# Ecological Infrastructure in the Calgary Region
# "What We Know Now"
# Final Report

Prepared for
**The Calgary Regional Partnership**
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MIISTAKIS INSTITUTE FOR THE ROCKIES

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## PREFACE

The following document is the final draft of a project conducted over the summer of 2007. The data and information was compiled by graduate students from the Faculty of Environmental Design at the University of Calgary. The report reflects the information that was readily accessible and makes no claims of comprehensiveness. The information is intended solely for use in supporting the Calgary Regional Partnership planning exercises. The project was supported by funding from the Calgary Regional Partnership under the supervision of Drs. Mary-Ellen Tyler and Michael Quinn.

## Executive Summary

The purpose of the Calgary Regional Partnership's "What Do We Know Now?" project was to identify all spatial data sets currently existing for approximately 17,000 $km^2$ within the boundaries of the Calgary Regional Partnership (CRP). The collection of these existing data sets is necessary to answer the question "What do we know now?" about the landscape features, human activities, population growth and land development pressures affecting the future of the Calgary region. The objective is to use the results of this project as critical input to the CRP's upcoming scenario development and land use planning exercise. The collection and storage of existing regional information data sets on behalf of the CRP is being coordinated by the Land Information and Mapping (L.I.M.) group at the City of Calgary and O2 as CRP's project managers.

As part of CRP's Research Partnership with the University of Calgary, a summer research project was undertaken in the context of the "What Do We Know Now?" process to specifically assess the current state of knowledge on the presence and function of *regional ecological infrastructure* in relation to population growth and land development pressures in the CRP region. 'Ecological infrastructure' is the system of structural and functional terrestrial and aquatic landscape features, interrelationships and processes that produce ecological goods and services (such as clean water and habitat) at a regional scale. The objectives of the ecological infrastructure summer project work were:

1. to identify existing spatial data indicative of regional ecological infrastructure systems structure and function.
2. to identify existing 'gaps' in available spatial data sets connected with understanding ecological infrastructure function at a regional scale.
3. to interpret and provide an assessment of the state of knowledge currently available to understanding ecological infrastructure functions and spatial connectivity related to future land use planning and sustainable development at a regional scale.
4. to compare the results of objective 3 above with the CRP's projected regional growth and development areas to identify areas of important interconnection related to habitat and hydrology functions at the landscape level.

The intention is that the results of this regional ecological infrastructure project work will help inform the regional land use planning and municipal services planning process by contributing to a better understanding of how regional growth and development spatial patterns may affect important regional ecological infrastructure components and functions.

Understanding how important regional ecological system functions are spatially organized and interconnected can help organize the spatial configuration for future growth patterns. This contributes to land use planning that supports and maintains the important interrelationships

between human activities and ecological processes necessary for the region's sustainable development.

Based on the results of this summer's work, a preliminary answer to the question "what do we know now about regional ecological infrastructure?" is summarized as follows. These results are based on an interpretation of the existing and available spatial data sets identified and acquired through LIM. The existing data sets were interpreted for three specific ecological infrastructure functions: regional scale wildlife habitat, regional scale hydrology, and regional scale land cover.

**What Do We Know Now About Regional Scale Ecological Infrastructure?**

Planned growth areas for most CRP members seem to occur primarily in natural amenity areas, such as the Bow Valley corridor to the west, the areas south and southwest of Calgary including the Sheep and Highwood River corridors, the areas east along Highway 1, and north along Nose Creek. These areas all overlap with areas of known or suspected ecological infrastructure that have been identified in this project. Some of the critical ecological infrastructure "hot spots" that need to be considered in strategic regional land use planning and growth management are described below:

1. North-south ridges southwest of Calgary, extending from highway 22x south towards the Porcupine Hills
    - The occurrence of ridge-top springs supports the growth of shrub communities and mixed forest patches, providing important wildlife habitat and movement corridors between the foothills and parkland ecoregions, particularly for elk and deer, but also for large carnivores. The springs provide high humidity and high soil moisture, which promotes diverse vegetative growth, providing food, shelter and a mild microclimate.
    - The ridges occur within the regional growth corridor along highway 22 which is an area experiencing among the highest amount of rural residential development in the CRP region. Excessive development could act as a barrier to wildlife movement along the ridge corridor, increasing water demands may disrupt the groundwater-surface water connections, and road/lot development could significantly alter surface water movement.

2. River valleys and riparian corridors in the CRP region
    - Valley bottoms and low, slumping slopes provide important coulee driven wildlife habitat areas due to nutrient-rich groundwater discharge and seepage that produce a positive soil moisture balance for vegetation growth. Riparian zones are linked to the landscape through groundwater as well as above ground tributary flows. Riparian zones play a critical role in maintaining spatial connectivity across the landscape and providing vital wildlife movement corridors and habitat. River valleys and riparian corridors also act as important recreational amenities.
    - Bow River Valley
        - The Bow River corridor west of Calgary hosts high habitat diversity and favorable climate due to the frequent Chinook winds that bring warm, dry weather. This, along with its variable topography and surface and

groundwater flow regimes encourages wildlife to congregate here. Since deep snow prevents grazing, elk and deer prefer drier open areas exposed to sun and Chinook winds for their fall and winter ranges, such as windblown ridges and sunny south-facing slopes that occur in the Bow corridor. The Bow River corridor also provides a vital link for large mammals moving between Kananaskis, Banff and areas to the north and south.

        - Vegetated coulees and draws leading up from the Bow River across the CRP region also provide important habitat for deer species and movement corridors from the river.
        - The Bow River valley is an increasingly important amenity area experiencing high levels of rural residential and commercial development, which could affect wildlife habitat availability and connectivity. As the Bow River supplies water for half of Calgary's population, increased development could also influence surface water flow regimes, supply and quality by increasing runoff and sedimentation, and creating downstream flood problems.
    - Elbow River Valley
        - The Elbow River supplies water for half of Calgary's population and preservation of riparian functions west of Calgary is critical for maintaining quality water supply and downstream flood management.
    - Highwood River Valley
        - Maintaining the riparian functions of the Highwood River floodway is critical for downstream flood management.
    - Sheep River Valley
        - The Sheep River corridor provides key cougar, bighorn sheep and deer habitat, and important rainbow trout spawning areas.

3. Wetland complex along the eastern edge of Calgary, extending along a slight northwest to southeast gradient
    - Important groundwater-surface water connections occur in this area, illustrated by the presence of wetlands occurring in groundwater discharge areas. These discharge areas are also associated with poorly drained soils, and are nutrient rich, supporting the presence of diverse, abundant vegetation. These wetlands function as prime habitat areas for waterfowl and migratory birds, and represent the regional flyway corridor for migratory birds.
    - Groundwater discharge areas are also important sources for wetlands and headwaters for tributaries, maintaining the base level of permanent streams and ponds, and regulating water temperature, providing critical spawning habitat for fish. This groundwater-surface water connection is critical to maintaining water supply and quality. The presence of functional wetlands play large roles cleaning and filtering water and regulating run-off and sedimentation across the NW to SE topographic gradient as water drains into the Bow River downstream. These are critical processes that provide clean water for human use.
    - The regional growth corridor east along highway 1 is considered a natural amenity area for rural residential development as well as industrial development.

This increasing development could disrupt the green-blue flow interface. Because surface water features are relatively scarce in the CRP, special consideration needs to be given to the interrelationship between ground and surface waters and how human activities on the surface affect springs and streams.

4. Wetland complex along the eastern edge of Wheatland County
    - Wetlands that are connected to groundwater discharge areas and poorly drained soils provide important waterfowl and migratory bird habitat within the regional flyway corridor.

5. Large areas and patches of intact forest along the western edge of the CRP. The aspen parkland patch geometry provides a rich mixture of interior and edge habitat for a wide variety of species. The forested patch size increases towards the west and the natural patterns should be maintained as much as possible.
    - The ecological roles of intact forested areas include providing habitat to interior wildlife species sensitive to edge effects and disturbance; act as carbon sinks helping to modify climate change; protect water quality and regulate water flow; and reduce soil erosion and sediment loading.

**What Don't Know Now About Regional Scale Ecological Infrastructure?**

Information and regional spatial data set gaps were identified. Further research in these areas would assist in understanding functional and spatial ecological interrelationships: These areas are:

- Regionally significant wildlife movement patterns and corridors;
- Regional hydrogeology processes and characteristics;
- Terrestrial components and processes in the regional hydrologic cycle;
- Regional nutrient cycle dynamics and links to hydrological processes and land cover;
- Regional aquifers and groundwater storage capacity data to support strategic water resource management;
- Instream flow needs and critical habitat thresholds;
- Regional Watershed contributions.

**A spatial approach to strategic regional land use planning should organize future growth patterns at the landscape level in order to support critical ecological infrastructure functional interrelationships.**

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## <u>Part 1</u>: Background and Approach

Municipalities and their economic and residential activities are reliant on a number of engineered infrastructure systems. For example, transportation systems support the flow of people and products, utility systems provide the delivery of waste and energy, and communication systems facilitate the flow of information. This built infrastructure represents a significant public investment, both in capital costs and long-term maintenance. However, there is another kind of infrastructure that provides life support services and functions. '*Ecological infrastructure*' consists of the spatial and functional interrelationships among terrestrial and aquatic landscape features and processes that capture, store and transport biological or trophic energy, water, nutrients and matter. The so-called 'ecological goods and services' provided by ecological infrastructure are essential to human health and regional sustainability. Therefore, as part of the Calgary Regional Partnership's research partnership with the University of Calgary, a summer project was undertaken for the purpose of:

1. identifying existing and available regional spatial data sets for ecological infrastructure components (such as soil and land cover);
2. assessing the current state of knowledge about *regional ecological infrastructure*.

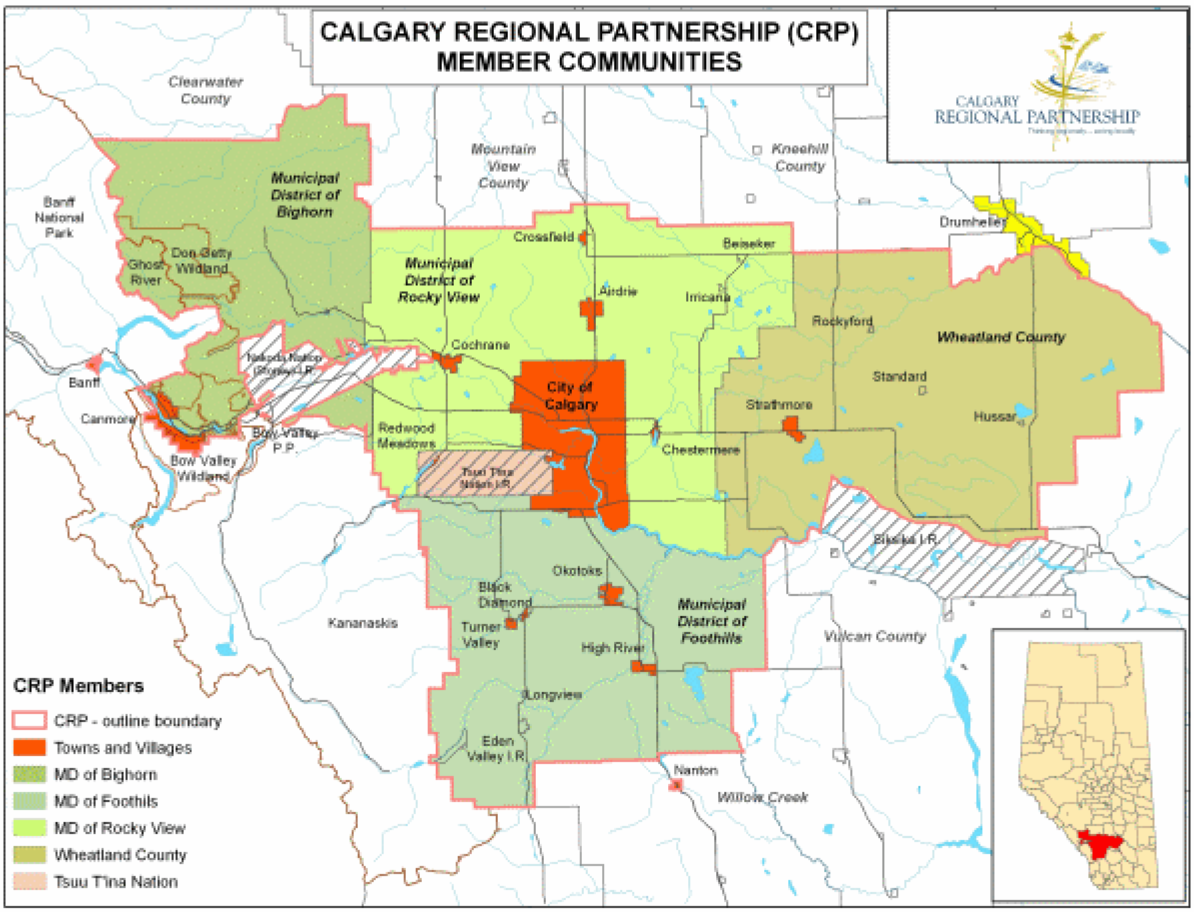
'Ecological infrastructure' represents the structural and functional landscape connections among terrestrial and aquatic landscape features, interrelationships and processes. At a regional scale, this spatial system of interconnections produces ecological goods and services (such as clean water and habitat). Therefore, the objectives of the summer project work were:

**1.** to identify regional ecological infrastructure systems based on available spatial data sets.
**2.** to identify 'gaps' in spatial data sets and knowledge of ecological infrastructure function at a regional scale.
**3.** to interpret and provide an assessment of this state of knowledge relative to regional scale land use planning and sustainable development.

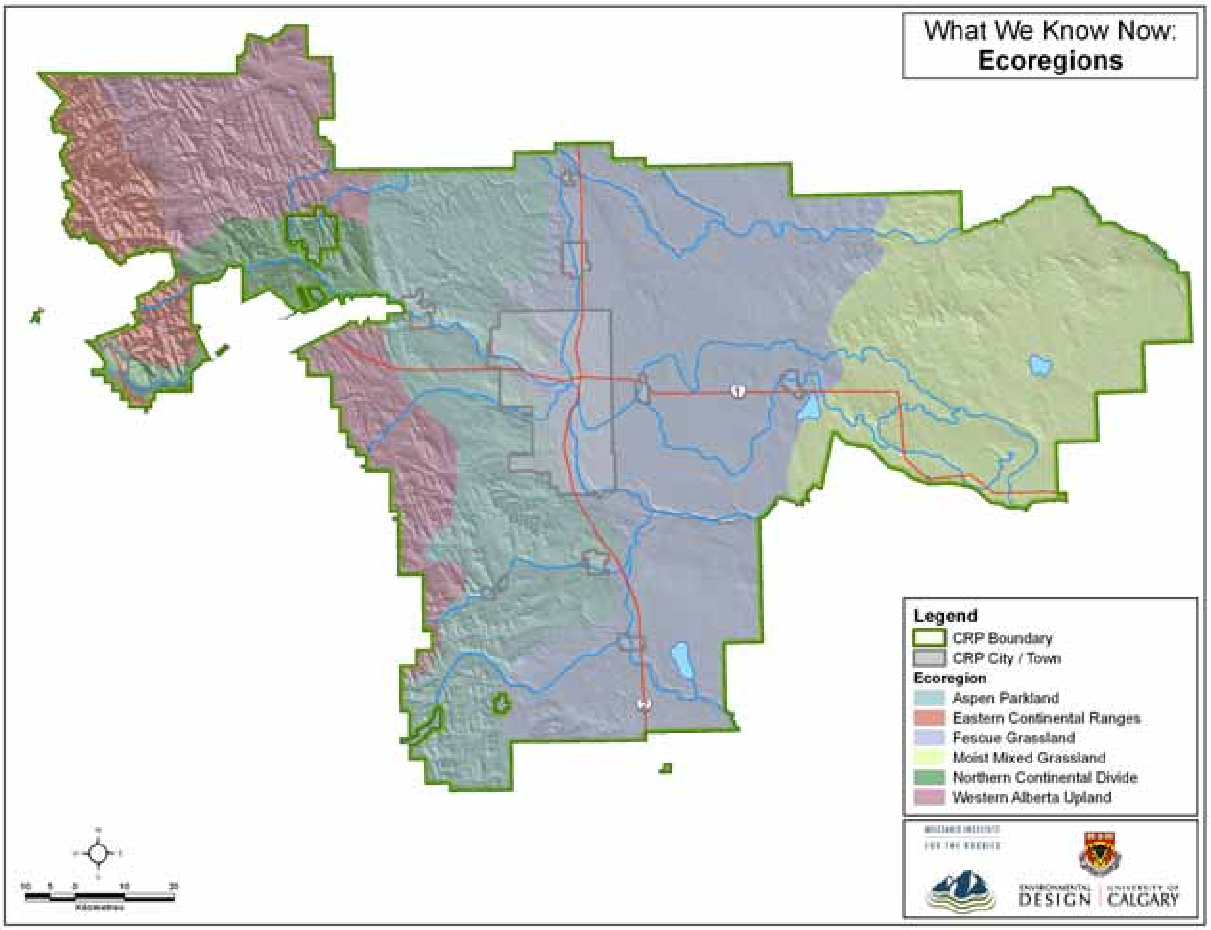
The results of this regional ecological infrastructure project work are intended to inform the regional land use planning and municipal services planning process by contributing a better understanding of how regional growth and spatial development patterns relate to important regional ecological infrastructure components and functions at the landscape level.

