

“When we try to pick out anything
by itself, we find it hitched to
everything else in the Universe.”
- John Muir

BIODIVERSITY



Wetlands

134.6

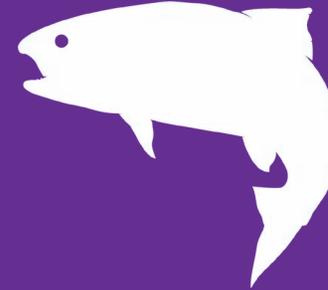
hectares in Lethbridge



Parks

38.16 km²

of park space in Lethbridge



Riparian Condition

7%

considered to be in healthy
condition



Species-at-Risk

23

species confirmed in
Lethbridge

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Background & Context

Canadians recognize the importance of maintaining a healthy environment. We are concerned with the degradation of ecosystems and the loss of animal and plant species which have resulted from human activity. Ecosystems perform functions that are essential to human existence, such as the production of oxygen and filtration of water. Humans use at least 40,000 species of plants and animals every day. We rely on biodiversity for many things, including medicine and clothing¹. The health and protection of biodiversity in our community is important to the success of our community. In this section, we are asking:

- What is the status of our local species and ecosystems?
- What are the priorities for biodiversity conservation in Lethbridge?



Figure 1. Lethbridge is situated in the Grassland Natural Region, which was historically dominated by native grasslands. Photo courtesy Leta Pezdaric/ Oldman Watershed Council.

The International Convention of Biological Diversity defines biodiversity as “the variability among living organisms from all courses including, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part; this includes diversity within species, between species and of ecosystems.”²

An ecosystem is a biological community of interacting organisms and their physical environment. Biodiversity is a key factor in the health of an ecosystem. Ecosystems interact with each other. Their success or degradation is dependent on that interaction and on the way that humans interact with them. Disturbing and/or altering an ecosystem can reduce biodiversity, which can change the way that organisms interact with the physical and chemical environment³.

Biodiversity is managed by all levels of government, who have focused on conservation and protection of ecosystems and the biodiversity within these ecosystems. Because of this, we must look at biodiversity in Canada, Alberta, the South Saskatchewan Region as well as within Lethbridge to understand the state of biodiversity in the city.

Industry, farming, forestry, commercial fishing, expanding urban areas, developing transportation corridors and our high per capita consumption of resources all have an impact on biodiversity. To support the protection of biodiversity in Canada, the Government of Canada (with the support of provincial and territorial governments) signed and ratified the United Nations Convention on Biological Diversity in 1992. This document is a global and national instrument for promoting and guiding efforts to conserve biodiversity. From this, the Canadian Biodiversity Strategy (CBS) was developed. The responsibility of the CBS is shared among the federal, provincial/territorial and municipal governments. It is also important that all Canadians must support the CBS in order for it to be successful. The CBS includes five goals:

1. Conserve biodiversity and use biological resources in a sustainable manner;
2. Improve our understanding of ecosystems and increase our resource management capability;
3. Promote an understanding of the need to conserve biodiversity and use biological resources in a sustainable manner;
4. Maintain or develop incentives and legislation that support the conservation of biodiversity

and the sustainable use of biological resources; and

5. Work with other countries to conserve biodiversity, use biological resources in a sustainable manner and share equitably the benefits that arise from the utilization of genetic resources⁴.

The CBS also serves as a guide for local and indigenous communities, urban and regional governments, business and industry, conservation groups, educational and scientific institutions and interested individuals. Over the past two decades, federal, provincial and territorial governments have developed and implemented a wide range of laws, policies and programs that support the five goals listed above in order to conserve the vast amount of biodiversity in Canada⁵.

In addition to the Canadian Biodiversity Strategy and our system of National Parks and National Wildlife Areas, biodiversity conservation in Canada is also guided by the National Accord for the Protection of Species at Risk (1996), the Committee On the Status of Endangered Wildlife In Canada (formed in 1977) and the Species At Risk Act (Canada 2002).

Biodiversity Conservation in Canada

Biodiversity in Alberta

In Alberta, data regarding biodiversity is collected by the Alberta Conservation Information Management System and species-at-risk are managed through Alberta's Strategy for the Management of Species-at-Risk. Alberta also maintains a diverse portfolio of Provincial Parks and Protected Areas.

Alberta is home to more than 60,000 species⁶ of which the majority are invertebrates, fungi and algae. The Alberta Conservation Information Management Systems maintains a list of the

Table 1: Approximate Number of Species known to occur in Alberta⁸

Taxonomic Group	# of Species
Mammals	93
Birds	411
Reptiles	8
Amphibians	10
Fish	65
Vascular Plants ⁹	2235
Mosses & Liverworts ¹⁰	755
Lichens ¹¹	840
Invertebrates – Insects (aquatic, beetles, bees, grasshoppers, ants, dragonflies & damselflies, spiders, armoured mites...) ^{12,13}	~20,000
Invertebrates – Snails, slugs, mussels	125

approximate number of species in Alberta⁷ (see Table 1).

Central to the maintenance of biodiversity is the conservation of landscapes. Conserving a range of landscapes that are representative of Alberta's natural diversity provides for habitat that will support and maintain native species and ecosystems. Alberta has been classified into six major Natural Regions each of which is subdivided into Natural Subregions (21 in total) based on differences in vegetation, soils, climate, elevation, latitude or physiographic features¹⁴:

1. Boreal Forest Natural Region
2. Canadian Shield Natural Region
3. Foothills Natural Region
4. Grassland Natural Region
5. Parkland Natural Region
6. Rocky Mountain Natural Region

Lethbridge lies within the Grassland Natural Region and more specifically the Mixedgrass Natural Subregion (see Figure 1). The Grassland Natural Region is the warmest and driest Region and occupies approximately 96,000 km², or 14% of Alberta stretching from the Rocky Mountains and foothills to the Saskatchewan border and from the Alberta-Montana border north to the parkland. It includes four subregions: Dry Mixedgrass, Mixedgrass, Northern Fescue

and Foothills Fescue. The Mixedgrass Natural Subregion is approximately 20,000 km² and characterized by native grasslands dominated by needle grasses and wheat grasses on typically gently undulating to rolling plains broken in places by coulees and river valleys. Moister

sites such as depressions and northerly aspects support shrub communities. Cottonwoods and willows occur adjacent to rivers. Trees, shrubs and herbaceous plants making up the native vegetation are adapted to the semi-arid climate and summer droughts. Wetlands cover about 5% of this Subregion¹⁵. The Mixedgrass Natural Subregion is intensely cultivated, with only 35% of its area remaining as native vegetation. Only 1% of the Mixedgrass Natural Subregion is managed as protected area¹⁶.

Habitat conservation is an important component of supporting biodiversity. The Government of Alberta has created Alberta's Natural Regions Landscape Classification Framework that identifies natural landscapes found in the province. Connectivity of wildlife habitat across landscapes, within the region and across regions, is also an important factor in maintaining biodiversity.

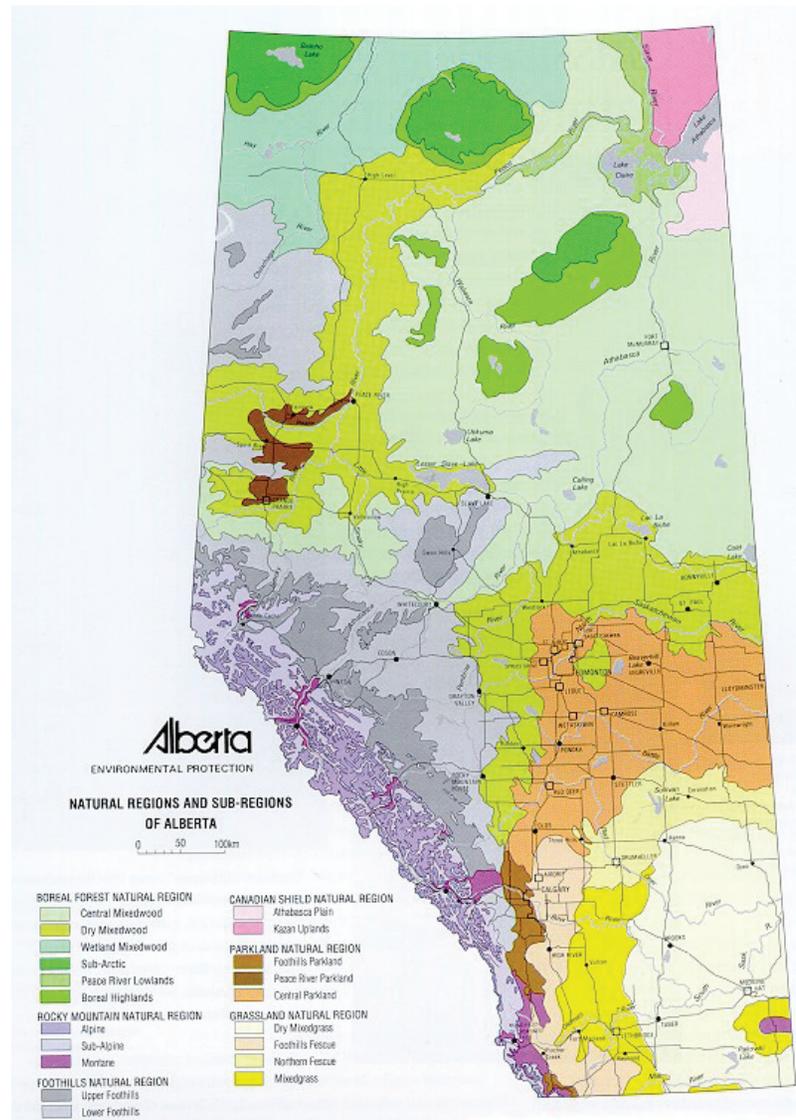


Figure 2. Natural Subregions in southern Alberta. Map courtesy Alberta Environment.

Biodiversity Planning in the South Saskatchewan Region

Lethbridge lies within the South Saskatchewan Region (SSR), one of seven Land-use Framework planning regions in Alberta, defined based on main watersheds (see Figure 3). The SSR is nearly 84,000 km² in area spanning from east to west and includes four of Alberta's six Natural Regions – Grassland (78%), Parkland (5%), Foothills (2%) and Rocky Mountains (15%)¹⁷. The Alberta Biodiversity Monitoring Institute (ABMI) found that human development footprint in the SSR is 57%, including 50% agricultural cultivation. Human development has significantly affected biodiversity in the SSR.

The status of 85 common native bird, vascular plant and soil arthropod species in the SSR were assessed by ABMI and found to be on average 54% intact. Sixty-nine species at risk, as listed under the federal Species at Risk Act and the provincial Wildlife Act occur in the SSR, many of these reliant on remaining native grasslands. Only 6% of the SSR is managed as protected areas.

The South Saskatchewan Regional Plan (SSRP) was approved by the Alberta Government in 2014 to guide future resource management



Figure 3. Sub Basins of the South Saskatchewan River Basin. Map courtesy Partners for the Saskatchewan River Basin

decisions in the region. Regional objectives for biodiversity and ecosystems include:

- Terrestrial and aquatic biodiversity are maintained.
- Long-term ecosystem health and resiliency is maintained.
- Species at risk are recovered and no new species at risk are designated.
- Intact grasslands habitat is sustained.
- Biodiversity and healthy, functioning ecosystems continue to provide a range of benefits to communities in the region and all Albertans and there is sustainable use of Alberta's biodiversity resources.

Additional objectives include a network of conservation areas on Crown lands and support for stewardship on private lands.

In developing the SSRP, intact native grasslands were mapped as were areas assessed as having high biodiversity values and connecting corridors of native habitat that allow for wildlife movement¹⁸. The Oldman River valley through Lethbridge is part of a wildlife corridor.

A key outcome for the region in the SSRP is that "biodiversity and ecosystem function are sustained through shared stewardship¹⁹". A strategy identified to achieve this outcome is

completion of the South Saskatchewan Region Biodiversity Management Framework (BMF). In 2015 a draft BMF was prepared and subjected to public review and consultation. Once the BMF is finalized, it will build upon the foundation of policy and management practices that currently support biodiversity in Alberta. Some examples are: species at risk planning, integrated land management, sub-regional planning, hunting and fishing regulations and rangeland management²⁰. The BMF seeks to improve land use practices so that the biodiversity we see today will be maintained into the future.

