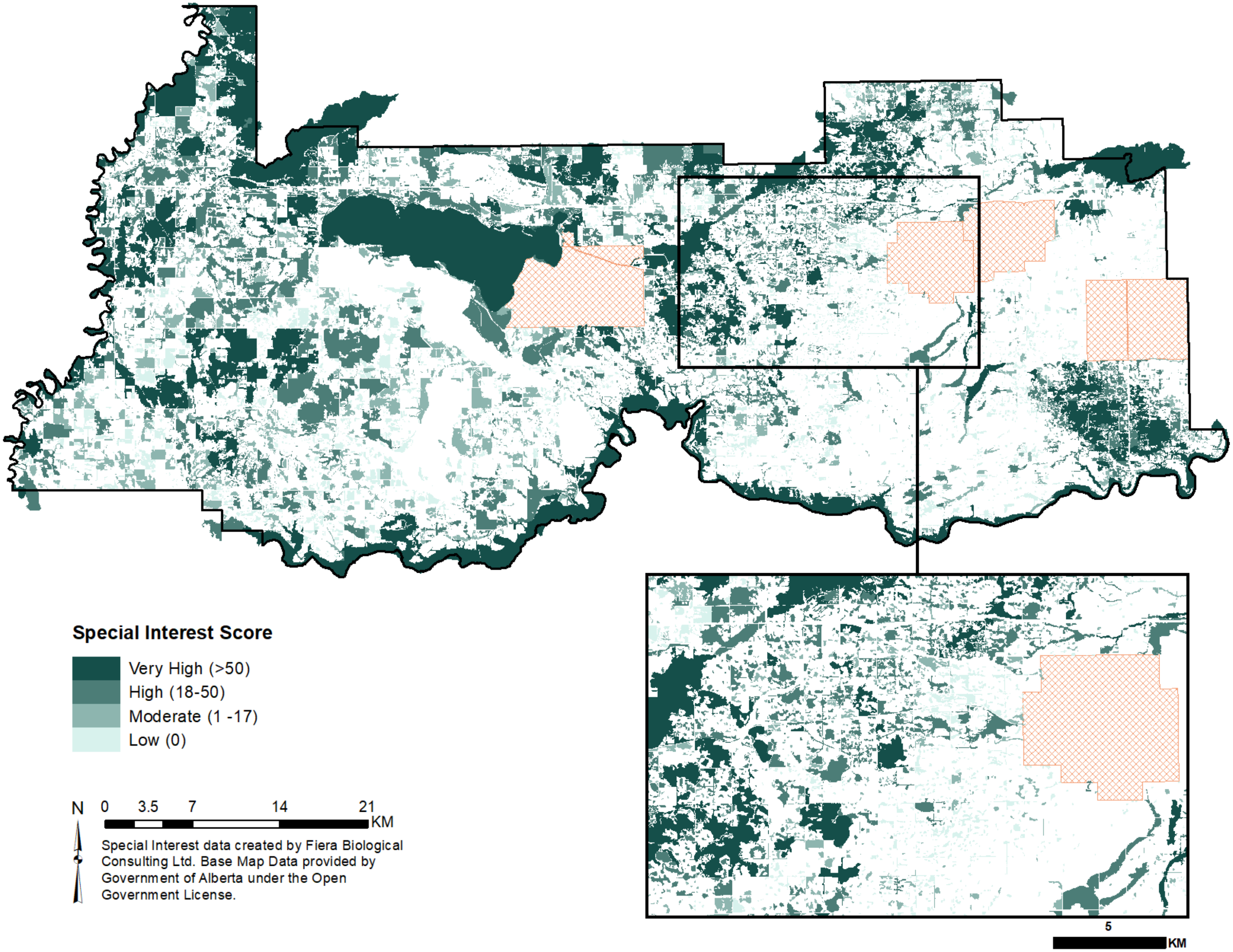


Figure 6. Special interest scores for natural assets identified in Parkland County.

3.1. Ecosystem Service Supply

3.1.1. Control of Soil Erosion

The relative avoided erosion score and relative avoided export score for natural assets in Parkland County is shown in Figure 7 along with the predicted potential soil loss. High scoring assets for avoided erosion are associated with locations of high potential soil loss and a high proportion of woody cover. Assets that score lower for avoided erosion tend to be associated with locations where potential soil loss is lower and where the cover type is predominantly open water or wetland cover. Because the avoided export measure takes into account how well an asset traps sediment eroded from upslope alongside how it prevents erosion, landscape position plays a greater role in the score for the asset. Because of this, assets located downslope from high potential soil loss locations tend to score higher for avoided export.

3.1.2. Water Flow Regulation

The InVEST model predicts amount of runoff at the pixel level, which is then used to estimate relative runoff reduction by natural assets and their potential for mitigating flooding. The relative retained runoff score for natural assets along with the predicted runoff amount is shown in Figure 8. Areas of high runoff are associated with built up areas, with soil type also playing a role in amount of potential runoff. Thus, landscape position and land cover type influence an asset's score for retaining runoff. In Parkland County, open water areas and areas with a high proportion of wetland cover that are juxtaposed among areas of built features or where clay-dominated soils are located tend to score the highest.

3.1.3. Water Quality Regulation

The relative nitrogen retention score for natural assets in Parkland County is shown in Figure 9 along with the predicted nitrogen load. High scoring assets tend to be located where the nitrogen load is high, with cover type also factoring into the score. Wetland cover, and to a lesser extent woody cover, tends to be associated with greater nitrogen retention.

The relative phosphorous retention score for natural assets in Parkland County is shown in Figure 10 along with the predicted phosphorous load. High scoring assets tend to be located where the phosphorous load is high, with cover type also factoring into the score. The highest phosphorous loads tend to be associated with crop cover, and thus, natural assets with wetland cover or a mix of wetland and woody cover in these areas tend to have the highest phosphorous retention scores.

3.1.4. Carbon Storage & Sequestration

The InVEST model predicts amount of carbon stored at the pixel level, which is then used to estimate relative carbon storage by natural assets and their potential for contributing to climate regulation. The InVEST model does not provide estimates of sequestration, so carbon sequestration by assets was estimated using values sourced from the literature. The relative carbon storage score and relative carbon sequestration score for natural assets along with the predicted carbon storage is shown in Figure 11. Areas of high carbon storage are associated with woody areas and areas with a high proportion of peatland wetland cover (graminoid and woody fen areas). Thus, natural assets with a high proportion of these cover types tend to score the highest for carbon storage. Woody cover has the highest rate of carbon sequestration, and thus, assets with a high proportion of woody cover, especially small forest stands and hedgerows, score the highest for carbon sequestration.

3.1.5. Temperature Regulation

Average summer temperature across a 10-year period ranged from roughly 6°C to 29°C across the County, with a mean of 16.5°C (Figure 12). Cooler temperatures were associated with open water areas and natural vegetation cover, warmer temperatures were associated open agricultural areas, and the warmest temperatures were associated with urban areas and mines. When natural assets were ranked on their potential to moderate temperature and assigned a relative cooling score, open water areas scored the highest, and areas with a high proportion of woody (forest and woody wetlands) cover scored the next highest. Less of a cooling effect is associated with larger assets with predominantly graminoid or grassland cover, and the lowest cooling scores are associated with small, isolated natural assets.

3.1.6. Nature-based Recreation

Parkland County hosts a plethora of nature-based recreation opportunities including, but not limited to (Parkland County 2025):

- Chickakoo Lake Recreation Area, offering trails for walking, cycling, and cross-country skiing, as well as picnic areas, a playground, and lake-related activities like non-motorized boating and fishing.
- Constable Chelsey Robinson Park, offering river-related recreation such as fishing and picnicking.
- Devonian Trail, offering trail activities such as birding, hiking, and cycling.
- Hasse Lake Recreation Area, offering day-park activities such as birding, hiking, and picnicking, as well as lake-related activities such as boating and fishing.
- Jackfish Lake Boat Launch and Recreation Area, offering a variety of lake-related activities such as boating, fishing, swimming, and picnicking.
- Prospector’s Point Day Use Area, offering river-related recreation such as fishing and picnicking.
- Wabamun Lake, offering a variety of lake-related recreation such as boating, camping fishing, picnicking, and swimming.

The County also hosts three Provincial Parks (Pembina River, Wabamun Lake, and Lois Hole Centennial), ten Provincial Natural Areas (including Clifford E. Lee Nature Sanctuary and Wagner Natural Area), as well as smaller day-use parks with recreation opportunities and access to Wabamun Lake, Lake Isle, and Muir Lake (Parkland County 2025). Additionally, over 150 km^2 of the County is designated as Crown Land, which can be accessed for nature-based recreation activities. The Nature Conservancy of Canada (NCC) also has lands that provide opportunities for nature-based recreation activities, including Bunchberry Meadows Conservation Area (Figure 13).

Due to a lack of data and information, nature-based recreation condition is not assessed in this study. Instead, this high-level description of nature-based recreation supply available in the County is used to inform the monetary valuation estimate outlined in Section 4.2.6. below.