The CRP (Map 1) covers an area of approximately 17,000 $km^2$. It is located within a semi-arid biogeoclimatic transition zone along a significant elevation change gradient between the slopes of the Rocky Mountains on the West and prairie to the East. Water availability and soil moisture are limiting factors for regional ecology, population growth and land development. As illustrated in Map 2, five distinct ecological zones representing these regional gradients and local topographic microclimates are represented within the CRP's boundaries from west to east: Sub-alpine, Montane, Foothills, Aspen Parkland and Northern Grassland.

## Map 1. Calgary Regional Partnership Area

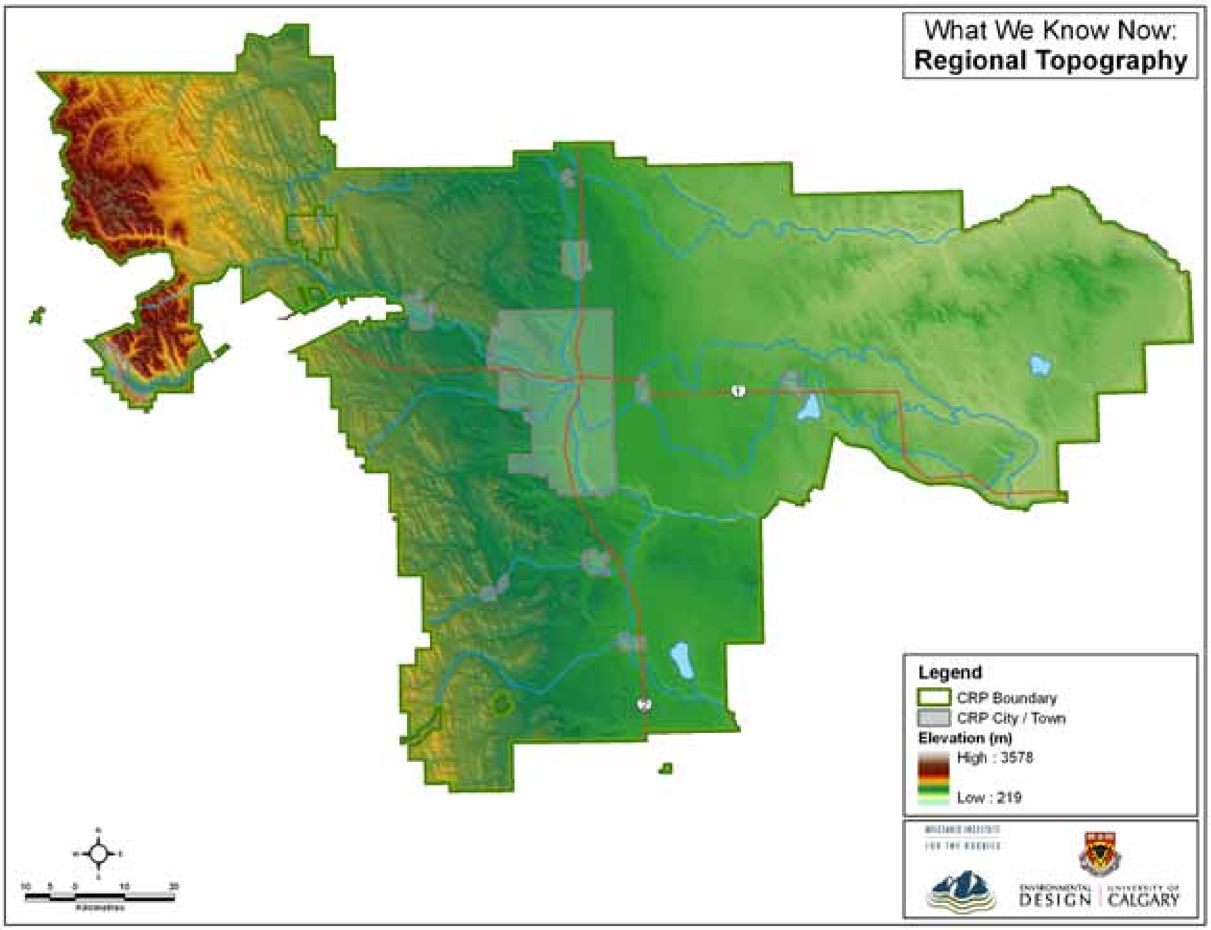


**Map 2. Natural Regions in the CRP Area**




Glaciation has historically been the driving force shaping the regional landscape pattern. Glaciers originating high in the Rocky Mountains joined with a continental ice sheet in the vicinity of the current boundary between the foothills and plains. As the continental ice sheet retreated, trapped meltwater created large lakes and overflow from these lakes eventually eroded the major north-south meltwater channels, which are now the prominent topographic feature of the CRP region landscape as illustrated in Map 3.

**Map 3. Regional Topography**

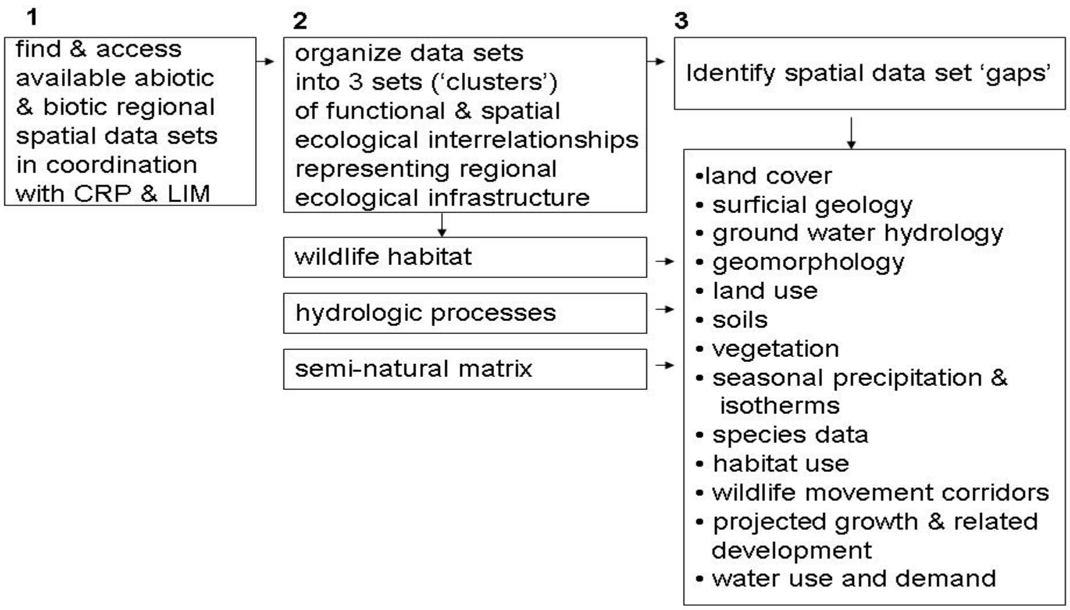


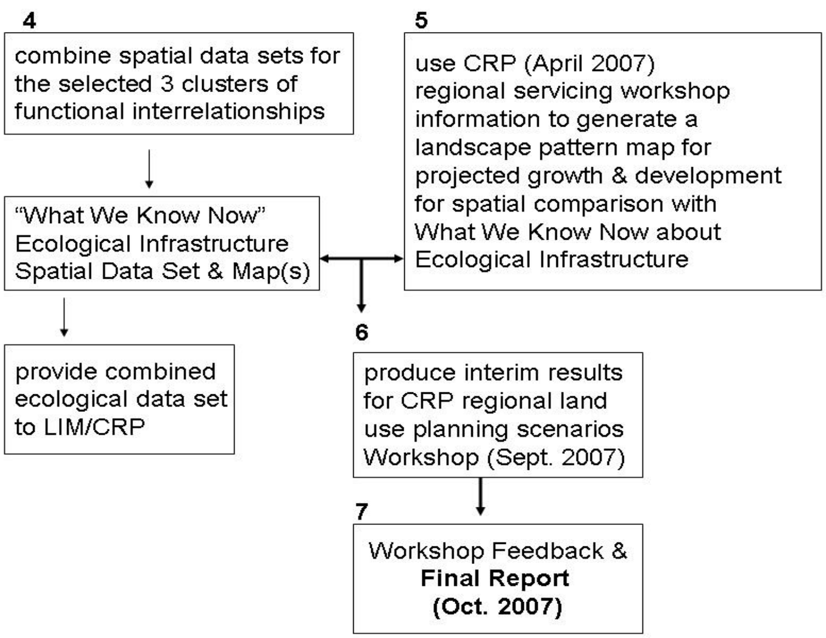

The 17,000 $km^2$ encompassed by the CRP continues to experience dramatic population growth and the cumulative effects of urbanization and land use intensification affect the region's ecological systems and hydrologic cycle. Historically, patterns of human land use and development activities have been a reflection of the natural biodiversity found across the regional landscape and conversely, landscape patterns and ecological processes have been influenced by human activities and land use. For example, increased country residential development and recreation pressures are causing changes in spatial landscape connectivity and changing drainage patterns in the region. In this way, interacting human driving forces and socio-economic values are directly shaping and altering ecological patterns and processes at the landscape level. As a result, the regional landscape is increasingly moving from one of human activities in a natural landscape to restricted ecological processes in a human landscape. The landscape of Southwestern Alberta is on of the few regions of North America and the world where human settlement activities are less than 125 years old. This relatively recent settlement history enables the Calgary regional landscape to still sustain significant wildlife populations and a relatively intact system of ecological infrastructure and natural landscapes. The land use planning challenge facing the CRP, given ongoing urbanization and land development pressures, is to sustain a semi-natural landscape matrix which enables ecological infrastructure and historical natural landscapes to exist and co-exist with human land use and settlement patterns.

The capacity of ecological systems to withstand landscape changes without compromising critical ecological functions is referred to as resiliency. Maintenance of biodiversity, landscape heterogeneity and spatial connectivity across the regional landscape promotes the resiliency of ecological systems. From a growth management and land use planning perspective, a regional scale enables a strategic approach to land use planning and policy to maintain the functional interaction and spatial connectivity of ecological infrastructure relative to land development and land use intensity.

Land use planning opportunities and constraints for maintaining connectivity in the semi-natural matrix in the regional landscape can be identified with an ecological infrastructure approach. Identifying critical ecological infrastructure at the landscape level is necessary to ensure sustainable development. The objective of this approach is to organize future growth patterns, ecological infrastructure functions and landscape connectivity in a way that supports the best mutual relationship between ecological and human processes and spatial landscape patterns. Regional growth management must protect the spatial or landscape connectivity of critical ecological infrastructure in order to maintain the resilience of ecological processes and the flow of ecological goods and services in the face of increasing population growth and land use intensification.

The steps in the approach taken for this project are described below:


1
find & access available abiotic & biotic regional spatial data sets in coordination with CRP & LIM
2
organize data sets into 3 sets ('clusters') of functional & spatial ecological interrelationships representing regional ecological infrastructure
wildlife habitat
hydrologic processes
semi-natural matrix
3
Identify spatial data set 'gaps'
•land cover
• surficial geology
• ground water hydrology
• geomorphology
• land use
• soils
• vegetation
• seasonal precipitation & isotherms
• species data
• habitat use
• wildlife movement corridors
• projected growth & related development
• water use and demand


4
combine spatial data sets for the selected 3 clusters of functional interrelationships
"What We Know Now" Ecological Infrastructure Spatial Data Set & Map(s)
provide combined ecological data set to LIM/CRP
5
use CRP (April 2007) regional servicing workshop information to generate a landscape pattern map for projected growth & development for spatial comparison with What We Know Now about Ecological Infrastructure
6
produce interim results for CRP regional land use planning scenarios Workshop (Sept. 2007)
7
Workshop Feedback & Final Report (Oct. 2007)

**Part 2: Three Ecological Infrastructure Functions at a Regional Scale**

Ecological Infrastructure is the spatial and structural features of the regional landscape that support the critical process interrelationships necessary for ecological functions and the ecological goods and services they provide. Interrelationships between landscape form (topography and geomorphology) and spatial patterns of biogeoclimatic processes (vegetation, soils, water) are visible parts of how regional ecosystems function over time. The biosocial complexity of these interrelationships is a function of the interaction and feedback between ecological processes and human activities as manifested on the regional landscape.

Because of its dynamic, complex and interconnected nature, ecological infrastructure cannot be identified by a single or specific piece or type of data and neither can it be identified by simply 'overlaying' spatial data sets using GIS technology. Simply overlaying data sets does not identify the critical and dynamic functional ecological interrelationships among the data layers. This is a significant realization in trying to determine what we know now about regional ecological infrastructure – that is spatial data sets by themselves do not constitute and understanding of ecological infrastructure function. Therefore, it is necessary to create a 'framework' for envisioning interconnections among regional spatial data sets in order to identify both ecosystem functions and spatial connectivity at the landscape level.

Given the timeline for this summer project and the types of abiotic and biotic spatial data sets accessible at a regional scale; three types of ecosystem infrastructure of interest to CRP's regional land use planning scenario workshop were identified and an interpretive framework created for three corresponding sets or 'clusters' of structural and functional ecological interrelationships. These 3 sets or clusters of interrelationships were then used to determine the spatial data sets that needed to be spatially combined to identify regional infrastructure and its pattern on the landscape.

The three functional clusters used to provide a framework for evaluating existing and available spatial data sets are regional scale wildlife habitat functional interrelationships, regional scale hydrology functional interrelationships and human activity-land cover functional interrelationships. Their significance for regional land use planning is summarized below:

1) Regional Scale Wildlife Habitat Functional Relationships keep landscape features and processes spatially inter-connected to enable seasonal movement and life cycles of wildlife species and maintain predator-prey dynamics. Spatial habitat connectivity is a key principle in landscape ecology. Wildlife and characteristic seasonal habitat is also a significant cultural and heritage resource and is a characteristic natural amenity of the region and its landscapes.