Indicators for managing biodiversity and ecosystems proposed in the SSRP (p. 75) are amount of land in conservation easements, amount of intact native grasslands and area of conserved land. The BMF proposes monitoring of biodiversity indicators, representing species and habitats from terrestrial and aquatic ecosystems against trigger values. Triggers are a type of threshold that have been defined in the Alberta Land Stewardship Act as "a limit, target, trigger, range, measure, index or unit of measurement." Triggers are the quantitative basis for evaluating biodiversity conditions and assessing whether management action is required²¹. Municipal governments have a key role to play in implementation of the BMF.

Ecosystem Services

We sometimes have a tendency to think of ecosystems as providing habitat for wildlife and plants, but with little or no connection to cities and communities. However, ecosystems provide a variety of ecological goods and services that have benefits for everyone.

Ecosystem services can be broken into four main categories²² (see Figure 5):

Provisioning services are those services that provide a direct material output such as food, raw materials, fresh water, and medicines.

Regulating services are those services that act as a regulating or mitigating force on our environment. Examples include air and water

filtration, carbon sequestration, pollination, and flooding and erosion controls.

Supporting services are the services we typically think of, including providing habitat for plants and animals and protecting genetic diversity.

Cultural services are those services that we gain from our enjoyment of nature such as recreation, mental health, tourism, and spiritual connections.

Because ecosystems benefit our communities, it is possible to determine an economic value for these services. As an example, the Delaware River Basin, which includes cities such as New York and Philadelphia, provides \$21 billion in ecosystem services. This includes \$2.4 billion in water quality, \$3.8 billion in water supply, and \$1.2 billion in health benefits from parkland²³.

Although ecosystems are not always front of mind, ecological goods and services highlight the importance that biodiversity and ecosystems have for our communities.



Figure 4. The Lethbridge River Valley provides a variety of ecosystem services including flood control, recreation and biodiversity. Photo courtesy Paige McGeorge/Flickr.

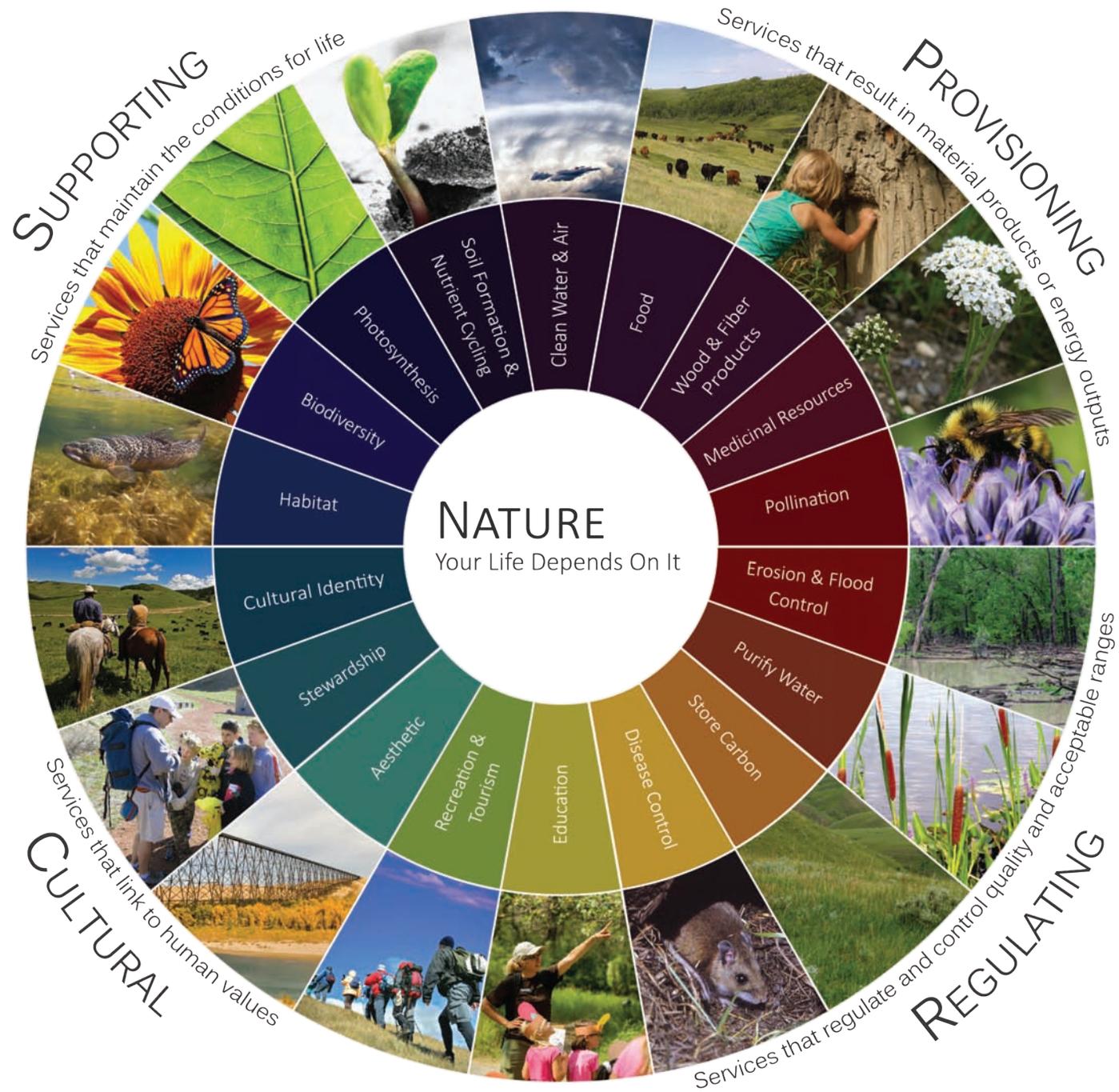


Figure 5. Ecosystem Services.
Graphic courtesy Helen Schuler
Nature Centre

Biodiversity in Lethbridge

Within Lethbridge, biodiversity is represented by a range of grassland, coulee, wetland and river valley ecosystems that each have their own distinct species. Within a short walk, citizens of Lethbridge can see everything from lush cottonwood forests up to dry, cacti-covered coulee slopes. The city is surrounded by grassland and cultivated farmland with the Rocky Mountains just off in the distance. Lethbridge is fortunate to be home to one of the largest urban park systems in North America. The Lethbridge river valley parks encompass an area of over 1,600ha²⁴. The wide range of flora and fauna contribute to the river valley's biodiversity. The Lethbridge river valley has a diverse landscape and provides the city with many ecological services including: slope stability, water filtration, wildlife habitat and resiliency to major flooding. The river

valley's landscape of grasses, shrubs and trees are an important wildlife habitat that provides an important migratory corridor through the city.

The river valley's diverse vegetation and landforms are home to a large assortment of mammals, birds, amphibians, reptiles, fish, invertebrates and a number of species at risk²⁵. Some of the common species found in the river valley are the Nuttall's cottontail and white-tailed prairie hares, porcupines, Richardson's ground squirrels, striped skunks, beavers, badgers and mule and white-tailed deer. There are many other species that have been sighted all over the city, including over 230 species of birds recorded in Lethbridge, with the greatest diversity found in the river valley.



Figure 6. Wetland areas, such as the Elizabeth Hall Wetlands, provide important habitat for a diversity of wildlife species. Photo courtesy Carole Anne Oikawa/Flickr.

The biodiversity in Lethbridge is important to the vibrancy, health and tourism of the city. Protecting parks and the river valley is important to maintaining the biodiversity that is found in Lethbridge. To explore whether or not ecosystems and local species are being adequately protected we have looked at nine indicators of biodiversity within the city.

The Alberta Wetland Policy defines wetlands as “land that is saturated with water long enough to promote the formation of water altered soils, growth of water tolerant vegetation, and biological activity adapted to a wet environment²⁶”. They provide food, habitat and shelter for wildlife. Wetlands are categorized as being either peatlands or non-peatlands. Peat is partially decomposed organic vegetation that develops in acidic soils. The vast majority of wetlands in the southern portion of Alberta are non-peatlands, which do not accumulate peat. Wetlands are highly diverse, productive ecosystems that provide many different ecological services. Table 2 includes a list of the ecological services and benefits that

wetlands provide. The protection of wetlands are critical as they contribute significantly to the biodiversity in our community.

Close to 21% of the province is covered in wetlands. Over time, wetlands in Alberta have been significantly altered or destroyed by human activities such as urban development, expanding cultivation agriculture and oil and gas industrial activities. The Institute of Wetlands and Waterfowl Research estimates that approximately 64% of the slough/marsh wetlands in the settled areas of Alberta no longer exist. Concern over loss of wetlands prompted the provincial government to develop the Alberta Wetland Policy (2013) with a goal “to

Indicator: Wetlands



As data on the past extent of wetlands in Lethbridge is not available, a trend cannot be determined for this indicator.

Table 2: Ecological Services of Wetlands²⁷

Ecological Service	Description
Water filtration	As water passes through a wetland, impurities are removed.
Recharge groundwater	Soaking up surface water and letting some of it seep back into the ground where it is filtered even further.
Moderate climate change	Takes Carbon Dioxide from the air and sequester the carbon in the soil.
Reduce the effects of drought	Wetlands are a valuable source of water. Livestock and wildlife are able to forage there during times of drought.
Reduce the effects of flooding	Reduce the effects of soil erosion by storing runoff water and releasing it slowly downstream.
Economic benefits	Promote tourism, boating, bird watching, nature photography, hunting and fishing.
Support biodiversity	Wetlands provide habitat for plants, birds, mammals and fish.

conserve, restore, protect and manage Alberta's wetlands to sustain the benefits they provide to the environment, society and economy²⁸.

There are 134.6 ha of wetlands in Lethbridge²⁹. These wetlands have been classified into four different types described in Table 3. The

percentage for each type of wetland are provided in Figure 5³⁰. Wetlands in Lethbridge host a large amount of biodiversity. They provide habitat to many animals especially bird species. At the Elizabeth Hall Wetlands in the river valley, over 120 species of birds have been observed, as have Western painted turtles, muskrats and beavers.

Table 3: Type of Wetlands by Classification in Lethbridge³¹

Classification	Description	# of Hectares
Ephemeral Wet Areas	Wetlands or wet areas that hold free surface water for only a short period of time. Some may fill up with water after a precipitation event but will not contain water long enough to support wetland vegetation. They may include sedges, fine-stemmed grasses or forbs.	71.1
Seasonal Wetlands	Wetlands that hold water most years, but are dry in the summer or fall and contain permanent riparian vegetation such as emergent wetland grasses, sedges and rushes/cattails.	30.8
Semi-Permanent Wetlands	Wetlands that hold surface water year-round, but may occasionally become dry (in instances of very dry years). These wetlands usually include emergent and submergent vegetation such as cattails, bulrushes and pondweeds.	18.2
Permanent Wetlands	Wetlands that hold water year round, over multiple years and include an open water zone that is devoid of vegetation and perimeter with riparian vegetation.	13.9

Wetlands provide many benefits to the community. They support biodiversity, reduce the effects of flooding and boost water quality among other benefits. With the many benefits that wetlands provide, it is important that we continue to protect these areas so that they may continue to provide these services. Threats to

wetlands include conversion to agricultural, industrial or residential lands, pollution and water contamination. While Lethbridge continues to expand and develop, maintaining and protecting wetlands is important. Steps need to be taken to reduce the impacts that human activities can have on wetlands.

