Regional District of Central Okanagan

2021 Update of the Central Okanagan Sensitive Ecosystem Inventory

Change Summary and Technical Report

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Change Summary and Technical Report

Prepared For:

Regional District of Central Okanagan
1450 KLO Road
Kelowna, BC
V1W 3Z4

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Prepared By:

Ecoscape Environmental Consultants Ltd.
#2 – 2030 Matrix Crescent
Kelowna, BC
V1V 0G5

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Acronyms

Acronym	Definition
BEC	Biogeoclimatic Ecosystem Classification
BGC	Biogeoclimatic
BW	Broadleaf Woodland
CDC	B.C. Conservation Data Centre
CoK	City of Kelowna
CoWK	City of West Kelowna
DLC	District of Lake Country
DP	District of Peachland
ECCC	Environment and Climate Change Canada
FS	Seasonally Flooded Field
GR	Grassland
IR	First Nations Reserve
GIS	Geographic Information Systems
masl	metres above sea level
MF	Mature Forest
NS	Not Sensitive
OCP	Official Community Plan
OF	Old Forest
QEP	Qualified Environmental Professional
RDCO	Regional District of Central Okanagan
RDOS	Regional District of Okanagan-Similkameen
RI	Riparian
SARA	Species at Risk Act
SEI	Sensitive Ecosystem Inventory
SER	Sensitive Ecosystem Ranking
SV	Sparsely Vegetated
TEI	Terrestrial Ecosystem Inventory
TEM	Terrestrial Ecosystem Mapping
WD	Coniferous Woodland
WN	Wetland
WHR	Wildlife Habitat Rating

Executive Summary

This report outlines the key findings of the 2021 update to the Central Okanagan Sensitive Ecosystem Inventory (SEI). It provides a comprehensive snapshot of ecosystem change since the 2012 amalgamated inventory, offering important insights for future land use planning, including the locations of remaining sensitive ecosystems, critical habitat corridors and land cover changes at both the municipal and regional scale. One of the key outcomes of the SEI update is a comprehensive database of current ecosystem conditions.

The methodology to update the Central Okanagan SEI included reclassifying ecosystems to reflect recent land use changes, assigning new disturbance fields, and calculating SEI attributes. The methodology systematically identified anthropogenic development changes from a land-use perspective, reflecting both use and intensity. Ecosystems were categorized as either Sensitive, Other Important Ecosystems or Not Sensitive (NS).

The comparison of SEI from 2012 and 2021 revealed a 9.4% increase in anthropogenically influenced codes and a 4.2% decrease in natural ecosystems. The examination of regional changes between the pre- and post-update revealed notable shifts, with losses in most categories. The changes reflected in the SEI are a mixture of anthropogenic change, forest successional changes, and natural events, primarily due to wildfire. However, it should be noted that ecosystem change due to the 2023 wildfire season is not included in this update. Key results include:

- Grassland (GR) and Coniferous Woodland (WD) experienced the greatest losses of 749.8 ha (-11%) and 853.4 ha (-5%), respectively.
- Gains in Mature Forest (MF) were significant (+9,253.6 ha). This is the result of a structural stage update that applied tree age values to a subset of the region's ecosystems.
- Not Sensitive (NS), which is a combination of natural and anthropogenic units, decreased because many previously NS forest ecosystems shifted into MF and because development was focused in NS areas.
- Gains in Wetland (WN) were attributable to natural expansion (e.g., Roberts Lake, Tatamiki Basin) and from higher resolution mapping.
- Sparsely Vegetated (SV) units appeared stable, likely due to their high value in earlier SEI conservation models, and because they are less favourable for development (i.e., steep slopes, cliffs).

The main drivers of anthropogenic change within the region were due to agriculture and residential expansion with roughly 2,500 ha and 5,500 ha of new development, respectively. Approximately 80% of the development in the Central Okanagan occurred in NS areas, indicating that policies to protect sensitive areas, such as environmental development permit areas (eDPAs), are being implemented and have a notable effect. The largest conversion of SEI units to anthropogenic disturbance categories, excluding NS, was WD to Residential, GR to Agriculture, and GR to Residential. With Residential and Agriculture accounting for 40% and 30%, respectively.

Wildlife Habitat Values, which were calculated using the conservative highest value method across the region, were generally High and indicated the importance of the remaining natural elements and green urban spaces to the region's ten rare, umbrella species.

Assessing the High conservation value areas reveals a fragmented landscape with few large contiguous High value patches. On the west side of Okanagan Lake north of West Kelowna, there are a series of modest-sized patches of High conservation value primarily associated with excellent condition WD, MF, and SV.

The east side of Okanagan Lake has a more fragmented mosaic of High conservation value areas. The landscape is characterized by High-value riparian corridors that lose their lustre when reaching the urban interface and three broad semi-fragmented ecosystem corridors. The first corridor follows a similar elevation band from Okanagan Mountain Provincial Park around the south and east side of the municipalities across

the west face of Black Mountain towards the east shores of Kalamalka Lake. The other main north-south corridor is along the ridgeline above the east shore of Okanagan Lake, spanning from Knox Mountain to Ellison Ridge and then further north. The last ecological corridor is east-west oriented and connects the easternmost portion of the study area, through Joe Rich, to the north-south ecological corridor in the central valley. This corridor is primarily forested and follows the natural topography down from the mountains to the valley. The remaining habitat corridors identified in this are biodiversity hotspots, warranting stronger protections to prevent further fragmentation.

Similar to the regional changes, jurisdictions experienced losses in most SEI categories, except MF, which had growth due to changes in age structure and WN due to finer scale mapping and natural expansion.

- » Regional District of Central Okanagan (RDCO) had small losses for most SEI categories, except for a 9.3% relative decrease (200 ha) in GR. Most of the region's increase in MF (5,793 ha) and OF (63 ha) occurred in the RDCO. Natural areas in the RDCO decreased by 1 percentage point, resulting in 89% coverage by natural ecosystems.
- » City of Kelowna experienced losses in all non-NS categories. Most notable were the percent changes of -29%, -22%, and -11% for Broadleaf Woodland (BW), GR, and WD, respectively. Despite the 500-plus ha increase in MF within the municipality, NS still increased by 222 ha.
- » District of Lake Country (DLC) experienced an 18% (4 percentage point) increase in anthropogenically influenced codes relative to pre-update conditions. The major SEI unit changes occurred in MF (+1,486 ha), GR (-208 ha), and WD (-241 ha). DLC has natural and anthropogenic coverages of 77% and 23%, respectively.
- » Okanagan Indian Band (OKIB) (IR#7) experienced a complete loss of BW (-3.7 ha), though the remainder of the jurisdiction was unchanged. OKIB (IR#7) has 79% anthropogenically influenced coverage.
- » District of Peachland (DOP) experienced small areal losses in Sensitive Ecosystems, but the percent change in BW (-22%) and RI (-7%) were significant. Notably, Peachland had a 73.6 ha increase (168.9%) in MF. Anthropogenic codes in Peachland increased by 1 percentage point, resulting in 54% anthropogenic coverage.
- » Westbank First Nation (IR#8, IR#9, IR#10, and IR#12) experienced a 4 ha decrease in natural ecosystems, resulting in 47% natural coverage. Among the Sensitive Ecosystems, GR decreased by 1%, WD decreased by 6%, and WN increased by 45%. Additionally, MF increased by nearly 200% (208 ha) relative to pre-update conditions.
- » City of West Kelowna (CWK) experienced 162 ha loss in Sensitive Ecosystems. This included a notable 40% loss in GR, and losses between 2 and 5% for RI, SV, and WD. Conversely, WN increased by 0.9 ha (9% change) and MF increased by 1,180 ha. Anthropogenic codes in the municipality increased by 3 percentage points to 40%.

Given the findings of the Central Okanagan SEI Update, some key recommendations include:

- » Environmental DPAs, relevant supporting policies, and protection measures should undergo reassessment in light of the updated SEI. This is particularly important given Central Okanagan's changing climate, projected growth, and associated impacts. This reassessment is important as it will likely reveal new areas that warrant inclusion and/or exclusion for environmental protection.
- » Terrestrial ecosystems, including GR, WN, and BW, stand out as specific Sensitive Ecosystems that require prioritization for the establishment of retention targets and enhanced protection policies. A landcover change projection analysis may be beneficial in providing a better understanding of future risks to Sensitive Ecosystems
- » The extent of the Central Okanagan SEI does not cover the full boundaries of all jurisdictions, limiting the potential for accurate cumulative effects monitoring and municipal tracking of retention targets. The extent of SEI mapping should be expanded to include the entire municipal boundaries of the DOP and CWK.

» It is essential to note that all natural environments provide valuable ecosystem services, irrespective of their categorial status as Sensitive, Important or Not Sensitive. Building on this point, it is recommended that Young Forest be added to the list of Other Important Ecosystems within the framework of the Central Okanagan SEI. This would better reflect the value of the currently "less sensitive" ecosystems, especially given local climate projections and the importance of maintaining tree canopy for carbon storage and wildlife refuge habitat.

» It is recommended that the Central Okanagan SEI be updated regularly (at least every five years). And further, implementing an approach for regularly documenting changes from development would streamline and enhance the cost-effectiveness of these updates, with the most significant changes, other than development, occurring from landscape alterations, such as wildfire. Regular updates are important to understand the effectiveness of any policy changes.

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Introduction

Ecoscape Environmental Consultants Ltd. (Ecoscape) has been retained by the Regional District of Central Okanagan (RDCO) to provide an update of the Sensitive Ecosystem Inventory (SEI) in the Central Okanagan.

Sensitive Ecosystem Inventories are invaluable for promoting environmental stewardship and sustainable development. By identifying and mapping unique and fragile ecosystems, these inventories aid in the conservation of biodiversity, offering imperative insights for habitat protection and management. This information is vital for informed decision-making in land use planning, water resource management, and climate change adaptation. Sensitive ecosystem inventories also play a role in preserving cultural and recreational values, fostering public awareness, and ensuring legal compliance with environmental regulations.

This SEI update provides a snapshot of the land use changes that have occurred since the original inventories and will be instrumental in guiding future policy development and land use management. Furthermore, this data improves the ability to assess cumulative effects at both the local and regional scale so that considerations of broadscale habitat connectivity can be integrated into future retention targets of sensitive ecosystems in the face of a changing climate.

This report identifies the remaining sensitive ecosystems at regional and municipal scales and the critical corridor connections between them, characterizes the types and severity of land cover changes, and outlines a method for assessing and tracking land cover changes within SEIs from a land-use planning perspective. Understanding the spatial relationships between ecosystems in the Central Okanagan is crucial in developing mitigation measures for the projected impacts of climate change and human development in the Okanagan. As it stands, climate risk assessments anticipate further adverse effects on habitat connectivity, quality, and suitability, leading to loss of ecosystem services and biodiversity – which are projected to contribute to major losses in social cohesion, natural resources, and economic productivity in the region (ICF, 2019; Pinna, 2020; Utzig, 2012).

This report is intended for use as a companion product to the 2021 update of the spatial dataset, which is publicly available and was directly delivered to Environment and Climate Change Canada (ECCC), the Province of BC, and member municipalities to be utilized by Qualified Environmental Professionals (QEPs), governments, and other agencies for research and reference. This report builds upon existing SEIs and is not meant to replace previous iterations (Haney & Sarell, 2006; Haney & Iverson, 2009; Iverson & Cadrin, 2003; Iverson et al., 2004; Iverson et al., 2008; Iverson & Mackenzie, 2006; Sarell et al., 2003). Local governments may use this data and report as a reference in assisting in the evaluation of development proposals and the development of future policies such as development permit areas (DPAs).

Background

BC’s Central Okanagan basin is of great ecological significance due to its high biodiversity and many rare and endangered ecosystems, flora, and fauna. The area is home to 53 species listed as endangered or threatened by the Government of Canada (COSEWIC). These sensitive ecosystems are at risk for loss or further fragmentation due to agriculture, urban, rural, commercial, and industrial development. A changing climate has also caused losses due to drought, wildfire, and invasive species. With few intact sensitive ecosystems remaining in the area, it is paramount to balance the retention and ecological sustainability of sensitive ecosystems with sustainable land development.

In the early 2000s, several SEIs were completed in the region, providing an inventory base to support sound land management decisions and promote effective stewardship. The RDCO inventoried the low and mid elevations within its jurisdiction in 2001. Using the provincial inventory standards, the Central Okanagan SEI identified and mapped several ecosystem categories that are considered at-risk, fragile, or rare (e.g., wetland, riparian, old and mature forests, grassland, river, broadleaf woodland, coniferous woodland, sparsely vegetated, and seasonally flooded fields). The following Central Okanagan SEI projects comprising the composite dataset were completed between 2002-2012:

- » Central Okanagan – 2000 (1996 imagery), 2008 (2005, 2006 imagery)
- » Ellison – 2000, 2005 (1996 imagery)
- » Kelowna – 2007 (2006 imagery)
- » Lake Country – 2005 (1994 and 2003 imagery)
- » Joe Rich – 2006 (1994 imagery)
- » South Slopes – 2001 (1996 imagery), 2007 (2006 imagery)
- » South Okanagan – 1991-1994 (mid-1980s imagery), 2005 (2003 imagery). 2009 (2004, 2005, 2007, 2008 imagery), 2012 (2008, 2010 imagery)

Over the past two decades, significant change has occurred in the Central Okanagan. As one of the fastest-growing regions in Canada, the region's population has increased by over forty percent between 2001 and 2021 (StatsCan, 2002; StatsCan, 2022; StatsCan, 2023) and is expected to increase by 80,000 by 2040 (Urban Development Institute). A comprehensive SEI update provides insight for land use managers to better understand where the remaining rare and fragile ecosystems exist, the connectivity between these ecosystems, and the change that has occurred to support local governments and others who are working to maintain biodiversity through policy and land use planning.