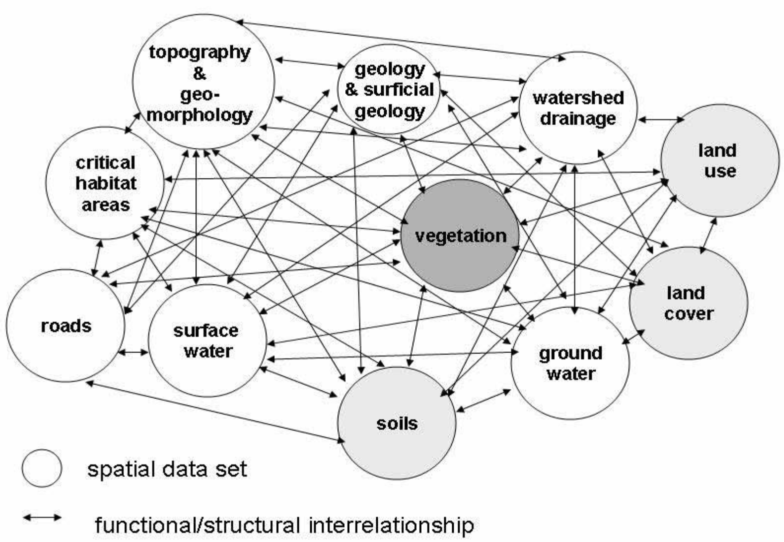
2) Regional Scale Hydrology functional interrelationships are critical in linking processes both within the aquatic and terrestrial environment as well as between them. These relationships within the regional hydrologic cycle of both terrestrial ('green' flow) and aquatic ('blue' flow) are critical in a semi-arid region like Calgary. Water is clearly a limiting factor in the region for ecological processes as well as land use. Both water

supply and access to water determine the type and intensity of human activities possible in the regional landscape.

3) Regional Scale Human Activity – Land Cover functional interrelationships are important to understand the long term cumulative effects of regional land use. Understanding the relationships between current and future patterns of human and ecological infrastructure is essential for sustainable development. Ideally, if land use activities and natural land cover can be spatially organized to create and maintain a semi-natural regional landscape matrix then the cumulative effects of land cover change can be reduced.

The spatial configuration of these clusters of functional interrelationships is a manifestation of ecological infrastructure at the regional landscape level. The temporal dimension is expressed by change over time in these spatial patterns within the landscape mosaic. These spatial patterns indicate areas with the capacity to provide specific types of ecological goods and services resulting from specific ecological processes and functional interactions over time. The three types of ecological infrastructure functional 'clusters' link ecological functions and human activities within the regional landscape, thereby connecting spatial data to spatial pattern. Giving these functional clusters spatial pattern and organizational structure on the regional landscape, can help determine where land use and development and land cover change will maximize or minimize ecological function.

**Figure 1**. **Regional Ecological Infrastructure Functional Interrelationships**




The following sections address:

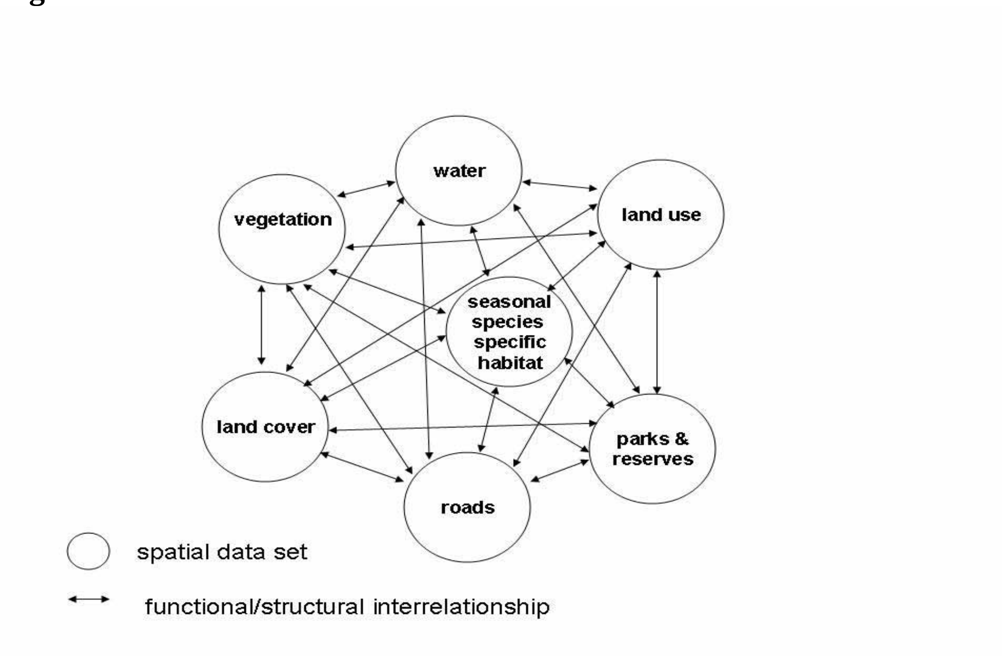
- the critical interrelationships involved in these functional clusters,
- what we know about these functional interrelationships versus what we don't know,
- gaps in spatial data sets,

- regional distribution and variability of the spatial patterns created by these functional clusters.

**Ecological Functional Cluster 1: Regional Scale Habitat Functional Interconnections**

Connectivity is essentially a measurement of the extent to which a landscape's spatial structure and organization facilitates or impedes the flow of energy, materials, nutrients, species, and human activities. Connectivity represents functional interconnections among ecological processes, human activities and landscape spatial organization and structure.

**Figure 2. Habitat Interconnections Framework**




Similarly, wildlife corridors represent functional and spatial connections enabling daily and seasonal movement, dispersal and migration of wildlife species and populations across the landscape.

Landscape modification through human land use activities can result in landscape fragmentation and a loss of connectivity. Natural landscape features such as river valleys and topographic ridge lines create corridors. Human activities in the form of roads, powerlines, irrigation canals and recreational trails also create landscape corridors. While human induced landscape corridors can sometimes function as movement corridors for wildlife, they more often become barriers to wildlife movement. A single barrier, such as a busy highway, can jeopardize the function of an entire wildlife corridor and multiple barriers can effectively fragment the landscape and isolate critical habitat and breeding populations from one another. Simply designating fragmented habitat patches in a human dominated landscape as "protected" does not ensure they will continue to maintain their functional ecological and spatial interrelationships at a regional scale. Maintaining and enhancing landscape connectivity is increasingly critical to ensuring ecological infrastructure functions. Known migration and movement routes, seasonal and life cycle habitat needs, biophysical landscape linkages such as ridges, riparian corridors, land cover and vegetation patches, designated reserve lands (such parks and conservation areas), and hydrologic processes and patterns all create spatial and functional linkages important to maintaining and enhancing species specific wildlife habitat functional and spatial interrelationships.

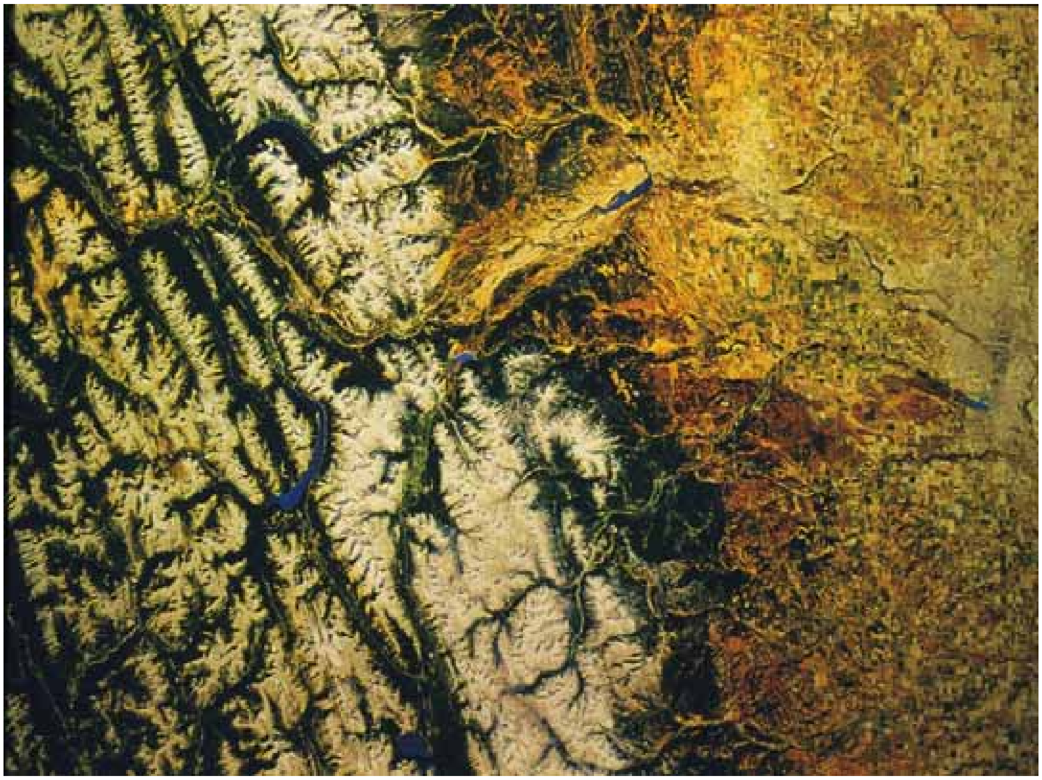
***This is an area where not much is currently known. There are gaps in regional spatial data sets necessary to understand these interactions and further research would be required to develop a better understanding of critical wildlife movement patterns and corridors at a regional scale*.**

**<u>Important Factors and Functional Interrelationships</u>:**

1. **Climate and moisture conditions**:

   The position of the CRP region adjacent to the high mountain ranges has a profound influence on climate and moisture availability, and in turn, the distribution of vegetation and habitat connectivity. The region receives relatively low amounts of precipitation, typically varying between 40 and 50 cm annually. Low humidity levels encourage a high rate of evaporation, resulting in a semi-arid regional landscape dominated by grassland and shrubland communities. Annual precipitation decreases from west to east, whereas summer temperatures tend to increase significantly across the same gradient. This available moisture gradient is reflected in the transition from coniferous pine and spruce forests in the alpine and foothills zones to mixed evergreen-deciduous stands in the parkland zone, to fescue and mixed grass. Alpine areas obtain the most precipitation in winter in the form of snow, while the montane, foothills and parkland zones obtain more precipitation in the early spring and summer months. In the grassland zone, spring runoff events are followed by summer moisture deficits and high evapotranspiration losses which create a need for irrigation to support certain types of crops. As the temperature gradient increases west to east, so does the frost-free growing period and early summer moisture gradients. The region is also characterized by intermittent periods of high winds and warm seasonal ‘Chinooks’, are another climatic feature induced by proximity to the mountains and instrumental in determining the types of land cover and vegetation communities that can persist in the region’s semi-arid conditions (Figure 3).

**Figure 3. Satellite image to show Chinook zone/effects (see Bow River Valley in upper centre of image – orange color indicates the effect of drying winds)**



## 2. Vegetation and habitat patches:

Plant ecology is responsive to and limited by available seasonal moisture and hydrologic processes in the landscape such as groundwater springs or riparian zones. Solar 'aspect' plays a significant role in controlling seasonal light, heat and moisture gradients. Specifically, coniferous forests dominate on moist northern and eastern slopes in the alpine and foothills zones; while mixed coniferous and deciduous aspen woodlands occur on north and east slopes in the lower foothills and parkland zones. Similarly, grasslands dominate on south and west slopes due to the combination of greater sunlight, warmer temperatures and drier conditions. As moisture levels increase, shrub communities become increasingly abundant, occurring in suitable niches such as on steep north facing slopes, in ravines and on seepage sites. These regional topographic microclimates induce land cover and vegetation communities patterns across the landscape which creates habitat networks (Map 4). For example, Douglas fir-lodgepole pine and limber pine forests in the subalpine zone provide prime habitat for songbirds, as well as elk and mule deer wintering habitat. Other bird species, such as Clarks's nutcrackers, are restricted to coniferous subalpine forests and aid in the distribution and regeneration of whitebark pine through seed caching.

Mixed forest stands occur along topographic ridges with springs or on lower slopes that experience seepage. They are also found in sheltered hollows and valleys where winds are calmer and cold air sinks and creates moister conditions due to less evaporation. Localized deciduous forests and aspen stands have special habitat significance in the foothills zone due to their occurrence in groundwater discharge areas such as valley bottoms and slumping slopes, where nutrient-rich groundwater and groundwater seepage can be found. These foothills forests host high levels of avian biodiversity largely because it has the highest amount of native vegetation due to minimal cultivation.

The Bow Corridor in particular hosts high habitat diversity due to Chinook winds topographic variation and surface and groundwater flow regimes. These conditions encourage a variety of wildlife species to utilize this corridor. Similarly, the foothills are an important transitional zone for elk due to the abundance of native vegetation. Elk are primarily grazers, preferring a diet of grasses or forbs, but will also browse on winter range.

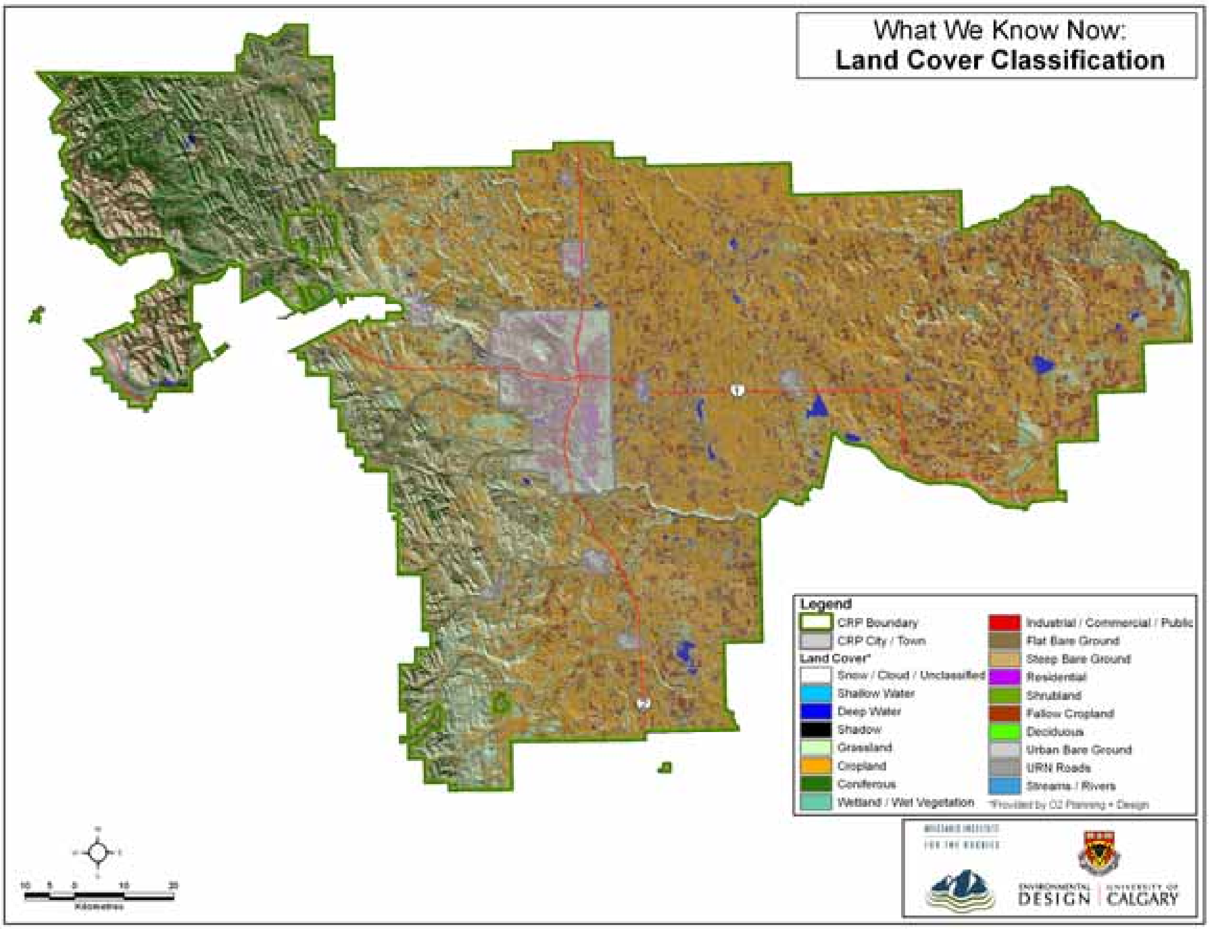
The Aspen Parkland zone is one of the most agriculturally productive areas of Alberta and as a result, most of the native vegetation has been replaced by agricultural species. However, significant remnant patches of natural parkland occur in areas not suitable for agriculture, such as river bottoms and dune fields. These remnant habitat units are very important for species such as white-tailed deer, prairie vole, horned grebe, and the threatened piping plover.