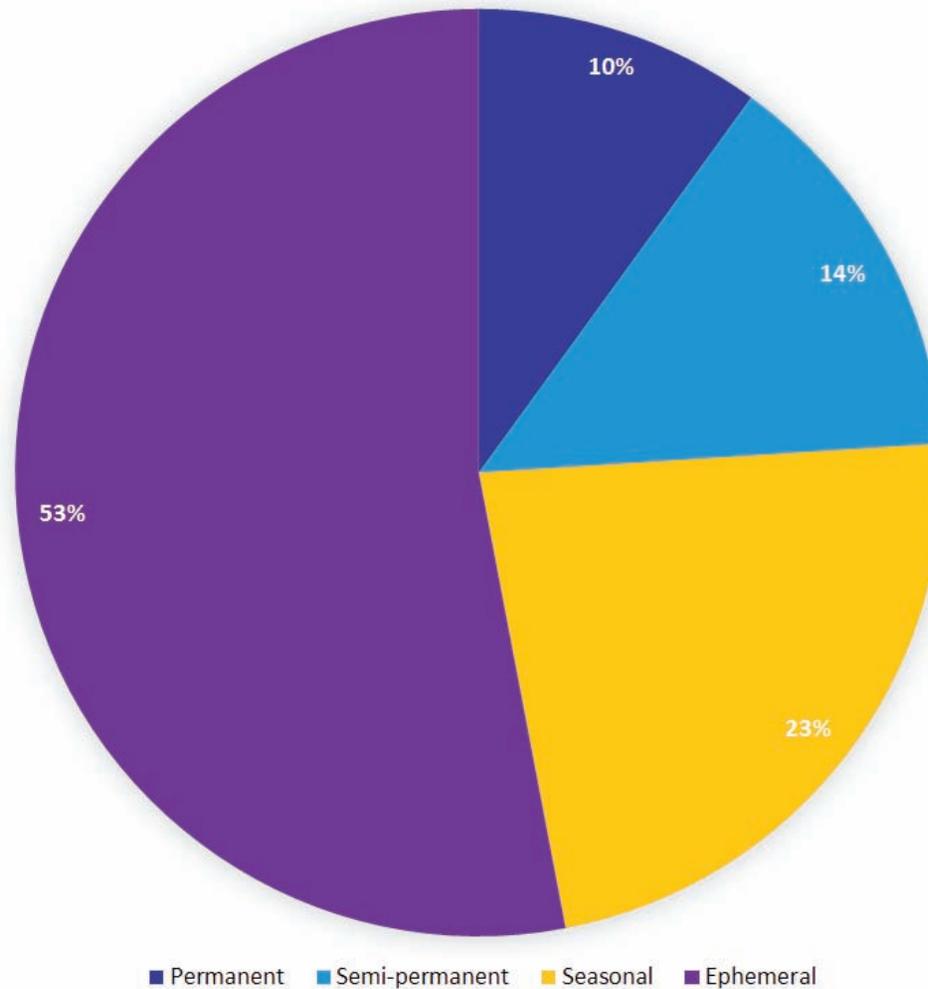


Figure 7. Percentage of each wetland type in Lethbridge. Data courtesy City of Lethbridge.

Indicator: Riparian Areas

Riparian functions of the Oldman River in Lethbridge are impaired.



Riparian areas are the portion of the landscape that is strongly influenced by water and can be recognized by water-loving vegetation adjacent to rivers, streams, lakes, springs, ponds and seeps. They have been described as green zones around lakes and wetlands and bordering rivers and streams³². Riparian areas are one of the most ecologically diverse ecosystems in the world. They sustain fish and wildlife populations, improve water quality, provide stable water supplies and support people on the landscape. The ecological functions performed by riparian areas include:

- Trapping and storing sediment to maintain and build banks;
- Recharging groundwater supplies;
- Providing stable flows and flood protection.;
- Improving water quality by filtering runoff and reducing the amount of contaminants and nutrients reaching the water; and
- Providing habitat for fish and wildlife.

Approximately 2-5% of the total landscape is comprised of riparian area, however, the ecological benefits that this area provides is proportionately much greater³³.

Riparian areas face many risks with development and multiple land use pressures increasing in and around waterbodies and urban areas. Increasing demands are being placed on water resources in the entire Oldman River basin. Primary riparian health issues include:

- Lack of root mass protection;
- Density and distribution of invasive plant species and disturbance-caused plant species;
- Removal of water from the system; and
- Control of flood peak/timing.

There are 514.1 ha of riparian area in Lethbridge. Alberta's Riparian Habitat Management Society (Cows and Fish) evaluated the health of riparian areas in Lethbridge³⁴. Considering the size of Lethbridge, there is a high proportion of

Table 4: Description of Riparian Health Rankings

Health Category	Assessment Score Range	Description	# of Sites in Lethbridge
Healthy	80-100%	Little to no impairment to any riparian functions.	1
Healthy with Problems	60-79%	Some impairment to riparian functions due to management or natural causes.	10
Unhealthy	<60%	Severe impairment to riparian functions due to management or natural causes.	4

riparian area due to the river valley and the park designation that it has been given. A description of the health categories of riparian areas is provided in Table 4.

During the riparian health inventory performed by Cows and Fish, 79 health inventories were examined to provide comprehensive and detailed information on riparian function based on soil, hydrology and vegetation criteria. As these parameters are so important to the health of a riparian area, Cows and Fish gave separate

health ratings for these as well as the overall health rating of the riparian areas.

The overall health assessment of these areas is that they are healthy, but with problems. Ten out of the fifteen sites (67%) were rated in this category. One site (7%) rated healthy and the other four sites (27%) rated unhealthy (see Figure 6). This compares to overall riparian health in the South Saskatchewan River Basin where 26% of riparian areas are healthy, 25% are unhealthy and 49% are healthy with problems³⁵.

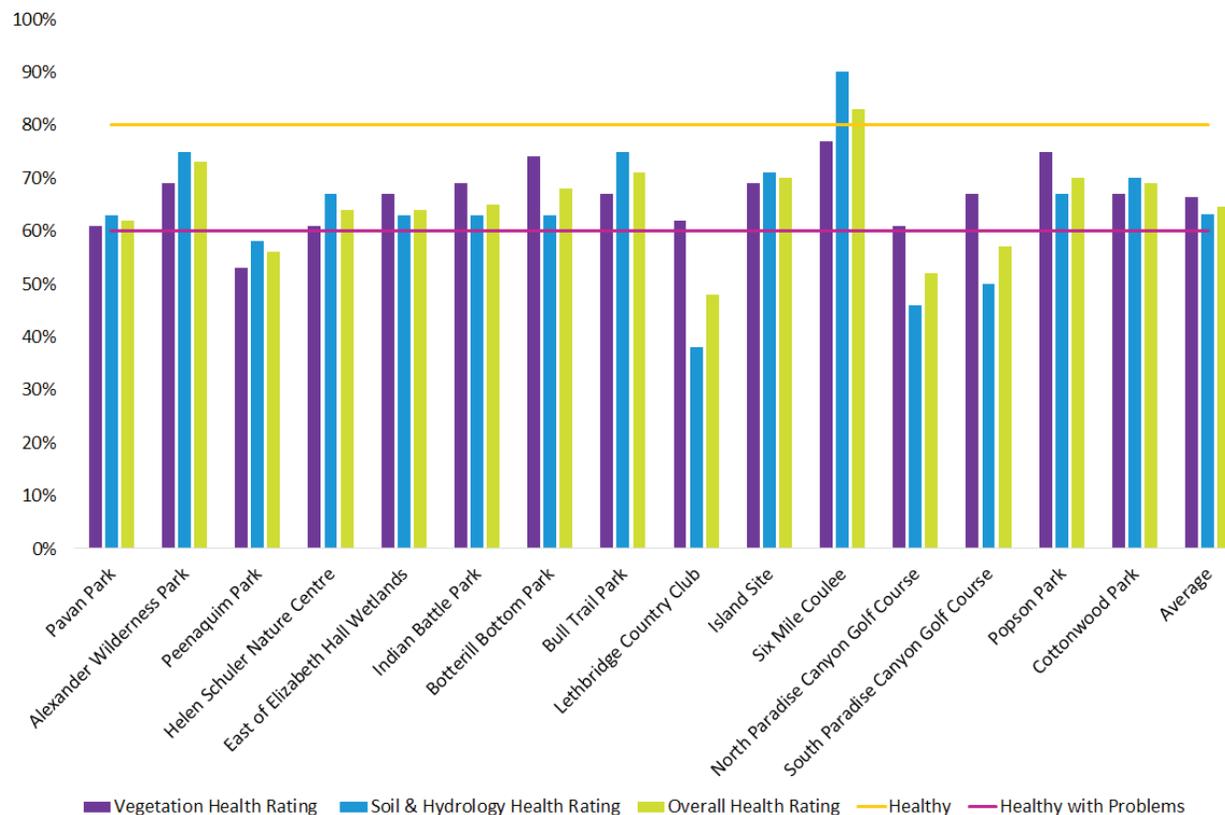


Figure 8. Riparian health assessments for the Oldman River Valley in Lethbridge. Adapted from Cows and Fish.

When riparian health degrades, it typically means that one or more of the pieces has been impacted by natural or human-caused disturbances such as development, recreation, grazing, flooding or fire. As the rate and intensity of disturbances increases, the severity of health degradation can reach a point where the riparian area fails to perform its functions. Management actions need to be taken to ensure the health and restoration of these areas.

The primary health issues with the riparian areas in Lethbridge are³⁶:

- Invasive plant species occur on every site and collectively occupy more than 15% of the area surveyed. The most common invasive species are leafy spurge and Canada thistle.
- Disturbance-caused plant species dominate the understory and open areas of most sites.



Figure 9. Healthy riparian areas are characterized by established native vegetation, natural flooding processes and lack of erosion. Photo courtesy Leta Pezdaric/ Oldman Watershed Council

Some of the common species are smooth brome, Kentucky bluegrass and crested wheat grass.

- Root mass protection is lacking along portions of the riverbank of the Oldman River. These deep-rooted, riparian vegetation (such as native trees and shrubs) are important for maintaining bank stability.
- Removal of water from the system has restricted the supply of water available for supporting riparian ecosystem in the city.
- Control of flood/peak timing by upstream dams has affected the long-term sustainability potential of cottonwood forests and other natural plant communities.

Cows and Fish have made several guiding principles to restore and manage the Oldman River valley riparian areas. These recommendations will assist in maintaining the health of riparian areas, which have an impact on the health of biodiversity in our community.

Riparian areas are some of the most important and diverse ecosystems in our community. It is important that government, businesses and community members work together to maintain and improve the health of riparian areas so that we may continue to receive the ecological services of these sites.

In Lethbridge, the Oldman River is home to 23 species of native fish, including the Endangered Lake Sturgeon (*Acipenser fulvescens*). Historically, it is likely that Bull Trout (*Salvelinus confluentus*) would have been present in this stretch of the Oldman River, however, it is believed to have been extirpated from the lower reaches of the River following the construction of the Oldman River Dam³⁷. An additional five species of introduced fish are also present in Lethbridge (see Table 5).

Among the introduced fish species present in Lethbridge are Goldfish (*Carassius auratus*) and Common Carp or koi (*Carassius carpio*). These fish are aquarium fish that have been illegally released into city storm ponds or other waterbodies where they may escape into the river system³⁸. Releasing goldfish and other aquarium fish is prohibited in Alberta as they can spread rapidly and disrupt local aquatic ecosystems by reducing food sources and outcompeting native fish³⁹.

This stretch of the Oldman River contains a number of native sport fish including Walleye, Goldeye, Lake and

Mountain Whitefish and Northern Pike. As well, introduced Rainbow and Brown Trout are present which were introduced into Alberta rivers in the 1920's for both sport and food purposes⁴⁰.

Lethbridge is located along a portion of the Oldman River that is transitional between the colder upstream waters and the cooler downstream waters. As a result, cold water fish species such as trout and whitefish tend to move upstream as the water warms in the summer, while cool water species such as Goldeye and Mooneye move downstream to take advantage of food resources. The weir on the Oldman River at the Lethbridge Water Treatment Plant creates a barrier to this movement and may be disrupting the food web for this part of the River⁴¹.