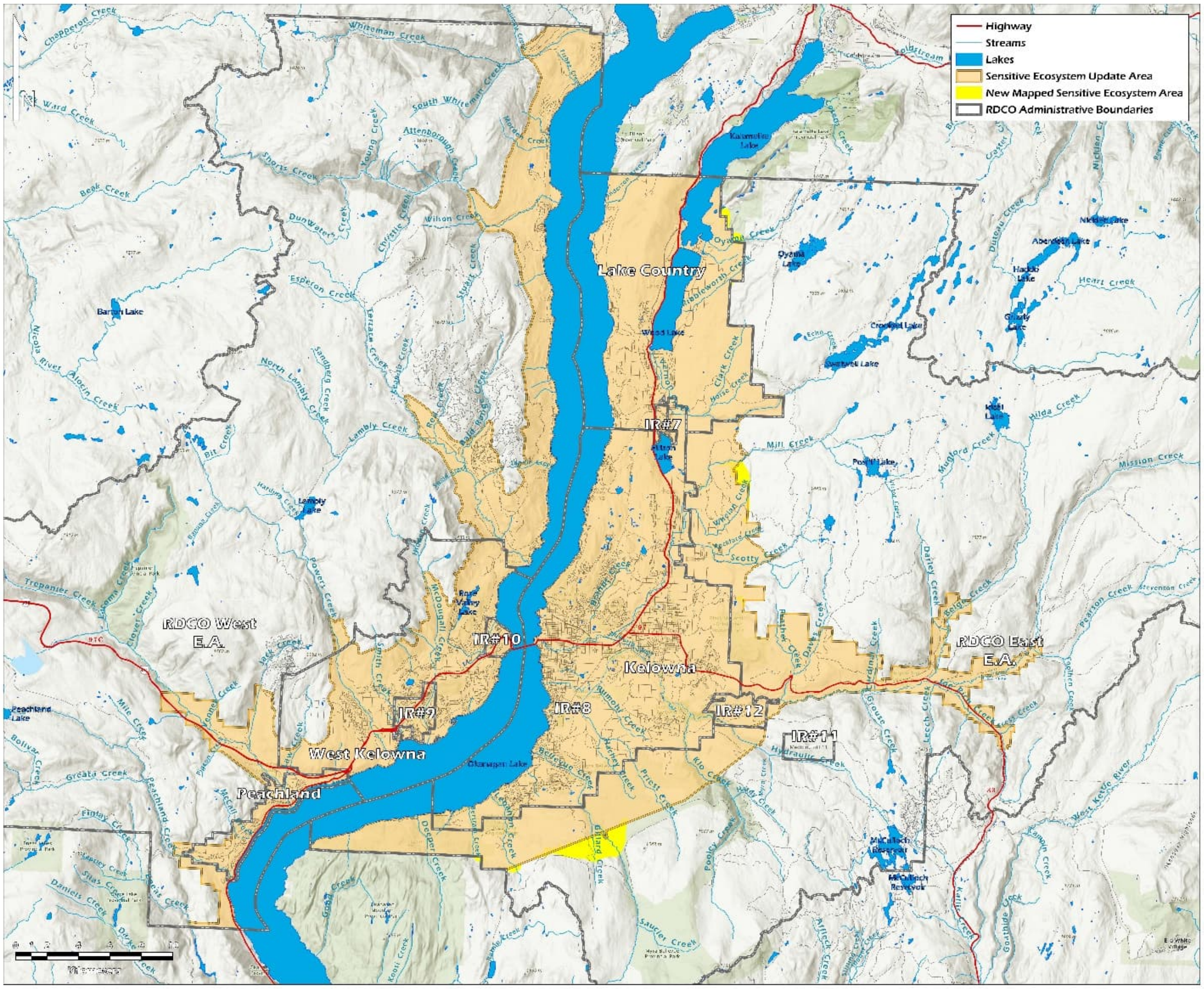
Study Area

The study area ranges from 343 masl (metres above sea level) to 1420 masl. It encompasses the upland areas east and west of Okanagan Lake in the central Okanagan Valley in south-central British Columbia (Inset Figure 1). The central Okanagan basin is a complex landscape broadly shaped by the retreating Cordilleran Ice Sheet that covered the landscape until approximately 10,000 years ago and has since been sculpted by localized geomorphic forces (Iverson & Cadrin, 2003). The valley's topography is characterized by steep rock bluffs, gradually sloping glacial terraces, highland plateaus, and valley-bottom floodplains. This landscape is an integral part of the north-to-south corridor that connects BC's dry interior landscapes to the southern grasslands of the Columbia Basin in the United States.

Based on climate normal data from the Kelowna A station (STN ID 1123970) between 1981 and 2010, the average annual total precipitation (rain and snow) was 386.9 mm with an average rainfall of 311.3 mm, indicating that the study area's climate is arid – particularly the valley bottom where the station and a large proportion of the study area are located. The highest precipitation typically occurs between May and July (as rain) and again in December and January (as snow). The daily average temperatures for July (the warmest month) and December (the coldest month) were 19.5 °C and -2.6 °C, respectively (Environment Canada, 2023).

It is important to note, however, that most climate models for southern BC indicate that seasonal precipitation and temperature patterns will likely shift from the above-referenced "normals", which are based on data collected over two decades ago. Specifically, we can expect longer, warmer, and drier summers, earlier springs, later autumns, and consequently, shorter and warmer winter seasons (Pinna, 2020; Utzig, 2012). The models predict that precipitation is likely to increase through winter, spring, and autumn, and winter will experience increased precipitation falling as rain as opposed to snow, particularly in low-elevation areas (Pinna, 2020; Utzig, 2012).

The study area covers the previous SEI project areas in the Central Okanagan with new additional areas that are associated with the main and alternate regional ecosystem connectivity corridors. The area encompasses privately owned lots, crown land, regional parks, provincial parks, and First Nations reserves (IRs). It includes the administrative areas of the City of Kelowna (CoK), City of West Kelowna (CoWK), District of Peachland (DP), District of Lake Country (DLC), Okanagan Indian Band (OKIB) (IR#7), Westbank First Nation (WFN) (IR#8, IR#9, IR#10, and IR#12), RDCO (inclusive of the RDCO East and West electoral areas), and a small portion of the Regional District of Okanagan-Similkameen (RDOS).



Inset Figure 1. Study Area Overview

Biogeoclimatic Zones

Several Biogeoclimatic (BGC) zones, subzones, and variants are found in the study area (Table 1). The Ponderosa Pine Very Hot Dry Okanagan (PPxh1) covers the dry valley bottom, which transitions upslope in the east, west, and south to the more densely forested Interior Douglas-fir Very Dry Hot Okanagan (IDFxh1). The remaining 10% of the study area comprises five BGC codes that generally occupy the higher elevation valley fringe where temperature and moisture regimes are more moderate. Climate change projections for the southern BC interior anticipate that areas below 1000 masl are likely to transition to a predominantly grassland/steppe BGC zone with possibilities of ponderosa pine or grand fir forests, while the remainder of the study area above 1000 masl is likely to experience an upward expansion of the grassland/steppe BGC zone with an accompanying forest type depending on the particular temperate and precipitation regime (Utzig, 2012).

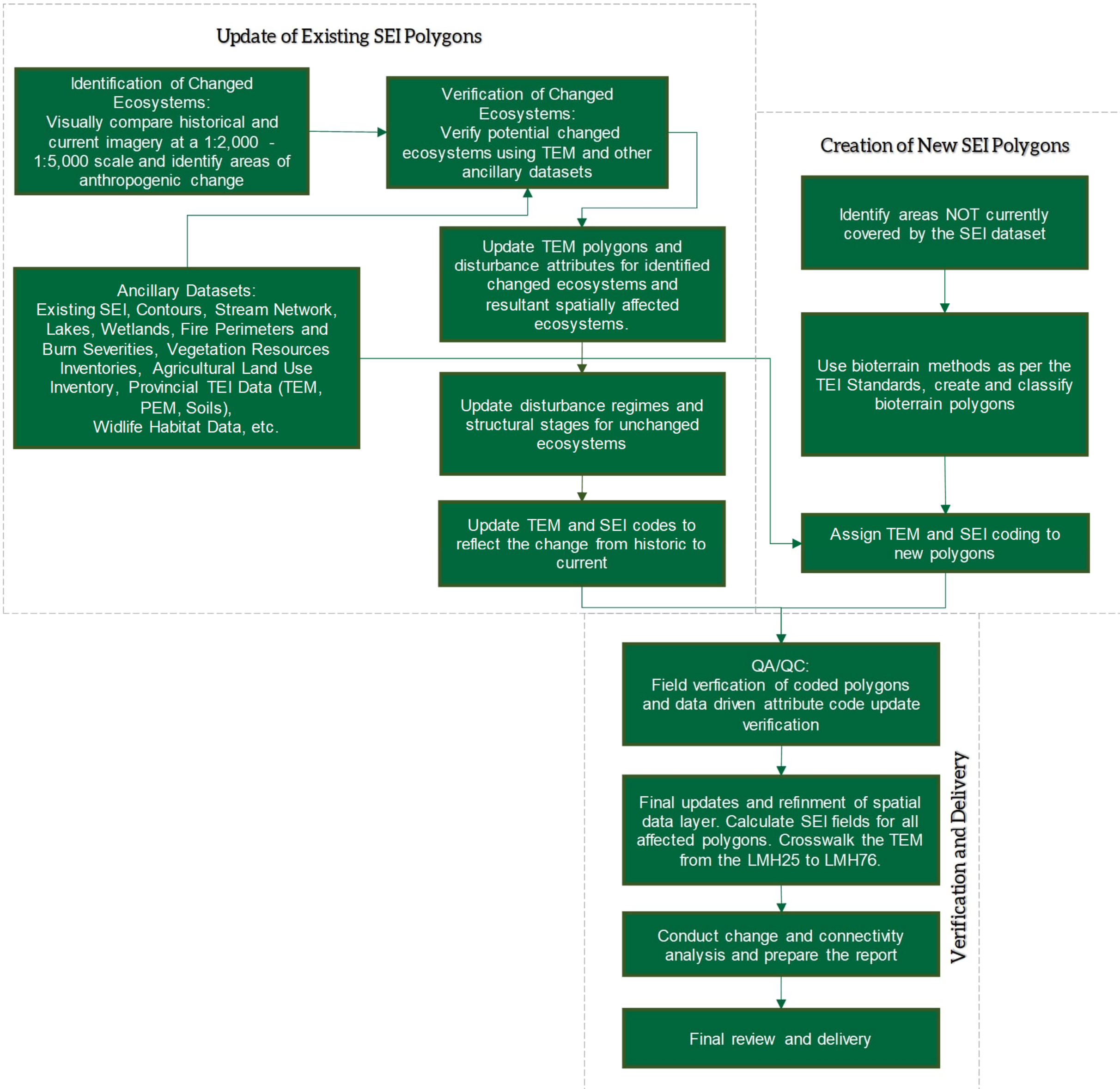
Table 1. Summary of BGC subzones in the study area				
Code	**Zone**	**Subzone**	**Variant**	**Proportion**
IDFxh1	Interior Douglas-fir	Very Dry Hot	Okanagan	46.5%
PPxh1	Ponderosa Pine	Very Dry Hot	Okanagan	42.7%
IDFmw1	Interior Douglas-fir	Moist Warm	Shuswap	7.5%
IDFdm1	Interior Douglas-fir	Dry Mild	Kettle	2.6%
IDFdk2	Interior Douglas-fir	Dry Cool	Cascade	0.6%
MSdm1	Montane Spruce	Dry Mild	Okanagan	0.1%
BGxh1	Bunchgrass	Very Dry Hot	Okanagan	0.001%

Data source: BEC version 12; https://open.canada.ca/data/en/dataset/f358a53b-ffde-4830-a325-a5a03ff672c3

Methodology

General

Ecoscape employed a systematic approach to updating the SEI database and creating new polygons for the SEI (Inset Figure 2). Initially, the land cover was visually screened to detect differences between the historical imagery most closely associated with the original SEI mapping (1995-2012) and the most up-to-date imagery at the project start-up (2021). Base data was used to support the classification of changes, and those changed areas – primarily anthropogenic – were remapped and reclassified. Spatially affected polygons were updated mostly with tabular data changes, and then spatially unaffected polygons were updated with the new Central Okanagan-specific disturbance codes defined at the project outset. TEM codes were updated to match the coding in the region's new land management handbook (LMH76), and the TEI approved ecosystem mapping codes. New SEI polygons were created using the standard methods for mapping and classifying terrain and ecosystems (see Creation of New SEI Polygons). Updates to the SEI fields were completed using the general rulesets and logic from the provincial standards and previous work in the Central Okanagan (RISC, 2006; Haney & Iverson, 2009; Haney & Sarell, 2006; Iverson & Cadrin, 2003; Iverson & Mackenzie, 2006; Sarell et al., 2003).



Inset Figure 2. General SEI Update Procedure

Changes to the Classification System

A series of Central Okanagan-specific disturbance fields have been added to the SEI dataset to explain the character of the Not Sensitive (NS) ecosystems defined by the SEI and the anthropogenic influences on the landscape (Table 2). These additions to the classification system were established and reviewed with the project's Technical Advisory Committee (Appendix F) prior to the onset of the SEI update.

The new attribute fields and values were matched to the existing disturbance (sub)class values where possible (e.g., biotic effects – domestic grazing/browsing, soil disturbance – cultivation, terrain-related effects – terrain failures, etc.) (BCMSRM, 2003); the remaining unmatched values were categorized under the existing “soil disturbance” disturbance class (DISTCLS_#) with a user-defined code for the subclass (DISTSCLS_#) with a value of “x”.