### 3. Topography (Slope/Aspect):

Regional topographical features such as ridges and canyons provide important winter habitat for elk, bighorn sheep, and other wildlife species due to groundwater seepage and associated vegetation patches. For example, Exshaw and Grotto Mountains are important wintering areas with these characteristics. Since deep snow prevents grazing, elk and deer prefer drier open areas which are exposed to sun and Chinook winds for their fall and winter ranges. Similarly, coulees, river valleys, rock outcrops, and wetlands in the parkland and grassland zones provide important nesting areas for birds of prey including golden eagles, ferruginous hawks and prairie falcons, as well as critical dancing habitat for sharp-tailed grouse. Vegetated coulees and draws connected to rivers and streams also provide important movement and habitat connectivity corridors (Map 5).

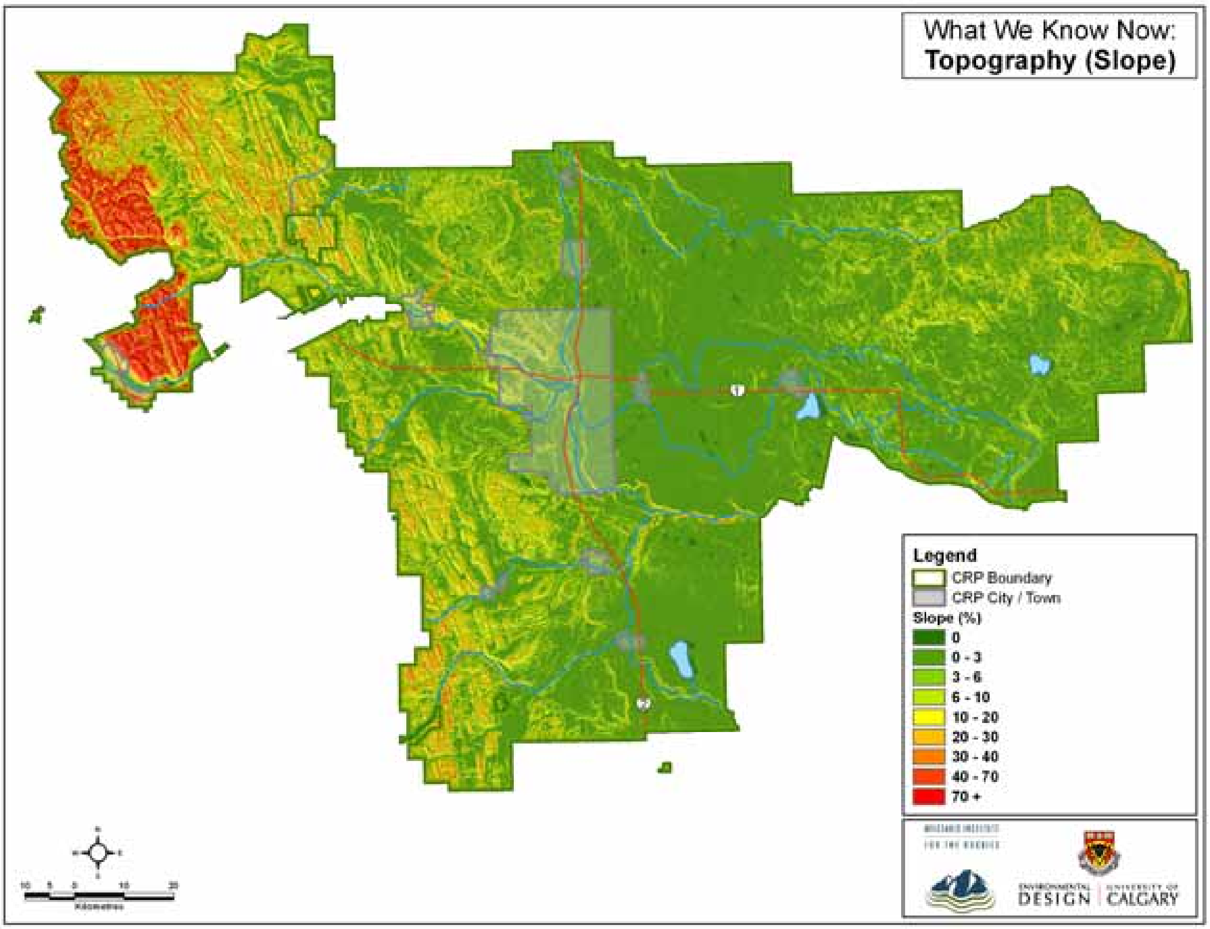
For example, the high altitude, vegetated ridges with mixed coniferous and deciduous forest patches that emerge in the presence of springs or groundwater seepage sites provide prime conditions for wildlife movement corridors and connectivity for elk and deer between alpine, foothills and parkland zones. Springs create relatively higher humidity and soil moisture which in turn promotes plant growth, providing food, minerals, shelter and a relatively mild microclimate.

**Map 4. Regional Land Cover**




Specific examples of such areas include the topographic ridge between the Cross Conservation Area and the Leighton Centre, and south towards the Porcupine hills is a critical movement corridor for elk. The Highland-Pekisko uplands also provide prime moose and elk habitat, and connectivity with and between the Porcupine Hills. The Yamnuska Natural Area is also a key ecological area due to the presence of springs, seepages, wetlands, ponds, and rare flora and fauna. Bighill Coulee extending from the Cochrane area to the headwater of Beaverdam Creek contains a year round spring-fed creek which supports significant riparian forest vegetation and serves as both a habitat and movement corridor. The Sheep River corridor provides key cougar, bighorn sheep and deer habitat, and important rainbow trout spawning areas. The Bow Corridor provides a vital link for large mammals moving between Kananaskis, Banff and areas to the north and south. It also offers important spring calving grounds for elk. The dedication of over 3,000 acres of ranchlands located along the Bow River between Calgary and Cochrane for the new Glenbow Ranch Provincial Park will greatly aid in protecting a large expanse of important riverine ecosystem. The area serves as both important habitat and a movement corridor for many species including white-tail and mule deer, red-tailed and Swainson's hawks, and weasels.   The isolated remnant landscape of the Wintering Hills also provides a refuge for forest species within the grassland-dominated environment.

**Map 5.                    Regional Topography (Slope)**

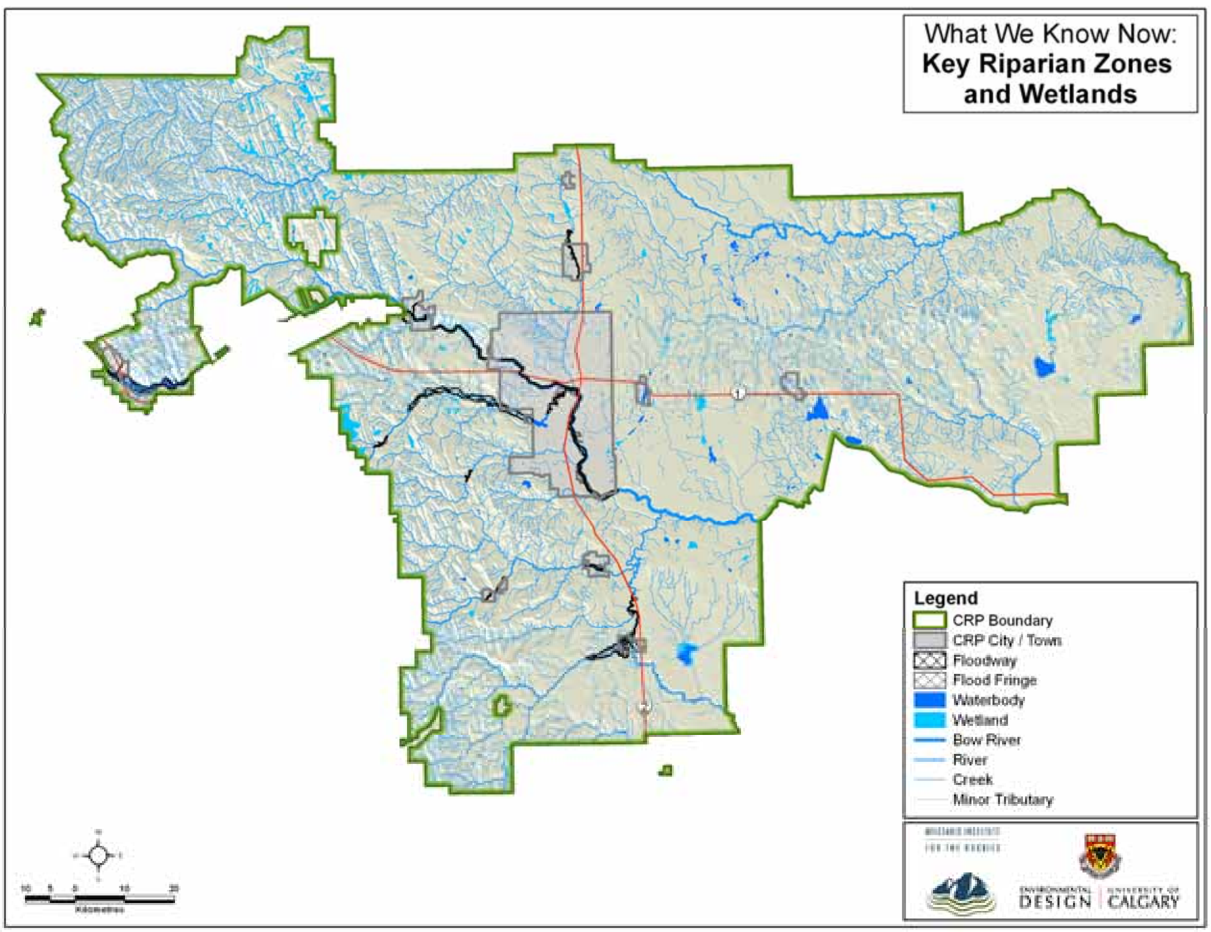



## 4. Riparian Zones and Wetlands:

River systems and floodplains provide conditions for riparian vegetation networks to flourish and function as extensive movement corridors and habitat linkages for many species of wildlife.  These corridors are especially important in the CRP region, where large, contiguous patches of vegetation are rare and moisture is critical.  Due to the relative abundance of nutrients and water, riparian areas can support a greater variety of plant and animal species than adjacent uplands.  Approximately 70 - 80 percent of Alberta wildlife species use riparian areas for some, or all, of their life cycle requirements.  In fast-flowing streams, algae are the predominant plant life and aquatic invertebrates burrow into the riverbed while others cling to or dwell among rocks or adhere to vegetation and woody debris along the channel or channel substrate. These invertebrates are the major food source for many fish and duck species. Major river valleys, such as the Bow, the Red Deer and the Rosebud, extend riparian forest elements into the grassland portion of the region, and these habitats are common to species that occur primarily in the grasslands such as the red-tailed hawk, great-horned owl, diving ducks, yellow warbler, white-tailed deer, snowshoe hare and the American porcupine. In the M.D. of Bighorn, the stream valleys stand out as being the major ecologically significant landscapes as they provide the most wildlife habitat. The Meadow Creek area, in conjunction with the adjacent mountain and foothills environments, is noted as being a zone of particularly high ecological diversity.

Wetlands also provide prime habitat for waterfowl as well as nesting grounds and stopover areas for migrating bird species. In low-lying areas of floodplains, they also function in nutrient storage and cycling, and contribute to the habitat network (Map 6).

**Map 6. Key Riparian Zones and Wetlands**



## 5. Significant Regional Wildlife Species

The regional landscape is home to a number of significant wildlife species. It is one of the best areas in North America for large ungulates, including bighorn sheep, mountain goat, elk, moose, mule-deer and white-tailed deer. Mule deer and white-tailed deer are adapted to edge conditions and are common throughout the region while other species are largely confined to the mountains and foothills.

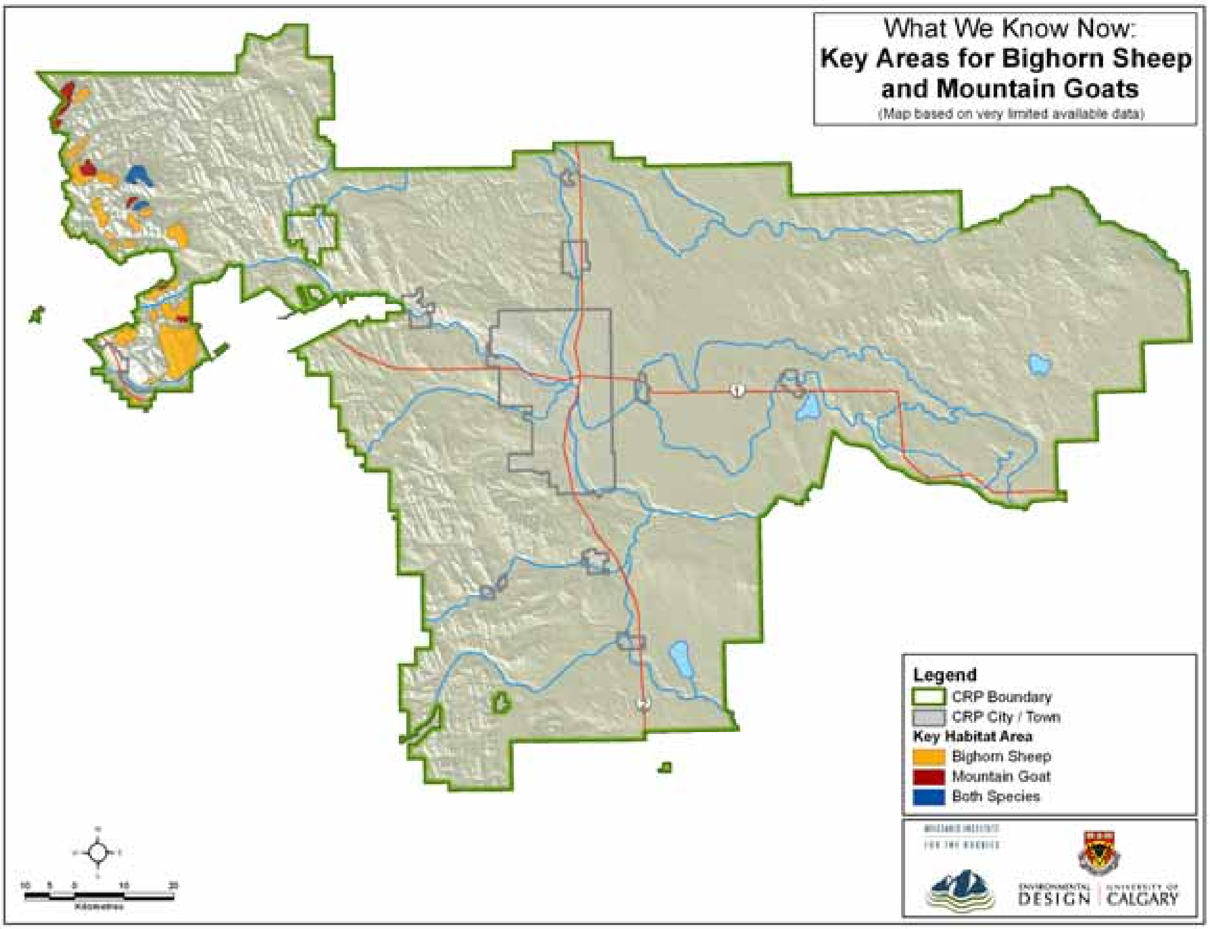
Large predators in the region include grizzly bear, black bear, cougar, coyote and wolves. Smaller mammals such as beavers and porcupines are common within the forested and parkland areas, while badgers and Richardson's ground squirrels are characteristic of the parkland and grassland zones. The Richardson's ground squirrel is a good example of an ecosystem 'integrator' in grassland systems. It provides a number of functions including being a key food source for carrion feeders and predators, such as the ferruginous hawk and american badger. Its burrows are also utilized by other mammal, insect, amphibian, snake, and bird species, including the endangered burrowing owl. The following summaries provide an overview of the regional distribution of significant wildlife species (Nb – published information on specific wildlife distribution and abundance was not readily available):