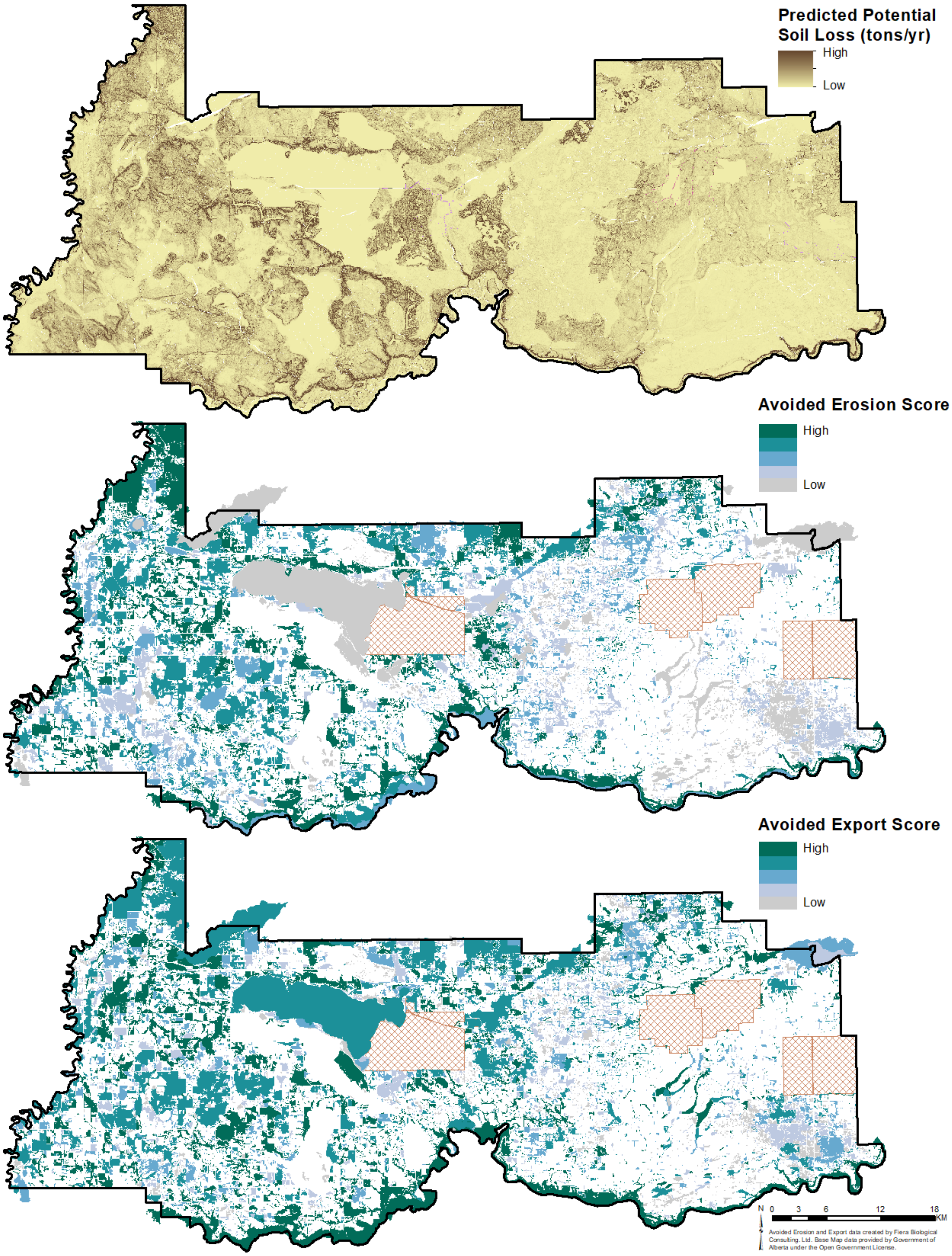


Figure 7. Predicted potential soil loss modelled using the InVEST Sediment Delivery Ratio (SDR) model (top) and the corresponding avoided erosion score (middle) and avoided export score (bottom) for natural assets in Parkland County. Assets with high avoided erosion scores represent areas that are more likely to prevent erosion, and assets with high avoided export scores are locations that are more likely to trap and retain sediments.

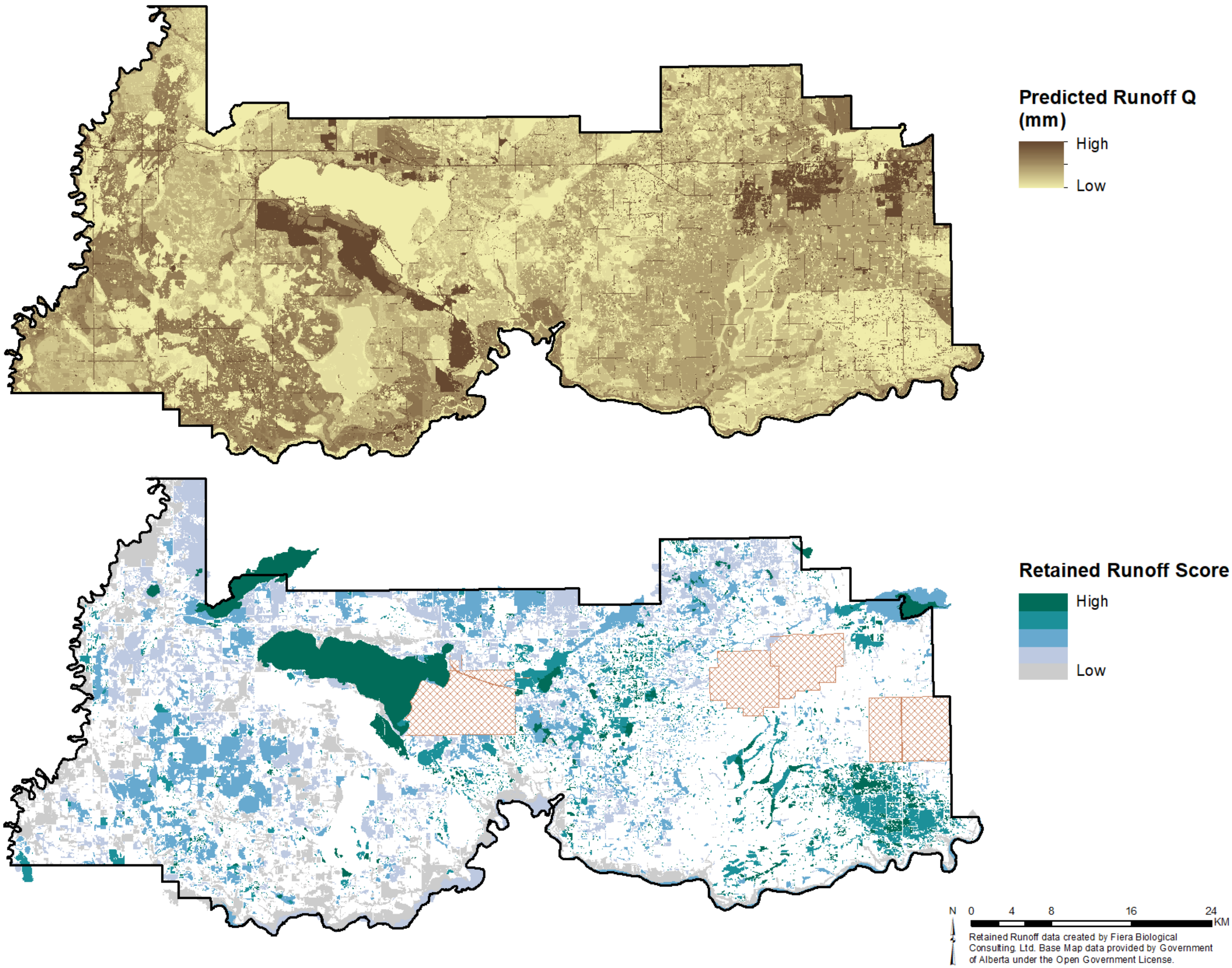


Figure 8. Predicted surface water runoff modelled using the InVEST Urban Flood Risk Mitigation model (top) and runoff retention score for natural assets in Parkland County (bottom). Assets with high retained runoff scores represent areas that are more likely to attenuate downstream flooding.

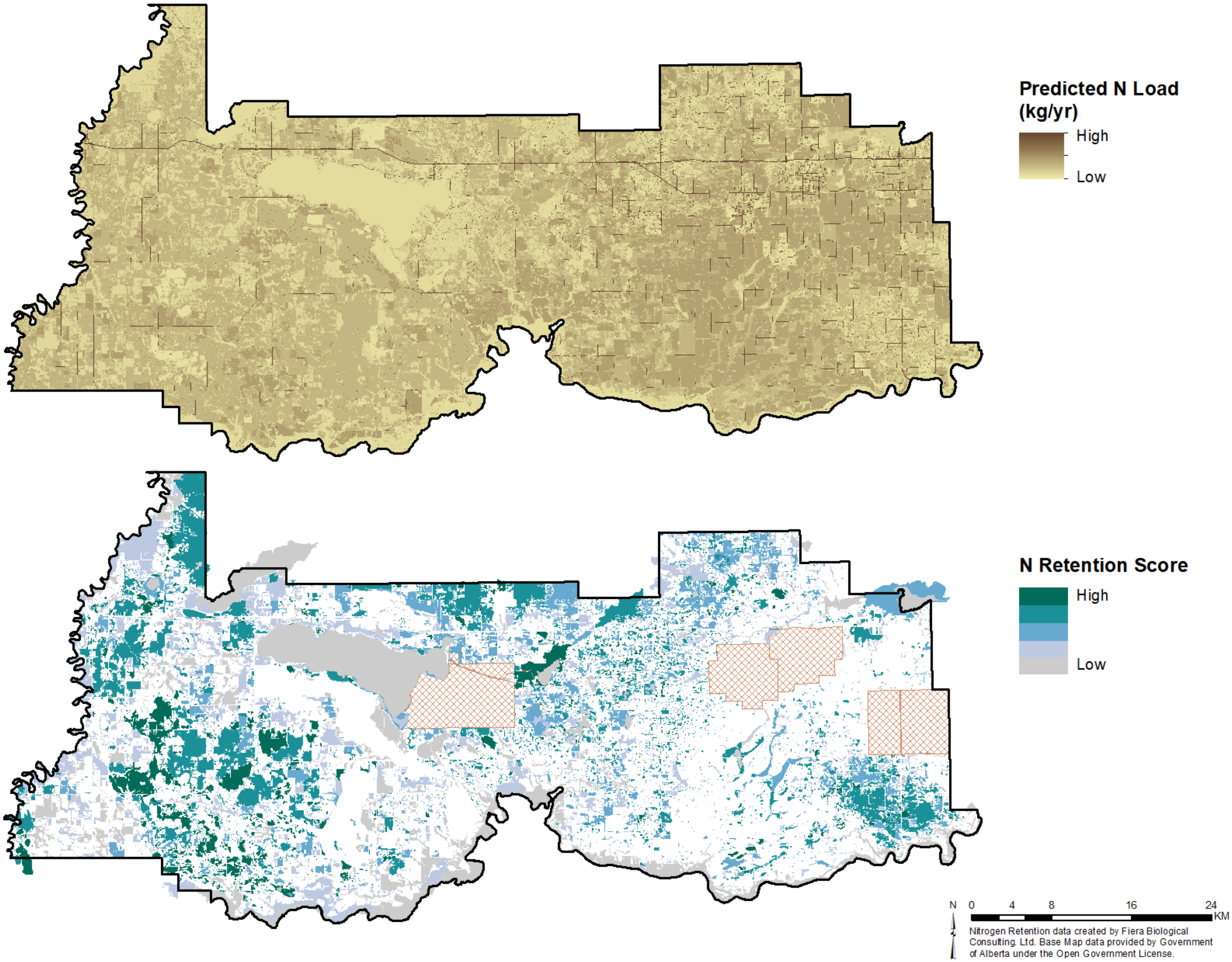


Figure 9. Predicted nitrogen (N) loading modelled using the InVEST Nutrient Delivery Ratio (NDR) model (top) and nitrogen retention score for natural assets in Parkland County (bottom). Assets with higher N retention scores contribute more to water quality regulation than those with lower scores.