Focus Area: Fish



Figure 10. The weir on the Oldman River presents a barrier to fish movement. Photo courtesy Jayme Carrera Lopez/ Oldman Watershed

Table 5: Fish species in the Oldman River at Lethbridge⁴²

Common Name	Scientific Name	Conservation Status
Lake Sturgeon	<i>Acipenser fulvescens</i>	Endangered
Goldeye	<i>Hiodon alosoides</i>	
Mooneye	<i>Hiodon tergisus</i>	
Lake Chub	<i>Couesius plumbeus</i>	
Pearl Dace	<i>Margariscus margarita</i>	
Emerald Shiner	<i>Notropis atherinoides</i>	
River Shiner	<i>Notropis blennius</i>	
Spottail Shiner	<i>Notropis hudsonius</i>	
Northern Redbelly Dace	<i>Phoxinus eos</i>	
Fathead Minnow	<i>Pimephales promelas</i>	
Longnose Dace	<i>Rhinichthys cataractae</i>	
Longnose Sucker	<i>Catostomus catostomus</i>	
White Sucker	<i>Catostomus commersoni</i>	
Mountain Sucker	<i>Catostomus platyrhynchus</i>	
Northern Pike	<i>Esox lucius</i>	
Lake Whitefish	<i>Coregonus clupeaformis</i>	
Mountain Whitefish	<i>Prosopium williamsoni</i>	
Rainbow Trout	<i>Oncorhynchus mykiss</i>	Introduced
Brown Trout	<i>Salmo trutta</i>	Introduced
Trout-Perch	<i>Percopsis omiscomaycus</i>	
Burbot	<i>Lota lota</i>	
Brook Stickleback	<i>Culaea inconstans</i>	
Spoonhead Sculpin	<i>Cottus ricei</i>	
Sauger	<i>Stizostedion canadense</i>	
Walleye	<i>Stizostedion vitreum vitreum</i>	
Goldfish	<i>Carassius auratus</i>	Introduced
Common Carp	<i>Carassius carpio</i>	Introduced
Grass Carp	<i>Ctenopharyngodon idella</i>	Introduced
Bull Trout	<i>Salvelinus confluentus</i>	Extirpated from Lower Oldman

The floodplain of the Oldman River creates a unique ecosystem in Lethbridge. Cottonwoods trees, which includes three species: the Plains or Western Cottonwood (*Populus deltoides*), the Balsam Poplar (*Populus balsamifera*), and the Narrowleaf Cottonwood (*Populus angustifolia*) are an indicator species for the river valley. This stretch of the Oldman River is the only place in the world where these three species are found together. As a result, the species frequently hybridize⁴³.

Cottonwoods are highly adapted to disturbance, particularly flooding, which they rely on for the establishment of new seedlings. Flooding, and to a lesser extent fire and river ice, expose new areas of barren ground and provide nutrients for new cottonwood seedlings⁴⁴.

Cottonwood forests are a critical part of our prairie ecosystems. Often, these riparian forests are the only native forestlands available for birds and wildlife. As a

result, they provide important food and shelter for a variety of species that would not otherwise be found locally. Cottonwoods also provide important stability to river banks, decreasing the impact of flooding, providing habitat for fish and improving water quality⁴⁵.

Flood control and management of river flows has had a negative impact on cottonwood forest in southern Alberta. These management activities have decreased the opportunities for new cottonwoods to become established during spring flood events when seeds are viable⁴⁶.

Focus Area: Cottonwoods



Figure 11. Cottonwood seedlings rely on flooding to become established. Photo courtesy Bob Pruner/Flickr.

Indicator: Native Grasslands

The majority of grassland habitat in Lethbridge is disturbed.



Lethbridge is a part of the Grassland Natural Region, which occupies approximately 96,000 km², or 14% of Alberta. The Mixedgrass Subregion (which Lethbridge and its surrounding area are a part of) originally covered more than 8.7 million hectares of land in Alberta. Most of the native prairie land in the South Saskatchewan Region has been transformed into farmland. Today only about 40% of the grassland area is in native cover and much of it is managed for livestock grazing. The SSRP found that this is due in part to the last three decades of oil and gas development in the region that has impacted remaining prairie landscapes. The infrastructure required to develop oil and gas in the grasslands has translated into more human activity and installations. It has resulted in considerable fragmentation of the region's

landscape and has impacted biodiversity⁴⁷. Many human activities such as agriculture and development have also impacted native grassland habitat. Habitat alteration places major pressures on biodiversity⁴⁸.

In Lethbridge, there are 20.6 km² (2058 ha) of grasslands within the city. These grasslands are diverse and the vegetation that is able to grow is dependent on soil and climatic conditions. The native grasslands in the river valley are mostly intact on the steep south-facing slopes. The prevailing native grasses are the wheatgrass/needle-and-thread grass/june grass community. On the plateau and gently rolling range areas in Lethbridge, only 16% Lethbridge's grasslands are in a natural state (see Figure 12). The modified grasslands have more than 70% cover from non-native species. This is mainly due to the historical conversion of native grassland to agricultural lands⁴⁹.

It is rare to find undisturbed native grasslands in Lethbridge. These remaining patches of native grassland must be preserved. Disturbed native grasslands site require management process to restore native species and to ensure the health of these regions does not worsen. Grasslands are rapidly declining and there must be processes put into place so that the remaining grasslands are persevered.

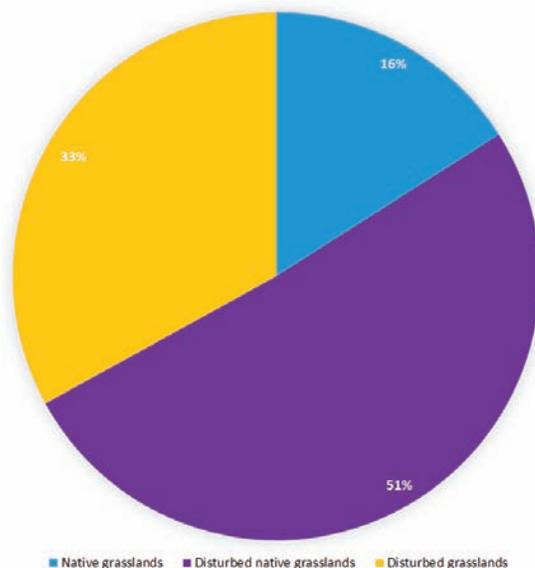


Figure 12. Undisturbed, native grasslands comprise just 16% of Lethbridge's grasslands. Data courtesy City of Lethbridge.

Invasive species are those species introduced by human activities outside their natural past or present distribution that threaten the environment, economy or society, including human health.⁵⁰.

In Lethbridge, there are many invasive species that are cause for concern. The most common invasive species that are found in Lethbridge are leafy spurge, Canada thistle and spotted knapweed. In the Cows and Fish assessment of riparian areas, leafy spurge was found at every site. Nine of the fifteen sites that were evaluated had more than 50% of the riparian covered in disturbance-caused herbaceous species. These species covered approximately 56% of the project area. The more prevalent of these herbaceous species are smooth brome, Kentucky bluegrass and crested wheatgrass. In total, 63 different introduced herbaceous species were found⁵¹.

Lethbridge has successfully implemented education and awareness programs on invasive species. The Helen Schuler Nature Centre has educational materials on invasive species and how to prevent further spread. They also host many weed pulls throughout the spring and summer to help stop the spread of invasive species in the coulee and river valley. In addition to these educational programs, a more detailed inventory of invasive species that

are in Lethbridge and where they are located must be created. This inventory should assess the number of invasive species in Lethbridge, cataloguing where they are located and creating a baseline for where we are at with regards to invasive species management.

Invasive species are not only plants. We also need to focus on the increasing threat that some introduced animal species are causing. Quagga



Indicator: Invasive Species

 Invasive plant species have an extensive distribution, particularly in the River Valley.

Figure 13. Leafy Spurge is one of the most common invasive plant species in the Lethbridge River Valley. Photo courtesy Oldman Watershed Council.

and zebra mussels are a threat to ecosystems and the economy in Alberta and they are nearly impossible to eradicate. Invasive mussels are filter feeders that strain suspended matter and food particles out of the water, disrupting natural food chains and leading to depleted fisheries as fish do not have enough food. Invasive species are able to attach themselves to boats and other recreational equipment which lead to them moving between waterbodies. Adult mussels can also survive out of water for 30 days. The Alberta government has implemented an aggressive campaign to stop the spread of invasive mussels by having people clean, drain and dry their

boats. They also have dogs trained to sniff out invasive mussels. These dogs are used at various check points throughout the province⁵².

Invasive species continue to threaten the biodiversity and health of our ecosystems. Increased numbers of invasive animals and plants force out and destroy local species. They can change habitats and ecosystems, which can have a huge impact on the local environment and the economy. Invasive species threaten the sustainability of biodiversity and without proper management can cause severe damage to ecosystems in Alberta.



Figure 14. Throughout the summer, local organizations such as the Helen Schuler Nature Centre host weed pulls to control invasive species. Photo courtesy Oldman Watershed Council.

Parks and open spaces are an important aspect of conservation management. Natural spaces connect people to nature and preserve and enhance the ecological diversity of an area while providing citizens with a place to recreate. Conserving these natural landscapes supports natural ecological functions and assist in the maintenance of biodiversity. Parks and open spaces provide largely natural habitats that will support and maintain local species.

The City of Lethbridge has 38.16 km² of park space within the city limits⁵³. The per capita park and open space in Lethbridge is 0.039 ha. In comparison to other cities in Alberta, such as Calgary (0.007 ha) and Red Deer (0.018 ha), we have a large amount of park and open space per capita⁵⁴ (See Figure 15).

Lethbridge’s river valley is the primary natural open space system within the city (see Figure 16). In contrast to other large parks in the city, such as Henderson Lake, Nicholas Sheran and the newly developed Legacy Park, the parklands in the river valley are in a natural state and have been protected for ecological purposes.

The City of Lethbridge’s Parks Master Plan strives to conserve, enhance and where possible restore the biological diversity of the river valley and riparian areas within. Parks and open spaces provide habitat to the majority of species within the city limits. They are also the most common habitat for the majority of species-at-risk in Lethbridge. Parks and green spaces are important to the vibrancy of the city, health of citizens and their benefits to biodiversity.

Indicator: Parks & Protected Areas



Lethbridge has significantly more area of parks and protected areas than other cities.

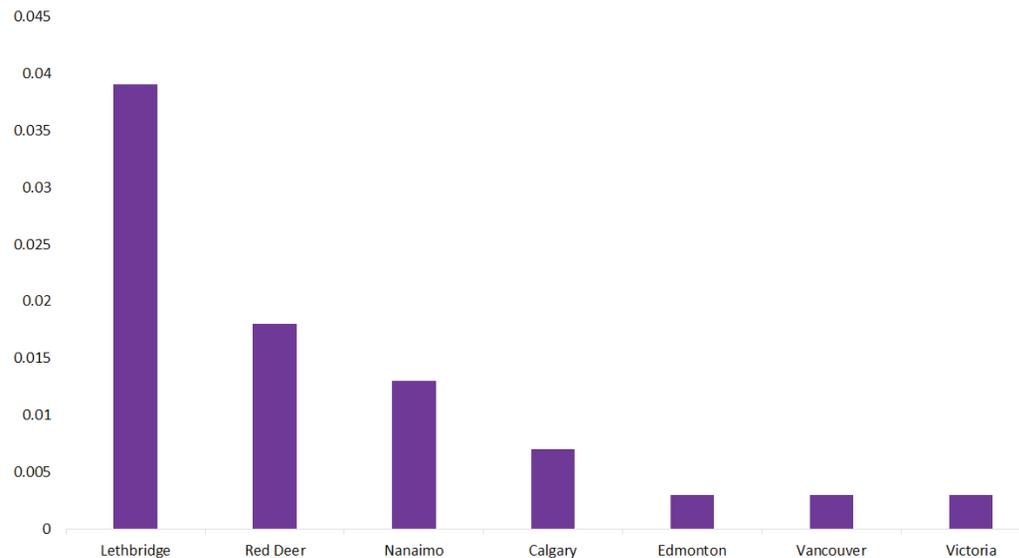


Figure 15. Per capita parks and open space by city (in hectares)^{55,56,57,58,59}.