- ***Bighorn Sheep and Mountain Goats***

  Within the CRP region, bighorn sheep and mountain goats are present in the western portion of the M.D. of Bighorn and just west of the M.D. of Foothills. The primary range of bighorn sheep in Canada is along the Front Ranges of the Rocky Mountains and a significant portion of this range lies within the CRP's boundary. Mountain goats favor rugged mountain terrain and steep grassy slopes of rock debris occurring at the base of cliffs. They do not undertake seasonal migrations and occupy more or less the same range in both winter and summer. The Canmore Corridor is an important overwintering area for sheep due to the warm Chinook winds, which blow down the Bow River Valley, reducing snow cover. Wind Ridge is a high alpine meadow lying to the east of Three Sisters Mountain and is reported to be one of the finest winter ranges for bighorn sheep in the Canadian Rockies (Map 7).

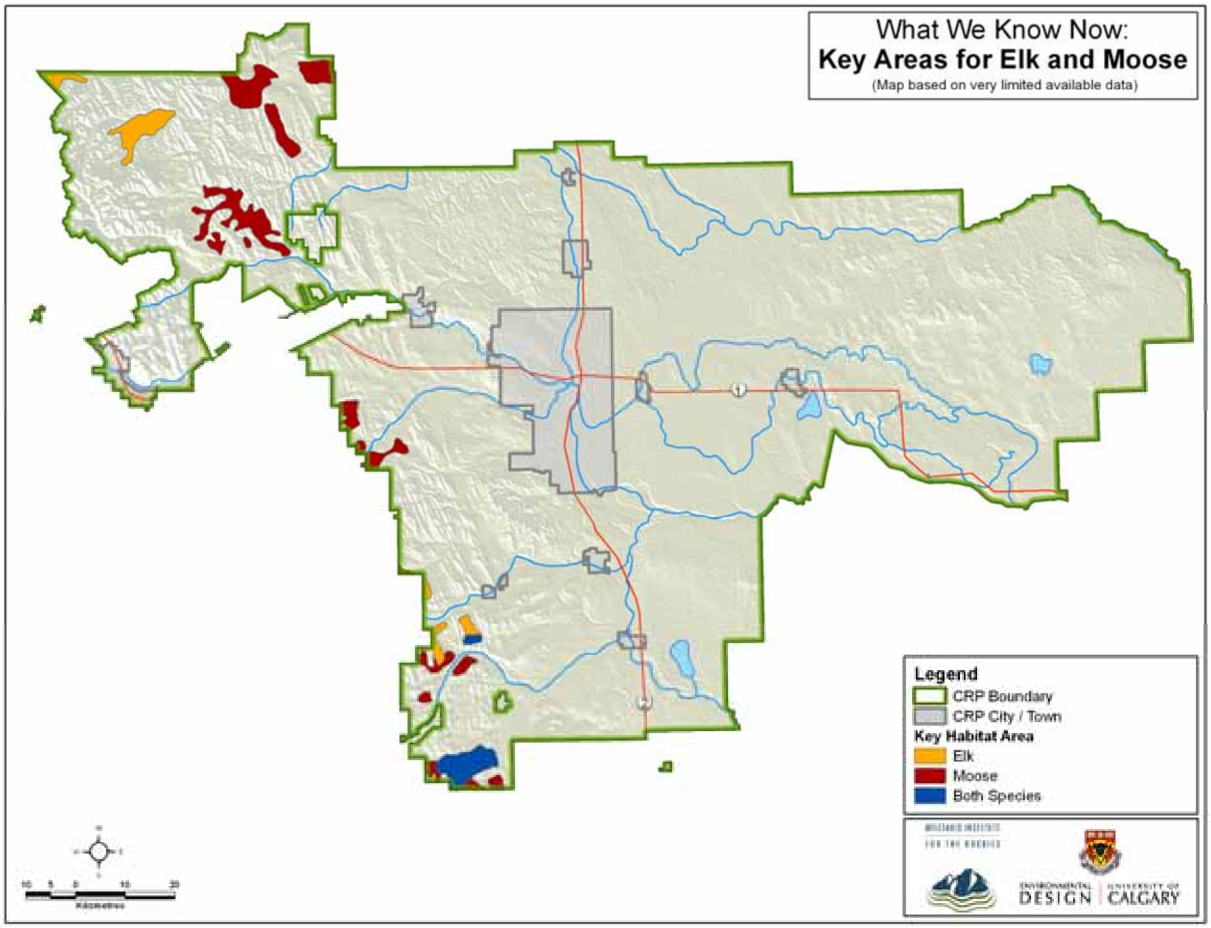
  Key areas within the CRP's boundaries for mountain goats are much more restricted in their occurrence than those for sheep. The principal areas are on Otuskwan Peak, Mt. Oliver, the mountains adjacent to the headwaters of Waiparous Creek, Saddle Peak and in the general vicinity of End Mountain (Map 7).

**Map 7. Key Areas for Bighorn Sheep and Mountain Goats**




- ***Elk***
  The Foothills and Front Ranges of the Rocky Mountains now constitute the primary range of elk in Canada. The CRP region lies within the heart of this species primary Canadian range. Elk occur in the western parts of the M.D. of Bighorn and the M.D. of Foothills in foothill and mountain environments where grasslands or agricultural croplands can be found adjacent to relatively large blocks of forest cover. Elk undertake altitudinal migrations between summer ranges on grassy subalpine and foothills slopes and winter ranges in the protected valleys. In late winter and spring, south and west facing slopes are important to elk because of the lighter snow cover and the earlier greening of the vegetation (Map 8).

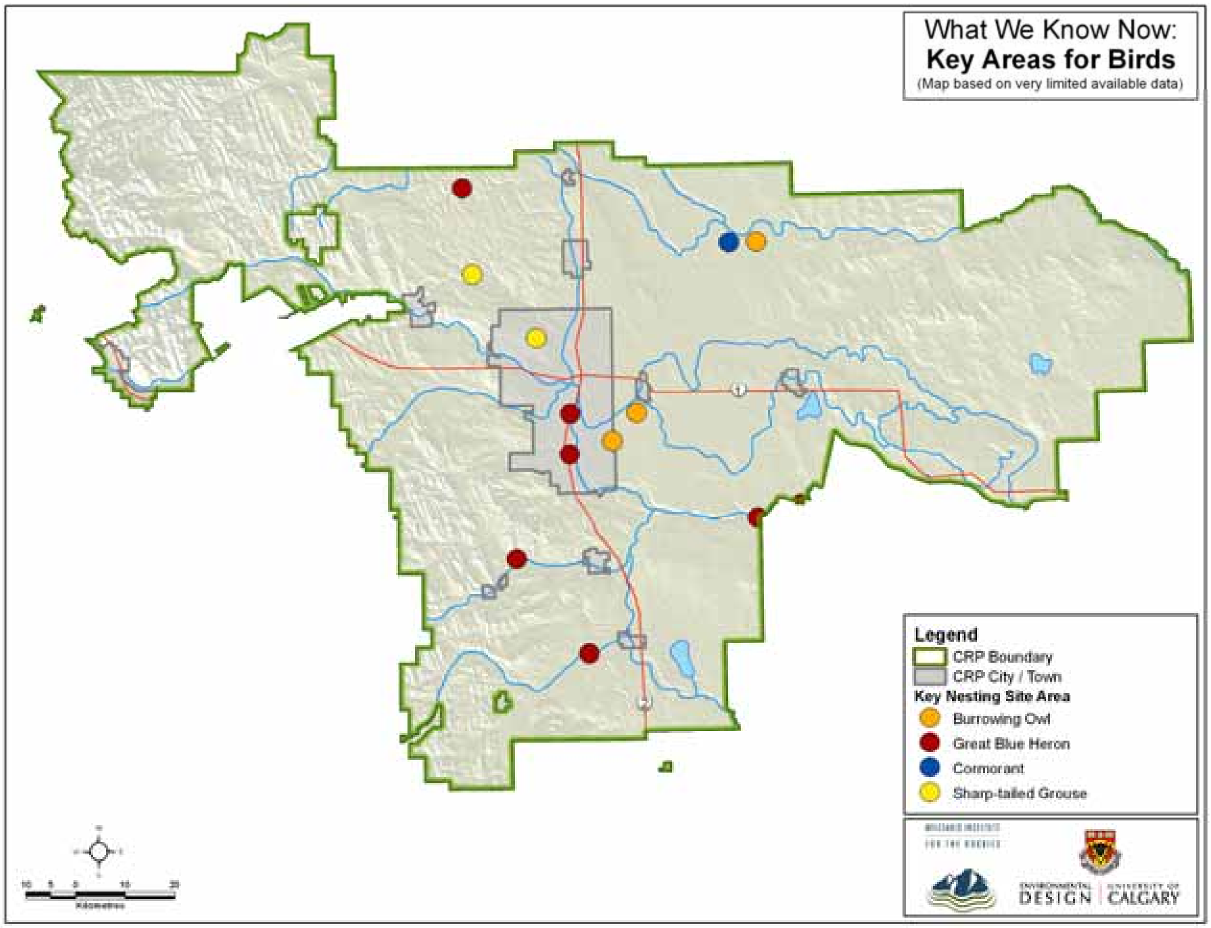
**Map 8. Key Areas for Elk and Moose.**




- ***Birds***

  The CRP region has a significant diversity of bird species. Approximately 309 of the 329 birds known to Alberta have been sighted within an 80-kilometre radius of downtown Calgary. The eastern part of the region contains significant seasonal habitat for breeding and migrating waterfowl. Frank Lake, east of High River, has become a regionally significant staging and migratory bird habitat area. The critical flyway for Trumpeter Swans includes wetlands in the foothills and parkland zones. The Irricana reservoir and Janet Sloughs are important breeding grounds for Canada geese and California gulls, within a critical flyway corridor for these species. Islands in larger regional water bodies such as lakes and reservoirs are also important nesting sites for Canada geese, gulls, American white pelicans and Double-crested cormorants. Oxbow lakes are prime bird habitat as well as key habitats for breeding amphibians such as chorus frogs, leopard frogs, plains spadefoots, plains and wandering garter snakes, and a highly diverse invertebrate community. For a comprehensive review of breeding birds within the CRP area, readers are referred to *The Atlas of Breeding Birds of Alberta: A Second Look.*

**Map 9. Selected Key Areas for Birds**

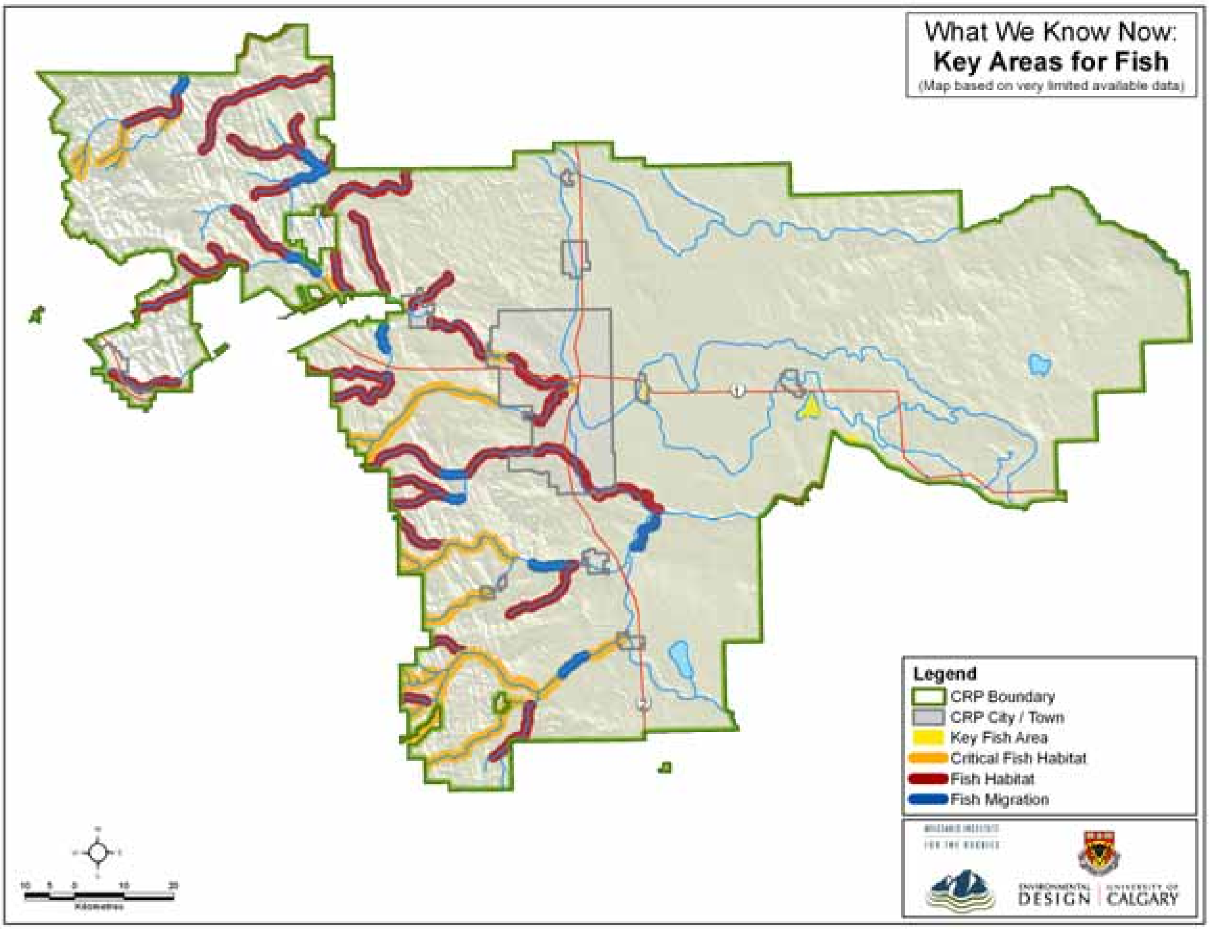



- ***Fish***

  Fish habitats offer a functional connection to hydrology in terms of critical thresholds and seasonal low flows. Most of the important streams in the CRP region are cold-water, originating in the mountains and foothills. Depending on their characteristics, these may contain Mountain Whitefish, Rainbow Trout, Brown Trout, Bull Trout, Cutthroat Trout or Eastern Brook Trout. Reaches 3 and 4 of the Bow River, from the Glenmore Trail Bridge in Calgary to the western boundary of the Blackfoot Indian Reserve, are considered to be among the finest trout streams in North America. Rainbow Trout depend on smaller streams in the Highwood and Sheep River systems for spawning. Alberta Environment's Instream Flow Needs Study found habitat loss criteria have been exceeded in Reach 3 of the Bow River for rainbow trout spawning. From Banff to Calgary, the Bow River provides important spawning habitat for mountain whitefish and brown trout. Brown trout also spawn in the lower Elbow River. Mountain whitefish overwinter in the Bow and lower Highwood rivers, and spawn in the upper Sheep and Highwood rivers.