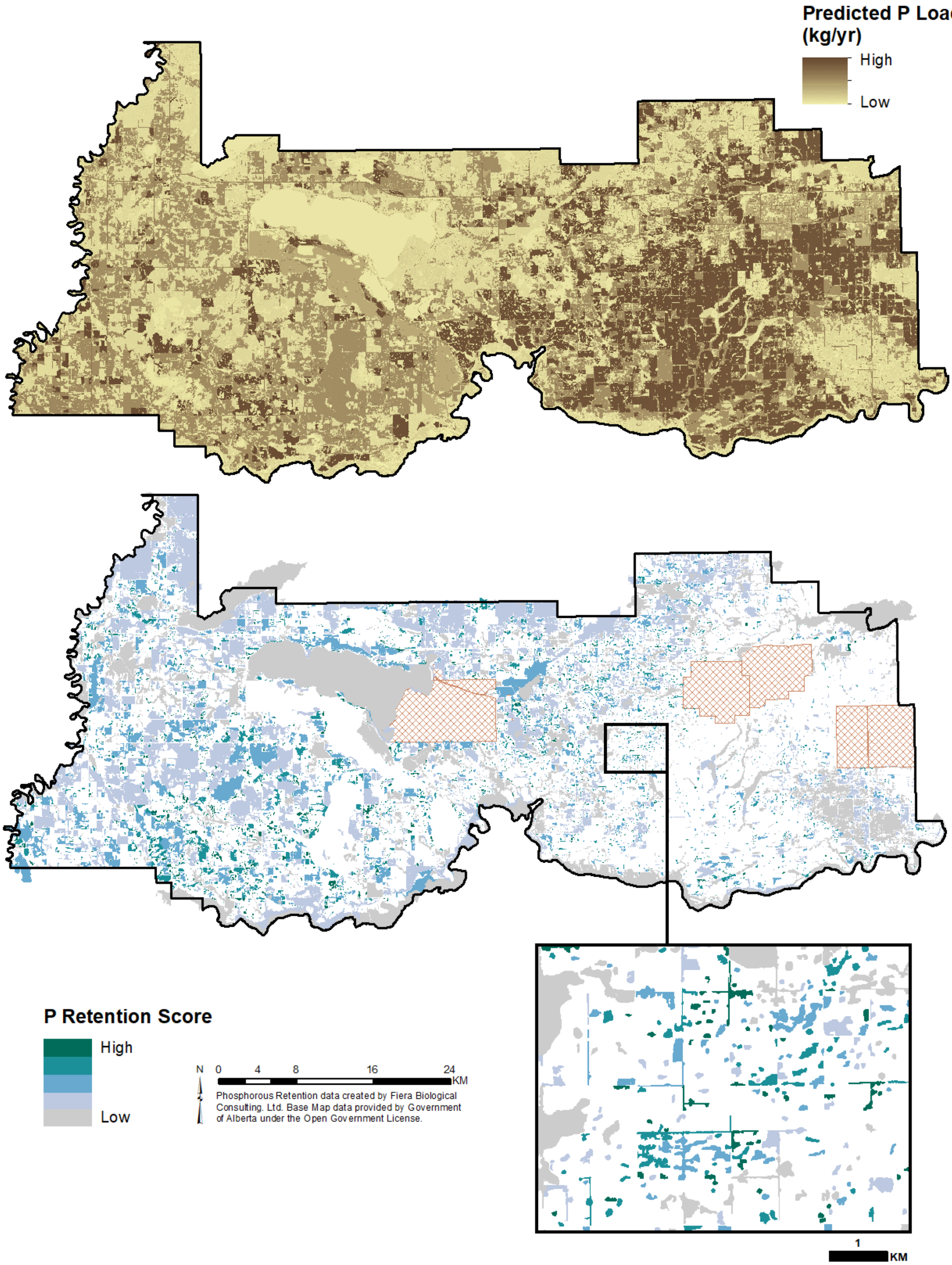


Figure 10. Predicted phosphorus (P) loading modelled using the InVEST Nutrient Delivery Ratio (NDR) model (top) and phosphorus retention score for natural assets in Parkland County (bottom). Assets with higher P retention scores contribute more to water quality regulation than those with lower scores. Inset shows contribution of small wetlands in agricultural fields.

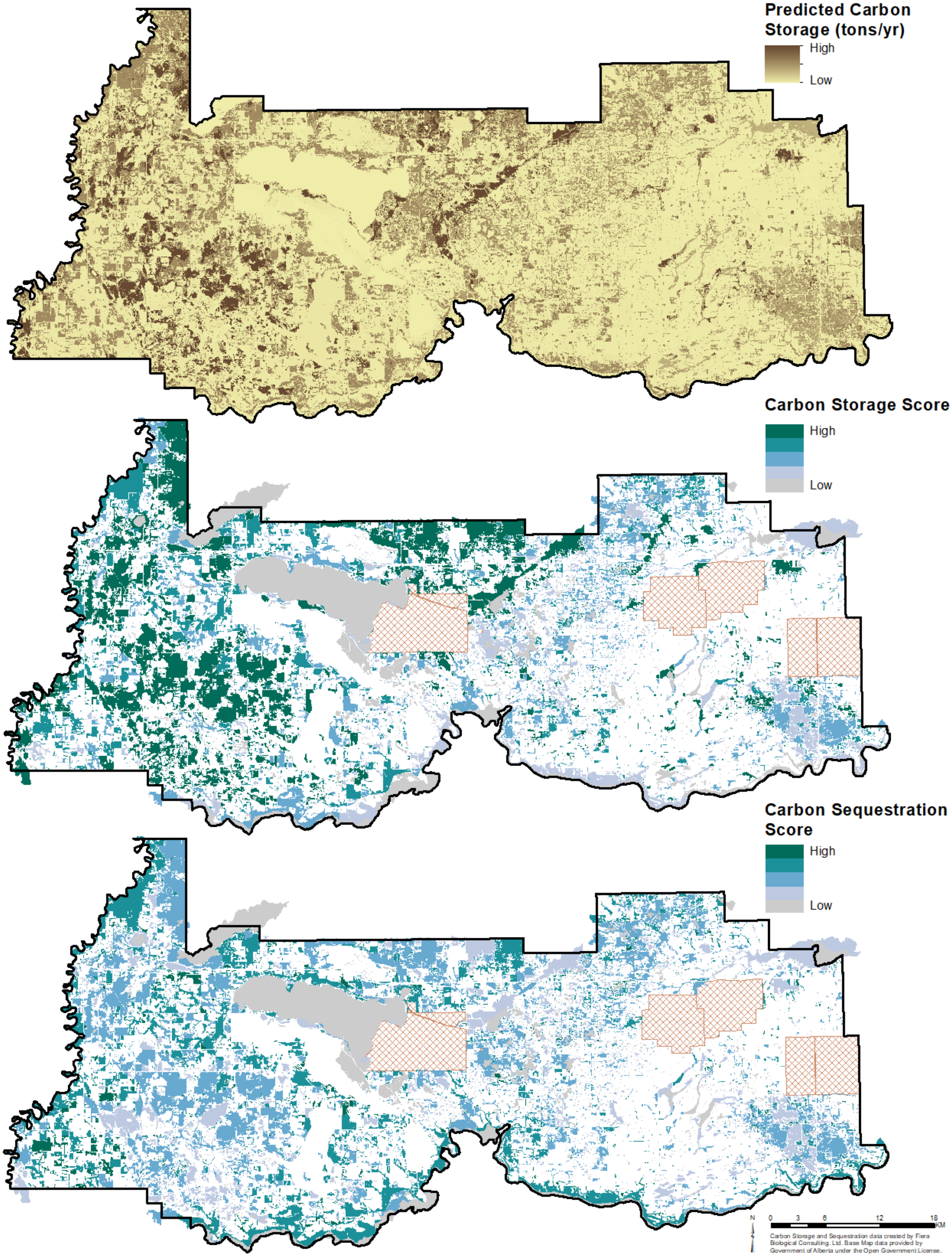


Figure 11. Predicted carbon storage (top) and corresponding carbon storage score (middle) modelled using the InVEST Carbon Storage model, and carbon sequestration score (bottom) estimated from carbon sequestration rates applied to land cover classes for natural assets in Parkland County. Assets with higher scores contribute more to atmospheric regulation than those with lower scores.

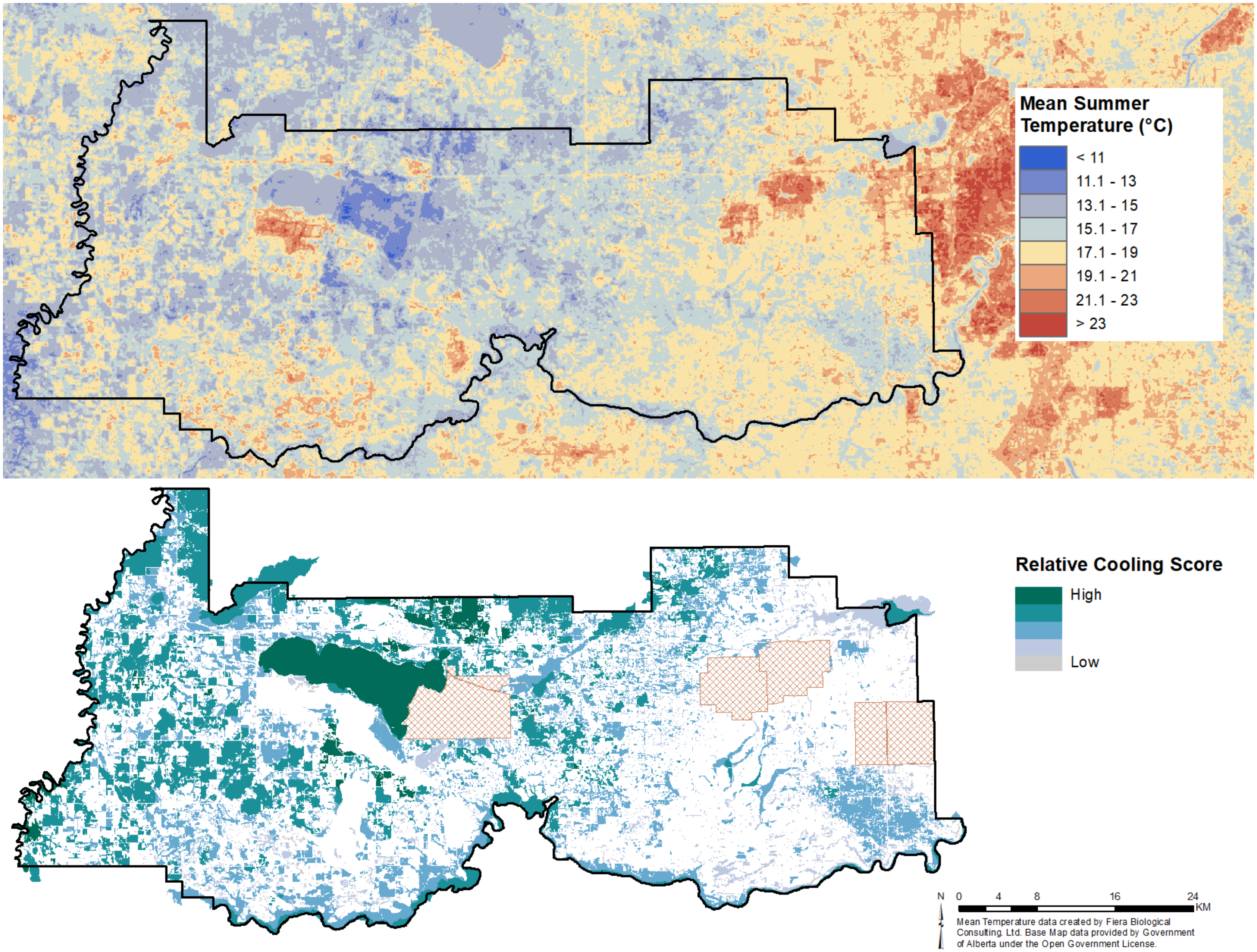


Figure 12. Average (mean) summer temperature calculated between 2014 and 2024 using Landsat imagery (top) and relative cooling score of natural assets in Parkland County. Assets with higher relative cooling scores have a higher cooling potential than assets with lower scores.