Table 2. New disturbance classes linked to TEM disturbance codes

TEM Disturbance Codes		Central Okanagan SEI Update Disturbance Codes and Descriptions					
DISTCLS _#	DISTSCLS_#	CO_DCL_#	CO_DCL_# Description	CO_DSCL_#	CO_DSCL_# Description	CO_DSSCL_#	CO_DSSCL_# Description
S	x	C	Commercial development	c	Urban commercial: Traditional city centre commercial uses (i.e., retail, service, tourist, mixed commercial development)	1, 2, 3, 4, 5	No disturbance, minor, moderate, high, very high
				y	Recreational commercial: Indoor and outdoor commercial uses (i.e., golf courses, drive-ins, racetracks, amusement centres)	1, 2, 3, 4, 5	No disturbance, minor, moderate, high, very high
				w	Wilderness commercial: Primarily outdoor commercial uses (i.e., ski resort, fishing resort, campgrounds, cabins, bike parks, etc.)	1, 2, 3, 4, 5	No disturbance, minor, moderate, high, very high
S	x	I	Industrial activity	h	Heavy industrial: Inclusive of factories, toxic materials storage, tank farms, etc.	1, 2, 3, 4, 5	No disturbance, minor, moderate, high, very high
				m	Light/Medium industrial: Business and general industrial and manufacturing	1, 2, 3, 4, 5	No disturbance, minor, moderate, high, very high
				e	Excavation/Resource extraction: Inclusive of mining, timber processing, and gravel extraction	1, 2, 3, 4, 5	No disturbance, minor, moderate, high, very high
F	c, g, r, s	N	Natural events	f	Fire: Historical fire	1, 2, 3, 4, 5	No disturbance, minor, moderate, high, very high

Table 2. New disturbance classes linked to TEM disturbance codes							
TEM Disturbance Codes		Central Okanagan SEI Update Disturbance Codes and Descriptions					
DISTCLS _#	DISTSCLS_#	CO_DCL_#	CO_DCL_# Description	CO_DSCL_#	CO_DSCL_# Description	CO_DSSCL_#	CO_DSSCL_# Description
W	i			i	Flood: Inundation (including temporary inundation from beaver activity)	1, 2, 3, 4, 5	No disturbance, minor, moderate, high, very high
T	s			s	Mass wasting: Terrain failures (active/recent slumps, slides, solifluction, etc.)	1, 2, 3, 4, 5	No disturbance, minor, moderate, high, very high
S	x	P	Public and institutional	g	Institutional: Institutional property where land is primarily hardscaped and developed (i.e., hospitals, schools, recreation centres)	1, 2, 3, 4, 5	No disturbance, minor, moderate, high, very high
				p	Parks: Institutional lands, either natural or modified, that act as gathering places or have recreational value (i.e., parks, community gardens, etc.)	1, 2, 3, 4, 5	No disturbance, minor, moderate, high, very high
				z	Utilities: Lands that house infrastructure for electricity, gas, water, sewerage, or telecommunications, rights-of-way, reservoirs, roads	1, 2, 3, 4, 5	No disturbance, minor, moderate, high, very high
S	x	R	Residential development	u	Urban: An area in which high-density residences and other associated human developments form an almost continuous cover of the landscape.	1, 2, 3, 4, 5	No disturbance, minor, moderate, high, very high

Table 2. New disturbance classes linked to TEM disturbance codes

TEM Disturbance Codes		Central Okanagan SEI Update Disturbance Codes and Descriptions					
DISTCLS _#	DISTSCLS_#	CO_DCL_#	CO_DCL_# Description	CO_DSCL_#	CO_DSCL_# Description	CO_DSSCL_#	CO_DSSCL_# Description
				R	Rural: Any area in which residences and other human developments are scattered and intermingled with forest, range, farmland, and native vegetation or cultivated crops (forested areas and cultivated fields are mapped as separate units)	1, 2, 3, 4, 5	No disturbance, minor, moderate, high, very high
				L	Suburban: Any area in which low-density residences and other associated human developments form a semi-continuous covering of the landscape; these areas are interspersed with more manicured greenspace than urban environments and have fewer natural areas and agricultural areas mixed in than rural environments	1, 2, 3, 4, 5	No disturbance, minor, moderate, high, very high
S	a	S	Agriculture and steadings	a	Cultivated: An agricultural area that contains arable land that is plowed, sowed, and actively or recently used for raising crops (inclusive of orchards, vineyards, fallow, food crops, and flooded fields)	1, 2, 3, 4, 5	No disturbance, minor, moderate, high, very high

Table 2. New disturbance classes linked to TEM disturbance codes

TEM Disturbance Codes		Central Okanagan SEI Update Disturbance Codes and Descriptions					
DISTCLS _#	DISTSCLS_#	CO_DCL_#	CO_DCL_# Description	CO_DSCL_#	CO_DSCL_# Description	CO_DSSCL_#	CO_DSSCL_# Description
B	d			d	Animals/Livestock: Lands utilized primarily for management, breeding and feeding of domestic livestock (i.e. inclusive of feedlots, grasslands leased for grazing, hobby farms, and mixed-use of crops/livestock)	1, 2, 3, 4, 5	No disturbance, minor, moderate, high, very high
S	x			b	Farm structures: Agricultural lands that are primarily occupied by buildings and infrastructure (i.e., greenhouses, processing plants, worker housing, loading docks, parking)	1, 2, 3, 4, 5	No disturbance, minor, moderate, high, very high

Notes: Field names with '#' indicate that this portion of the field name changes based on the decile (1, 2, or 3)
DISTCLS = Disturbance Class; DISTSCLS = Disturbance Subclass; CO_DCL = Central Okanagan Disturbance Class; CO_DSCL = Central Okanagan Disturbance Subclass; CO_DSSCL = Central Okanagan Disturbance Intensity

Terrestrial Ecosystem Mapping (TEM) units with disturbance modifiers were further broken down using a disturbance intensity value – a user-defined field – that is a proxy for the amount of natural ecosystems remaining within a disturbed area, which can also be thought of if the area were left to natural forces what is the likelihood it would recover to a natural state (Table 3). Disturbance intensity values range from 1 (little to no anthropogenic disturbance present; wildfires fall in this category) to 5 (very high intensity disturbance; almost entirely hardscaped with little to no natural environment present).

Table 3. Disturbance intensity definitions

Value[1]	Label	Description
1	No Disturbance	Natural, undisturbed, or not recently disturbed (i.e., little to no human impacts) and natural vegetation communities in good condition.
2	Minor	Low Disturbance/Alteration - Natural vegetation communities are generally intact but partially fragmented, and invasive plants are distinctly present but not extensive. Light persistent human impacts (<25%) (e.g., presence of trails, minimal roads, disturbance to adjacent lands that result in edge effects).
3	Moderate	Moderate Disturbance/Alteration – A natural tree canopy may persist over a disturbed understory, and 25% - 75% of vegetation communities remain intact. Includes rural properties that may contain dirt roads, understory disturbance, or moderate levels of disturbance.
4	High	High Disturbance/Alteration - modified with little to no natural habitats, soils actively modified or disturbed, but not hardscaped (i.e., agricultural fields, vineyards, orchards).
5	Very High	Severe Disturbance/Alteration - 100% urban/industrial/commercial/infrastructure (i.e., roads, parking lots, buildings, etc.) with little to no capability or site potential to regenerate into natural vegetation communities.

[1] = Values come from the fields CO_DSSCL_1, CO_DSSCL_2, and CO_DSSCL_3 in the updated data layer.

Data Acquisition and Preparation

Numerous data files (imagery, shapefiles, geodatabases, etc.) were obtained and, in some cases, amalgamated before the SEI update (Table 4). This data comes from municipal, regional, and provincial data sources and our in-house repository of base data acquired over many years of completing similar projects. Where possible, data was downloaded from open data portals, but in some cases, it was provided by the custodian of that data.

The data preparation primarily entailed optimizing the base data for efficient visualization and usage and centralizing the historical SEI datasets, which involved a series of data-driven geo-processes and manual manipulations.

Table 4. Data sources used to support SEI update

Data Layer	Year	Source	Usage
Current SEI data	2012	RDCO	Base for updating data
Topographic/Contour Data	2017, 2021	RDCO and municipal sources	Additional information for polygon delineation
Stream Networks	2023	RDCO, provincial, and municipal sources, and SHIM	Help to identify sensitive ecosystems
Mapped Wetlands	2017, 2023	COK, RDCO, and provincial sources	Help to identify sensitive ecosystems
Critical Habitat and CDC Mapped areas	2023	Provincial sources	Help to identify sensitive ecosystems
Biogeoclimatic Zone Data	2021	Provincial sources	Help to identify sensitive ecosystems
Historical Fire Perimeters and Fire Burn Severity	2022	Provincial sources	Aide in structural stage and disturbance updates
Vegetation Resources Inventory (VRI)	2021	FLNRORD	Aide in species composition and structural stage updating
Agricultural Land Use Inventory (ALUI)	2014	BC Ministry of Agriculture and Food	Help in updating changes to SEI polygons in agricultural areas
Wildlife Habitat Ratings	2003	Provincial sources	Supporting information for the SEI Update
Imagery	2021, 2018, 2012,2009, 2006, 2003, 1995	Regional, provincial, municipal, and external sources	Used to guide the changes to be mapped in the SEI Update
Administrative Areas	2023	Regional, provincial, and municipal sources	Used to scale the land cover change analysis
Zoning	2021	Municipal and regional sources	Supporting information for the SEI Update
LiDAR	2018	RDCO	Base data for bioterrain mapping

Terrestrial Ecosystem Mapping Update

Visual differences between the current and historical imagery were checked against the existing TEM codes and supporting base data, and substantive differences (approximately >10% change) were accounted for. This visual inspection was mostly done around the 1:2,000 – 1:5,000 scale because the changes needed to be identified at approximately one-tenth of the 1:15,000 scale polygon in which nearly one-thirteenth of the base SEI polygons have areas less than 0.5 hectares. Polygons with substantive change were remapped, retaining existing polygon boundaries where possible and ensuring the adjacent spatially affected polygons required minimal updates. However, the spatial boundaries in highly anthropogenic areas were influenced more by landcover than the base bioterrain because the anthropogenic terrain is considerably modified from its pre-existing state.

The initial update primarily involved adding anthropogenic ecosystem deciles into the pre-existing natural ecosystem polygons, adjusting the remaining deciles, and adding relevant disturbance classes. The major secondary update was reviewing the adjacent spatially affected polygons from the first update – polygon size and proportional comparisons of pre- and post-update areal data provided exclusion rules; the remainder were manually reviewed, and ecosystem composition and disturbance classes were updated where necessary.

A round of updates for ecosystem structural stages and disturbance classes was completed for the remaining polygons whose ecosystem composition and spatial extent were unchanged (e.g., fire-affected ecosystems had fire disturbance classes added and their structural stages updated[1]; predominantly unchanged urban areas had disturbance classes added to describe the primary type of development present; where appropriate, recently undisturbed forested ecosystems had their structural stages updated based on the tree age classes in the vegetation resources inventories (VRI) dataset).

Qualitative and quantitative QA/QC measures were regularly employed by technical staff to ensure the integrity of the dataset throughout the different phases of spatial and tabular changes.

Creation of New SEI Polygons

Bioterrain Mapping

The areas not previously captured in the SEI data were created based on the standard bioterrain polygon creation processes outlined in the Terrestrial Ecosystem Inventory (TEI) methods (Howes & Kenk, 1997; WLRS, 2023; RIC, 1996; RIC, 1998; BC Min. Forests & Range, 2010). These areas were completed to polygon limits, not just to the edge of the corridor, so full polygons were made around the areas to be filled in.

To facilitate future land use planning, the mapping was undertaken at a scale of 1:10,000 instead of the SEI's previous 1:20,000 scale. It was completed per the Standard for Terrestrial Ecosystem Mapping in British Columbia (RIC, 1998), and field inventory procedures followed the Field Manual for Describing Terrestrial Ecosystems; 2nd Edition (BC FLNRO and MOE, 2010 – 2023 version).

Terrain mapping is a classification system used to describe the surficial material (the loose materials on top of bedrock) and their textures, surface expressions (the three-dimensional shape of the surficial materials), and geomorphological processes (the active mechanism that continues to shape the landscape) in a given area.

A terrain map is a map of surficial materials; it shows the surficial material type and thickness combined with surface expression or landform type (and geomorphological processes if applicable). Each surficial material type is classified based on its genesis. It has its own characteristics of deposition and, therefore, physical properties such as texture and consolidation.

Terrain maps are the basis for many kinds of land use planning, including terrain stability, ecosystem mapping, urban road and development planning, assessment of geological hazards, and aggregate mining. Terrain mapping with an ecological emphasis is called **bioterrain mapping**. Bioterrain mapping forms the basis of TEM by delineating polygons with similar ecological conditions such as soil moisture, aspect, and vegetation characteristics.

- Terrain mapping is based on the interpretation of imagery, which is then ground-truthed in the field. For this project, terrain mapping followed the current provincial guidelines and standards for terrain and TEM mapping, including:
    - Howes and Kenk, 1997. Terrain Classification System for British Columbia;

[1] Fires from 2022 and 2023 are not included (i.e., the 2023 McDougall Creek wildfire)

- British Columbia Ministry of Water, Land and Resource Stewardship (WLRS). 2023. Terrestrial Ecosystem Information Digital Data Submission Standard. Version 3.0; and
- Resources Inventory Committee, 1996. Guidelines and Standards to Terrain Mapping in British Columbia.

Delineation of bioterrain polygons was based on criteria such as the following:

- Terrain type;
- Material depths;
- Landform;
- Soil drainage;
- Slope breaks;
- Slope position;
- Aspect: cool (from 285 to 135°) and warm (from 135 to 285°);
- Geomorphological processes;
- Surface expression and slope morphology (e.g., concave or convex);
- Vegetation patterns;
- Riparian zones and corridors; and
- Any other ecologically significant areas such as cliffs, talus slopes, and ponds.

Bioterrain mapping took place within the yellow areas shown on Inset Figure 1. Polygons created during the current mapping were edge matched to the legacy mapping. Challenges were encountered during the edge-matching due to the advancement of mapping and image technology. The legacy mapping was completed in the pre-LiDAR era where polygon identification and delineation was based on airphoto interpretation. With the advent of high-resolution LiDAR imagery, landform identification and delineation is more accurate and concise. For example, it was noted that there are a lot more glaciofluvial landforms present within the areas mapped than were captured during the legacy mapping. Mapping is now completed on ArcGIS platforms that allow mapping to occur at a larger scale than on traditional airphotos. The ortho imagery used on the current project is 10 to 20 years newer than the airphotos used in the legacy mapping, where land use and vegetation cover may have changed in some locations during this time period.

Bioterrain mapping completed for the project used a hillshade raster layer derived from 1 m resolution, bare-earth LIDAR as a base layer and 15 cm resolution, 2021 orthophoto. The mapping was completed by Polly Uunila, P.Geo. The final spatial file of the mapping, dated July 7, 2023, is titled RDCO_TEM_GAP_7JUL2023.shp.

Bioterrain mapping forms the foundation of TEM mapping. Upon delivery of the mapping, it is understood that the project vegetation ecologist will be making minor changes to the spatial file including cutting in the provincially derived biogeoclimatic (BEC) subzones into the polygons and adding ecological data to the attribute table and other minor adjustments based on structural stage.

Initial Terrestrial Ecosystem Mapping

TEM is based on a combination of bioterrain and ecosystem mapping. TEM describes a given study area by mapping like units (polygons) based on climate, elevation, terrain, soil, and dominant vegetation. Each polygon can describe up to three terrain and ecosystem types, with the proportion of each described by a decile (10% increments). To the greatest extent possible, polygons are delineated to contain pure units of terrain or ecosystems. Bioterrain and ecosystem mapping were performed using LiDAR data recent orthophotos, ArcMap 10.8 and ArcGIS Pro 3.2. TRIM contours, wetlands, and watercourse data were also mapping aids. Portions of the previous TEM mapping were used where possible.