  The most important regional lakes for cold water salmonids are the Ghost Reservoir on the Bow River and Glenmore Reservoir on the Elbow River.  Lake trout occur only in the Ghost and Bearspaw Reservoirs.  Eagle Lake, in the eastern part of the region supports Walleye and Northern Pike.  Namaka Lake, just downstream of Eagle Lake, hosts Northern Pike and Lake Whitefish.

**Map 10 Key Areas for Fish**

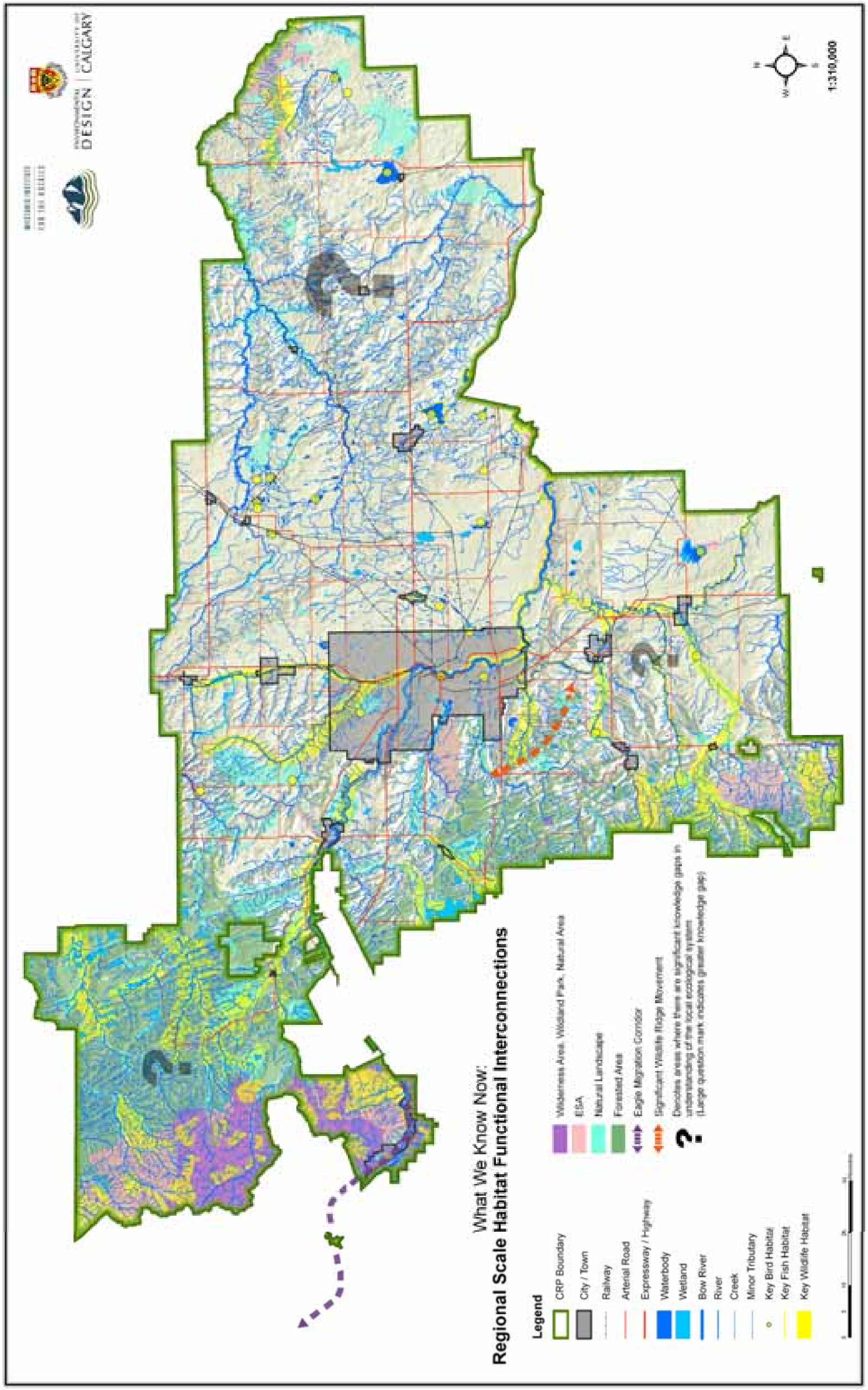



## Ecological Infrastructure Wildlife Habitat Interconnections and Land Use Planning

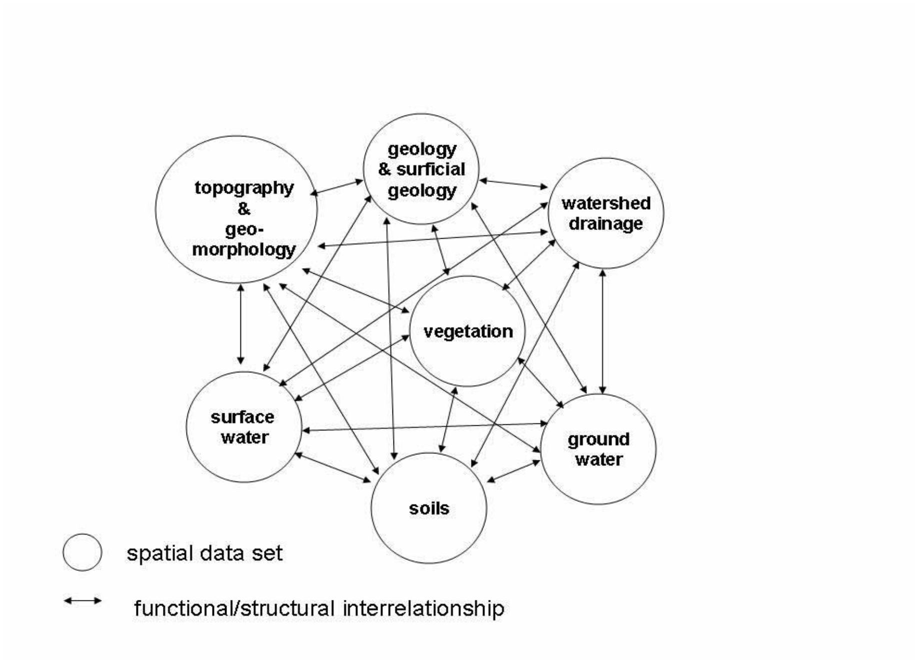
Significant functional wildlife hubs occur in areas where coniferous and deciduous forest patches, high ridges and/or wetlands and riparian zones intersect and interconnect. Valley bottoms are also critical hubs due to nutrient-rich groundwater discharge and seepage areas that produce a positive soil moisture balance for vegetation growth. Spatially and functionally, 'hubs' provide movement corridors and connectivity between important species specific and seasonal habitat patches.

The amount of native fescue prairie remaining in Alberta is about five percent of its historical coverage.  The amount of natural parkland remaining is estimated between 5 and 15 percent. Habitat areas for native prairie species have become relatively small and highly fragmented over time in the regional landscape as a result of land cover and land use change related to increased agricultural production, roads and utilities infrastructure development, population growth and urbanization as well as expansion of the forestry and energy industries required networks of access roads, seismic lines, pipelines and related facilities. Regional landscape spatial design solutions are possible for mitigating fragmentation and facilitating connectivity are possible. Map 11 presents a summary of the information presented in this section.

**Map 11. Cluster 1 Summary: Regional Scale Habitat Functional Interconnections**



**Ecological Functional Cluster 2: Regional Scale Hydrologic Interactions**




The hydrologic cycle involves the movement of water and precipitation in a complex system of interconnected pathways connecting weather patterns, surface runoff, evapotranspiration, infiltration, recharge and storage of water in terrestrial sinks and sources including geology, soils, surface water, wetlands and vegetation. These interactions are distributed across the landscape in varying spatial patterns that are vital to the operation of the hydrologic cycle. The primary source of water in the regional landscape is precipitation although glacier melt and groundwater also contribute on a seasonal basis. Regional climate and landforms determine the region's annual range of expected precipitation and net moisture balance given high loss from evapotranspiration.

In semi-arid regions like Southern Alberta, water taken up by vegetation and held in various forms in the terrestrial environment is referred to as '*green flow*'. This component of the regional hydrologic cycle is critical to terrestrial ecosystem function and atmospheric conditions/exchanges. This terrestrial component or so called green flow, accounts for approximately 65% of the global hydrologic cycle. In contrast, water is generally thought of as liquid and in its liquid form; it represents the hydrologic cycles '*blue flow*'. This blue flow is the essence of aquatic ecosystem function and is generally connected to groundwater and aquifer storage systems. However, the blue flow only accounts for approximately 35% of the hydrologic cycle. This seems counter intuitive given the general perception of water and hydrology as liquid $H_2O$. However, the significant but generally invisible importance of the green flow means that in order to manage the hydrologic cycle in a semi-arid region it is critical to manage both the traditional blue flow focus of water management as well as the green flow management which is not generally recognized as being as important if not more important in the hydrologic cycle. Maintaining the functional and spatial interface between blue and green flows is critical to functioning of the regional hydrologic cycle. It is also necessary to integrate ecological and human land use activities across the regional landscape.

**<u>Important Factors and Functional Interrelationships</u>:**

1. **Geology and surficial geology**
   The geology of the region's alpine and montane zones consists predominately of limestone, dolomite, with locally exposed conglomerates and shales. The calcarious nature of the rock results in very rapid drainage and generally inhospitable conditions for vegetation. Siltstones and sandstones begin to dominate in the foothills. Limestone and sandstone are the most permeable to infiltration for groundwater recharge. The permeability of these materials creates hydraulic linkages between surface water and groundwater. Subsurface flows find a path through permeable rock or fractures in impermeable formations, emerging from the ground as springs.

   Historically, glaciation from the mountains extended to the plains through the Bow River Valley and formed a series of elongated, smoothly rounded hills or drumlins, south and west of Calgary. As the ice retreated, sand and gravel were extensively deposited in the form of outwash, kames, and eskers. Large terraces of glaciofluvial (sands, silts, gravels) and glaciolacustrine (silts and clays) deposits can be found in river valleys throughout the region. Further to the east, sandstones, mudstones and shales dominate in parkland and grassland zones.

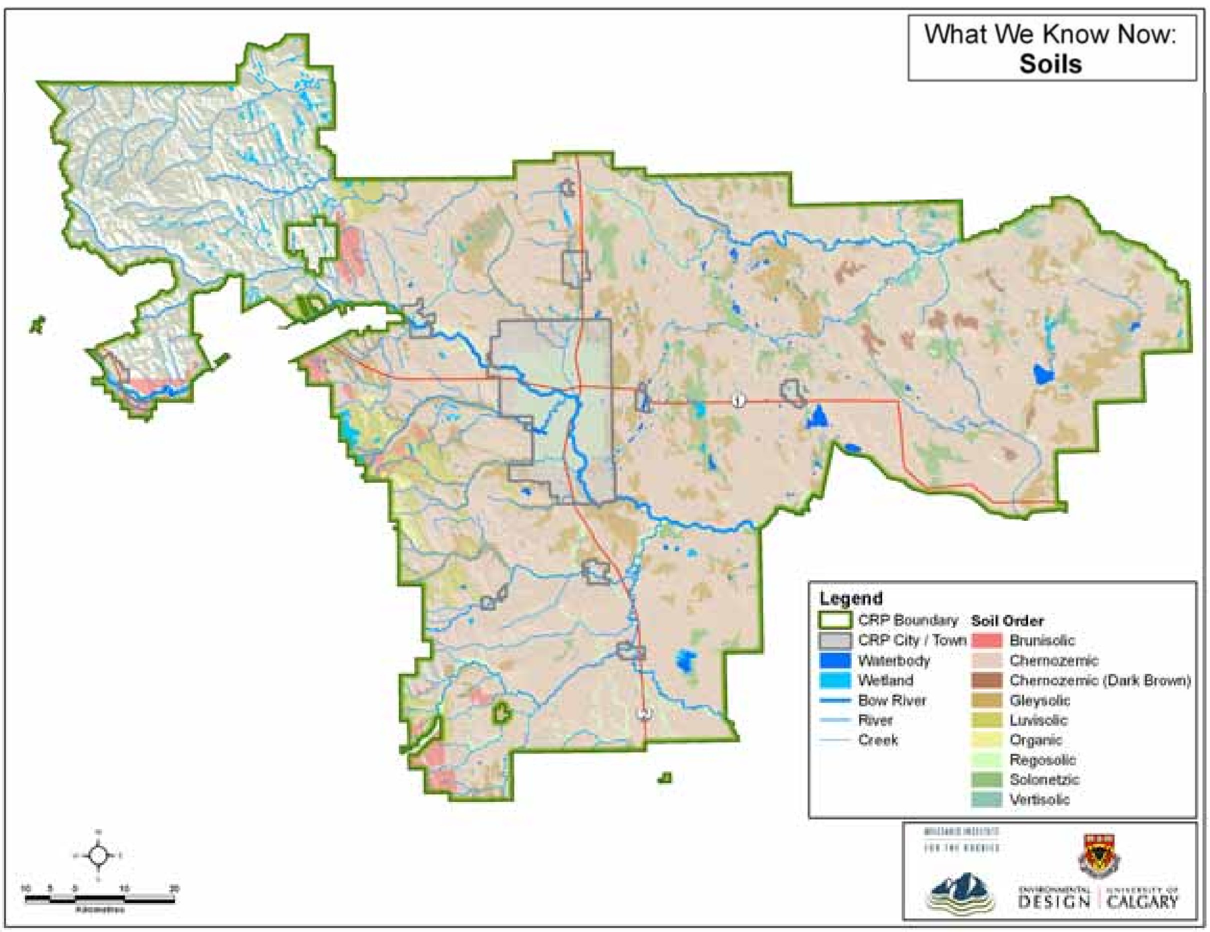
   ***This is an area where not much is currently known. There are gaps in regional spatial data sets necessary to understand these interactions and further research would be required to develop a better understanding of hydrogeology at a regional scale.**

2. **Topography and geomorphology**
   Over time, climactic processes and geology ultimately create the landscape's topographic characteristics and geomorphology. For example, the elevation gradient from west to east across the Calgary region changes from mountains to rolling foothills and dissected plateaus to hummocky uplands and undulating plains. Runoff potential tends to be high on well-developed slopes with coarse textured soils, and low on flat, closed, or poorly developed slopes with fine textured soils. These variations in landforms and slope in conjunction with vegetation influence runoff potential across the landscape. Land cover filters overland run-off and infiltration and contributes to green and blue flow interactions. Topographically controlled moisture and temperature gradients produce abrupt vegetation changes relative to slope aspect. In turn these vegetation patches influence soil properties and blue-green hydraulic flows across the landscape. Topography also influences the locations of groundwater recharge and discharge areas. Similarly, slope affects soil nutrient levels. Specifically, levels of nitrogen, phosphorous, potassium, and organic matter tend to decrease on steep slopes, while soil density and calcium carbonate levels tend to increase.