Lethbridge's native landscape has been significantly altered over time due to the pressures of population growth and economic development. This has had a significant impact on the landscape of the region. In the Profile of the South Saskatchewan Region it is estimated that "the South Saskatchewan Region has 80% of the province's species at risk."⁶⁰ These species include mammals, birds, amphibians, reptiles, fish, plants and invertebrates.

In general, these species may be declining due to disappearing, fragmented or degraded habitat, over harvesting, pesticides, disease, human disturbances, introduction of exotic or invasive species or a combination of these factors⁶⁴. Information about population size, distribution and habitat use for species-at-risk is lacking and further inventory work is needed. Efforts are being made on several levels, to protect habitats and increase populations of these species.

At the federal level, species are assessed by the Committee on the Status of Endangered Wildlife (COWEWIC) in Canada and may be protected under the Species-at-Risk Act (SARA). Species listed under SARA receive additional habitat protections and are subject to recovery planning. At the provincial level, the Endangered Species Conservation Committee provides advice to the Minister of Environment and Parks about

species-at-risk. This includes recommendations on legal designations and the implementation of recovery programs. Alberta's approach to species-at-risk planning and recovery uses scientific expertise and input from land owners, land managers and users to determine the best approach for ensuring species-specific recovery plans are relevant and practical⁶¹.

In addition to the species listed in Table 6, at least 13 rare plants have been identified in the river valley based on rare plant surveys conducted in 1997, 1998 and 2004. A new species-at-risk inventory is necessary to evaluate the health of biodiversity in Lethbridge. Species-at-risk are the most vulnerable components of biodiversity and require special attention to maintain and recover their populations and habitats.



Indicator: Species-at-Risk



Additional data is needed to determine local occurrences and habitat availability for species-at-risk.

Figure 17. Species such as the Greater Sage Grouse are Endangered and are no longer seen near Lethbridge. Photo courtesy Ken Orich/Flickr.

Table 6: Species-at-Risk Expected for Lethbridge

Common Name	Scientific Name	Federal Status ⁶²	Provincial Status ⁶³	Habitat	Confirmed in Lethbridge ^{64,65}
American Badger	<i>Taxidea taxus taxus</i>	Special Concern		Grasslands	Yes
Baird's Sparrow	<i>Ammodramus bairdii</i>	Special Concern		Grasslands	Yes
Bank Swallow	<i>Riparia riparia</i>	Threatened		Riparian	Yes
Barn Swallow	<i>Hirundo rustica</i>	Threatened			Yes
Bobolink	<i>Dolichonyx oryzivorus</i>	Threatened		Wetlands/ Grasslands	Yes
Burrowing Owl	<i>Athene cunicularia</i>	Endangered	Endangered	Grasslands	No
Chestnut-collared Longspur	<i>Calcarius ornatus</i>	Threatened		Grasslands	Yes
Common Nighthawk	<i>Chordeiles minor</i>	Threatened		Grasslands	Yes
Ferruginous Hawk	<i>Buteo regalis</i>	Threatened	Endangered	Grasslands	Yes
Greater Prairie Chicken	<i>Tympanuchus cupido</i>	Extirpated	Extirpated	Grasslands	No
Greater Sage Grouse	<i>Centrocercus urophasianus urophasianus</i>	Endangered		Grasslands	No
Horned Grebe	<i>Podiceps auritus</i>	Special Concern		Wetlands	Yes
Lake Sturgeon	<i>Acipenser fulvescens</i>	Endangered	Threatened	Aquatic	Yes
Little Brown Myotis	<i>Myotis lucifugus</i>	Endangered			Yes
Loggerhead Shrike	<i>Lanius ludovicianus excubitorides</i>	Threatened	Special Concern	Grasslands	Yes
Long-billed Curlew	<i>Numenius americanus</i>	Special Concern	Special Concern	Grasslands	Yes
McCown's Longspur	<i>Rhynchophanes mccownii</i>	Threatened		Grasslands	Yes
Northern Leopard Frog	<i>Lithobates pipiens</i>	Special Concern	Threatened	Riparian	No
Peregrine Falcon	<i>Falco peregrinus anatum/ tundrius</i>	Special Concern	Threatened		Yes
Piping Plover	<i>Charadrius melodus circumcinctus</i>	Endangered	Endangered	Grasslands/ Wetlands	No
Plains Bison	<i>Bison bison</i>	Extirpated	Extirpated	Grasslands	No
Prairie Falcon	<i>Falco mexicanus</i>		Special Concern	Grasslands	Yes
Prairie Rattlesnake	<i>Crotalus viridis</i>	Special Concern		Grasslands	Yes

Table 6: Species-at-Risk Expected for Lethbridge (Continued)

Common Name	Scientific Name	Federal Status ⁶²	Provincial Status ⁶³	Habitat	Confirmed in Lethbridge ^{64,65}
Red-necked Phalarope	<i>Phalaropus lobatus</i>	Special Concern		Wetlands	No
Rusty Blackbird	<i>Euphagus carolinus</i>	Special Concern		Wetlands	Yes
Short-eared Owl	<i>Asio flammeus</i>	Special Concern		Grasslands	Yes
Sprague's Pipit	<i>Anthus spragueii</i>	Threatened	Special Concern	Grassland	Yes
Western Grebe	<i>Aechmophorus occidentalis</i>	Special Concern	Threatened	Wetland	Yes
Western Small-footed Bat	<i>Myotis ciliolabrum</i>	Special Concern		Grasslands	No
Western Tiger Salamander	<i>Ambystoma mavortium</i>	Special Concern		Grasslands	Yes
White-winged Scoter	<i>Melanitta deglandi</i>	Special Concern		Wetlands	Yes



Figure 18. Once common, American badgers are now considered a species of Special Concern. Photo courtesy Ken Orich/Flickr.

Focus Area: Rattlesnakes

Prairie Rattlesnakes (*Crotalus viridis*) are found in grasslands in south-eastern Alberta, including in Lethbridge, particularly in or adjacent to the river valley. Rattlesnakes were designated as a species of Special Concern by the COSEWIC in 2014⁶⁶.

Rattlesnakes are at the northern extent of their range in Canada. Populations are concentrated near Medicine Hat and Brooks with Lethbridge being the western extent of their range. Rattlesnakes rely on river bottoms, coulees, Cottonwood stands and neighbouring grassland habitats. Of particular importance are hibernacula, which are communal winter denning sites, usually located in cracks or

holes on south-facing slopes⁶⁷. In Lethbridge, Rattlesnakes are most commonly seen on the west side of the Oldman River, particularly in Popson Park and near Bridge Drive⁶⁸.

Habitat loss from urban development and agricultural conversion and road mortalities are the largest threats to rattlesnakes. In addition, as one of Canada's few venomous snakes, many people are cautious or unnecessarily aggressive towards rattlesnakes. Historical declines in population are thought to be linked to persecution of rattlesnakes.

Prairie Rattlesnakes are protected under Alberta's Wildlife Act and may not be killed without a permit. In 2016, the Alberta Government released the Prairie Rattlesnake Conservation Management Plan to guide education and conservation of this species⁶⁹.



Figure 19. Habitat in the Oldman River Valley is important for Prairie Rattlesnakes. Photo courtesy Andrew DuBois/Flickr.

As with species-at-risk, certain plant communities are also endangered or threatened in southern Alberta. Ecological communities are groupings of particular plant species that tend to grow together due to an affinity for certain soil and water conditions. The Alberta Conservation Information Management System has compiled information about ecological communities for each Natural Subregion in Alberta. These communities are ranked using the criteria found in Table 7⁷⁰.

There are 10 rare ecological communities that occur in the Mixedgrass Subregion that may be found within Lethbridge (see Table 8). Further inventory work is needed to determine if these ecological communities are present within the City of Lethbridge.

Table 7: Ecological Community Rankings⁷¹

Rank	Description
S1	Five or fewer occurrences or very few remaining hectares
S2	Six to 20 occurrences or few remaining hectares
S3	21 to 80 occurrences. May be rare and local throughout its range or found locally, even abundantly, in a restricted range (e.g. a single county or Natural Subregion).
S4	Apparently secure Province wide, though it may be quite rare in parts of its range, especially at the periphery.
S5	Demonstrably secure Province wide, though it may be quite rare in parts of its range, especially at the periphery.

Focus Area: Ecological Communities

Table 8: Ecological Communities Potentially Found in Lethbridge⁷²

Common Name	Scientific Name	Rank	Habitat Type
Narrow-leaf cottonwood / red-osier dogwood	<i>Populus angustifolia</i> / <i>Cornus stolonifera</i>	S2S3	Riparian forest associated with flood plains on the Oldman River.
Narrow-leaf cottonwood / buckbrush	<i>Populus angustifolia</i> / <i>Symphoricarpos occidentalis</i> woodland	S2S3	Riparian forest associated with alluvial deposits on major streams and rivers.
Lance-leaf cottonwood / buckbrush	<i>Populus x acuminata</i> / <i>Symphoricarpos occidentalis</i> woodland	S1S2	Isolated stands associated with riparian floodplains.
Water birch	<i>Betula occidentalis</i> grassland riparian shrubland	S2S3	Grassland community found in moist areas and streambanks.
Buckbrush / giant wild rye	<i>Symphoricarpos occidentalis</i> / <i>Elymus piperi</i> shrubland	S2S3	Riparian plant community associated with occasional flooding.
Buckbrush / northern wheat grass - needle-and-thread	<i>Symphoricarpos occidentalis</i> / <i>Elymus lanceolatus</i> - <i>Stipa comata</i>	S2	Shrub community associated with floodplains.
Buckbrush / needle-and-thread - sand grass - low sedge	<i>Symphoricarpos occidentalis</i> / <i>Stipa comata</i> - <i>Calamovilfa longifolia</i> - <i>Carex stenophylla</i>	S2	Shrub community found on sandy slopes.
Little bluestem - mountain rough fescue	<i>Schizachyrium scoparium</i> - <i>Festuca campestris</i>	S1?	Shrub community found on sandy slopes.
Narrow-leaf cottonwood / recent alluvial	<i>Populus angustifolia</i> / recent alluvial	S2S3	Riparian plant community associated with rocky and gravelly soils.
Widgeon-grass aquatic community	<i>Ruppia cirrhosa</i> aquatic community	S1	Associated with brackish wetlands and saline ponds.

Trees help to purify the air, reduce storm water runoff and erosion, create wildlife habitat, store carbon dioxide, produce oxygen and save energy through shading and wind reduction. There are 91 different species of trees within the City of Lethbridge. The three most common species are the green ash, American elm and the white poplar⁷³. As Lethbridge is naturally a grassland, other than cottonwood species in the river valley, the majority of trees in the city have been planted.

One large tree can absorb 150 kilograms (kg) of Carbon Dioxide (CO₂) per year and filter some airborne pollutants including fine particulate matter. An analysis on the public tree inventory in Lethbridge was conducted in 2011 and

reported that trees in Lethbridge store over 128 million kg of CO₂. Public trees improve air quality through the deposition of over 24,000 kg of other air particles and chemicals⁷⁴. Pressures on urban forests include: invasive species, pests, disease, drought, climate change and urban development.

Tree canopy is the uppermost layer in a forest and it is formed by the crowns of the trees⁷⁵. Tree canopy provide urban areas with a significant cooling effect and cool cities by between 2°C and 8°C⁷¹. This provides increased comfort to citizens and provides an energy cost savings. Public trees in Lethbridge save an estimated 18,000+ of gigajoules of electricity and 135,000+ of gigajoules of natural gas annually⁷⁶.

Indicator: Tree Coverage



Given Lethbridge's semi-arid climate, we have established a significant urban forest.