Bioterrain polygons were mapped at a scale of 1:10,000 in areas that had not been previously mapped (i.e., ~1100 hectares associated with the main and alternate regional corridor). These polygons form the basis of TEM and allow an ecosystem mapper to further divide the bioterrain polygons into smaller areas based on ecosystem classification, structural stage (shrub, young forest, old forest, etc.), and canopy composition (conifer, broadleaf, mixed). To meet the requirement of TEM mapping at a scale of 1:10,000, a minimum polygon size of 0.5 hectares was employed for previously unmapped areas.

The first pass of TEM mapping was primarily limited to delineating bioterrain and ecosystem polygons. Attributes (describing the surficial material, ecosystem classification, etc.) were limited to areas with high confidence, and field verification is not expected to change the mapping significantly. The resultant mapping was used to guide field sampling.

A crosswalk and linkages to the new Biogeoclimatic Ecosystem Classification (BEC) system was generated to lay the framework for scripting a revised database that converts the existing site series and vegetation associations that will be carried forward into the updated mapping to an equivalent site series of the new BEC system (Ryan et al., 2022).

In-Field Verification and Quality Assurance

In 2023, ecological plots (FS882 forms) were completed following established protocols for terrestrial ecosystem classification. The field sampling, guided by the Field Manual for Describing Terrestrial Ecosystems, 2nd Edition (Min. of Forests and Range, 2010), focused on previously unmapped areas in the south slopes area and upper Ellison area. Ecosystems were classified using A Field Guide to Site Identification and Interpretation for the Kamloops Forest Region (Lloyd et al., 1990), A Field Guide to Ecosystem Classification and Identification for the Southern Thompson–Okanagan (LMH 76) (Ryan et al., 2022), and Wetlands of British Columbia (MacKenzie & Moran, 2004).

Data collection included location details, site information, substrate cover, terrain and soil characteristics, vegetation composition, and photographs. Where appropriate, conservation evaluation forms from the Conservation Data Centre (CDC) assessed ecosystem condition, fragmentation, and viability, informing the SEI and Sensitive Ecosystem Ranking (SER) system and mapping (see SEI Update and Conservation Value Updates sections for additional details).

Fieldwork, conducted from April to August, prioritized public lands and areas with landowner permission. Effective communication strategies were employed for private lands, ensuring the successful implementation of the project.

Final Terrestrial Ecosystem Mapping

Data from the field sampling was used to update ecosystem attributes, populate attribute tables, correct initial attributes as required, and modify polygon boundaries. The final product is a complete TEM map consisting of a geodatabase containing the bioterrain and ecosystem data in the template feature classes with all required attributes per the provincial standards and TEI Contractor Package.

SEI Update

The final TEM mapping and field data were used for new polygons to develop SEI classes and subclasses for the study area. The updated polygons had their SEI class and subclass adjusted according to the updated TEM codes and pre-existing SEI data. Most classes and subclasses were taken from the SEI methodology and previously completed projects. The TEM polygons created a comprehensive SEI layer for the study area. The SEI attributes are similar to those of the TEM in that up to three SEI units can be mapped per polygon using deciles (10% increments). The SEI units included in the update are shown below in Table 5.

Table 5. Sensitive and other important ecosystems in the study area		
SEI Unit	**Ecosystem**	**Ecosystem Description**
Sensitive Ecosystems		
BW	Broadleaf Woodland	Ecosystems dominated by trembling aspen include aspen copse ecosystems (BW:ac) occurring in depressions and moist areas in grasslands, and aspen seepage ecosystems (BW:as) occurring on slopes with subsurface moisture in a matrix of coniferous forest; old Broadleaf Woodlands are part of the Old Forest category.
GR	Grassland	Non-forested ecosystems dominated by bunchgrasses (grassland, GR:gr), grasslands occurring on steep slopes (GR:st), grasslands occurring on steep shallow-soiled slopes (GR:ss), and shrubland (GR:sh) ecosystems that occur in a grassland matrix, or non-native invasive plants with some bunchgrasses (disturbed grassland, GR:dg).
OF	Old Forest	Forest ecosystems dominated by large, old trees that are subdivided by dominant tree type: coniferous (OF:co) forest, mixed (OF:mx) forest, and broadleaf (OF:bd) forest; includes old Coniferous Woodlands, old Broadleaf Woodlands, and old Riparian forests.
RI	Riparian	Streamside ecosystems occurring on bench/floodplains (RI:fp) or in gullies with intermittent or permanent creeks (gully, RI:gu) and fringe ecosystems associated with pond and lake shorelines (fringe, RI:ff); also includes river (RI:ri) and beach (RI:be) ecosystems. Old Riparian forest ecosystems are part of the Old Forest category.
SV	Sparsely Vegetated	Ecosystems with little vegetation occurring on bedrock or colluvial features (shrub, SV:sh), grassy or unvegetated rock outcrops (SV:ro), talus (SV:ta) slopes, and cliffs (SV:cl).
WD	Coniferous Woodland	Open stands of Douglas-fir or ponderosa pine, often on shallow soils, with typically grassy understories; coniferous woodlands are split into young (WD:co) and mature (WD:mc) categories. Old Coniferous Woodlands are part of the Old Forest category.
WN	Wetland	Non-forested ecosystems where the water table is at or near the surface; includes wet meadows (WN:wm), marshes (WN:ms), swamps (WN:sp), and shallow open water (WN:sw) including ponds.
Other Important Ecosystems		
FS	Seasonally Flood Agricultural Field	Cultivated fields that flood annually and provide important migratory habitats for birds and habitats for other wildlife. These sites were formerly riparian or wetland ecosystems and may have some potential for restoration of these ecosystems.
MF	Mature Forest	Forests dominated by mature trees include broadleaf (MF:bd) forests, coniferous (MF:co) forests, and mixed (MF:mx) deciduous and coniferous forests, excluding mature Riparian forests and mature Coniferous and Broadleaf Woodlands.

Note: "mature" indicates structural stage 6 (age 80-250 yrs) in the TEM data, while "old" indicates structural stage 7 (age < 250 yrs)
Source: Modified from Table 2 in Haney & Iverson, 2009

Conservation Value Updates

Conservation Value within the framework of the SEI functions as a high-level method for identifying areas that should be conserved, protected, and/or connected. It is a product of the relative value of the ecosystem, which is based on a general assessment of ecological sensitivity, provincial and local rarity, and importance to wildlife species, the overall condition value of the ecosystem, and wildlife habitat suitability rankings, which are a function of assessing the life requisites of select regionally important species.

Conservation Value is calculated for each decile within a polygon using a three-variable equation of relative ecosystem value (i.e., SEI Value (SEIVAL_#) multiplied by Condition Value (CONDV_#)) and Wildlife Habitat Rating (i.e., Wildlife Habitat Value (WLHV_#)), which are detailed further below. To calculate the Conservation Value (CONS_#) and, in turn, the SER, the following steps were taken (Haney & Iverson, 2009):

- » Multiply the SEI Value by the Condition value for each decile;
- » Add SEI/Condition value and wildlife value, with a weighting of 2 to 1 for SEI/Condition, for each decile;
- » Cons_1 = (2 [SEIVAL_1 * CONDV_1] + WLHV_1) / 3)
- » Assign Conservation Value to the polygon based on the highest value of all components (CONS_VAL = highest value of CONS_1, CONS_2, and CONS_3); and,
- » Classify Conservation Values into three levels to give SER
- » (Haney & Iverson, 2009).
- » SER 1 = High Conservation Value (7 to 10)
- » SER 2 = Medium Conservation Value (3 to 6.9)
- » SER 3 = Low Conservation Value (0 to 2.9)

The SEI class and subclasses were ranked using a 0-10 rating scheme to create the SEI Values. The ratings used are based on previous regional mapping, the relative rarity provincially and locally, the ecological sensitivity of the ecosystem, and its general importance to wildlife (Table 6).

Table 6. SEI class and subclass relative rankings and rationale

SEI Class	SEFIN Unit (Class:subclass)	SEI Subclass	Relative SEI Value	Rationale	Proportion of Study Area
Sensitive Ecosystems					
Broadleaf Woodland	BW:ac	Aspen Copse	7	Sensitive; very rare in study area	0.30%
	BW:as	Aspen Seepage	7	Sensitive; extremely rare in study area	0.03%
Grassland	GR:dg	Disturbed Grassland	6	Disturbed but provide values for many grassland species, including rare wildlife; rare in study area	1.70%
	GR:gr	Grassland	9	Very sensitive and provincially rare; common in study area	5.30%

Table 6. SEI class and subclass relative rankings and rationale

SEI Class	SEFIN Unit (Class:subclass)	SEI Subclass	Relative SEI Value	Rationale	Proportion of Study Area
Sensitive Ecosystems					
	GR:sh	Shrubland	9	Very sensitive and provincially rare; very rare in study area	0.60%
	GR:ss	Steep Shallow-soiled	9	Very sensitive and provincially rare; extremely rare	0.01%
	GR:st	Steep	9	Very sensitive and provincially rare; extremely rare	0.01%
Old Forest	OF:co	Coniferous	10	Very sensitive; very important wildlife habitat; very rare	0.5%
	OF:mx	Mixed	10	Very sensitive; very important wildlife habitat; extremely rare	0.01%
Riparian	RI:be	Beach	10	Very sensitive; very important wildlife habitat; extremely rare in study area	0.01%
	RI:ff	Fluvial Fringe	10	Very sensitive; very important wildlife habitat; very rare	1.0%
	RI:fp	Bench / Floodplain	10	Very sensitive; very important wildlife habitat; rare	1.2%
	RI:gu	Gulley	10	Very sensitive; very important wildlife habitat; rare	1.6%
	RI:ri	River	10	Very sensitive; important wildlife habitat; very rare	0.2%
Sparsely Vegetated	SV:cl	Cliff	10	Sensitive; very important wildlife habitat; very rare	0.1%
	SV:ro	Rock Outcrop	8	Sensitive; important wildlife habitat; rare	1.2%
	SV:sh	Shrub	10	Sensitive; very important wildlife habitat; very rare	0.2%
	SV:ta	Talus	8	Sensitive; important wildlife habitat; rare	0.7%
Coniferous Woodland	WD:co	Coniferous	6	Sensitive; very important wildlife habitat; common	13.9%
	WD:mc	Mature Coniferous	8	Sensitive; very important wildlife habitat; rare	5.0%

Table 6. SEI class and subclass relative rankings and rationale

SEI Class	SEFIN Unit (Class:subclass)	SEI Subclass	Relative SEI Value	Rationale	Proportion of Study Area
Sensitive Ecosystems					
Wetland	WN:wm	Wet Meadow	10	Sensitive; important wildlife habitat; extremely rare	0.02%
	WN:ms	Marsh	10	Very sensitive; very important wildlife habitat; very rare	0.15%
	WN:sp	Swamp	10	Sensitive; important wildlife habitat; extremely rare	0.02%
	WN:sw	Shallow Open Water	10	Very sensitive; very important wildlife habitat; very rare	0.9%
Other Important Ecosystems					
Seasonally Flooded Fields	FS		4	Less sensitive; important wildlife habitat; extremely rare in study area	0.04%
Mature Forest	MF:co	Coniferous	2	Less sensitive; common in study area	14.3%
	MF:bd	Broadleaf	3	Less sensitive; extremely rare	0.05%
	MF:mx	Mixed	3	Less sensitive; very rare	0.5%
Not Sensitive					
Not Sensitive	NS		0	Not sensitive; both anthropogenic and natural ecosystems, usually common forest ecosystems; some important wildlife habitat	50.6%

Condition Values (CONDV_#), which help adjust SEI Values downward based on a very general assessment of anthropogenic disturbance in the decile using aerial imagery and the new CO_DSSCL_# fields, are assigned using the following rubric:

- 1 = Excellent condition;
- 0.8 = Good condition;
- 0.5 = Fair condition; and,
- 0.1 = Poor condition.

Condition values were applied to all affected polygons in the study area. Unaffected polygons were not reassessed for condition values unless values were missing for one of the deciles and, therefore, already being updated.

Wildlife Habitat Ratings (WHR) and habitat suitability mapping were updated for the study area. A large scale update was not originally anticipated, but it needed to be done following the broad structural stage updates that were applied. Ecosystems in previously unmapped areas and new areas were added to a habitat ratings lookup table so that the model can be rerun for the entire new data set. Wildlife species and life requisites considered in habitat ratings and modelling are listed in Table 7 (below).

The logic for the habitat ratings is based on updated wildlife Species Accounts for the ten species previously modelled. The selected species for the WHR models have been used previously and are deemed suitable umbrella species that cover the range of habitats throughout the study area and collectively represent surrogate species for the diversity of fauna within the Central Okanagan. For each unique ecosystem in the study area, the species' life requisites were assigned a WHR of 0 (None), 1 (Low), 5 (Moderate), or 10 (High) based on the suitability of the ecosystem for that life requisite.

The highest-value method was used for the Wildlife Habitat Value calculation, which involves assigning the Wildlife Habitat Value for the ecosystem decile to be equal to the highest WHR. This method overstates the amount of higher value habitats because the whole polygon is considered high even if only a small proportion is high value. This method highlights areas that have the potential for high value habitat (Sarell et al., 2003).

There are two other methods that can be used, and each has a different set of features to understand (Sarell et al., 2003). The averaged method calculates the average Wildlife Habitat Value for the polygon using the Wildlife Habitat Value from each decile. This method will overvalue certain areas of the polygon while undervaluing others. The other method is largest area, which applies a Wildlife Habitat Value to the polygon using the value that is in the largest decile.

The composite moderate and high-rated polygons (for all species) were assessed and evaluated to consider core habitat areas and to build on previous corridor planning project initiatives and climate change considerations.