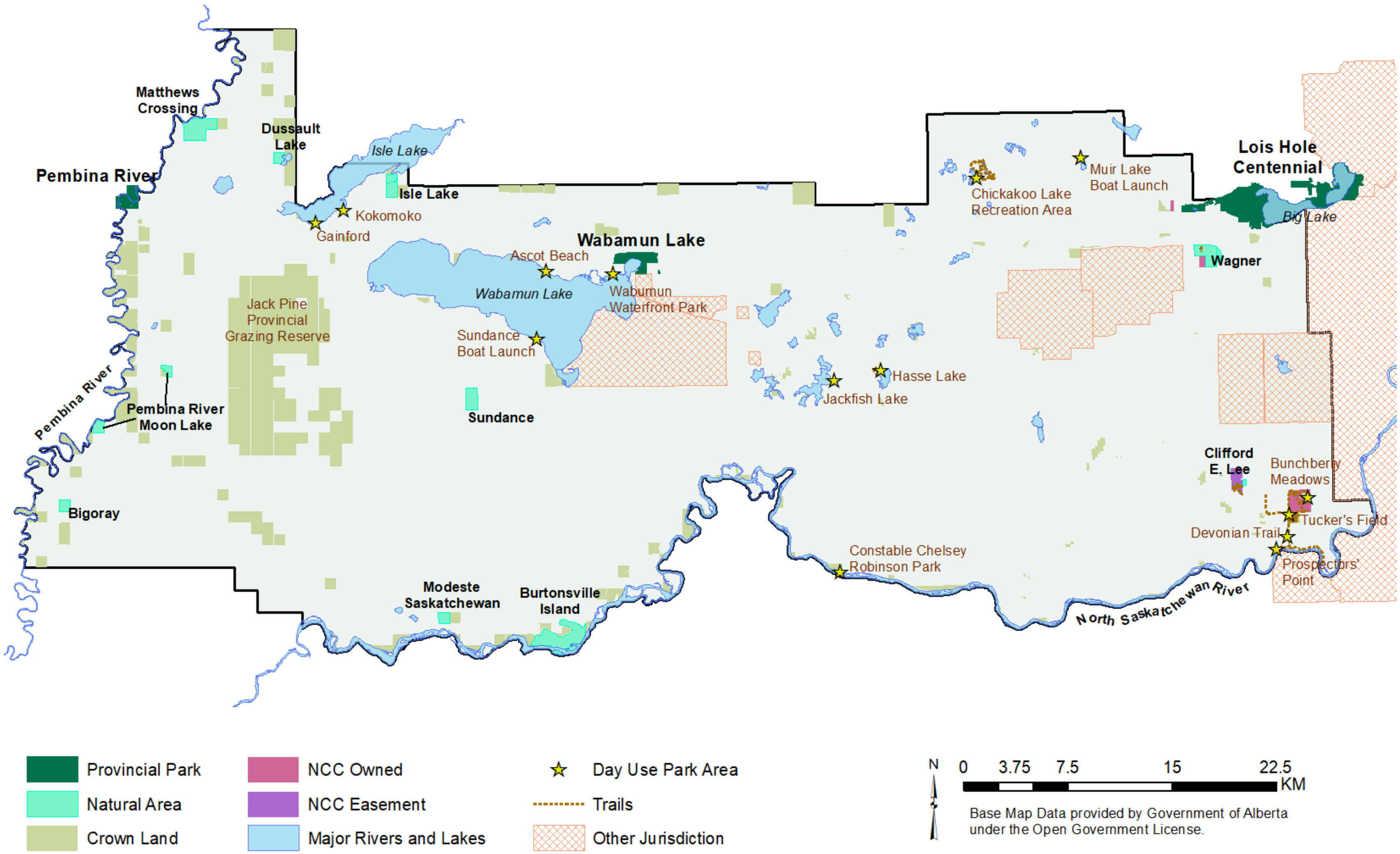


Figure 13. Areas within Parkland County that support nature-based recreation opportunities.

4.0 Ecosystem Service Valuations

The total estimated value of the ecosystem services evaluated in Parkland County is **$4.0 billion**[3] (Table 11). This includes estimates for:

- Control of Soil Erosion,
- Water Flow Regulation,
- Atmospheric Regulation, and
- Nature-based Recreation.

Quantitative values specific to Water Flow Regulation and Temperature Regulation services were not estimated individually; instead, these values are discussed in the context of carbon sequestration values as they relate to the social cost of carbon. A detailed overview of the valuation of each ecosystem service assessed in this study is provided below. For ecosystem services that provide a stream of benefits into the future (e.g., annual benefit transfer values), a present value estimate was calculated assuming a 50-year period and a discount rate of 3% (Treasury Board of Canada Secretariat 2019). For more information regarding how present values were calculated, see Appendix B.

Table 11. Monetary estimates and confidence level associated with ecosystem services evaluated in Parkland County.

Ecosystem Service	Monetary Estimate ($2023)	Confidence in Estimate
Control of Soil Erosion	$12 million	
Water Flow Regulation	*Captured in Atmospheric Regulation Service*	-
Water Quality Regulation	$60 million	
Atmospheric Regulation	$2.9 billion	
Temperature Regulation	*Captured in Atmospheric Regulation Service*	--
Nature-based Recreation	$1 billion	
Total Quantified Monetary Estimate	**$4.0 billion**	

Notes:

	Some assumptions or estimation was used to derive estimate, but the value is considered uncontroversial.
	Some assumptions or estimation was used to derive estimate, which may be open to question. Accuracy of estimate is better than +/- 50%.
	Estimates are in the right order of magnitude. Order of magnitude implies that for an estimate of 5 the real value is within the range of 0.5 to 50.
--	A value that is in the right order of magnitude cannot be estimated. This is due to the unquantifiable uncertainty in the science, valuation, or the relationship between them. What is understood can only be discussed qualitatively.

[3] All values are CAD $2023 unless otherwise stated.

4.1. Control of Soil Erosion

Vegetative land cover plays an important role in controlling and retaining sediment, supporting the preservation of topsoil and minimizing sediment pollution into watercourses. The monetary value of soil erosion control has been estimated in several studies in Canada, primarily through avoided cost estimation as opposed to stated or revealed preferences. For example, Olewiler (2004) estimated the value of natural areas in agricultural regions in Canada, including the Upper Assiniboine River Basin located along the Saskatchewan-Manitoba border. In this case study, Olewiler (2004) estimated that natural areas provide a benefit of between roughly $2 and $14 per hectare per year in avoided sediment removal in watercourses. This estimate was based on avoided costs of sediment removal through water treatment. The author presents a "best estimate" of roughly $7 per hectare per year. More recently, Aziz (2018) developed estimates of sediment removal benefits associated with various land cover types in the Grand River watershed in Ontario. In this study, the author estimated the value of sediment filtration through an avoided cost method, resulting in a range of roughly $110 and $180 per hectare per year depending on the land cover type, much higher than the Olewiler (2004) estimate range.

A robust avoided cost estimate of sediment removal benefits from natural assets in the County would require detailed information regarding the sediment control rates of various land cover types and the extent to which this sediment control helps keep sediment concentrations below acceptable limits in the Region's treated water. If that information were available, EPCOR's overstrength surcharge rate for sediment removal could be applied to estimate the erosion control benefits from natural assets in the County (EPCOR 2025).

Due to a lack of available data regarding sediment control rates and resulting impacts on sediment concentration in treated water in the Region, the monetary value of soil erosion control in the County was estimated using a benefit transfer value from Olewiler (2004), specifically the "best estimate" value of $7 per hectare per year. This benefit transfer value was selected over the more recent Aziz (2018) estimate as the Olewiler (2004) case study was completed in a more comparable region to the County as compared to Aziz (2018) and provides a more conservative value estimate. We apply this value to all woody, grassland, and wetland land cover in the County. Because the benefit transfer value used for erosion control rates is an annual value, the valuation of erosion control was estimated as the present value over a 50-year time period.[4] In total, the present value of these benefits equals roughly $133 per hectare. Given that there are almost 90,000 hectares of woody, grassland, and wetland area in the County, the estimated value of erosion control associated with this land cover is **$12 million**.

The Study Team assigns a confidence rating of "medium" to the control of erosion rates monetary estimate. While this estimate does not represent a WTP for soil erosion prevention by stakeholders, the Study Team is confident of Olewiler's (2004) estimate of the avoided costs of sediment removal in watercourses and the applicability to the County context, and thus believe this estimate provides the County with useful information regarding the value of this ecosystem service.

[4] For ecosystem services that provide a stream of benefits into the future (e.g., annual benefit transfer values), a present value estimate was calculated assuming a 50-year time period and a discount rate of 3% (Treasury Board of Canada Secretariat 2019). For more information regarding how present values were calculated, see Appendix A.