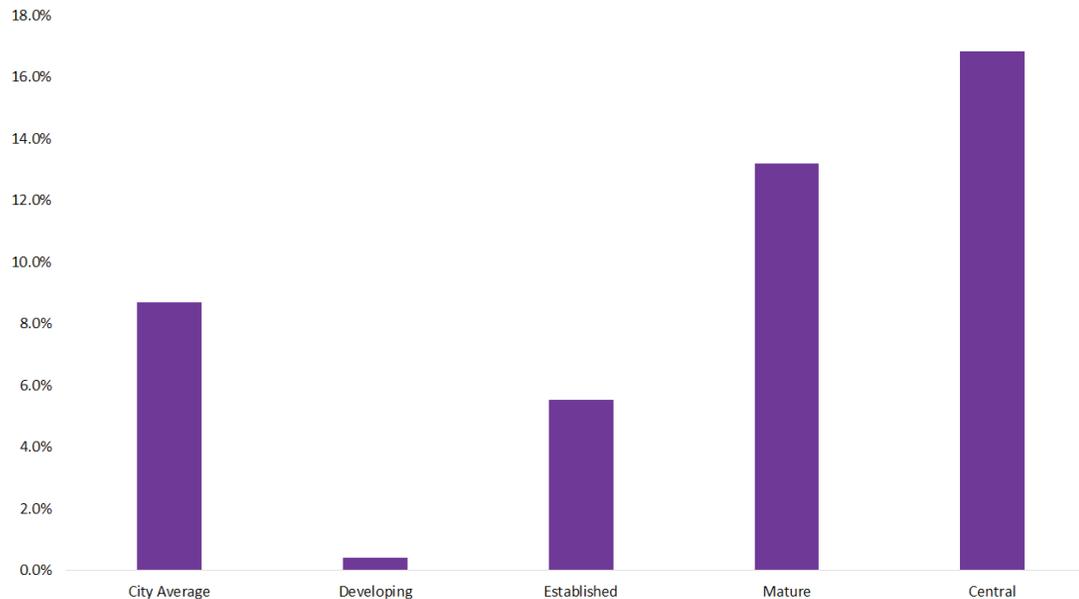


Figure 21. Tree Canopy Coverage in Lethbridge by Neighbourhood Type. Data courtesy City of Lethbridge.

Trees and natural areas in Lethbridge also play significant roles in helping to protect important city infrastructure, prevent erosion and reduce the stress on systems such as storm water systems. Trees and park spaces provide a buffer between development and urban bodies of water, such as the Oldman River and Henderson Lake. Trees filter the street and storm water runoff, decreasing the amount of pollution that enters the water stream. They also limit urban development which has a significant impact on shorelines. This significantly protects riparian areas and the biodiversity these areas provides our community. On an annual basis, it is estimated that public trees in Lethbridge intercept over 331,000 cubic metres of rainfall from entering the storm water system⁷⁷.

Urban forests also provide significant health benefits to the community. People living in neighbourhoods with higher numbers of trees were found to have fewer health problems. Trees and being outdoors can bring down cortisol levels in walkers, which means less stress. Urban forests should be viewed as a critical part of our public health system. Increasing the number of trees in our community can decrease anxiety and depression in citizens and improve air quality. The more trees added in our community, the healthier we will be.

In Lethbridge there are approximately 43,461 public city owned trees. Of these, 20,964 are street trees and 22,497 are in parks and open spaces⁸⁰. There are 631ha of coniferous and deciduous

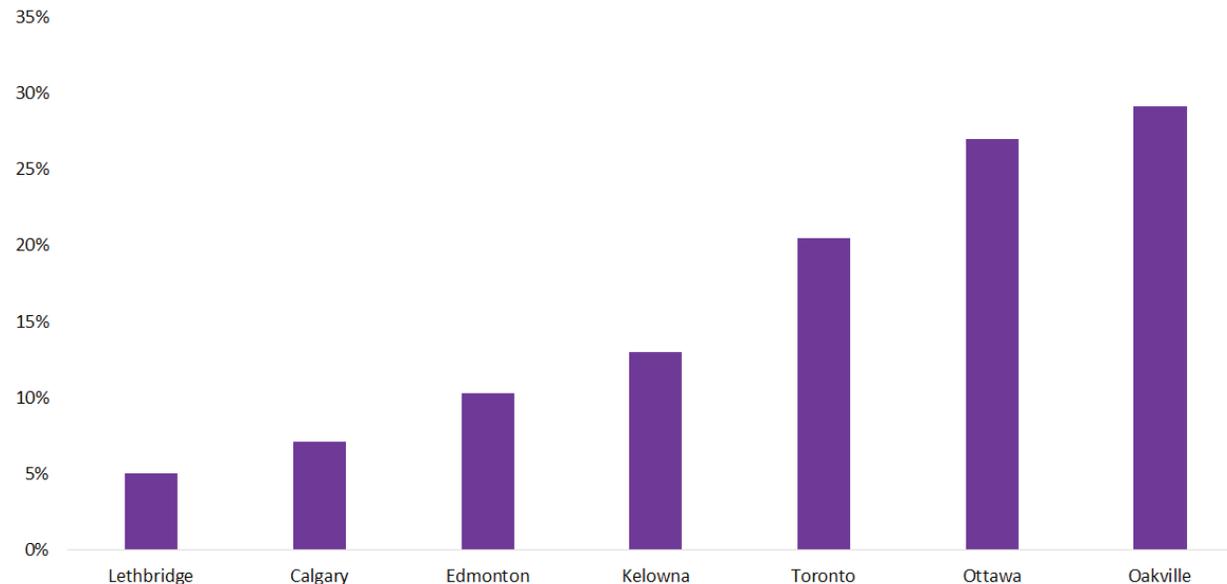


Figure 22. Percentage of Tree Canopy Cover in Canadian Cities. Lethbridge data is from 2016, all other cites from 2007⁷⁹.

forest in Lethbridge. 5.03% of land in Lethbridge is covered by trees. Mature and well-developed neighbourhoods have increased tree coverage, while developing and newer neighbourhoods have a smaller percentage of tree canopy coverage. Figure 22 shows the percentage of land covered by tree canopy. This is largely because of the tree canopy is still developing and the trees are still very young. As they mature there will be increased coverage. It is also important that new developments incorporate parks and trees to take advantage of their important health and environmental impacts.

Lethbridge's tree canopy cover is less than other cities (see Figure 22). This may be due in part to our semi-arid climate and related lack of native forest cover. Urban forest management has become an important piece of sustainability policy within many municipalities. Many cities, such as Edmonton, Oakville and Calgary, have all created aggressive targets to expand urban forests in these cities. The City of Lethbridge created a Lethbridge Urban Forestry Plan in 1991. The plan was created to protect and maintain the City's urban tree population. The City of Lethbridge's current plan is 26 years old and it needs to be updated to reflect

the importance of urban forests on public and environmental health. A plan to grow and more clearly establish Lethbridge's tree canopy also needs to be established. This plan must include factors such as tree health, tree biomass and tree canopy. Growing our urban forests is not only the responsibility of environmental and park staff but should also be a priority in the public health and community development sectors.

When adding trees to our existing open spaces and developments, it is also important that the right trees are planted to provide the most benefits to the environment and citizens. Climate, wind direction, soil, safety and security must all be considered when designing parks and adding trees to the community.



Figure 23. A large proportion of Lethbridge's urban forest can be found in the river valley. Photo courtesy Mel Lefevre/ Environment Lethbridge.

Indicator: Native Pollinators

Native pollinators are declining throughout Canada.



Pollination is a necessary part of plant reproduction, without it, plants would be unable to produce viable fruits or seeds and would be unable to pass their genetic material on to the next generation. 75% of all flowering plants rely on insects to pollinate their flowers⁸¹ while the others rely on other animal species, wind, or other mechanisms to facilitate pollination.

We tend to think of honeybees as our primary pollinators. However, many people may be unaware that honeybees are an introduced species to North America. For our native plants and ecosystems, native pollinators have adapted to the needs of native plants and are much more effective pollinators⁸². Canada's prairie grasslands are home to nearly 400 species of bees and Lethbridge is located an area with some of the highest species diversity in the prairie provinces⁸³.



Figure 24. Tri-colored Bumble Bee.
Photo courtesy Ken Orich/Flickr.

Native pollinators include species such as wasps, flies, butterflies, beetles, native bees, and particularly bumblebees which are the most common and effective pollinators of native plants⁸⁴. Unlike honeybees, bumblebees are better equipped to deal with complex flower structures that are often found on native plants, and as a result, are better pollinators for these flowers⁸⁵.

Unfortunately, like their domestic cousins, populations of native pollinators are also in decline. These declines are thought to be related to habitat loss, declines in native plant species, increases in invasive species, climate change and pesticides⁸⁶. In Alberta, three species of bumblebees have been assessed by COSEWIC: Gypsy Cuckoo Bumble Bee *Bombus bohemicus* (Endangered)⁸⁷, Western Bumble Bee *Bombus occidentalis* (Threatened)⁸⁸ and Yellow-banded Bumble Bee *Bombus terricola* (Special Concern)⁸⁹. All three species are likely to occur in or around Lethbridge.

Supporting native pollinators should be a priority for individuals and municipal governments. Retaining and restoring key habitats, such as native shrub habitats and fencerows, planting native flowering plants and reducing the use of pesticides can all help to support native pollinators⁹⁰.

None of the themes included in this report are independent. Each theme is linked to the others in a variety of ways. We have attempted to briefly outline some of the connections that can be seen between the different areas. In keeping with the focus of this report on the

city of Lethbridge, we have tried to keep these linkages focused on impacts that may occur as locally as possible. This list is not intended to be a fully comprehensive analysis of the connections between the different areas of the report.

Loss of biodiversity is caused by:	Declining biodiversity results in:
<p>Water Water pollution has been shown to make ecosystems less resilient to climate change⁹¹.</p>	<p>Local Food Nearly ¼ of our food supply comes from only 12 plant species. However, those species are reliant on thousands of others including pollinators and microbes⁹⁵.</p>
<p>Air Ozone has been found to decrease plant photosynthesis and productivity while other air pollutants can cause acidification of soil or water⁹². The impacts of air pollution may not be visible as they affect small organisms before larger ones. Air pollution may also affect species distribution⁹³.</p>	<p>Air Trees and other plants remove air pollutants including NO2 and O3.⁹⁶</p>
<p>Energy Both renewable and non-renewable energy sources have impacts on biodiversity including fragmentation, habitat loss and wildlife mortality⁹⁴.</p>	<p>Water Biodiverse streams have been shown to be more effective at removing pollutants from water than less diverse ones⁹⁷. Healthy wetlands and riparian areas limit damage from flooding⁹⁸.</p>

Linkages to Other Themes

Loss of biodiversity is caused by:	Declining biodiversity results in:
<p>Climate Change Climate change is expected to change precipitation amounts, potentially causing drought or flooding in different areas which may impacts wetlands and other habitats⁹⁹. As well, increased water temperatures may affect the distribution of cold water fish species. Climate change may also lead to changes in seasonal cycles, causing species that rely on one another to be out of sync. Disruption of food webs and changes in range distributions of species may also occur, potentially causing species extinctions as ranges contract¹⁰⁰.</p>	<p>Economy Biodiversity provides a variety of ecosystem services such as flood control, water filtration, supplying food and medicines that would be more costly for us to create on our own¹⁰¹. Biodiversity also provides protections from the impacts of climate change and natural disasters¹⁰².</p>
	<p>Health Biodiversity provides critical ecosystem services, particularly related to air and water quality that impact human health¹⁰³.</p>

We began this section by asking two questions:

- What is the status of our local species and ecosystems?
- What are the priorities for biodiversity conservation in Lethbridge?

Lethbridge has made policy and conservation management steps to adequately protect the ecosystems and local species in the area. Large pieces of land, especially in the river valley, have been conserved to protect biodiversity. Steps are now being taken to mitigate the effects that human activity has on riparian areas, wetlands and grasslands so that they may be better protected and restored for future generations.

Sustainable growth and development within the city will help to maintain biodiversity. Limiting development and other human activity in ecologically sensitive areas will help to protect and restore biodiversity. Proper control of invasive species and updating existing policies on urban forests, park spaces and invasive species to use current management processes will further improve biodiversity in Lethbridge.

An accurate catalogue and inventory of both invasive species and species-at-risk will provide us with a baseline understanding of species diversity and distribution. Policy can then be created to protect species-at-risk and properly evaluate how current policies are working. Without a baseline, we are unable to properly assess the state of invasive species or species-at-risk that are within the city of Lethbridge.