### *3.* Soils

Soils in the region developed after the last glaciation in response to moisture conditions. Brunisols (poor horizon development) are generally found on slopes, and regosols are characteristic of valleys. In the sub-alpine, montane and foothills zones, fine textured soils are prevalent on steep slopes, while fine to medium textured soils are associated with lower slopes. In the foothills, luvisols (mostly silicate clay) are more prevalent, but medium textured grey chernozems (zerophytic and mesophytic) are also found in areas of the foothills and in the parkland zone primarily under forests where organic litter accumulates. Black chernozems occur under grasslands where organic content in the topsoil is high. Brown chernozems are characteristic of cultivated lands with higher soil temperatures and less organic content. A characteristic band of Solonetzic soils in east central Alberta is prevalent where saline parent materials are found on low relief plains. In wetlands across the region, gleysols are characteristic of poorly drained areas.

**Map 12. Soils**



Soil properties also affect runoff and infiltration potential in conjunction with slope and land cover influences. High runoff coefficients are characteristic of brunisols and luvisols which have restrictive layers, shallow horizons and fine textured silt and clay loam. Moderate runoff occurs in grey chernozems with deep horizons and moderately fine textured loam, silt loam and sandy loam. Low runoff occurs in black chernozems and regosolics which have deep horizons and permeable, coarse textured loam, sandy loam and sand.

Land cover disturbance from human activities such as urban, industrial or agricultural development can affect soil nutrient and organic litter processes and compaction can lead to impermeable surfaces. In rural areas, extensive soil compaction from over-grazing leading can reduce water infiltration and increase soil desiccation which in turn affects vegetation renewal and replacement.

***This is an area where not much is currently known. There are gaps in regional spatial data sets necessary to understand soil characteristics and their linkages to hydrological processes and vegetation dynamics. Further research would be required to develop a better understanding of these interactions at a regional scale.***

**4. Vegetation**

Regional plant communities follow characteristic moisture gradients. For example, riparian zone vegetation (willow, poplar, cottonwoods, white spruce) reflects the relatively higher moisture content of flood plain soils. As an important *green flow* contributor, riparian vegetation stores water (bioretention) that would otherwise quickly be lost by evaporation or surface run off. This terrestrial water uptake though retention in riparian biomass along streams and rivers participates in regulating downstream flows. Riparian vegetation slows the erosive force of the flowing water, provides shade to help regulate water temperatures and reduces sedimentation from run-off. Riparian vegetation contributes nutrients to flowing water ecosystems in the form of leaves and woody debris, and provides habitat for aquatic insects. These interrelationships and connections illustrate the critical role riparian zones play in maintaining spatial connectivity across the landscape and providing vital wildlife movement corridors and habitat. However, riparian zones are decreasing due to urbanization over grazing and agriculture practices.

Native fescue grasses and grasslands also play a regionally significant role in blue and green flow interactions by holding water in the landscape and facilitating infiltration through their deep root systems. However, most of the regions native fescue grasslands have been converted to cereal crop production which does not provide the same critical water retention capacity.

***5.* Nutrient cycling**

Nutrient cycling is driven by several processes such as geological weathering, nutrient spirals in water flowing downstream and periodic flood events that directly transfer nutrients between aquatic and terrestrial ecosystems. Such ecological processes and feedback systems are critical to maintaining the regional landscapes ecological functioning.

***This is an area where not much is currently known. There are gaps in regional spatial data sets necessary to understand nutrient cycles and their spatial functional interactions. Further research would be required to develop a better understanding at a regional scale.***

6. **Groundwater**
   In a semi-arid region with high evapotranspiration rates, groundwater is critical resource. Groundwater provides base flow to regional rivers and streams and maintains aquifer storage capacity necessary to maintain agricultural and residential wells. It is a major interactive mechanism linking the blue and green water flows in the regional hydrologic cycle. Groundwater discharge zones and perched water tables in Paskapoo sandstone and other porous, permeable sediments create lateral flows capable of supporting grassland and parkland vegetation. Low flows using gravity-driven pressure on predominately glacial clay tills and shales are characteristic of the foothills. Groundwater recharge areas typically occur in topographic highs with coarse substrates and/or shallow, fractured bedrock such as sandstone or limestone. Groundwater discharge and springs are important sources for wetlands and tributary headwaters and for maintaining base flows in permanent streams and ponds which serve as critical fish and waterfowl habitats. Groundwater flow also helps regulate stream temperature in spawning habitat for regionally significant fish species such as bull trout.

   Aquifer storage capacity is more precarious in sub-alpine and montane zones due to greater runoff. This risk decreases in the foothills, parkland and grassland zones as topographic relief decreases across the region from west to east. Conversely, groundwater contamination risk increases in parkland, floodplain and grassland zones where more permeable geological conditions and wetlands are found. In these areas, riparian vegetation is critical to maintaining water quality. However, in highly permeable areas groundwater quality can be affected by agricultural and intensive livestock operations and energy development activities including coal bed methane.

   ***This is an area in which substantial spatial data gaps exist. Groundwater and hydrogeological spatial data sets are currently unavailable from Provinical government and private sources related to regional aquifers and storage capacity. Significant research in this area will be necessar to support regional land use planning and growth management strategies.***

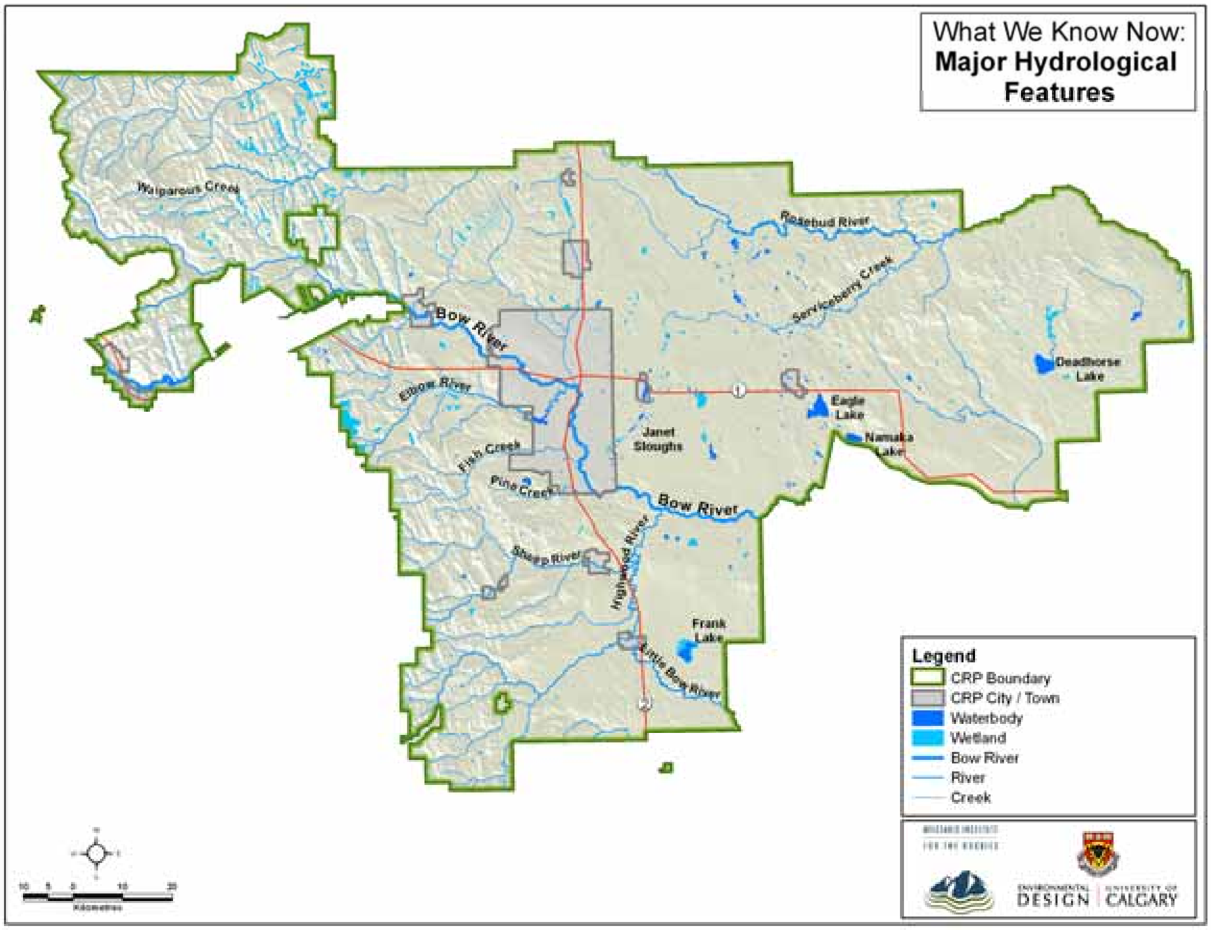
7. **Surface water**
   The boundaries of the CRP region fall within the South Saskatchewan River Basin 9Map 13). The Bow River is the largest river in the region and the Bow Valley Corridor is one of the most significant physical landscape features of the region for wildlife habitat and wildlife population movement. It is also a primary focus for urban and recreational development pressures. Similarly, the Highwood and Sheep Rivers are of major importance in the foothills as are the Ghost and Elbow Rivers. The Red Deer River drains the northwestern and northeastern parts of the region. The southeast corner of the

region is drained by the Little Bow River and Mosquito Creek, which are two small tributaries of the Oldman River. All regional rivers have headwaters in the mountains and melting snow contributes approximately 75 percent of the flow while precipitation and groundwater discharge contribute the remaining 25 percent. Drainage systems throughout the region generally have well developed gradients and there are few lakes.

The rivers that flow within the boundaries of the CRP region support approximately one-half of the Alberta population's water needs. Rivers are the source of approximately 85 percent of water allocated in Alberta. Lakes and groundwater provide the remaining 15 percent. These rivers and their tributaries are the only water source for the grassland zone and all of the Province's 13 irrigation districts are located within the South Saskatchewan River Basin (SSRB). Irrigation is by far the largest water use of water in the SSRB, followed by municipal use.

The abundance and distribution of surface water varies widely within the region. Wetland occurrence increases from west to east. Western wetlands are predominately related to surface water and eastern wetlands predominately groundwater related. The parkland zone has the greatest number of wetlands in the region. A large number of these wetlands are small and seasonal or ephemeral but provide nesting and stopover habitat for migrating birds and waterfowl in spring. In the foothills, wetlands tend to be confined to major valleys and floodplains. In the southern grasslands, most sizeable water bodies are reservoirs, with few natural lakes or wetlands. Many of the region's larger prairie wetlands have been enhanced through cooperative efforts involving Ducks Unlimited Canada and other public and private agencies. Permanent, ephemeral, natural and constructed wetlands all provide habitat and filter water through wetland vegetation root zones. Wetlands also act as carbon sinks, capable of storing carbon as well as acting like sponges to hold and release water slowly in floodplains helping with flow regulation and reducing sedimentation and erosion.

**Map 13. Significant Surface Water Features**




Lakes in the region are typically shallow and warm, and contain relatively high levels of minerals and nutrients when situated within basins containing fertile soil. Most lakes are eutrophic and experience algal blooms or extensive growth of aquatic macrophytes due to high levels of phosphorus from natural and agricultural sources through surface runoff, groundwater, and sedimentation. Reservoirs are deliberately created or modified natural water bodies that regulate flows for human use. Because of their fluctuating water levels, reservoirs generally lack the ecological habitat and productivity of shoreline and littoral zones of natural lakes. However, they often provide nesting islands for populations of pelicans and cormorants.

In addition to providing regionally important seasonal and life cycle habitat needs, wetlands and lakes and reservoirs are a critical part of the regional hydrologic cycle. Approximately 2/3 of all water in the hydrologic cycle is moved via evaporation and evapotranspiration. This moisture is forms clouds and is returned to the landscape through precipitation. This cycle is disrupted when the area covered by surface water is decreased. Specifically, approximately 70% of wetlands in the southern settled areas of Alberta have disappeared since European settlement as a result of landscape changes which have resulted in a significant decrease in the volume of surface water. This has contributed to historical periods of drought and has the potential to contribute to future drought conditions unless regional scale land use planning incorporates hydrologic management objectives.

***8.*** **Watershed contribution and instream flow needs**

Seasonal water flows supplied by rivers are critical to the region's urban and agricultural users as well as regional fish populations. In order to maintain the instream thresholds necessary to sustain regionally significant fish populations like Bull Trout (Alberta's Provincial fish). For example, in the upper reaches of the Sheep River during the fall spawning season, habitat conditions must be maintained within the species' preferred range of temperature and nutrient content in order for the fish to survive to adulthood. Plant communities, soil conditions and the presence of functional wetlands are all factors in regulating runoff, nutrient loading and sedimentation in rivers in order to maintain spawning habitat conditions.

An assessment of riparian and aquatic ecological conditions of 33 river reaches in the South Saskatchewan River Basin (SSRB), revealed that 31 are approaching unacceptable to below acceptable habitat conditions. For example, in the Bow River, habitat loss criteria were exceeded for rainbow trout spawning in Reach 3 as a result of land use intensification in the area. It is expected that cottonwood trees will disappear from the lower reaches of the Bow River in the next 100 to 150 years as a result of insufficient regeneration conditions including low flows and a lack of flood events attributable to human controls and encroaching agriculture and grazing practices. Land uses substantially affecting the flow and quality of surface water, riparian zones and associated habitat, include urban, agricultural and industrial development and associated changes to the landscape and variability in water allocations.

The current rate of economic development and land use intensification in the region is further increasing water demand in the SSRB. For example, Alberta's commitment to Saskatchewan requires one-half of the natural flow of water in the SSRB to be passed on to Saskatchewan each year. However, by the time the Bow River reaches its confluence with the Oldman River in Alberta, 68% of its average annual flow has already been allocated. Seasonal flow variability influences this percentage, which ranges from 25% in high flow years, to 80% in low flow years. Water licensing commitments on the tributaries of the Bow River and on groundwater are not included in these allocation percentages but should be taken into consideration as well. As a result, the total licensed allocation for the Bow River may at times exceed the natural flows of the Bow River. Therefore, new and future allocations to accommodate regional growth will be at risk of not receiving water in drier years.