4.2. Water Flow Regulation

When quantifying the value of water flow regulation (i.e., flood mitigation) provided by natural or man-made infrastructure, the most common approach is to estimate the value of flood damages that are avoided because of natural or man-made infrastructure. Economists will typically estimate an annualized value of total potential damages (including both market and non-market damages) from a variety of cost events. These damages are typically estimated using modelling data that describe the spatial extent of flooding, and this information is used to create an Average Annual Damages (AAD) curve for flood events under consideration. Damages estimated in this type of analysis include:

- **Market Damages:**
    - **Direct Damages –** Including damages to residential, industrial, and institutional structures and contents, as well as infrastructure damages.
    - **Indirect Damages –** Including other market costs associated with flooding such as residential/commercial displacement, business disruption, traffic delays, cleanup, etc.
- **Intangible Damages**: Including non-market damages such as loss of ecosystem goods and services and mental health impacts associated with flood events.

For example, Moudrak et al. (2017) used hydrologic and hydraulic modelling that included an analysis of flood extents and flood depths for a range of precipitation events (2-year, 5-year, 10-year, 25-year, 50-year, and 100-year) for different regions in Ontario under various wetland loss scenarios. These flood extents were then analyzed in a GIS model to assess the number and types of buildings that would be inundated under each scenario, which then informed an estimate of the total value of annual flood damages with and without wetlands. A similar approach could be taken to estimate the flood mitigation value that natural assets provide to the County. For example, scenario modelling could include an evaluation of different rates of natural asset loss and/or restoration, as well as an examination of how the spatial configuration of natural asset loss or restoration (e.g., headwater wetlands versus riverine wetlands) may impact model outputs. However, detailed hydrologic modelling and economic valuation of market and non-market values are required (see Clare et al. 2021 for an example of how such as study could be conducted and the data sources required).

In the absence of detailed hydrologic and avoided flood damage data, the flood mitigation value of natural assets in the County cannot be robustly measured. However, the valuation of carbon sequestration provided by natural assets in the County described in Section 4.2.4. below provides key insights into the potential value associated with flood mitigation provided by natural assets as it relates to climate change. Indeed, the social cost of greenhouse gas emissions published by Environment and Climate Change Canada (ECCC) includes estimated damages associated with various climate change-related impacts, including property damage from increased flood risk. As a result, the carbon sequestration value estimated for the County in Section 4.2.4. incorporates flood mitigation provided by natural assets due to climate change-related events.

4.3. Water Quality Regulation

Vegetative land cover supports water quality in the County through the filtration of contaminants such as phosphorous. The monetary value of water quality services provided by natural assets as they relate to phosphorous removal has been estimated in several studies in Canada through avoided cost estimation, including Olewiler (2004) and Aziz (2018). Olewiler (2004) estimated that natural areas in the Grand River watershed (Ontario) provide a benefit of between roughly $4 and $67 per hectare per year in avoided costs of phosphorous removal through water treatment. The author presents a “best estimate” of roughly $35 per hectare per year. In Aziz (2018), phosphorous removal benefits were estimated for various land cover types in in the Grand River watershed, providing a range of roughly $1 to $13 per hectare per year.

Similar to the benefits of sediment removal from natural assets described above, a robust avoided cost estimate of phosphorous removal benefits from natural assets in the County would require detailed information regarding the phosphorous control rates of various land cover types and the extent to which this water quality control helps keep phosphorous concentrations below acceptable limits in the Region’s treated water. If that information were available, EPCOR's overstrength surcharge rate for phosphorous removal could be applied to estimate the water quality benefits from natural assets in the County (EPCOR 2025).

Due to a lack of available data regarding phosphorous control rates and resulting impacts on phosphorous concentration in treated water in the Region, the monetary value of water quality regulation in the County was estimated using a benefit transfer value from Olewiler (2004), specifically the "best estimate" value of $35 per hectare per year. Similar to Aziz (2018), the Olewiler (2004) benefit transfer value comes from a case study in the Grand River watershed and was selected over the Aziz (2018) estimate as it is a greater unit value than the $7 per hectare per year unit value for sediment removal from Olewiler (2004) used in Section 4.2.1 above. This is consistent with EPCOR's posted overstrength surcharge rates for phosphorous (total phosphorous) and sediment (total suspended solids), which suggests that phosphorous is costlier to remove as compared to sediment. This value was applied to all woody, grassland, and wetland land cover in the County. Over a 50-year period, the present value of these benefits equals roughly $676 per hectare. Given that there are almost 90,000 hectares of woody, grassland, and wetland area in the County, the estimated value of water quality regulation associated with this land cover is **$60 million**.

The Study Team assigns a confidence rating of "medium" to the water quality regulation monetary estimate. While this estimate does not represent a WTP for water quality regulation by stakeholders, the Study Team is confident of Olewiler's (2004) estimate of the avoided costs of phosphorous removal in watercourses, and thus believe this estimate provides the County with useful information regarding the value of this ecosystem service.

4.4. Atmospheric Regulation

Natural assets in the County provide important climate regulation services through carbon storage and sequestration. Forest ecosystems in particular store large amounts of carbon, and the County hosts over 50,000 hectares of woody land cover (almost half of the evaluated area). The estimated monetary value of climate regulation services in the County focuses on carbon sequestration. Carbon storage, while an important ecosystem service, is difficult to monetize as the extent to which stored carbon could/would be lost through natural asset loss is unclear. For example, development of a forested area that involves removal of timber does not necessarily result in a loss of stored carbon in the timber stock.

One of the most common methods for estimating the monetary value of carbon sequestration from natural assets is by using ECCC's suggested Social Cost of Greenhouse Gas (SC-GHG) emissions (Government of Canada 2024). In the published SC-GHGs, ECCC provides an estimated value for the social cost of CO_2 equivalent (SC-CO_2e); this value captures the estimated damages from various climate change impacts including, but not limited to changes in net agricultural productivity, human health effects, property damage from increased flood risk, disruption of energy systems, and the value of ecosystem services (Government of Canada 2024). According to the cost schedule provided by ECCC, the SC-CO_2e in 2025 is an estimated $301 per tonne CO_2e in $2023. This value is expected to increase gradually over time as climate change damages become incrementally larger and economic wealth grows, rising to about $550 per tonne CO_2e by 2074.

Because carbon sequestration represents an annual service, the valuation of carbon sequestration provided by natural assets in the County was estimated as the present value over a 50-year time period. In total, the present value of these benefits range between $3,700 per hectare for open water and $41,400 per hectare for woody areas.

Table 12. Carbon sequestration valuation by land cover class, 50-year present value

Land cover class	Carbon Sequestration Value ($/ha)
Open Water	$3,700
Grassland	$6,200
Wetland	$18,200
Woody	$41,400

In total, the estimated value of carbon sequestration associated with natural assets in the County is **$2.9 billion**.

A confidence rating of "medium" has been assigned to the carbon sequestration monetary estimate. While this estimate does not represent a WTP measure for climate regulation services by County stakeholders, the Study Team is confident in ECCC's updated SC-CO_2e estimate in the Canadian context, and thus believe this estimate provides the County with useful information regarding the value of this ecosystem service.

4.5. Temperature Regulation

Natural assets in the County can provide important cooling effects, particularly larger assets with open water and woody land cover. Extreme heat events are often a concern for urban areas, where the Urban Heat Island (UHI) effect can have significant economic and health impacts in a densely populated community. However, rural communities also face risks associated with extreme heat. In recent research published by Liang and Kosatsky (2020), the authors asserted that mortality increases during high temperature weather in both rural and urban settings. Furthermore, rural communities may host microzones with high heat retention in areas where there is limited tree cover (Liang and Kosatsky 2020). This phenomenon may exist in the County where residential buildings are in close proximity to open agricultural lands with minimal shade. Older demographics are also relatively more susceptible to health-related impacts associated with high temperatures (Liang and Kosatsky 2020). Parkland County hosts a population of over 32,000 with a median age of over 45 years, relatively higher than the provincial median of 38 years, making temperature-related health issues a potential concern.

While the value associated with heat regulation in urban communities has been studied (e.g., Rogers et al. 2018, Tapper et al. 2019, Whiteoak and Saiger 2019), rural communities have not been a focus of this area of research. As such, there is insufficient data to robustly estimate the value of temperature regulation that natural assets provide in the County. However, arguably the biggest threat to heat regulation in the County (and other Canadian communities) is climate change. The valuation of carbon sequestration provided by natural assets in the County described in Section 4.4. above therefore provides key insights into the potential value associated with temperature regulation provided by natural assets as it relates to climate change. The social cost of greenhouse gas emissions published by ECCC includes estimated damages associated with various climate change-related impacts, including human health effects from increasing temperature. As a result, the carbon sequestration value estimated for the County in Section 4.4. incorporates temperature regulation provided by natural assets due to climate change-related events.

4.6. Nature-based Recreation

The County hosts a variety of natural assets that support nature-based recreation opportunities, such as:

- birding,
- cycling,
- walking/hiking, and
- water-related activities (e.g., boating, fishing, etc.).

The economic value of nature-based recreation opportunities in the County is difficult to estimate, as primary data regarding visitation frequency and associated welfare or market proxy measures (e.g., travel cost data) are not available. However, the economic value of nature-based recreation elsewhere in Alberta and Canada has been studied extensively. For example, work by Boxall et al. (1996a) sought to estimate the value of recreational moose hunting in Alberta. Further work by Boxall et al. (1996b) relied on travel-cost modelling to estimate the value of camping near Alberta's Rocky-Clearwater Forest. In 2000, Haener and Adamowicz conducted a valuation study of both commercial and non-market activities (including recreational fishing, hunting, and camping) in an area of boreal forest in northeastern Alberta. More recently, several studies have undertaken valuation modelling to produce welfare estimates of a variety of outdoor recreation activities in Alberta (e.g., Lloyd-Smith and Becker 2020; Lloyd-Smith 2021; Spence et al. 2023).

Indeed, the most recent and relevant study is Spence et al. (2023). In this study the authors rely on a large, comprehensive survey of Canadians focusing on their participation in a wide variety of nature-based activities. The survey included over 24,000 responses of those aged 18 and over and estimated the average annual welfare value per person for various nature-based recreation activities (Table 13). To estimate the value of nature-based recreation in the County, the Study Team identified activities valued in Spence et al. (2023) that are available in the County (see Table 13). In total, these activities are estimated to provide benefits of roughly $3,800 per person per year.

The total monetary estimate of nature-based recreation in the County was made using the following assumptions,

- County residents participate in roughly 50% of their nature-based recreation in a given year within natural assets in the County, acquiring roughly $1,900 per person per year in value from nature-based recreation within the County.[5] Over a 50-year period, the present value of these benefits equals roughly $36,000 per person.
- Approximately 88% of individuals residing in the County participate in outdoor activities (the County's 2017 Parks, Recreation and Culture Master Plan (Parkland County 2017) states that approximately 88% of households in the County participate in outdoor activities; we assume this proportion holds at an individual level).