Biodiversity and healthy, functioning ecosystems provide a range of benefits to the community. They support our community in many ways by purifying the air, filtering our water and providing us with species for medicine and other economic resources. These ecological services are crucial to our society but are often under appreciated. Protecting biodiversity is key to

Conclusion & Recommendations



Figure 22. Lethbridge River Valley
Photo courtesy Kim Siever/Flickr.

having a vibrant and healthy community, rich with plant and animal species. Protecting this component of our environment is important so that future generations may have access to these ecological services, as well as the biodiversity and natural landscapes in our community.

To support biodiversity in the City, we make the following recommendations:

1. That inventory work for wetlands be ground-truthed to confirm extent and condition and that inventories be repeated regularly.
2. That restoration and/or planting of native species be considered for riparian areas along the Oldman River.
3. That inventory work for grasslands be ground-truthed to confirm extent and condition and that inventories be repeated regularly.
4. That invasive plant species in the city be inventoried and mapped and a management plan be adopted.
5. That the River Valley Master Plan be adopted and implemented.
6. That species-at-risk and their available habitat be inventoried within the city.
7. That ecological communities be inventoried within the city.
8. That the City of Lethbridge proactively seek opportunities to expand Lethbridge's urban forest.
9. That Lethbridge's Urban Forestry Plan be updated.
10. That bee-friendly plants be considered for use in City Parks and that local residents be encouraged to plant them as well.

- 1 Biodiversity Canada. 2015. *What is Biodiversity?* Accessed from www.biodivcanada.ca on January 14, 2017.
- 2 Convention on Biodiversity Secretariat. 1993. *The Convention on Biological Diversity*. Accessed from www.cbd.int/convention/ on January 10, 2017.
- 3 World Health Organization. 2017. *Biodiversity*. Accessed from www.who.int/globalchange/ecosystems/biodiversity/en/ on January 11, 2017.
- 4,5 Minister of Supply and Services Canada. 1995. *Canadian Biodiversity Strategy*. Downloaded from: www.biodivcanada.ca/560ED58E-0A7A-43D8-8754-C7DD12761EFA/CBS_e.pdf on January 10, 2017.
- 6 Alberta Biodiversity Monitoring Institute. 2014. *Diversity in Alberta*. Accessed from: www.abmi.ca/home/biodiversity/biodiversity-in-alberta.html on January 25, 2017.
- 7 Alberta Environment and Parks. nd. *Alberta Conservation Information Management System*. Accessed from: www.albertaparks.ca/albertaparksca/management-land-use/alberta-conservation-information-management-system-acims/overview/ on January 25, 2017.
- 8,9,10,11 Alberta Environment and Parks. 2015. *Element Occurance Data*. Downloaded from: www.albertaparks.ca/albertaparksca/management-land-use/alberta-conservation-information-management-system-acims/download-data.aspx#trackedWatch on January 25, 2017.
- 12 Bercha, R. nd. *Insects of Alberta*. Accessed from: www.insectsofalberta.com/main.htm on January 25, 2017.
- 13 Downing, D.J. and W.W. Pettapiece. 2006. *Natural Regions and Subregions of Alberta*. Natural Regions Committee. Downloaded from: www.albertaparks.ca/media/2942026/nrsrcomplete_may_06.pdf on January 25, 2017.
- 14 Alberta Parks. 2014. *Natural Regions and Subregions of Alberta: A Framework for Alberta's Parks*. Accessed from: www.albertaparks.ca/media/6256258/natural-regions-subregions-of-alberta-a-framework-for-albertas-parks-booklet.pdf on January 12, 2017.
- 15 Alberta Biodiversity Monitoring Institute. 2015. *The Status of Biodiversity in the Prairie and Parkland Regions of Alberta: Preliminary Assessment*. Alberta Biodiversity Monitoring Institute. Accessed from: ftp://public.abmi.ca/home/publications/documents/424-ABMI%202016_Status%20o

References

f%20Biodiversity%20in%20Prairie%20Region_FINAL%20REPORT.pdf on January 25, 2017.

16 Alberta Prairie Conservation Forum. nd. *Map of Natural Regions and Subregions in Southern Alberta*. Accessed from: www.albertapcf.org/rsu_docs/gr_map_grasslands_2011.gif on January 17, 2017.

17 Alberta Biodiversity Monitoring Institute. 2011. *2011 Status Report for the South Saskatchewan Planning Region* Accessed from: ftp://public.abmi.ca/home/publications/documents/14_ABMI_2011_PublicReportSouthSask_ABMI.pdf on January 25, 2017.

18,19 Government of Alberta. 2017. *South Saskatchewan Regional Plan 2014-2024: An Alberta Land-use Framework Integrated Plan* Available from: <https://www.alberta.ca/South-Saskatchewan-Regional-Plan.cfm>

20,21 Alberta Government. 2015. *South Saskatchewan Region Biodiversity Management Framework DRAFT*. November 20, 2015.

22 The Economics of Ecosystems and Biodiversity. nd. *Ecosystem Services*. Accessed from: <http://www.teebweb.org/resources/ecosystem-services/> on February 2, 2017.

23 Kauffman, G.J. 2016. *Economic Value of Nature and Ecosystems in the Delaware River Basin*. Downloaded from: http://www.ucowr.org/files/Journal/Issues/158/158_Kauffman.pdf on February 2, 2017.

24 O2. 2016. *Draft Lethbridge River Valley Parks Master Plan*. City of Lethbridge. Downloaded from: www.lethbridge.ca/Things-To-Do/Parks/Documents/DraftRiverValleyParksMasterPlan.pdf on January 15, 2017.

25 Helen Schuler Nature Centre. nd. *Coulees and Cottonwoods*. City of Lethbridge. Downloaded from: www.lethbridge.ca/Things-To-Do/Nature-Centre/Documents/HSNC%20Field%20Guide%20singlepages.pdf on January 17, 2017.

26, 27, 28 Government of Alberta. 2013. *Alberta Wetland Policy*. Downloaded from: aep.alberta.ca/water/programs-and-services/wetlands/alberta-wetland-policy.aspx on January 25, 2017.

29,30,31,32,33 O2. 2016. *Draft Lethbridge River Valley Parks Master Plan*. City of Lethbridge. Downloaded from: www.lethbridge.ca/Things-To-Do/Parks/Documents/DraftRiverValleyParksMasterPlan.pdf on January 15, 2017.

- 34 Wood, C. and N. Ambrose. 2011. *Oldman River Valley Riparian Health. Phase 1*. River Valley Management Plan. Prepared for the City of Lethbridge. Alberta Riparian Habitat Management Society (Cows and Fish).
- 35 Clare, S. and G. Sass. 2012. *Riparian lands in Alberta: Current state, conservation tools, and management approaches*. Report prepared for Riparian Land Conservation & Management Team, Alberta Water Council, Edmonton, Alberta. Fiera Biological Consulting Ltd. Report #1163. Downloaded from: <http://awchome.ca/LinkClick.aspx?fileticket=8e-3QdH48yU%3D&tabid=150> on February 9, 2017.
- 36 O2. 2016. *Draft Lethbridge River Valley Parks Master Plan*. City of Lethbridge. Downloaded from: www.lethbridge.ca/Things-To-Do/Parks/Documents/DraftRiverValleyParksMasterPlan.pdf on January 15, 2017.
- 37 Alberta Sustainable Resource Development. 2012. *Bull Trout Conservation Management Plan*. Downloaded from: aep.alberta.ca/fish-wildlife/species-at-risk/species-at-risk-publications-web-resources/fish/documents/SAR-BullTroutConservationManagementPlan.pdf on January 23, 2017.
- 38 Geisbrecht, T. 2016. *Okotoks isn't the only community dealing with rogue goldfish, with the City of Lethbridge saying it too is monitoring storm ponds for the invasive species*. 981. The Bridge. Accessed from: www.981thebridge.ca/news/lethbridge-news/city-of-lethbridge-continues-to-monitor-storm-ponds-for-invasive-goldfish/ on January 23, 2017.
- 39 Alberta Environment and Parks. 2017. *Prevent the Spread of Invasive Fish Species*. Accessed from: aep.alberta.ca/fish-wildlife/invasive-species/aquatic-invasive-species/fish.aspx on January 23, 2017.
- 40 Nelson, J.S and M.J. Paetz, 1992. *The Fishes of Alberta*. University of Alberta Press.
- 41 Piersol, L. 2010. *Water: There Is Not Substitutue*. Helen Schuler Nature Centre Downloaded from: www.lethbridge.ca/Things-To-Do/Nature-Centre/Documents/WaterConservation.pdf on January 19, 2017.
- 42 Nelson, J.S and M.J. Paetz, 1992. *The Fishes of Alberta*. University of Alberta Press.
- 43 Helen Schuler Nature Centre. nd. *Coulees and Cottonwoods*. City of Lethbridge. Downloaded from: www.lethbridge.ca/Things-To-Do/Nature-Centre/Documents/HSNC%20Field%20Guide%2

0singlepages.pdf on January 17, 2017.

44 Rood, S.B., L.A. Goater, J.M. Mahoney, C.M. Pearce and D.G. Smith. 2007. *Floods, fire, and ice: disturbance ecology of riparian cottonwoods*. Canadian Journal of Botany, 2007, 85:1019-1032. Downloaded from: www.nrcresearchpress.com/doi/abs/10.1139/B07-073#.WH-Sg_krKUk on January 18, 2017.

45 MULTISAR. nd. *Cottonwood Forests*. Downloaded from: multisar.ca/wp-content/uploads/2015/10/cottonwoods2.pdf on January 19, 2017.

46 City of Calgary. 2014. *City of Calgary Biodiversity Report*. Downloaded from: calgaryrivervalleys.org/wp-content/uploads/2015/01/2014-1647BiodiversityReport_V2C.pdf on January 18, 2017.

47,48 Government of Alberta. 2017. *South Saskatchewan Regional Plan 2014-2024: An Alberta Land-use Framework Integrated Plan* Available from: <https://www.alberta.ca/South-Saskatchewan-Regional-Plan.cfm>

49 O2. 2016. *Draft Lethbridge River Valley Parks Master Plan*. City of Lethbridge. Downloaded from: www.lethbridge.ca/Things-To-Do/Parks/Documents/DraftRiverValleyParksMasterPlan.pdf on January 15, 2017.

50 Environment and Climate Change Canada. 2010. *Invasive Alien Species Partnership Program - 2005-2010 Report*. Accessed from: <https://www.ec.gc.ca/nature/default.asp?lang=En&n=B008265C-1> on February 3, 2017.

51 Wood, C. and N. Ambrose. 2011. *Oldman River Valley Riparian Health. Phase 1*. River Valley Management Plan. Prepared for the City of Lethbridge. Alberta Riparian Habitat Management Society (Cows and Fish).

52 Alberta Environment and Parks. nd. *Aquatic Invasive Species*. Accessed from: <https://www.albertaparks.ca/albertaparksca/science-research/aquatic-invasive-species/> on December 10, 2016.

53 O2. 2016. *Draft Lethbridge River Valley Parks Master Plan*. City of Lethbridge. Downloaded from: www.lethbridge.ca/Things-To-Do/Parks/Documents/DraftRiverValleyParksMasterPlan.pdf on January 15, 2017.

54 City of Calgary. 2010. *2010 State of the Environment Report*. Downloaded from: <http://www.calgary.ca/UEP/ESM/Documents/ESM-Documents/2010-state-of-the-environment-report.PDF> on December 16, 2016.

55 City of Vancouver. 2016. Access to Nature. Accessed from: <http://vancouver.ca/green-vancouver/access-to-nature.aspx> on January 10, 2017.

56 City of Victoria. nd. *Plan. Grow. Play*. Downloaded from: <http://www.victoria.ca/assets/Departments/Parks~Rec~Culture/Parks/Documents/What%20is%20a%20Parks%20Master%20Plan,%20Timeline,%20What%20we%20Heard,%20What%20we%20Learned.pdf> on December 20, 2016.

57 Lanarc Consulting. 2005. *City of Nanaimo Parks Recreation and Culture Master Plan*. Downloaded from: <https://www.nanaimo.ca/assets/Departments/Parks~Rec~Culture/Parks/Master%20Plan%20Report.pdf> on December 20, 2016.