Table 7. Life requisites for selected at-risk wildlife species included in the WHRs

Species	Life Requisite	Rating Code	BC List[1]
Western Rattlesnake	General Living during Summer	RCROR_LIS	Red
Western Rattlesnake	Security/Thermal habitat for General living, all year	RCROR_STLIA	Red
Gopher Snake	Food for general Living during Growing season	RPICA_LIS	Red
Gopher Snake	Security/Thermal habitat for Reproduction (egg-laying sites)	RPICA_STRE	Red
Lewis's Woodpecker	Security/Thermal habitat for Reproduction	BLEWO_STRE	Red
Western Screech-owl	Security/Thermal habitat for Reproduction	BWSOW_STRE	Red
Western Screech-owl	Food for Reproduction	BWSOW_FDRE	Red
Badger	General living, all year (denning and foraging)	MTATA_LIA	Red
Badger	General Living during Growing season	MTATA_LIG	Red

Table 7. Life requisites for selected at-risk wildlife species included in the WHRs

Species	Life Requisite	Rating Code	BC List[1]
Townsend's Big-eared Bat	Security/Thermal habitat for general Living, Growing season	MCOTO_STLIG	Blue
Townsend's Big-eared Bat	Food for general Living during Growing season	MCOTO_FDLIG	Blue
California Bighorn Sheep	Food for general Living during Growing season	MOVCA_FDLIG	Blue
California Bighorn Sheep	Security habitat for general Living during Growing season	MOVCA_SHLIG	Blue
California Bighorn Sheep	Food for general Living during Winter	MOVCA_FDLIW	Blue
California Bighorn Sheep	Security habitat for general Living during Winter	MOVCA_SHLIW	Blue
California Bighorn Sheep	Security habitat for Reproduction (lambing cliffs)	MOVCA_SHRE	Blue
Painted Turtle	General living, all year (foraging/overwintering)	RCHPI_LIA	Blue
Painted Turtle	Security/Thermal habitat for Reproduction (egg-laying sites)	RCHPI_STRE	Blue
Flammulated Owl	Security/Thermal habitat for Reproduction	BFLOW_STRE	Blue
Flammulated Owl	Food for general Living during Growing season	BFLOW_FDLIG	Blue
Mule Deer	Thermal habitat for general Living during Winter	MODHE_THLIW	Yellow
Mule Deer	Food for general Living during Winter	MODHE_FDLIW	Yellow
Mule Deer	Security habitat for general Living during Winter	MODHE_SHLIW	Yellow
Mule Deer	Food for general Living during Growing season	MODHE_FDLIG	Yellow
Mule Deer	Security habitat for general Living during Growing season	MODHE_SHLIG	Yellow

[1]**Provincial status:** Red = endangered or threatened. Blue = of special concern. Yellow = not at risk.

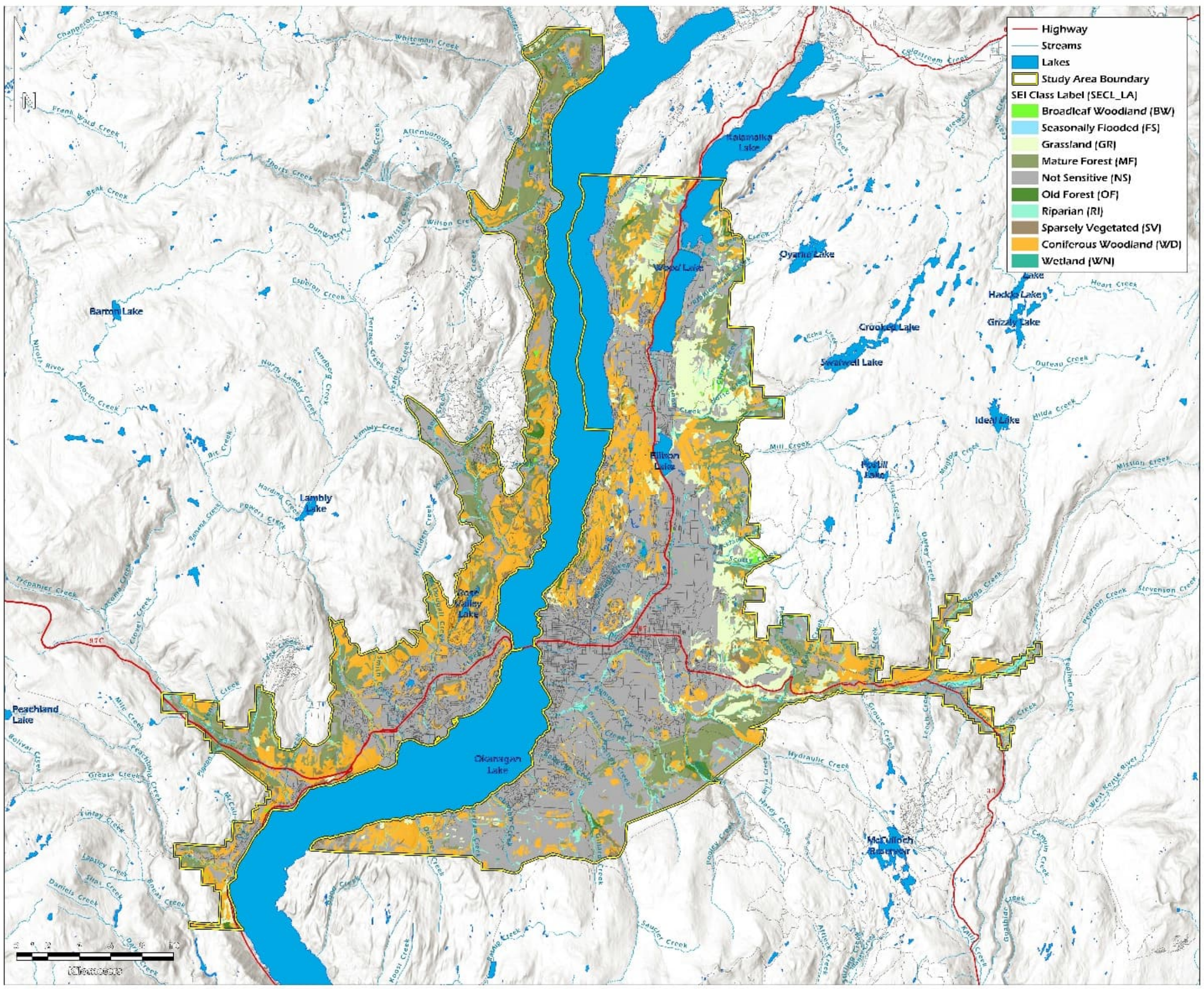
Analysis for Update

Once the SEI update was complete, geospatial analyses were undertaken to understand how sensitive ecosystems have changed. Pivot tables of ecosystem types (i.e., grassland, coniferous woodland, etc.) and anthropogenic character at the municipal and regional scales were generated and compared with previous SEIs. These types of analyses were undertaken for each municipality (see Municipal Changes section for results) so that the outcomes are clearly communicable to key decision-makers. This change was projected into the future, assuming that current environmental policies are kept consistent. These analyses help us understand the efficacy of environmental policies for certain types of sensitive ecosystems (i.e., wetlands compared to forests). In addition, this helps to assess the varying degree of risk to each ecosystem type.

Results and Analysis

Regional Changes

The changes between the two SEI products (2012 and 2021) are difficult to compare directly. As polygons and the deciles within polygons changed, the proportions and distribution of areas between the two products changed independently. Therefore, a 1:1 comparison is not possible. However, reviewing the changes between the two products as totals within the study area and each jurisdiction makes it possible to understand what changes have been captured. As described above, the changes reflected in the SEI products are a mixture of anthropogenic change, forest successional changes, and natural events (primarily wildfire). As a result, it is erroneous to account for all losses in sensitive areas as anthropogenically caused and, conversely, to attribute all sensitive area gains to habitat restoration and improvements. The regional assemblage of leading SEI categories is shown in Inset Figure 3.



Inset Figure 3. Leading SEI Category

Table 8 (below) shows the proportional breakdown between the SEI units for 2012 and 2021. Losses were prevalent in all categories except for Old Forest (OF), Mature Forest (MF), and Wetland (WN). Gains in OF and MF and the loss in NS are directly attributable to the structural stage update; before that update, an estimated percent increase in NS of 3-4% would have been experienced with decreases in OF and MF due to logging and development, and it should be noted that the concealed increase of NS areas was not made of newly established young forests that are not captured by the SEI class definitions. The 27-hectare increase in WN is a product of identifying gaps using the Okanagan Wetlands base data, visually inspecting areas to identify previously unmapped wetlands, and the natural expansion of some wetland areas (e.g., Roberts Lake, Tatamiki Basin, and other smaller wetland features).

After accounting for these caveats, the regional changes within the updated SEI intuitively reflect the trends and changes the valley has experienced in the time since the original SEIs were completed. GR and WD, more common in the lower elevations of the valley where residential and agricultural development is pronounced, experienced the greatest losses of 749.8 ha and 853.9 ha, respectively. The relatively low rates of change occurring in WN and Riparian (RI) are likely a product of the stringent provincial and regional environmental policies regarding development near watercourses, particularly the fish-bearing watercourses that are common in the region.

To break down the spatial growth of urban development within the region, masked by the factors listed above, the ecosystem codes were categorized based on their character as natural or anthropogenic. Table 9 (below) shows that anthropogenic ecosystem codes increased by 9.4% relative to pre-update conditions (this does not consider human activities that do not alter base ecosystem codes, such as logging) and natural ecosystems decreased by 4.2%. The current study area comprises 33.7% anthropogenic ecosystem codes, a 3 percentage point increase from pre-update conditions.

Table 8. Regional summary of SEI classes before and after the update

			Original		Updated		Change	
Type	SEI Category	SEI Unit	Area (ha)	Proportion	Area (ha)	Proportion	Difference (ha)	% Change [3]
Sensitive	Broadleaf Woodland	BW	254.0	0.3%	230.7	0.3%	-23.3	-9.2%
Sensitive	Grassland	GR	6,911.9	8.5%	6,162.1	7.6%	-749.8	-10.9%
Sensitive	Old Forest	OF	368.1	0.5%	440.6	0.5%	72.5	19.7%
Sensitive	Riparian	RI	3,219.4	4.0%	3,167.5	3.9%	-51.8	-1.6%
Sensitive	Sparsely Vegetated	SV	1,821.8	2.2%	1,786.7	2.2%	-35.1	-1.9%
Sensitive	Coniferous Woodland	WD	16,211.5	20.0%	15,357.6	18.9%	-853.9	-5.3%
Sensitive	Wetland	WN	874.7	1.1%	901.7	1.1%	27.0	3.1%
Important	Seasonally Flooded	FS	36.2	0.04%	30.6	0.0%	-5.6	-15.5%
Important	Mature Forest[1]	MF	2,779.6	3.4%	12,033.2	14.8%	9,253.6	332.9%
Not Sensitive	Not Sensitive[1]	NS	48,750.7	60.0%	41,121.3	50.6%	-7,629.4	-15.7%
Totals			**81,227.9**	**100%**	**81,232.1**	**100%**	**4.2**	

Note: Red text indicates a loss in area pre- to post-update

[1] The increase in MF was from a regional structural stage update; those ecosystems were previously NS. Outside of that update, NS would have increased by 3-4%

[2] The increase in area is a result of reconciling the spatial data in and between the original products

[3] *Percent change* is the amount each category has changed from pre to post update. % change = [difference (ha) / original area (ha)] * 100

Note: A *percentage point* change is difference between the pre and post update proportional values. For example, in the above table Grassland decreased by 0.9 percentage points; 7.6% - 8.5 % = -0.9% pts, meaning that 0.9% of the study area that used to be grassland is no longer so.

Table 9. Regional summary of anthropogenic and natural areas before and after the update						
	Original		Updated		Change	
Type	Area (ha)	Proportion	Area (ha)	Proportion	Difference (ha)	% Change[2]
Anthropogenic	25,019.3	30.8%	27,362.9	33.7%	2,343.0	9.4%
Natural	56,208.5	69.2%	53,869.2	66.3%	-2,338.7	-4.2%
Totals	**81,227.9**	**100%**	**81,232.1**	**100%**	**4.2**[1]	

Note: Red text indicates a loss in area pre to post

[1] The increase in area is a result of reconciling the spatial data in and between the original products

[2] *Percent change* is the amount each category has changed from pre to post update. % change = [difference (ha) / original area (ha)] * 100

Note: A *percentage point* change is difference between the pre and post update proportional values. For example, in the above table natural areas decreased by 2.9 percentage points; 66.3% - 69.2 % = -2.9% pts, meaning that 2.9% of the study area that used to be natural is no longer so.

Municipal Changes

Similar to the regional changes, most local governments experienced losses in most categories. Many local governments saw growth in Mature Forest due to changes in age structure and slight growth in Wetlands (Table 10, below). These results come with the same caveats as the regional ones. Grasslands and Coniferous Woodlands ex consistently the greatest losers across the municipalities. The growth in anthropogenic and decrease in natural areas in every municipality emphasizes the population growth and intense development pressure in the Central Okanagan over the study period (Table 11, below; StatsCan, 2022).

Minor areal differences in the table outputs are due to reconciling the gaps and overlaps in the base SEI data layer. Figures 3–1 to 3-28 in Appendix B show zoomed-in samples of the updated SEI mapping, including the newly mapped areas displayed using the dominant SEI category. A focused view of anthropogenic areas and their character based on the new disturbance classes can be seen in Figures 4-1 to 4-28 in Appendix B.