Note that the valuation of nature-based recreation from natural assets in the County is focused on County residents. In reality, many of the natural assets in the County provide value to residents of other neighbouring jurisdictions as well. For instance, there are 13 Provincial Parks, Natural Areas, or Day Use Park Areas in the County that are within 50 km of Edmonton, St. Albert, and Devon, and 20 Provincial Parks, Natural Areas, or Day Use Areas in the County within 50 km of Spruce Grove and Stony Plain.

Given that there are an estimated 32,205 residents in Parkland County (Statistics Canada 2021), we estimate the annual value of nature-based recreation in the County for County residents as being about **$1 billion**. Note that this valuation is not divisible across individual natural assets. As outlined in the literature cited above, non-market values for nature-based recreation are most often tied to households or

[5] Note that we acknowledge this assumption likely varies substantially depending on the activity. For example, residents within the County who are avid nature photographers likely travel outside of the County frequently for their photography, while avid gardeners likely acquire all their gardening welfare from their properties within the County.

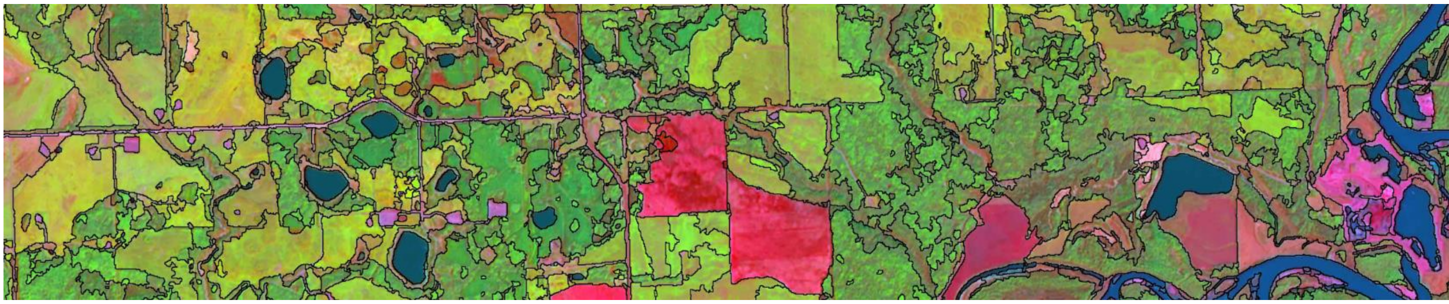
individuals who participate in those activities, and households or individuals can have recreation value for both publicly- and privately-owned natural assets. However, we can likely attribute much of the nature-based recreation value accruing to Parkland County residents to some of the more popular recreation sites in the County, such as Wabamun Lake Provincial Park and the Chickakoo Lake Recreation Area.

A confidence rating of "medium" has been assigned to the nature-based recreation monetary estimate. While this estimate does represent a welfare measure for nature-based recreation, the published literature from which a benefit transfer value was estimated was not specific to the County context. Furthermore, details regarding recreation area usage from those within and outside of the County were not available. As such, the Study Team is confident that this estimate provides the County with useful information regarding the value of this ecosystem service but may be conservative.

Table 13. Average annual benefits per person per year for various nature-based activities.

Activity	Value[a] ($/person/year)
Birding[b]	$392
Camping[b]	$84
Cycling[b]	$169
Fishing[b]	$234
Gardening[b]	$542
Golfing[c]	$195
Hiking[b]	$1,071
Hunting birds	$36
Hunting large animals	$94
Hunting other	$26
Hunting waterfowl	$32
Recreational motor vehicles[b]	$446
Photography[b]	$286
Cross-country skiing[b]	$51
Downhill skiing	$60
Motorized boating[b]	$277
Beach/non-motorized boating[b]	$217
All activities	**$4,276**
Activities available in Parkland County[b]	**$3,769**

Notes:
[a] Spence et al. 2023 specifically estimate welfare values for various demographic sub-groups including "Indigenous", "Immigrant", and "Neither". The welfare values presented in this table and used in the recreation valuation for the County are for the "Neither" sub-group, which included values that were predominantly in between the "Indigenous" and "Immigrant" sub-group values.
[b] Denotes activities assumed to be available through nature-based recreation in the County.
[c] While there are golfing opportunities in the County, golf courses were not included in the natural asset inventory.



5.0 Gaps, Uncertainties & Limitations

5.1. Other Ecosystem Services of Interest

This assessment focused on a short list of priority ecosystem services that could be reliably assessed as part of this study. The complete list of ecosystem services produced by natural assets in Parkland County is extensive and includes dozens of provisioning, regulation and maintenance, and cultural services that could not be assessed due to time, cost, and data limitations. While not an exhaustive list, Table 14 provides additional examples of ecosystem services that are produced by natural assets in Parkland County. Despite not being included in this study, these services, in addition to many others, provide important benefits that was not captured in the overall estimate of monetary value calculated as part of this study.

Table 14. Additional examples of ecosystem services that were not included in this study but are provided by natural assets in Parkland County.

ES Category	Ecosystem Service	Example of Ecosystem Good/Benefit to End-Users
Provisioning (Biotic)	Harvestable volumes of wild plants and animals	Food from wild plants (e.g., berries, fruits, mushrooms, etc.) and animals (e.g., moose, deer, ducks, grouse, etc.) for subsistence
Provisioning (Abiotic)	Surface and groundwater for drinking	Safe and secure potable water for human consumption
	Surface and groundwater for non-drinking purposes	Non-potable water for use in agriculture (irrigation, animal rearing) or industrial processes
Regulation & Maintenance (Biotic)	Pollination and seed dispersal by insects and animals	Germination and/or pollination of wild and cultivated plants that can be consumed (e.g., berries) or made into other products (e.g., canola oil)
	Fire regulation	Reduction in the incidence, intensity, or speed of spread of fire (e.g., wetlands and lakes acting as fire breaks)
	Air quality regulation	Reduction of harmful air pollutants/improved air quality due to filtering by trees and other vegetation
Cultural (Biotic)	Personal connection to a rural way of life and rural livelihood	Cultural identity and social cohesion

5.2. Regional & Intermunicipal Assets

While the scope of this study was limited to the current boundaries of Parkland County, several of the natural assets identified by the inventory either physically extend outside the County or they are significant components of a larger local or regional network of natural assets.

For example, the North Saskatchewan and Pembina Rivers are important local and regional natural assets that provide significant ecosystem services, such as water flow regulation, water quality control, water provision, and habitat provision not only to residents who live within the County, but to communities located upstream and downstream of the County. Further, the ecosystem services supplied by transboundary assets such as Big Lake flow to end-users in multiple jurisdictions (Parkland County, St. Albert, Edmonton), and Parkland County also shares natural assets with First Nations and other local municipalities located within the County (e.g., Spruce Grove, Stony Plain, etc.). Consequently, the County has an obligation to carefully manage locally and regionally significant assets within their jurisdictional boundaries, as do neighbouring municipalities with shared or ecologically linked assets. Thus, regional and intermunicipal cooperation is essential in the identification and management of natural assets that provide ecosystem services at a larger scale. Given this, regional planning and intermunicipal development plans are important tools for advancing the management of shared natural assets.

The County currently has Intermunicipal Development Plans (IDPs) with Brazeau County (Bylaw 2018-13), Lac Ste. Anne County (Bylaw 2018-19), and Yellowhead County (Bylaw 2018-18), and these plans address the management of shared environmental resources at a high level. Now that Parkland County has a detailed natural asset inventory, the County can work in collaboration with neighbouring municipalities to identify and manage key natural assets that extend across boundaries. Additionally, the County has IDPs with the communities of Betula Beach, Seba Beach, Spring Lake, and Wabamun. These smaller communities can play an important role in helping to co-manage the natural assets that overlap their jurisdictions.

Following the dissolution of the Edmonton Metropolitan Region Board (EMRB) in Spring 2025, coordination on natural asset management between individual municipalities will be more important than ever. Parkland County has an opportunity to reach out to neighbouring municipalities and use its natural asset inventory and ecosystem service assessment as both an example and a foundation for the identification and management of intermunicipal natural assets.

5.3. Willingness to Pay for Ecosystem Service

As mentioned earlier, monetary values for several ecosystem services were based on valuation techniques that do not represent WTP values. To this end, the County could benefit from undertaking additional revealed preference or stated preference work to acquire primary willingness to pay data for their top assets or assets they believe to be at particular risk of loss or degradation.

A potential revealed preference study that could support the County in acquiring primary natural asset valuation data would be a hedonic analysis of residential property values. Hedonic models of property values involve using real estate market data (i.e., housing prices) to isolate the various components of residential property prices including house characteristics (e.g., number of bedrooms, square footage, specific finishes), neighbourhood characteristics (e.g., school proximity, crime rates), and environmental characteristics (e.g., proximity to green space, desirable views). Using these data one can estimate the marginal WTP for environmental attributes and certain natural or semi-natural assets.

Stated preference work is also an option for the County to acquire robust primary natural asset valuation data. While the theory behind stated preference surveys and WTP estimation is relatively simple, conducting these studies in practice presents many challenges. Stated preference surveys require careful and thoughtful design to avoid allowing respondents to introduce various biases into the results including, but not limited to:

- Strategic bias, which occurs when respondents provide biased answers to influence a desired outcome.
- Information bias, which occurs when respondents must value attributes or assets with which they have limited experience or understanding.
- Hypothetical bias, which occurs when respondents feel there are no real-world outcomes associated with their responses, and thus, treat the survey casually instead of providing thoughtful responses.

These types of biases, and others that can occur in stated preference studies, can lead to substantially over- or under-estimated ecosystem values, leading to potentially costly municipal policy mistakes. As such, any future stated preference work conducted for the County should include expert survey design and implementation.