58 City of Edmonton. 2014. *Edmonton's Report on the Environment*. Downloaded from: https://www.edmonton.ca/city_government/documents/ReportOnTheEnvironment2014.pdf on December 20, 2016.

59 City of Red Deer. 2011. Environmental Master Plan: Our Environment, Our Future. Downloaded from: <http://www.reddeer.ca/media/reddeerca/city-services/environment-and-conservation/our-corporate-initiatives/2011-04-26-EMP-web-version.pdf> on December 12, 2016.

60 Government of Alberta. 2011. Profile of the South Saskatchewan Region. Downloaded from: <https://www.landuse.alberta.ca/LandUse%20Documents/Profile%20of%20the%20South%20Saskatchewan%20Region%20-%202009-11.pdf> on September 16, 2016.

61 Fish and Wildlife Division. 2008. Alberta's Strategy for the Management of Species-at-Risk. Alberta Sustainable Resource Development. Downloaded from: <http://aep.alberta.ca/fish-wildlife/species-at-risk/documents/StrategyManagementSpeciesRisk2009-14.pdf> on January 28, 2017.

62 Government of Canada. 2017. *Species at Risk Public Registry*. Accessed from: www.registrelep-sararegistry.gc.ca/sar/index/default_e.cfm on January 17, 2017.

63 Alberta Environment and Sustainable Resource Development. 2014. *A Guide to Endangered and Threatened Species and Species of Special Concern in Alberta*. Downloaded from: issuu.com/esrd/docs/species_at_risk_guidebook_final_for?e=12110136/8006392 on January 17, 2017.

64 eBird Canada. 2017. *eBird Canada Range Map*. Accessed from: <http://ebird.org/ebird/canada/map/> on January 17, 2017.

- 65 Deacon-Rogers, J. Helen Schuler Nature Centre. Personal communication January 23, 2017.
- 66,67 Committee on the Status of Endangered Wildlife in Canada. 2014. *COSEWIC Assessment and Status Report on the Prairie Rattlesnake Crotalus viridis in Canada - 2014* Accessed from: www.registrelep-sararegistry.gc.ca/default.asp?lang=En&n=D96797BE-1#_01 on January 17, 2017.
- 68 Ernst, R.D. and R.W. Quinlan. 2006. *Rattlers and People: Conserving Rattlesnakes in Lethbridge*. Alberta Sustainable Resource Development. Downloaded from: aep.alberta.ca/fish-wildlife/species-at-risk/species-at-risk-publications-web-resources/reptiles/documents/SAR109-RattlersPeopleConservingRattlesnakesLethbridge-Apr2006.pdf on January 17, 2017.
- 69 Alberta Environment and Parks. 2016. *Prairie Rattlesnake Conservation Management Plan 2016-2021*. Alberta Environment and Parks. Species at Risk Conservation Management Plan No.12. Edmonton, AB. 10 pp. Downloaded from: aep.alberta.ca/fish-wildlife/species-at-risk/species-at-risk-publications-web-resources/reptiles/documents/SAR-Rattlesnake-ManagementPlan-March2016.pdf on January 17, 2017.
- 70,71,72 Allen, L. 2014. Alberta Conservation Information Management System Ecological Community Tracking List. Alberta Tourism, Parks and Recreation, Edmonton, Alberta Downloaded from: https://www.albertaparks.ca/media/3259838/tracked_watched_list_ecological_communities_full_report.pdf on January 18, 2017.
- 73 Community Foundation of Lethbridge and Southern Alberta. 2015. *Vital Signs*. Downloaded from: <http://www.cflsa.ca/admin/resources/files/environment-pdf-for-webstite.pdf> on December 20, 2017.
- 74 City of Lethbridge. nd. *Parks are Good for Our Environment*. Downloaded from: <http://www.lethbridge.ca/Things-To-Do/Parks/Documents/Parks%20Benefit%208.pdf> on December 16, 2017.
- 75 Fleming, A. 2016. *The importance of urban forests: why money really does grow on trees*. The Guardian. Accessed from: <https://www.theguardian.com/cities/2016/oct/12/importance-urban-forests-money-grow-trees> on January 3, 2017.
- 76,77 City of Lethbridge. nd. *Parks are Good for Our Environment*. Downloaded from: <http://www.lethbridge.ca/Things-To-Do/Parks/Documents/Parks%20Benefit%208.pdf> on December 16, 2017.

78 Community Foundation of Lethbridge and Southern Alberta. 2015. *Vital Signs*. Downloaded from: <http://www.cflsa.ca/admin/resources/files/environment-pdf-for-webstite.pdf> on December 20, 2017.

79 City of Edmonton. 2012. *Urban Forest Management Plan*. Downloaded from: https://www.edmonton.ca/residential_neighbourhoods/PDF/Urban_Forest_Management_Plan.pdf on January 5, 2017.

80 Community Foundation of Lethbridge and Southern Alberta. 2015. *Vital Signs*. Downloaded from: <http://www.cflsa.ca/admin/resources/files/environment-pdf-for-webstite.pdf> on December 20, 2017.

81 Agriculture and Agri-food Canada. 2014. *Native Pollinators and Agriculture in Canada*. Downloaded from: www.ontariosoilcrop.org/wp-content/uploads/2015/08/Native-Pollinators-and-Agriculture-in-Canada-1.pdf on January 18, 2017.

82 Alberta Biodiversity Monitoring Institute. 2012. *Taking Bees for Granted: Bumble Bees in Decline*. It's Our Nature to Know: The Alberta Biodiversity Monitoring Institute Blog. Accessed from: blog.abmi.ca/2012/09/07/taking-bees-for-granted-bumble-bees-in-decline/#.WH-WKPkrKUI on January 18, 2017.

83 Sheffield, C. S., S. D. Frier, and S. Dumesh. 2014. *The Bees (Hymenoptera: Apoidea, Apiformes) of the Prairies Ecozone, with Comparisons to other Grasslands of Canada*. In *Arthropods of Canadian Grasslands (Volume 4): Biodiversity and Systematics Part 2*. Edited by D. J. Giberson and H. A. Cárcamo. Biological Survey of Canada. pp. 427-467. © 2014 Biological Survey of Canada Downloaded from: www.reginahortsociety.com/images/Sheffield,_Frier_and_Dumesh_2014_The_bees_of_the_Prairies_Ecozone_with_comparisons_to_other_grasslands_of_Canada.pdf on January 17, 2017.

84 Agriculture and Agri-food Canada. 2014. *Native Pollinators and Agriculture in Canada*. Downloaded from: www.ontariosoilcrop.org/wp-content/uploads/2015/08/Native-Pollinators-and-Agriculture-in-Canada-1.pdf on January 18, 2017.

85 Alberta Biodiversity Monitoring Institute. 2012. *Taking Bees for Granted: Bumble Bees in Decline*. It's Our Nature to Know: The Alberta Biodiversity Monitoring Institute Blog. Accessed from: blog.abmi.ca/2012/09/07/taking-bees-for-granted-bumble-bees-in-decline/#.WH-WKPkrKUI on January 18, 2017.

86 Agriculture and Agri-food Canada. 2014. *Native Pollinators and Agriculture in Canada*. Downloaded from: www.ontariosoilcrop.org/wp-content/uploads/2015/08/Native-Pollinators-and-Agriculture-in-Canada-1.pdf on January 18, 2017.

87 Committee on the Status of Endangered Wildlife in Canada. 2014. *COSEWIC Assessment and Status Report on the Gypsy Cuckoo Bumble Bee *Bombus bohemicus* in Canada - 2014*. Accessed from: www.registrelep-sararegistry.gc.ca/default.asp?lang=En&n=A6DF8D16-1#_02_2 on January 17, 2017.

88 Committee on the Status of Endangered Wildlife in Canada. 2014. *COSEWIC Assessment and Status Report on the Western Bumble Bee *Bombus occidentalis* in Canada - 2014* Accessed from: www.registrelep-sararegistry.gc.ca/default.asp?lang=En&n=F8760D74-1#_02_2 on January 17, 2017.

89 Committee on the Status of Endangered Wildlife in Canada. 2015. *COSEWIC Assessment and Status Report on the Yellow-banded Bumble Bee *Bombus terricola* in Canada - 2015* Accessed from: www.registrelep-sararegistry.gc.ca/default.asp?lang=en&n=177BD170-1#_02_2 on January 17, 2017.

90 Agriculture and Agri-food Canada. 2014. *Native Pollinators and Agriculture in Canada*. Downloaded from: www.ontariosoilcrop.org/wp-content/uploads/2015/08/Native-Pollinators-and-Agriculture-in-Canada-1.pdf on January 18, 2017.

91 The Freshwater Blog. 2016. *Water pollution makes river biodiversity more vulnerable to climate warming*. Accessed from: <https://freshwaterblog.net/2016/03/03/water-pollution-increases-makes-river-biodiversity-more-vulnerable-to-climate-warming/> on February 3, 2017.

92 Lovett, G.M. et al. 2009. *Effects of Air Pollution on Ecosystems and Biological Diversity in the Eastern United States*. The Year in Ecology and Conservation Biology 2009. Downloaded from: http://www.caryinstitute.org/sites/default/files/public/reprints/Lovett_NYAS_2009.pdf on February 2, 2017.

93 Dudley, N. and S. Stolton. nd. *Air pollution and biodiversity: a review*. Downloaded from: <http://www.equilibriumconsultants.com/upload/document/airpollutionandbiodi4f9.pdf> on February 3, 2017.

94 Jones, N.F., L. Pejchar, and J.M. Kiesecker. 2015. *The Energy Footprint: How Oil, Natural Gas, and Wind Energy Affect Land for Biodiversity and the Flow of Ecosystem Services*. Bioscience. Accessed

from: <https://academic.oup.com/bioscience/article/65/3/290/236920/The-Energy-Footprint-How-Oil-Natural-Gas-and-Wind?keytype=ref&ijkey=PCe5L5B9Ffc5CkU> on February 6, 2017.

95 Centre for Health and the Global Environment. nd. *Biodiversity and Food Production*. Harvard University. Accessed from: <http://www.chgeharvard.org/topic/biodiversity-and-food-production> on February 8, 2017.

96 World Health Organization and Secretariat of the Convention on Biological Diversity. 2015. *Connecting global priorities: biodiversity and human health: a state of knowledge review*. Downloaded from: <https://www.cbd.int/health/SOK-biodiversity-en.pdf> on February 3, 2017.

97 Phys.org. 2011. *Biodiversity improves water quality in streams through a division of labor*. Accessed from: <https://phys.org/news/2011-04-biodiversity-quality-streams-division-labor.html> on February 8, 2017.

98 Wetlands Alberta. nd. *Wetland Loss*. Accessed from <http://www.wetlandsalberta.ca/wetland-loss/> on February 9, 2017.

99 World Health Organization and Secretariat of the Convention on Biological Diversity. 2015. *Connecting global priorities: biodiversity and human health: a state of knowledge review*. Downloaded from: <https://www.cbd.int/health/SOK-biodiversity-en.pdf> on February 3, 2017.

100 Union of Concerned Scientists. 2011. *Lakes and Rivers*. Accessed from: <http://www.climatehot-map.org/global-warming-effects/lakes-and-rivers.html> on February 6, 2017.

101 United States Environmental Protection Agency. nd. *Climate Impacts on Ecosystems*. Accessed from: <https://www.epa.gov/climate-impacts/climate-impacts-ecosystems> on February 4, 2017.

102 Centre for Health and the Global Environment. nd. *Ecosystem Services*. Harvard University. Accessed from: <http://www.chgeharvard.org/topic/biodiversity-and-food-production> on February 8, 2017.

103 Secretariat of the Convention on Biological Diversity. 2010. *Global Biodiversity Outlook 3*. Montréal, 94 pages. Downloaded from: <https://www.cbd.int/doc/publications/gbo/gbo3-final-en.pdf> on January 30, 2017.

104 World Health Organization and Secretariat of the Convention on Biological Diversity. 2015. *Connecting global priorities: biodiversity and human health: a state of knowledge review*. Downloaded