Table 10. Municipal summaries of SEI classes before and after the update								
			Original		Updated		Change	
Type	SEI Category	SEI Unit	Area (ha)	Proportion	Area (ha)	Proportion	Areal Difference (ha)	% Change[1]
Kelowna								
Sensitive	Broadleaf Woodland	BW	43.4	0.2%	31.1	0.1%	-12.3	-28.3%
Sensitive	Grassland	GR	1,445.3	6.7%	1,121.9	5.2%	-323.4	-22.4%
Sensitive	Old Forest	OF	86.2	0.4%	84.6	0.4%	-1.6	-1.9%
Sensitive	Riparian	RI	502.3	2.3%	495.5	2.3%	-6.8	-1.4%
Sensitive	Sparsely Vegetated	SV	290.2	1.4%	268.7	1.2%	-21.5	-7.4%
Sensitive	Coniferous Woodland	WD	3,395.0	15.8%	3,006.9	14.0%	-388.1	-11.4%
Sensitive	Wetland	WN	246.6	1.2%	270.0	1.3%	23.4	9.5%
Important	Seasonally Flooded	FS	32.4	0.2%	26.8	0.1%	-5.6	-17.3%
Important	Mature Forest*	MF	70.1	0.3%	583.7	2.7%	513.6	732.7%
Not Sensitive	Not Sensitive	NS	15,387.8	71.6%	15,610.1	72.6%	222.3	1.4%
		Totals	**21,499.2**	**100%**	**21,499.2**	**100%**	**0.0**	
Lake Country								
Sensitive	Broadleaf Woodland	BW	91.8	0.6%	89.0	0.5%	-2.8	-3.1%
Sensitive	Grassland	GR	3,034.1	18.6%	2,826.6	17.3%	-207.5	-6.8%
Sensitive	Old Forest	OF	88.3	0.5%	100.0	0.6%	11.6	13.0%
Sensitive	Riparian	RI	472.6	2.9%	459.9	2.8%	-12.6	-3.0%
Sensitive	Sparsely Vegetated	SV	131.9	0.8%	125.1	0.8%	-6.8	-5.0%
Sensitive	Coniferous Woodland	WD	2,204.3	13.5%	1,963.7	12.0%	-240.5	-10.9%
Sensitive	Wetland	WN	553.7	3.4%	554.8	3.4%	1.1	0.2%
Important	Seasonally Flooded	FS	0.0	0%	0.0	0%	0.0	0.0%
Important	Mature Forest*	MF	281.4	1.7%	1,767.4	10.8%	1485.9	528.0%

Table 10. Municipal summaries of SEI classes before and after the update

			Original		Updated		Change	
Type	SEI Category	SEI Unit	Area (ha)	Proportion	Area (ha)	Proportion	Areal Difference (ha)	% Change[1]
Not Sensitive	Not Sensitive	NS	9,453.7	58.0%	8,425.1	51.7%	-1028.6	-10.9%
		Totals	**16,311.8**	**100%**	**16,311.6**	**100%**	**-0.2**	
Okanagan Indian Band								
Sensitive	Broadleaf Woodland	BW	3.7	1.9%	0.0	0.0%	-3.7	-100.0%
Sensitive	Grassland	GR	10.2	5.1%	10.2	5.1%	0.0	0.0%
Sensitive	Old Forest	OF	0.0	0%	0.0	0%	0.0	0.0%
Sensitive	Riparian	RI	20.4	10.3%	20.4	10.3%	0.0	0.0%
Sensitive	Sparsely Vegetated	SV	0.0	0.0%	0.0	0.0%	0.0	0.0%
Sensitive	Coniferous Woodland	WD	7.5	3.8%	7.5	3.8%	0.0	0.0%
Sensitive	Wetland	WN	2.6	1.3%	2.6	1.3%	0.0	0.0%
Important	Seasonally Flooded	FS	0.0	0.0%	0.0	0.0%	0.0	0.0%
Important	Mature Forest*	MF	0.0	0.0%	0.0	0.0%	0.0	0.0%
Not Sensitive	Not Sensitive	NS	154.4	77.7%	158.1	79.6%	3.7	2.4%
		Totals	**198.7**	**100%**	**198.7**	**100%**	**0.0**	
Peachland								
Sensitive	Broadleaf Woodland	BW	13.3	0.9%	10.4	0.7%	-2.9	-22.1%
Sensitive	Grassland	GR	18.1	1.2%	18.1	1.2%	0.04	0.2%
Sensitive	Old Forest	OF	3.2	0.2%	3.2	0.2%	0.0	0.0%
Sensitive	Riparian	RI	49.5	3.3%	46.1	3.1%	-3.4	-7.0%
Sensitive	Sparsely Vegetated	SV	48.4	3.2%	48.6	3.2%	0.2	0.5%
Sensitive	Coniferous Woodland	WD	449.1	29.7%	443.0	29.3%	-6.1	-1.3%
Sensitive	Wetland	WN	0.0	0.0%	0.0	0.0%	0.0	0.0%

Table 10. Municipal summaries of SEI classes before and after the update								
			Original		Updated		Change	
Type	SEI Category	SEI Unit	Area (ha)	Proportion	Area (ha)	Proportion	Areal Difference (ha)	% Change[1]
Important	Seasonally Flooded	FS	0.0	0.0%	0.0	0.0%	0.0	0.0%
Important	Mature Forest*	MF	43.6	2.9%	117.2	7.8%	73.6	168.9%
Not Sensitive	Not Sensitive	NS	884.9	58.6%	823.3	54.5%	-61.6	-7.0%
		Totals	**1,510.1**	**100%**	**1,509.9**	**100%**	**-0.2**	
RDCO								
Sensitive	Broadleaf Woodland	BW	97.4	0.3%	96.0	0.3%	-1.4	-1.5%
Sensitive	Grassland	GR	2,137.2	6.8%	1,937.9	6.2%	-199.3	-9.3%
Sensitive	Old Forest	OF	190.3	0.6%	252.8	0.8%	62.5	33.0%
Sensitive	Riparian	RI	1,840.4	5.9%	1,817.4	5.8%	-23	-1.0%
Sensitive	Sparsely Vegetated	SV	889.9	2.9%	892.7	2.9%	2.8	0.3%
Sensitive	Coniferous Woodland	WD	7,130.8	22.8%	7,047.9	22.5%	-82.9	-1.2%
Sensitive	Wetland	WN	59.1	0.2%	59.6	0.2%	0.6	0.9%
Important	Seasonally Flooded	FS	2.8	0.01%	2.8	0.01%	0.0	0.0%
Important	Mature Forest*	MF	2,071.5	6.6%	7,864.4	25.2%	5792.9	279.7%
Not Sensitive	Not Sensitive	NS	16,839.2	53.9%	11,287.2	36.1%	-5552	-33.0%
		Totals	**31,258.5**	**100%**	**31,258.7**	**100%**	**0.2**	
West Kelowna								
Sensitive	Broadleaf Woodland	BW	0.0	0.0%	0.0	0.0%	0.0	0.0%
Sensitive	Grassland	GR	45.7	0.5%	27.5	0.3%	-18.2	-39.9%
Sensitive	Old Forest	OF	0.0	0.0%	0.0	0.0%	0.0	0.0%
Sensitive	Riparian	RI	244.7	2.8%	238.9	2.7%	-5.8	-2.0%
Sensitive	Sparsely Vegetated	SV	451.6	5.1%	441.7	5.0%	-9.9	-2.0%

Table 10. Municipal summaries of SEI classes before and after the update

			Original		Updated		Change	
Type	SEI Category	SEI Unit	Area (ha)	Proportion	Area (ha)	Proportion	Areal Difference (ha)	% Change[1]
Sensitive	Coniferous Woodland	WD	2,896.9	33.0%	2,768.0	31.5%	-128.9	-4.4%
Sensitive	Wetland	WN	10.4	0.1%	11.3	0.1%	0.9	8.8%
Important	Seasonally Flooded	FS	0.0	0.0%	0.0	0.0%	0.0	0.0%
Important	Mature Forest*	MF	208.2	2.4%	1,387.9	15.8%	1179.7	566.6%
Not Sensitive	Not Sensitive	NS	4,930.0	56.1%	3,916.6	44.5%	-1013.3	-20.6%
		Totals	**8,787.4**	**100%**	**8,791.9**	**100%**	**4.5**	
Westbank First Nation								
Sensitive	Broadleaf Woodland	BW	4.3	0.3%	4.3	0.3%	0.0	0.0%
Sensitive	Grassland	GR	221.4	13.3%	219.9	13.2%	-1.5	-0.7%
Sensitive	Old Forest	OF	0.0	0.0%	0.0	0.0%	0.0	0.0%
Sensitive	Riparian	RI	89.5	5.4%	89.5	5.4%	0.0	0.0%
Sensitive	Sparsely Vegetated	SV	9.9	0.6%	9.9	0.6%	0.0	0.0%
Sensitive	Coniferous Woodland	WD	128.1	7.7%	120.5	7.3%	-7.6	-5.9%
Sensitive	Wetland	WN	2.3	0.1%	3.3	0.2%	1.0	44.5%
Important	Seasonally Flooded	FS	1.0	0.1%	1.0	0.1%	0.0	0.0%
Important	Mature Forest*	MF	104.9	6.3%	312.7	18.8%	207.8	198.2%
Not Sensitive	Not Sensitive	NS	1,100.7	66.2%	900.9	54.2%	-199.8	-18.2%
		Totals	**1,662**	**100%**	**1,662**	**100%**	**-0.01**	

Notes: Red text indicates a loss in area pre- to post-update.

* The increase in MF and OF was from a regional structural stage update; MF ecosystems were previously NS.

Changes in area of municipalities are a result of reconciling the spatial data in and between the original products

[1] Percent change is the amount each category has changed from pre to post update. % change = [difference (ha) / original area (ha)] * 100

A percentage point change is difference between the pre and post update proportional values. For example, in the above table WD in West Kelowna decreased by 1.5 percentage points; 31.5% - 33% = -1.5% pts, meaning that 1.5% of the West Kelowna study area that used to be WD is no longer so.

Table 11. Summary of anthropogenic vs natural areas by municipality

	Original		Updated		Change	
Type	Area (ha)	Proportion	Area (ha)	Proportion	Areal Difference (ha)	% Change[1]
Kelowna						
Anthropogenic	13,829.2	64.0%	14762.7	69.0%	933.5	6.7%
Natural	7,670.0	36.0%	6736.5	31.0%	-933.5	-12.2%
Totals	**21,499.2**	**100%**	**21,499.2**	**100%**	**0.0**	
Lake Country						
Anthropogenic	3120.7	19.0%	3680.8	23.0%	560.1	17.9%
Natural	13191.1	81.0%	12630.9	77.0%	-560.3	-4.2%
Totals	**16,311.8**	**100%**	**16,311.6**	**100%**	**-0.2**	
Okanagan Indian Band						
Anthropogenic	153.8	77.4%	157.5	79.2%	3.7	2.4%
Natural	45.0	22.6%	41.3	20.8%	-3.7	-8.3%
Totals	**198.7**	**100%**	**198.7**	**100%**	**0.0**	
Peachland						
Anthropogenic	806.6	53.0%	818.0	54.0%	11.4	1.4%
Natural	703.5	47.0%	691.9	46.0%	-11.6	-1.6%
Totals	**1,510.1**	**100%**	**1,509.9**	**100%**	**-0.2**	
RDCO						
Anthropogenic	3025.3	10.0%	3580.0	11.0%	554.7	18.3%
Natural	28233.2	90.0%	27678.7	89.0%	-554.5	-2.0%
Totals	**31,258.5**	**100%**	**31,258.7**	**100%**	**0.2**	
West Kelowna						
Anthropogenic	3212.0	37.0%	3487.6	40.0%	275.6	8.6%
Natural	5575.5	63.0%	5304.4	60.0%	-271.1	-4.9%

Table 11. Summary of anthropogenic vs natural areas by municipality

	Original		Updated		Change	
Type	Area (ha)	Proportion	Area (ha)	Proportion	Areal Difference (ha)	% Change[1]
Totals	**8,787.4**	**100%**	**8,791.9**	**100%**	**4.5**	
Westbank First Nation						
Anthropogenic	872.4	52.5%	876.3	52.7%	4.0	0.5%
Natural	789.6	47.5%	785.7	47.3%	-4.0	-0.5%
Totals	**1,662.0**	**100%**	**1,662.0**	**100%**	**-0.01**	

Notes: Red text indicates a loss in area pre- to post-update**.**

Changes in area of municipalities are a result of reconciling the spatial data in and between the original products
[1] Percent change is the amount each category has changed from pre to post update relative to itself. % change = [difference (ha) / original area (ha)] * 100
A percentage point change is difference between the pre and post update proportional values. For example, in the above table natural areas in Westbank First Nation decreased by 0.2 percentage points, 47.3% - 47.5% = -0.2% pts, meaning that 0.2% of the Westbank First Nation study area that used to be natural is no longer so, and since there are only two options, anthropogenic increased by that same amount.

Drivers of Change

In the lower elevations, anthropogenic changes to the landscape were the primary driver of changes in ecosystem composition. The change occurred in semi-natural areas within municipal boundaries and against the largely natural outer boundaries through urban expansion. New single-family residential neighbourhoods and agriculture were the major proponents of this change.

The pre-update SEI layer was not coded for the new Central Okanagan-specific disturbance classes, but post-update, the character of the disturbance is predominantly Residential development (40%) (Table 12, Figures 4-1 to 4-28 in Appendix B). Another significant driver was agricultural expansion into grasslands and forested areas, with Agriculture and Steadings making up 30% of the mapped disturbance. This level of detail on current disturbance regimes is not particularly useful in the change analysis since the pre-update conditions do not have comparable details, however, it will be valuable to the analyses in future SEI updates.

Table 12. Regional summary of new Central Okanagan SEI update disturbance codes

Disturbance Class	Disturbance Subclass		Proportion of Mapped Disturbance
Commercial development	c	Urban commercial	1.44%
	y	Recreational commercial	2.02%
	w	Wilderness commercial	0.12%
Industrial activity	h	Heavy industrial	0.08%
	m	Light/Medium industrial	0.84%
	e	Excavation/Resource extraction	2.75%
Natural events	f	Fire	19.53%
	i	Flood	0.00%
	s	Mass wasting	0.00%
Public and institutional	g	Institutional	0.12%
	p	Parks*	0.21%
	z	Utilities	2.64%
Residential development	u	Urban	16.54%
	r	Rural	13.39%
	l	Suburban	10.65%
Agriculture and steadings	a	Cultivated	29.27%
	d	Animals/Livestock**	0.16%
	b	Farm structures	0.21%

Notes: Logging is not included in these calculations, as that disturbance is captured well by the original TEM codes.
* Predominantly natural parks were not categorized in this exercise, and more dominant disturbance codes may cover many urban parks within a given polygon.
** Livestock is challenging to assess in aerial imagery, and some are likely categorized as Cultivated instead.

There were some gains realized in the WN SEI category. Most of these gains resulted from the expansion of existing waterbodies (e.g., Roberts Lake and Tatamiki Basin), which seasonal variations in imagery can, in part, cause. Additionally, several smaller wetlands and moisture-receiving environments not previously captured in the SEI are reflected in the updated version.

Another important driver in the SEI changes since the original mapping was several significant wildfires within the study area[2]. These resulted in a meaningful change to several forested ecosystems that sometimes depend on the structural stage to be classified as a Sensitive or Important Ecosystem and have high WHRs. As a result of the reduction in structural stage post-fire, there are cases where some of the polygons that were once considered to be are no longer defined as Sensitive or Important. This logic also applies to the logging that is common around study area fringes.