5.4. Study Limitations

While the natural asset inventory and the associated estimates of ecosystem service values for the County were developed following standard best practices, readers are asked to consider the following points as they interpret the results of this study:

- Natural assets were identified and mapped using air photographs and satellite imagery, the most recent of which was 2023. As a result, the location, size, and boundaries of the natural assets included in the inventory may not accurately reflect the status and/or presence of these features at present day. Further, the natural assets mapped in this assessment were not field verified, and so the spatial accuracy of boundaries for some of the assets, and particularly for wetlands, may not accurately reflect the actual ecological boundaries. Because of this, area estimates for each asset likely have some degree of spatial error associated with them.
- Natural assets were assigned a condition score using metrics that could be assessed in a geographic information system (GIS). As a result, the condition scores are not reflective of characteristics that must be assessed in the field (e.g., presence of invasive or weedy species). Conditions scores are generally reflective of impacts that may be influencing the ecological function of an asset but should not be considered a definitive assessment on the current ecological state of these assets.
- Estimates of ecosystem service values assume that the underlying function of the natural asset has not been substantially impaired and the assets have sufficient function to deliver the ecosystem services that are being valued. Land development that causes change to ecosystem function can lead to a decrease in the supply and flow of some ecosystem services (e.g., water quality control), but may also lead to an increase in the supply of other ecosystem services (e.g., aesthetic or recreational value). The estimates of ecosystem service value presented in this study do not account for the influence of condition on the current supply of ecosystem services.
- Natural assets provide a wide range of ecosystem services and not all services and their associated values could be evaluated in this study. Because of this, the economic value calculated for some assets may not reflect the true value of the asset.
- Collecting primary data for ecosystem service valuation was outside the scope of this study. The Study Team relied on estimates from other studies that may not be entirely representative of the ecosystem service values in the County. Furthermore, like market goods, the values of non-market ecosystem services are not necessarily static in nature. For example, as a natural asset becomes scarcer, the value of the asset will likely increase. Additionally, welfare estimates are known to change across income levels (those with higher incomes may be willing to pay more for natural assets than those with lower incomes). Because primary data were not collected in this study, the estimates provided are not sensitive to these nuances, and as such, should be considered estimates only with an acknowledgement that there are gaps in our knowledge of and ability to assess the monetary value of ecosystem services.

6.0 Recommendations

The development of a natural asset inventory is a huge accomplishment for any jurisdiction, but it is just the first step of many in managing and leveraging the value of these important resources into the future. Traditional engineered or built assets, such as sidewalks, sewers, and stormwater facilities are managed in well-established asset management systems that track their role and monitor monetary and physical depreciation over time; however, how natural assets fit into these existing systems, what information they are attributed with, and how to leverage this information is still a developing field. While there are still questions related to how to incorporate natural assets into traditional asset management systems, there is general agreement that doing so allows for better integration of natural assets into land use and development planning, infrastructure servicing, operations and maintenance, and budgeting and financial planning (Brown et al. 2019).

The goal of any asset management system is sustainable service delivery and there are three major steps in the process of integrating natural assets into an asset management framework: Assess, Plan, and Implement (Brown et al. 2019; Figure 14). Now that natural assets in Parkland County have been mapped and the current state is known, the planning phase starts, whereby policies and strategies are defined to ensure natural assets are formally built into decision-making procedures and made part of the operational and political dialogue by which the County is held to account (Sunderland et al. 2023). In the absence of strong policies and plans, it would be challenging for the County to implement actions centered on natural assets given the need for cooperation and integration of knowledge between people working across sectors and operating in different contexts (Albert et al. 2019).

Importantly, natural assets and engineered assets are different, and because of this, asset management systems should not treat them in the same way. For example, natural assets do not depreciate the way that engineered assets do, and in fact, many natural assets can appreciate over time. This, alongside other differences between engineered and natural assets, needs to be acknowledged for successful integration.

The aim of integrating natural assets into an asset management system should be to ensure that *relevant* information about natural assets is included, such that this information can be included in evaluations of trade-offs between service, costs, and risk (Brown et al. 2019). Further, if natural assets are not properly managed, the essential services provided by the assets may be lost, leading to increased costs and/or risks to the environment and human health. For example, groundwater sources can become contaminated leading to the loss of clean and safe drinking water, or wetlands can be drained leading to an increase in the frequency and severity of downstream flooding. This highlights the importance of properly accounting for and managing natural assets, the ecosystem services they produce, and the benefits they provide to end users in the municipality.

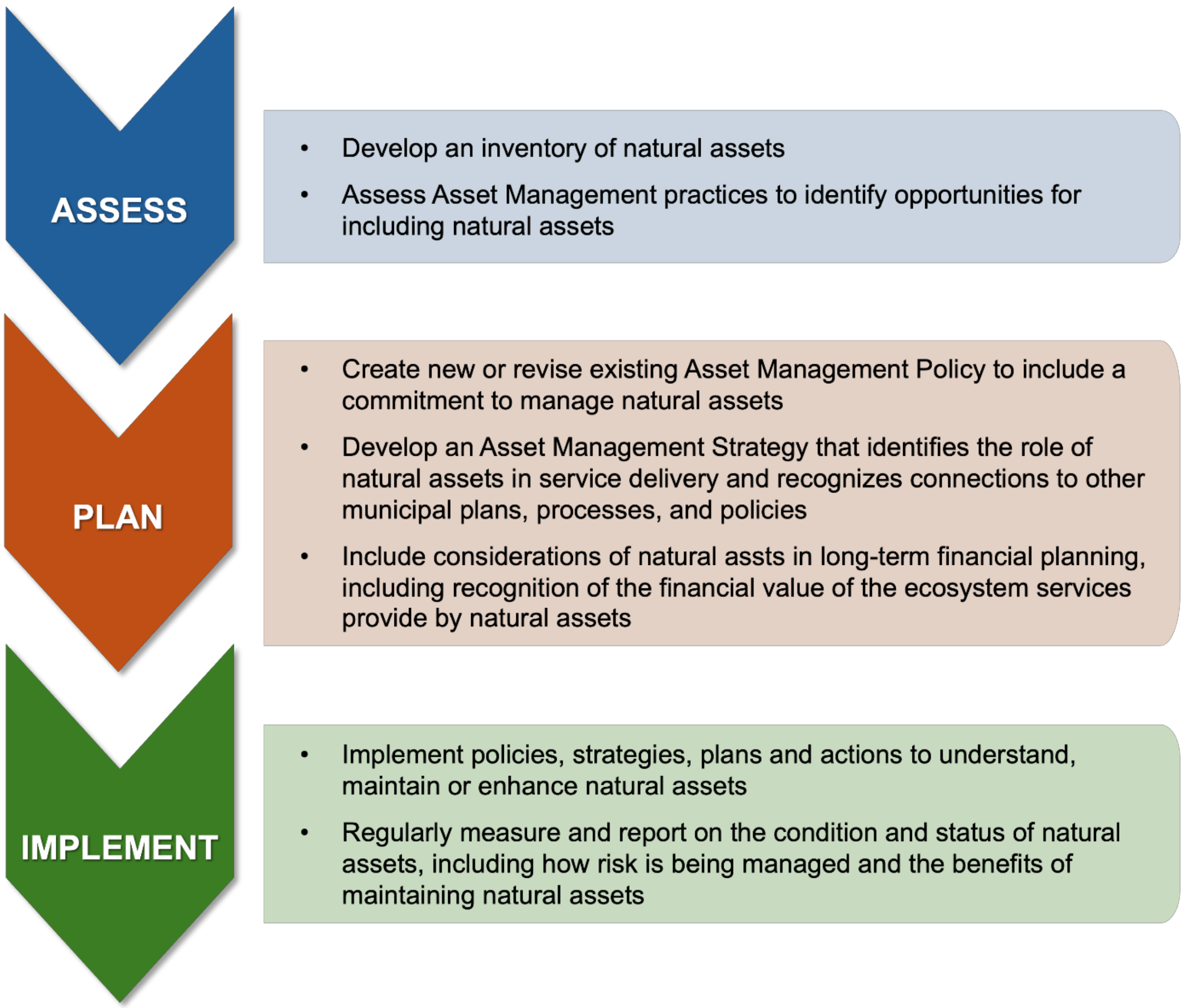


Figure 14. Major steps and actions required for successful integration of natural assets into an asset management system (adapted from Brown et al. 2019).

The amendment of existing asset management policies or the creation of a new asset management policy can provide important foundational guidance for municipal staff when making decisions about how to include natural assets in asset management practices. Policies that recognize and formalize the role of natural assets in the delivery of services and reflect the commitment to include natural assets in the overall asset management process is essential. Additionally, an asset management strategy should be developed to identify what the priorities and focus areas are with regards to including natural assets and their attributes in the asset management system. This can include providing context regarding the specific role(s) of natural assets in the delivery of services and the connections to other municipal plans, processes, and policies. The strategy should also include clear definitions and should identify the ecological benefits and co-benefits, as well as the human well-being co-benefits provided by natural assets (Albert et al. 2019). Clearly communicating the potential human benefits of natural assets can be particularly helpful in gaining support from and balancing the interests of diverse stakeholder groups. Finally, asset management plans and long-term financial plans can be implemented to document how natural assets are considered in the context of other assets. These plans can also identify and manage service delivery risks and the financial risks of not properly managing or considering natural assets.

One of the biggest challenges for any municipality is the management of natural assets that are not entirely located on municipally owned lands. Many of the natural assets in Parkland County are either located partially or fully on private or Crown land or are located across multiple jurisdictions. Additionally, many natural assets, such as lakes and wetlands, are managed under provincial policies (e.g., wetland policy) or regulations (e.g., *Water Act*), which gives municipalities limited power over how these assets are managed. Despite this, local governments can still understand and manage risks associated with the loss or degradation of natural assets in their jurisdiction. Additionally, municipalities can create policies or programs that incentivize desired management practices on private land, while also actively working with neighbouring jurisdictions to align management actions.

With over 9,000 natural assets identified within Parkland County, it can be overwhelming and difficult to know where to begin when it comes to developing management plans or prioritizing natural assets for conservation. Looking to existing plans, policies, and bylaws for guidance is a good starting place, as the County has many statutory documents that provide direction on how to manage natural assets. For example, the County's MDP embraces a "Conservation by Design" principle, whereby land subdivision incorporates consideration of economic, social, and environmental factors, including the identification of conservation areas (Parkland County 2025). Given this, the natural asset inventory could be used to identify natural assets that supply ecosystem services that are considered essential within the local subdivision area and/or at the County scale. For example, if flooding is a local issue, then natural assets with a high retained runoff score could be prioritized for conservation. Alternatively, if the County is interested in creating a carbon trading system, prioritizing natural assets with the greatest carbon sequestration potential for conservation may be the most desirable approach. These are just two examples of how the natural asset inventory can be used to inform land use decisions in the County.

7.0 Conclusion

The primary objective of this project was to create an inventory of natural assets in Parkland County and estimate the monetary value of priority ecosystem services that flow from these assets. This was done to provide a foundation for mapping and tracking the condition and status of natural assets over time, as well as to allow the County to better understand the economic and environmental trade-offs of land development.

A total of 9,473 natural assets covering 39% (or 1,079 km^2) of the County were identified and mapped as part of this study. Most (87%) of the natural assets in the County are <10 ha in size, with almost half (3,903) being 1 ha or smaller. There are also over 1,000 assets larger than 10 ha in size, representing large habitat patches that serve as core wildlife habitat at the local and regional scale. Together, this portfolio of natural assets represents a range of habitat types that support a diversity of wildlife and provide an important suite of ecosystem services.