On the other hand, using the Vegetation Resources Inventory (VRI) data from the Province to update the structural stage of undisturbed forest ecosystems to match the projected forest stand ages in the VRI data has numerically offset the losses from fire and logging.

Though it is not possible to precisely define what SEI categories were lost to what type of disturbance, a coarse analysis for the purposes of identifying the primary drivers of change was undertaken. This analysis involved intersecting a subset of the post-update data (i.e., only using newly mapped change polygons) with the pre-update data and summarizing the data using the leading SEI categories and Central Okanagan disturbance subclasses. The resultant values are not meaningful enough to portray; however, the general magnitudes of change (Table 13, below) and proportional impacts (Table 14, below) are useful in understanding the character of change that has occurred in the valley.

The relative magnitudes (Table 13, below) show that Residential development is the largest driver of change, followed by Agriculture. NS is the most impacted SEI category, which indicates that usage of the SEI in the municipal permitting processes is generally effective at conserving Sensitive Ecosystems. The main exception is Coniferous Woodlands, which is subject to all forms of development.

Residential development primarily impacts NS, GR, WD, and, notably, RI. The impacts to Riparian are a combination of creekside and lakefront development, and despite environmental protective measures, stream setbacks and Riparian ecosystem boundaries are developed on different scales and may not align. According to Table 14, Residential has the highest proportional impact on all SEI categories except BW, FS, and GR.

Agriculture is the other leading driver of land use change. Agricultural development shows Moderate to Very High relative magnitudes for NS, GR, and WD, and, expectedly, has the highest proportional impact on FS and GR.

[2] Wildfires in the study area during 2022 and 2023 are not included.

Table 13. Relative magnitude of SEI unit changes by newly mapped Central Okanagan disturbance classes

SEI Class	Agriculture	Industrial	Natural	Institutional	Residential	Commercial	Total
Broadleaf Woodland (BW)							
Seasonally Flooded (FS)							
Grassland (GR)							
Mature Forest (MF)							
Not Sensitive (NS)							
Old Forest (OF)							
Riparian (RI)							
Sparsely Vegetated (SV)							
Coniferous Woodland (WD)							
Wetland (WN)							
Total							

Note: Magnitudes displayed in the table are based on a subset of the data and compare leading SEI class (SECL_LA) to CO_DCL_#.

Legend:	No Change	Low	Moderate	High	Very High

Table 14. Drivers of SEI unit changes by newly mapped Central Okanagan disturbance classes						
SEI Class	**Agriculture**	**Industrial**	**Natural**	**Institutional**	**Residential**	**Commercial**
Broadleaf Woodland (BW)						
Seasonally Flooded (FS)						
Grassland (GR)						
Mature Forest (MF)						
Not Sensitive (NS)						
Old Forest (OF)						
Riparian (RI)						
Sparsely Vegetated (SV)						
Coniferous Woodland (WD)						
Wetland (WN)						

Note: Proportional changes displayed in the table are based on a subset of the data and compare leading SEI class (SECL_LA) to CO_DCL_1

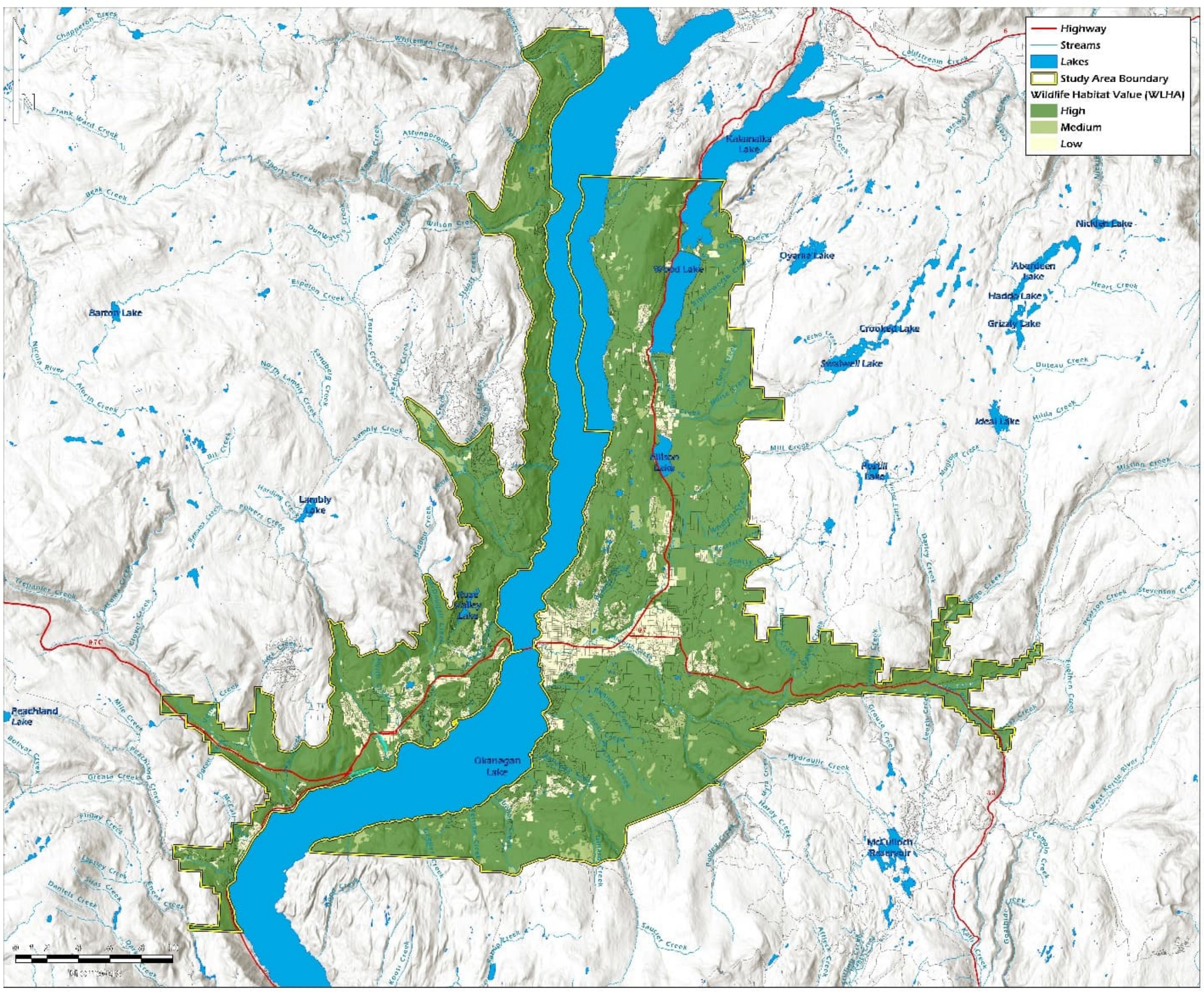
Legend: Proportion of change, gradient of green to red

Little to None	Moderate	High

Conservation Zones, Critical Corridors, and Connectivity

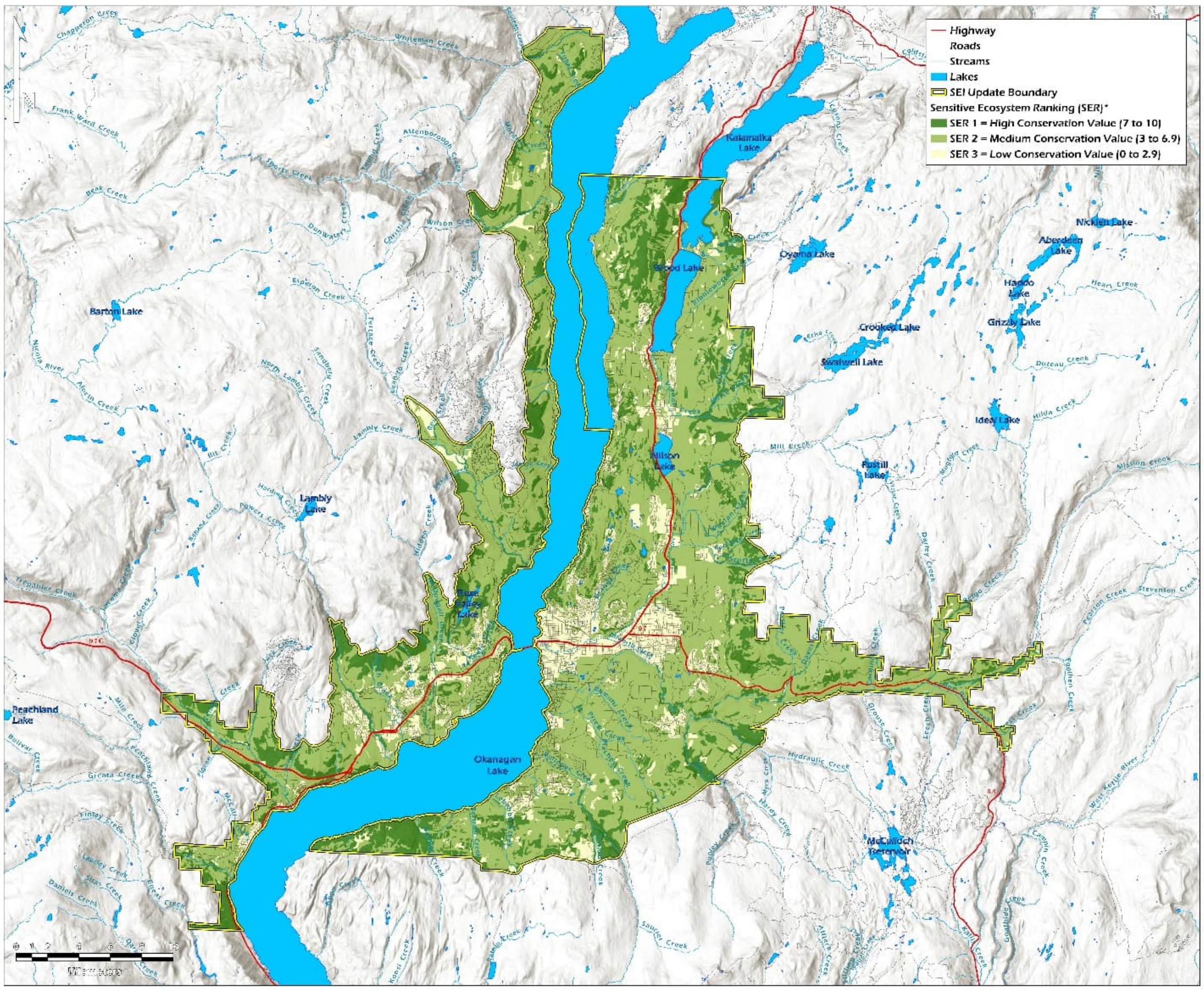
The model outputs are conservative and use the highest Wildlife Habitat Value (Inset Figure 4. Wildlife Habitat Value Using Highest-Value Method (Inset Figure 4) or Conservation Value (Figure 7-1 to 7-28 in Appendix B) from the polygon's three possible deciles. This conservative method respects both specialist and generalist species and acknowledges pockets of high-value ecosystems in otherwise lower-value areas. The habitat suitability and conservation mapping outputs were broadly assessed and evaluated to consider core habitat areas and ecosystem connectivity corridors. It is important to acknowledge that despite conservation efforts to retain specific sensitive forest ecosystems, unforeseen wildfire impacts on these ecosystems may hinder ecological succession, with a reduced likelihood of returning to the pre-fire state due to changing climatic conditions (Utzig, 2012).

Wildlife Habitat Values across the region are High, indicating the importance of the remaining natural elements to the region's key species (Inset Figure 4). Urban centres are the exception, but even rural and agricultural areas are generally considered good value to at least one life requisite of one of the ten umbrella species. A series of core habitat and connectivity assessments for individual species would better illuminate wildlife corridors, but that is a much finer resolution assessment than the SEI can accurately provide.



Inset Figure 4. Wildlife Habitat Value Using Highest-Value Method

From assessing the High Conservation Value areas in Inset Figure 5 and Figure 3-1 to 3-28 in Appendix B, one can see that the landscape is quite fragmented, and there are few large contiguous patches of high-value areas. On the west side of Okanagan Lake north of West Kelowna, there are a series of modest-sized patches of high conservation value primarily associated with excellent condition Sparsely Vegetated, Coniferous Woodlands, and Mature Forests, and it is essential to retain north-to-south connectivity between those areas as well as smaller east-west corridors into the eastern highland plateau, using natural topographic features, habitat types, and elevation bands as guides. Other conservation hotspots on the west side of Okanagan Lake are the north slopes of West Kelowna and the east-facing slope south of Peachland; however, the study area is not large enough to accurately capture the extent of connectivity in these areas.



Inset Figure 5. Sensitive Ecosystem Ranking using conservative method

The east side of Okanagan Lake has a more fragmented mosaic of high conservation value areas. The landscape is characterized by High-value riparian corridors that lose their lustre when reaching urban areas and three broad semi-fragmented ecosystem corridors.

The first corridor, containing mostly Coniferous Woodland, Grassland, and Mature Forest SEI categories, follows a similar elevation band from Okanagan Mountain around the south and east side of the municipalities across the west face of Black Mountain towards the east shores of Kalamalka Lake. The other main north-south corridor is along the ridgeline above the east shore of Okanagan Lake, spanning from Knox Mountain to Ellison Ridge and then further north. It comprises Coniferous Woodland, Wetland, Grassland, and Mature Forests SEI categories. Creating an ecologically functional east-west connection between these corridors is critical to retaining connectivity between the North and South Okanagan regions. The barriers along the least developed areas (i.e., the south end of Ellison Lake or the Oyama isthmus) are highways, agricultural land, and low-density residential areas. The last main ecological corridor observed is east-west oriented. It connects the easternmost portion of the study area, through Joe Rich, to the north-south ecological connectivity corridor in the central valley. This connective ecosystem tissue is primarily forested and follows natural topographic corridors down from the mountains and provincial interior.

Limitations

Methodological

The bioterrain spatial file was prepared as a desktop study using an interpretation of the LiDAR data and derivative products and a high-resolution orthophoto. No ground-based field verification was completed by the bioterrain mapper. Uncertainty is inherent in this type of analysis, which is affected by imagery quality, including resolution and presence of shadows and clouds. The accuracy of polygon boundaries is limited by the scale, resolution and dates of the imagery, and the LiDAR hillshade. The mapping was completed at a 1:10,000 scale, and mapping products are intended to be used at this or smaller scale.

Ecoscape assumed that the historical SEI was correct in its representation of the landscape. However, any apparent errors in unchanged areas were corrected where they were observed (e.g., an anthropogenic ecosystem polygon on a largely undeveloped area in both sets of imagery). Seasonal and temporal variations in imagery and relatively low-quality historical imagery (grainy, black and white) in some areas provided occasional difficulties in identifying ecosystem changes or loss of small amounts of a particular natural ecosystem within a given polygon.

Analytical

Inconsistencies were found within the coding of ecosystems and SEI classes in the datasets, both within individual central Okanagan SEI projects and between them, which are likely a result of human error and evolving standards, methods, and input data. Ecoscape rectified inconsistencies where they were identified and were reasonable to do. A large-scale cleanup of the amalgamated layer was beyond this project's scope, but it should be done moving forward to allow seamless future updates. Spatial inconsistencies (i.e., overlaps and gaps, particularly along project boundaries) were reconciled in the updated data. However, the borders of projects are still represented in the spatial data and could be reconciled if interested parties undertake further data management.

General

Ecoscape has prepared this report, and it is intended for the sole and exclusive use of the Regional District of Central Okanagan and its member municipalities and local governments, the Province of British Columbia, and Environment and Climate Change Canada for the purposes set out in this report. Ecoscape has prepared this report with the understanding that all available and applicable information on the past and present SEI work within the study area has been disclosed. Ecoscape has relied upon personal communications with the Regional District of Central Okanagan and other information sources to corroborate the documents and data available for the study area. The Regional District of Central Okanagan has also acknowledged that for Ecoscape to provide professional service properly, Ecoscape relies on full disclosure and accuracy of this information.

Any use of this report by a third party, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. Ecoscape accepts no responsibility for damages suffered by any third party because of actions or decisions made based on this report.

Conclusions

The SEI is a broad planning and flagging tool for understanding and quantifying sensitive ecological areas, including areas of potential wildlife habitat, provincially sensitive ecosystems, and rare ecosystems. More detailed field assessments are needed for site-specific evaluations and management recommendations. The accuracy of the boundaries of the update mapping is limited by the scale of the original mapping (1:15,000), whereas the newly mapped areas are at a finer scale of 1:10,000. One of the key outcomes of the SEI update is a comprehensive database of current ecosystem conditions.

The analysis of regional and municipal changes in the central Okanagan Valley SEI product from 2012 to 2021 has unveiled important insights into the evolving landscape and potential future scenarios. The implications of these changes underscore the landscape's dynamic nature, reflecting anthropogenic influences and natural processes.

Regional

The examination of regional changes between the pre- and post-update SEI products reveals notable shifts, with losses prevalent in most categories. The changes reflected in the SEI products are a mixture of anthropogenic change, forest successional changes, and natural events (primarily wildfire).

- » Grassland (GR) and Coniferous Woodland (WD) SEI categories, more common in the lower elevations and warm slopes of the valley where residential and agricultural development are pronounced, experienced the greatest losses of 749.8 ha (-11%) and 853.4 ha (-5%), respectively. These two SEI categories, plus Broadleaf Woodlands (BW), are the first categories projected to potentially reach local extinction based on the extrapolation of historical rates. These losses and rates of loss are due to a combination of factors, such as a lack of legislative environmental protection, locations in areas desirable for development, and relative abundance within the study area.
- » Gains in Mature Forest (MF) are significant (9,253.6 ha). They are caused by a structural stage update that applied tree age values within the VRI dataset to a subset of the region’s ecosystems. Wildfire and logging-affected forest stands were excluded, instead having structural stages updated according to those disturbances.
- » Increases in Wetland (WN) are attributable to natural expansion and identifying gaps in base data by working at a finer resolution (e.g., Roberts Lake, Tatamiki Basin, and other smaller wetland features). The relatively low rates of change occurring in WN and Riparian (RI) SEI units are likely a consequence of the stringent provincial and regional environmental policies regarding development near watercourses, particularly the fish-bearing watercourses that are common in the region.
- » Not Sensitive (NS), which is a combination of natural and anthropogenic ecosystem units, decreased because many previously NS forest ecosystems shifted into the MF category; prior to that shift, NS would have had a 3-4 percent increase prior to the structural stage update. The masked increase in urban development can instead be visualized by the 3 percentage point increase, or 9.36 percent increase, in anthropogenic ecosystem codes in the region.
- » The abundance of Sparsely Vegetated (SV) units appears stable. This is likely due to their high value in prior SEI conservation models and their less favourable development potential due to their common traits of bedrock outcrops, steep talus slopes, and cliffs.
- » The main drivers of anthropogenic change within the region were agriculture and residential with roughly 2500 ha and 5500 ha of new development, respectively. Approximately 80% of the development in the region occurred on previously mapped NS areas, indicating that policies to protect sensitive areas, such as DPAs, are effective. The largest conversion of SEI units to anthropogenic disturbance categories, excluding NS, involved WD to Residential, GR to Agriculture, and GR to Residential. As it stands, Residential and Agriculture account for 40% and

30%, respectively, of the mapped disturbance in the region (this mapped disturbance does not include logged areas but does include wildfires).

» Wildlife Habitat Values, which were calculated using the conservative highest value method, across the region are generally high and indicate the importance of the remaining natural elements and green urban spaces to the region's key species. Urban centres are the exception, but even rural and agricultural areas are generally considered good value to at least one life requisite of one of the ten umbrella species.

» From assessing the high Conservation Value areas, the landscape appears quite fragmented, with few large contiguous high-value patches.

» On the west side of Okanagan Lake north of West Kelowna, there are a series of modest-sized patches of high conservation value primarily associated with excellent condition WD, MF, and SV SEI units.

» The east side of Okanagan Lake has a more fragmented mosaic of high Conservation Value areas. The landscape is characterized by high-value riparian corridors that lose their lustre when reaching urban areas and three broad semi-fragmented ecosystem corridors. The first corridor follows a similar elevation band from Okanagan Mountain around the south and east side of the municipalities across the west face of Black Mountain towards the east shores of Kalamalka Lake. The other main north-south corridor is along the ridgeline above the east shore of Okanagan Lake, spanning from Knox Mountain to Ellison Ridge and then further north. The last main ecological corridor observed is east-west oriented. It connects the easternmost portion of the study area, through Joe Rich, to the north-south ecological connectivity corridor in the central valley. This connective ecosystem tissue is primarily forested and follows natural topographic corridors down from the mountains and provincial interior.

Municipal

Similar to the regional changes, most local governments experienced losses in most SEI categories. However, many local governments saw growth in Mature Forests due to a change in age structure and slight growth in Wetlands.

» City of Kelowna experienced losses in all non-NS SEI categories. Most notable were the percent changes of -29%, -22%, and -11% for BW, GR, and WD, respectively. Despite the 500-plus ha increase in MF within the municipality, NS still increased by 222 ha. Furthermore, Kelowna experienced a 934 ha increase (5 percentage points) in anthropogenic ecosystem codes relative to the pre-update mapping and, inversely, a 5 percentage point decrease in natural ecosystems.

» District of Lake Country experienced an 18% (4 percentage point) increase in anthropogenic ecosystem codes relative to pre-update conditions. The major SEI unit changes occurred in MF (+1486 ha), GR (-208 ha), and WD (-241 ha). Overall, Lake Country has a greater area of non-NS categories, although MF is considered an Other Important Ecosystem, and valued less by the modelling than the Sensitive Ecosystems. Lake Country has natural and anthropogenic coverages of 77% and 23%, respectively.

» Okanagan Indian Band (IR#7) experienced a full loss of BW (-3.7 ha), though the remainder of the jurisdiction was unchanged. OKIB (IR#7) has 79% anthropogenic ecosystem coverage.

» Peachland experienced small areal losses in Sensitive Ecosystems, but the percent change in BW (-22.10%) and RI (-7%) are significant. Notably, Peachland had a 73.6 ha increase (168.9%) in MF. Anthropogenic ecosystem codes in Peachland increased by 1 percentage point, resulting in 54% anthropogenic coverage for the district.

» Regional District of Central Okanagan had small losses for most SEI categories, except for a 9.3% relative decrease (200 ha) in GR. Most of the region's increase in MF (5,793 ha) and OF (63 ha) occurred in the RDCO. Natural areas in the RDCO decreased by 1 percentage point, resulting in the portion of the district within the study area having 89% coverage by natural ecosystems.

- West Kelowna experienced a 161.9 ha loss in Sensitive Ecosystems. This included a notable 40% loss in GR, and losses between 2 and 5% for RI, SV, and WD. Conversely, WN increased by 0.9 ha (9% change) and MF increased by 1180 ha. Anthropogenic ecosystem codes in the municipality increased by 3 percentage points to 40% of the overall area.
- Westbank First Nation (IR#8, IR#9, IR#10, and IR#12) experienced a 4 ha decrease in natural ecosystems, a 0.24 percentage point decrease, leaving the jurisdiction with 47% natural coverage. Among the Sensitive Ecosystems, GR decreased by 1%, WD decreased by 6%, and WN increased by 45%. Additionally, MF increased by nearly 200% (208 ha) relative to pre-update conditions.

Recommendations

Land Use Planning

- ***Environmental Development Permit areas*** established according to the previous version of the SEI ***should undergo reassessment in light of the updated SEI***. This revision is important as it is likely to reveal new areas that warrant inclusion or exclusion based on the latest data.
- ***Creating a systematic approach to documenting ecosystem change resulting from ongoing development is crucial***, especially if the database will be used for cumulative effects monitoring and establishing retention targets. It's imperative to integrate, monitor, and manage changes over time. Therefore, establishing a consistent process and schedule for updating ecosystem change that results from municipal development permits is highly advisable to effectively monitor the state of Central Okanagan ecosystems.
- Furthermore, it is recommended that the ***Central Okanagan SEI be updated regularly, at least every five years***. Implementing an approach for regularly documenting changes from development will streamline and enhance the cost-effectiveness of these updates, with the most significant changes, other than development, occurring from landscape alterations, such as wildfire. These regular updates will be important to understand the effectiveness of any policy changes.
- Given their extent of loss, ***Grasslands, Broadleaf Woodlands, and Coniferous Woodlands stand out as specific sensitive ecosystems requiring prioritization for the establishment of retention targets and enhanced policy for protection.*** These ecosystems are poised to become even more susceptible to disturbance due to the dual impacts of climate change, including shifting temperature and precipitation patterns alongside heightened occurrences of droughts, floods, wildfires, and storms, and anthropogenic influences like habitat fragmentation, invasive species proliferation, escalating developmental pressures from growing populations, and potential food supply challenges (IPCC, 2023; ICF, 2019; Utzig, 2012). Additionally, other sensitive ecosystems such as Old Forests are essential to identify retention targets due to their role as highly effective carbon sinks, storing significant amounts of carbon over long periods. Once lost, this stored carbon cannot be easily replenished within our lifetime through simple offsetting measures. A landcover change projection analysis may be beneficial in providing a better understanding of future risks to Sensitive Ecosystems.
- ***Formalize and protect the remaining ecological corridors in the central Okanagan.*** On the western shore of Okanagan Lake, scattered patches of High Conservation Value areas underscore the importance of establishing north-south connectivity. Conversely, the eastern side features valuable riparian draws that link the valley floor to cooler, upland regions, serving as crucial refuges amidst a changing climate. Additionally, two expansive, partially fragmented ecological corridors run in a north-south orientation. Ensuring an ecologically functional east-west connection between these primary corridors is paramount.
- The ***further refinement of core habitat areas and corridors*** is beyond the scope of this project's deliverables. However, it is important to lay the framework as this is an optimal goal of ecological land use planning. Core habitats are specific areas that contain the best and most stable habitats for wildlife populations that persist over time and are used year after year. A core area identifies those areas within a resident animal's home range that are used more intensively than others and

contains the home sites, refuges, and most dependable food sources. In short, core areas contain the critical habitat elements (i.e., nest sites, roost sites, access to food) for the survival and reproduction of a species. Smaller habitats, such as those that have already been fragmented or perforated by land development, are more transient in their function and may have less consistent use or value for wildlife. In setting the framework, Core habitats will be conceptualized based on habitat quality, habitat proximity (e.g., connectivity), and habitat persistence (i.e., the size of habitat patches). This will require that thresholds be set for habitat ratings, habitat adjacency/proximity, and habitat size. This will integrate previous corridor mapping in the central Okanagan and consider climate change, ecosystem, and habitat shifts that are expected to occur as a result.

Technical

» With an ongoing process of updating the SEI and having it function as a cumulative effects monitoring tool, ***a set of standardized methods for updating the SEI product with an internal version tracking system should be established.*** The data within the layer should be reconciled to ensure all necessary attributes are completed to allow for efficient translations and SEI calculations with code. Scripts and key tables used for regular updating should be publicly available to facilitate additional regional modelling exercises by other interested parties.

» Inconsistencies were identified within the coding of ecosystems and SEI classes in the datasets, likely stemming from human error and the evolution of standards, methodologies, and input data. Ecoscape addressed these inconsistencies where feasible, but a comprehensive data review was beyond the scope of this project. ***A comprehensive data review is recommended to improve accuracy and facilitate seamless future updates.***

» Recommendations from the previous SEI projects in the study area should be compiled and reviewed prior to engaging in the next regional update, and any relevant unaddressed recommendations should be considered before developing that project's scope.

» The Central Okanagan SEI mapping does not completely cover the full jurisdictional boundaries of the involved municipalities, so tracking changes to SEI units and establishing retention targets is made more difficult. ***It is recommended that further SEI mapping be completed to fill in the municipal boundaries of the District of Peachland and City of West Kelowna***.

» It is essential to note that all natural environments provide valuable ecosystem services in their natural state, irrespective of their categorial status as Sensitive, Important or Not Sensitive. Building on this point, ***it is recommended that the Young Forest SEI unit be added to the list of Other Important Ecosystems within the framework of the Central Okanagan SEI*** (Clark & Meidinger, 2020). This would better reflect the value of the currently "less sensitive" ecosystems, especially given local climate projections and the importance of maintaining tree canopy for carbon storage and wildlife refuge habitat.

» The conservation models adopt a conservative approach, prioritizing the highest Wildlife Habitat or Conservation Value in a polygon, respecting specialist and generalist species and niche ecosystems. ***The wildlife and conservation modelling underscores the importance of a strategic, regional approach to conservation; ecological connectivity of High Conservation Value areas must be prioritized for protection, to ensure functional ecosystems into the future.***

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