Within the scope of this study, six priority ecosystem services were identified, including: Control of Soil Erosion, Water Flow Regulation, Water Quality Regulation, Atmospheric Regulation, Temperature Regulation, and Nature-based Recreation. Ecosystem service value estimates were derived for four of the services, totalling approximately $4.0 billion ($2023). This value was calculated as a present value over a 50-year period at a 3% discount rate.

This study provides Parkland County with information about the extent of natural assets and the value of a select number of ecosystem services that flow from these assets, which can be used to help inform land use management decisions consistent with existing County policies and bylaws.

7.1. Closure

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Appendix A: InVEST Model Inputs & Parameters

Control of Soil Erosion – InVEST Sediment Delivery Ratio (SDR) Model

Spatial Dataset	Source
DEM:	5 m created from County LiDAR data and the Provincial DEM
Land Cover:	5 m updated land cover created by Fiera Biological Consulting
Streams/Drainages:	Raster layer created using the Provincial stream hydroline layer and the County's Overland Drainage dataset

Parameter Values	Source
Soil Erodibility (K):	Gupta et al. (2024)
Erosivity:	Calculated using Mean Annual Precipitation (acquired from the ABMI) multiplied by 1.03 (Lombardi Method as described in InVEST guidance documentation)
USLE C:	All values derived from Woznicki et al. (2020) (see Table B1)
Borselli K Parameter:	default value of 2
Maximum SDR Value:	default value of 0.8
Borselli IC0 Parameter:	default value of 0.5
Maximum L Value:	default value of 122
Threshold Flow Accumulation:	value of 100,000 used to override the InVEST stream layer and use the derived Streams/Drainages layer

Table A1. USLE C and USLE P values used in the InVEST SDR Model for Parkland County.

Land Cover Class	USLE C	USLE P
Coniferous/Deciduous	0.002	1
Shrub	0.01	1
Marsh/Swamp/Graminoid Fen/Woody Fen/Bog	0.001	1
Grassland	0.01	1
Natural Bare Ground	0.29	1
Open Water	0	1
Human Built/Exposed/Roads	0.88	1
Cropland	0.31	1
Pasture	0.21	1
Disturbed Vegetation	0.3	1

Water Flow Regulation – Urban Flood Risk Mitigation Model

Spatial Dataset	Source
Soil Hydrologic Groups:	Agrisid Soil Information cross-referenced to soil hydrologic group information
Land Cover:	5 m updated land cover created by Fiera Biological Consulting

Parameter Values	Source
Curve Numbers:	US Army Corps of Engineers Hydrologic Engineering Center look up tables (see Table B2)
Rainfall Depth:	Value of 100 mm, as determined in consultation with Parkland County

Table A2. Curve number data used in the InVEST Urban Flood Risk Mitigation model for Parkland County.

Land Cover Class	CN A	CN B	CN C	CN D
Coniferous	36	60	73	79
Deciduous	36	60	73	79
Shrub	35	56	70	77
Marsh/Graminoid Fen/ Swamp/Woody Fen/Bog	1	1	1	1
Grassland	49	69	79	84
Natural Bare Ground	77	86	91	94
Open Water	1	1	1	1
Human Built/Exposed	98	98	98	98
Roads	89	92	94	95
Cropland	63	75	83	87
Pasture	49	69	79	84
Disturbed Vegetation	49	69	79	84

Water Quality Regulation – Nutrient Delivery Ratio (NDR) Model

Spatial Dataset	Source
DEM:	5 m created from County LiDAR data and the Provincial DEM
Land Cover:	5 m updated land cover created by Fiera Biological Consulting
Mean Annual Precipitation:	ABMI

Parameter Values	Source
Nutrient Load Values for N & P:	Wetland values derived from Han et al. (2021); all other values derived from Donahue (2013) (see Table B3)
Borselli K Parameter:	default value of 2
Subsurface Maximum Retention Efficiency:	default value of 0.8
Subsurface Critical Length:	default value of 200
Threshold Flow Accumulation:	default value of 5000

Table A3. Nutrient Load and nutrient retention efficiency values for N and P used in the InVEST NDR model for Parkland County.

Land Cover Class	Load N	Eff N	Load P	Eff P
Coniferous	1.875	0.7	0.048	0.7
Deciduous	2.36	0.7	0.219	0.7
Shrub	2.07	0.6	0.373	0.6
Marsh/Graminoid Fen	3.9	0.72	0.25	0.35
Swamp/Woody Fen/Bog	7.3	0.85	0.25	0.38
Grassland	0.194	0.54	0.042	0.7
Natural Bare Ground	2.95	0.3	0.219	0.24
Open Water	2.2	0.1	0.1	0.69
Human Built/Exposed	6.417	0.08	0.797	0.24
Roads	43.916	0	1.404	0
Cropland	9.348	0.15	2.013	0.15
Pasture	6.532	0.45	1.142	0.8
Disturbed Vegetation	1.412	0.3	0.117	0.24

Atmospheric Regulation – Carbon Storage Model

Spatial Dataset	Source
Land Cover:	5 m updated land cover created by Fiera Biological Consulting

Parameter Values	Source
Carbon Pool Values:	Wetland values were acquired from two sources: aboveground carbon was determined from Goyette et al. (2024) and belowground carbon was determined from DUC (2017). Values for all other land cover classes were taken from InVEST example data, which is based on values provided by the IPCC (2006) (see Table B4)

Table A4. Carbon pool values used in the InVEST Carbon Storage and Sequestration Model for Parkland County.

Land Cover Class	C Above	C Below	C Soil	C Dead
Coniferous	200	130	130	65
Deciduous	200	130	130	65
Shrub	8	8	25	3
Marsh	20	289	0	0
Graminoid Fen	20	1123	0	0
Swamp	95	289	0	0
Woody Fen	80	1123	0	0
Bog	80	1109	0	0
Grassland	6	6	20	2
Natural Bare Ground	0	0	0	0
Open Water	0	0	0	0
Human Built/Exposed	0	0	0	0
Roads	0	0	25	0
Cropland	3	2	10	0
Pasture	5	4	25	1
Disturbed Vegetation	1	1	10	0

Appendix B: Economic Calculations

Accounting for Inflation

In instances where monetary estimates were taken from older sources, nominal dollar values (i.e., the dollar value in the year it was estimated) were adjusted to real 2023 dollars to reflect the general change in prices over time (i.e., inflation). Inflation adjustments were done using Statistics Canada's average annual Consumer Price Index (CPI), a numeric indicator of consumer price changes in Canada (Statistics Canada 2024). The inflation adjustment formula is provided below:

$$Dollars\ in\ current\ period = Dollars\ in\ previous\ period \times \frac{CPI\ for\ current\ period}{CPI\ for\ previous\ period}$$

Discounting

For ecosystem service benefits that take place in the future, values need to be adjusted to account for economic time preferences. Economic time preference refers to the general preference for monetary benefits today as compared to benefits of equivalent value in the future. Discounting a future stream of benefits is done to make values fully comparable at a single point in time, in other words, to ensure all values are represented in Present Value (PV) terms. It is important to note that discounting does not imply that the value of the asset is diminishing over time. The act of discounting simply takes the stream of future benefits and adjusts it to account for economic time preferences. The formula for discounting a stream of future benefits to PV is provided below:

$$PV\ (B_0, \dots, B_n) = \sum_{i=0}^{n} \frac{B_i}{(1+r)^i}$$

PV = Present value of a future stream of benefits
B_i = Benefits accruing in period i
r = Discount rate

The choice of discount rate is a controversial topic, as valid arguments exist for selecting higher or lower rates depending on the social rates of time preference. The Treasury Board of Canada Secretariat (2019) recommends a discount rate of 3% to 7%. We use a discount rate 5% for all PV calculations in this study based on the average of the Treasury Board's recommendation, and in line with other Canadian studies (e.g., Tanguay et al. 1995; Elgie et. al 2011).

Appendix C: Spatial Data Deliverables

Table C1. List and description of the spatial data layers created as part of the Natural Asset Inventory and Ecosystem Service Assessment project for Parkland County.

Name of Dataset	File Name	Description	Format
Natural Asset Inventory	Natural_Asset_Inventory	Natural assets and all ES, condition, and special interest attributes and score.	Vector/Polygon
Natural Asset Cover Types	NA_Cover_Types	Cover types (woody, wetland, water, grassland, bare ground) within the natural asset boundaries.	Vector/Polygon
Natural Asset Land Cover	NA_Land_Cover	Land cover classes (coniferous, deciduous, marsh, fen, etc.) within the natural asset boundaries. NOTE: the land cover classes did not receive a detailed QAQC at this class level.	Vector/Polygon
Predicted Potential Soil Loss	Potential_Soil_Loss	InVEST Sediment Delivery Ratio (SDR) model output showing predicted soil loss in tons/pixel/year.	Raster
Avoided Erosion	Avoided_Erosion	InVEST Sediment Delivery Ratio (SDR) model output showing the contribution of vegetation to keeping soil from eroding in tons/pixel/year.	Raster
Avoided Export	Avoided_Export	InVEST Sediment Delivery Ratio (SDR) model output showing the contribution of vegetation from entering a stream (combines local/on-pixel sediment retention with trapping of erosion from upslope of the pixel) in tons/pixel/year.	Raster
Predicted Runoff	Predicted_Runoff	InVEST Urban Flood Risk Mitigation model output showing runoff values per pixel (mm).	Raster
Runoff Retention	Runoff_Retention	InVEST Urban Flood Risk Mitigation model output showing runoff retention volume values per pixel (m^3).	Raster
Predicted Nitrogen Load	Predicted_Nitrogen_Load	InVEST Nutrient Delivery Ratio (NDR) model output showing above ground nutrient load for nitrogen per pixel (kg/year).	Raster
Nitrogen Retention	Nitrogen_Retention	InVEST Nutrient Delivery Ratio (NDR) model output showing per pixel nitrogen retention (kg/year).	Raster
Predicted Phosphorous Load	Predicted_Phosphorous_Load	InVEST Nutrient Delivery Ratio (NDR) model output showing above ground nutrient load for phosphorous per pixel (kg/year).	Raster
Phosphorous Retention	Phosphorous_Retention	InVEST Nutrient Delivery Ratio (NDR) model output showing per pixel phosphorous retention (kg/year).	Raster
Predicted Carbon Storage	Predicted_Carbon_Storage	InVEST Carbon Storage model output showing the amount of carbon stored in each pixel (metric tons). NOTE: Sequestration was not modelled in InVEST as was determined using values based on literature review and land cover types.	Raster
Mean Summer Temperature	Mean_Summer_Temp	Layer derived from Landsat image analysis showing the median summer temperature for 2014-2024.	Raster

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