A further complication in determining instream flow needs is that water removed from one reach is not necessarily returned to the same reach, or even the same sub-basin. For example, the City of Calgary can withdraw water from the Bow River in Reach 4, but return it in Reach 5. Irrigation, which is the biggest user of water in the southern portion of the region, can withdraw water through the Western Irrigation District (WID) in Reach

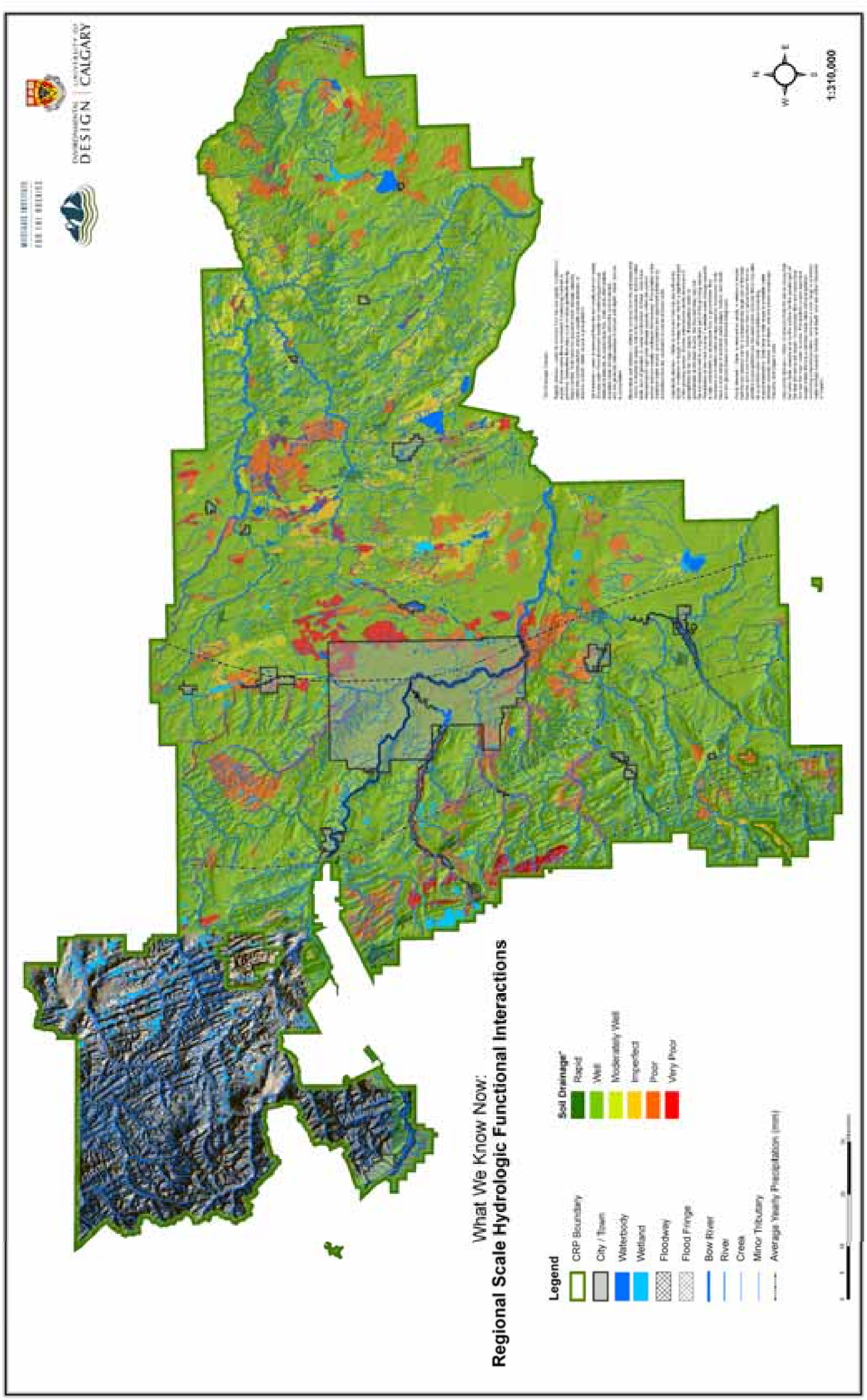
5, but returns the majority of it in Reach 7, while the Bow River Irrigation District (BRID) withdraws water from Reach 7, but returns it in Reach 8. Similarly, the WID returns some of this water taken from Reach 5 of the Bow River to the Red Deer River Basin, and the BRID returns some of its water from Reach 7 to the Oldman River Basin - both of which are outside of the Bow River Basin. Therefore, determining instream flow needs and watershed contributions by analyzing individual water licences and allocations is problematic because the threshold data set is extremely large and variable.

* ***Instream flow needs and watershed contributions are significant areas in which data gaps exist. Further research in this area is necessary to determine present instream flow needs and provide high quality and sufficient quantities of water to support regional populations and growth.***

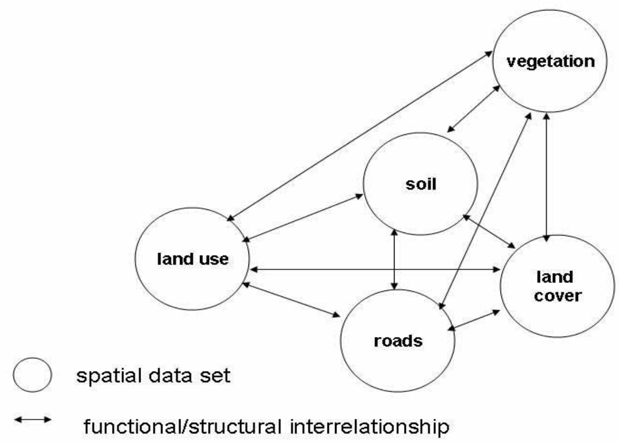
**Ecological Infrastructure Hydrologic Interconnections and Land Use Planning**

In order to maintain the blue and green flows of the regional hydrologic cycle and their landscape interactions what can be done to plan and manage spatial land use distribution and intensity? Land use and development affects the flow and quantity of water available to the CRP and water quality and availability are increasingly becoming limiting factors for regional growth. Strategic regional land use planning needs to respond to the ability and capacity of hydrologic systems to remain functional and provide ecological goods and services at the landscape level.

## Map 14. Regional Scale Hydrologic Functional Interactions



**Ecological Functional Cluster 3: Regional Scale Human Activity – Land Cover functional interrelationships**




**Human Activities and Land Cover Change Interactions in Land Use Planning**

Human settlements, rural or urban create spatial land use patterns in their surrounding regional landscapes that incorporate both human economic activities and natural areas or remnants of historical landscapes. This mix of different types of land uses, vegetation patches, water features, roads, municipal infrastructure and landforms creates 'heterogeneous' landscapes in which both human and ecological processes exist in a variety of spatial patterns. Landscape heterogeneity in landscape ecology is thought of as a measure of the 'naturalness' of a landscape or the degree of human dominance. Spatial heterogeneity generally results from three mechanisms: substrate heterogeneity, natural disturbances, and human activities. The interaction of these three mechanisms and their subsequent spatial matrix need to be considered in order to enhance ecological infrastructure connectivity through strategic spatial land use planning at a regional scale.

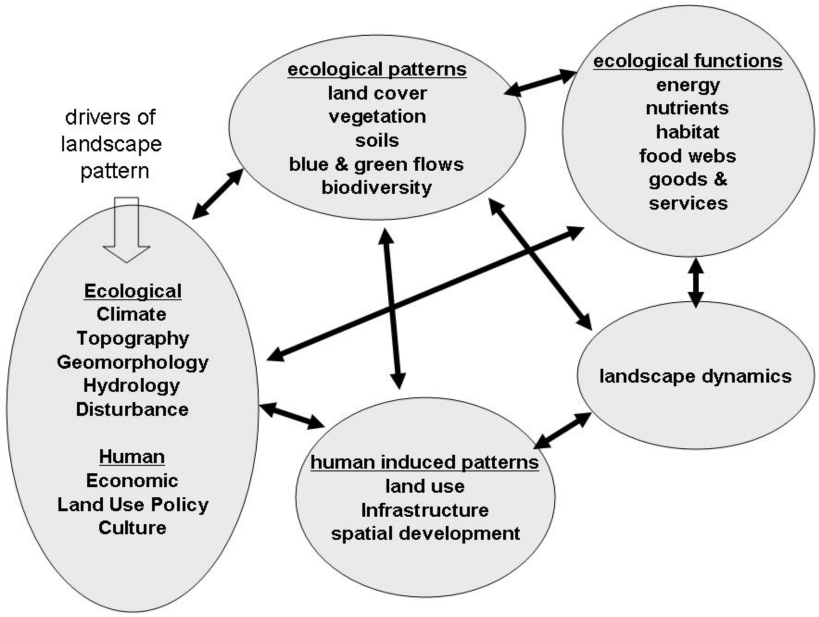



**Figure 4.** **Human Activity – Land Cover Interrelationships Framework**

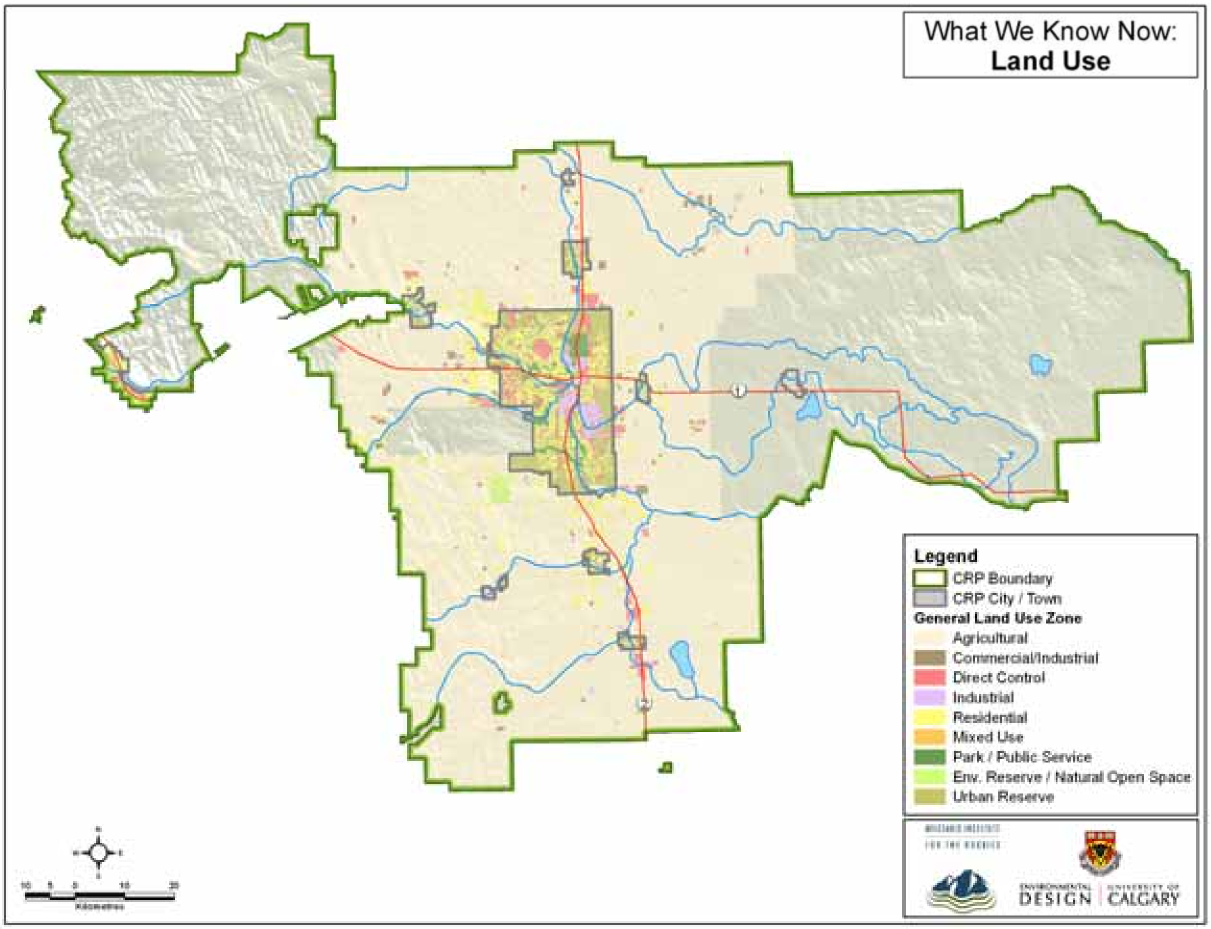
**Importance of Spatial and Functional Landscape Connectivity**

Landscapes that retain spatial connections among existing patches of natural landscapes or historic land cover features are more likely to maintain the ecological functional relationships necessary to support regional plant and animal communities and hydrologic cycle processes and interconnections originally or historically found in the landscape. Spatial connectivity is often easier to physically determine because it incorporates landscape features such as vegetation and land cover patches, landform features such as ridge lines and river valleys. Functional connectivity is more difficult to visualize as it refers to ecological processes in the landscape, such as hydrologic regimes, nutrient cycling, and trophic interrelationships which are dynamic over time and largely invisible but critical to ecological infrastructure function.

**Land Use and Land Cover Change**

Maintaining functional and spatial landscape connectivity is one of the most difficult tasks faced by CRP planners given current and projected population growth and land development pressures (Map 15). Land use in the western portion of the region is still predominantly resource based (grazing, forestry, recreation and conservation) while agricultural cultivation and irrigation dominate in eastern partion. The Stony, Tsuu T'ina, Siksika, and Eden Valley First Nations Reserves comprise a significant area of the Region. Most of the region's provincial Crown land is in the western part of the MD of Foothills and Bighorn bordering the Provincial Forest Reserve along the Eastern Slopes while the majority of the regional land base is privately owned. Land ownership has significant implications for maintaining long term ecological infrastructure functions and spatial interactions. Ideally, long-term arrangements with both public and private land owners and managers are necessary to ensure commitment to land use and land cover management practices that promote landscape connectivity and ecological function across both private and public lands.

**Map 15. Land Use**




The land cover patterns created by human landscape modification influences the types of species that can find suitable habitat in an area: benefiting some and pushing others out of the area. The effects of land use decisions on land cover change and functional ecological interrelationships are cumulative over time and need to be explicitly considered in long range planning for semi-natural regional landscapes. Cumulative effects can be described as changes to ecological processes and patterns accruing from past, present and foreseeable human land use activities such as urbanization, oil and gas development, pipelines, agriculture, irrigation, forestry, fisheries, country residential development and recreational activity. Maintaining ecological infrastructure functions and spatial connectivity across the regional landscape involves understanding regional cumulative effects. The identification of regional ecological infrastructure functional interrelationships and spatial patterns is one mechanism for retaining and restoring ecological processes and functions at a regional scale.

**Regional Land Use Pressures**

Urbanization and rural residential intensification lead to changes in land cover and land cover disturbance that affect and change ecological processes and functions including wildlife habitat, hydrology and nutrient availability   For example, increasing rural residential development on ridge tops may provide spectacular views along Highway 22 south, but are becoming major barriers to wildlife movement along the ridge line corridor. These developments also affect the springs that occur along the ridge tops which are vital to the maintenance of shrub communities critical to wildlife. In contrast, urban residential development has created new urban ecological systems which favor introduced species over native species. Specifically, the increased tree cover in Calgary has resulted in urban bird populations associated more with boreal mixed wood forest than foothill fescue landscapes. As more land cover is altered at a regional scale to support increasing urban and rural residential development in natural amenity areas like river valleys, the size and overall health of riparian zones and the subsequent flow and quality of water can be significantly modified over time.

The geographical distribution and spatial form of settlement patterns greatly influences ecological connectivity. For example, linear settlement patterns result in more landscape fragmentation than concentric patterns. Future growth patterns that promote high-density, concentric development along existing growth corridors promote connectivity within a semi-natural landscape matrix by reducing fragmentation.

Agricultural areas, particularly croplands, generally result in increased loss of native vegetation, which may affect habitat connectivity across the landscape. As agricultural lands expand, native habitats for prairie species are often left relatively small and fragmented, and biodiversity is generally diminished. The loss of native vegetation such as fescue grasses also affects water and soil retention capacity and nutrient cycling opportunities, which in turn affects vegetation and habitat conditions. Opportunities for habitat connectivity may occur in uncultivated areas or marginal lands with residual agricultural vegetation, as they are often free of barriers and create links and edge conditions, although the viability of these areas varies based on current and historical site conditions and land use decisions. Forested areas, upland areas or coulees also present an opportunity for connectivity in agriculturally dominated lands, as they are more attractive to wildlife and often host higher biodiversity.

Recreational trails and facilities also create disturbances and can be particularly problematic for wildlife in mountainous areas as recreation development tends to be concentrated in valley bottoms which are often the best habitat for many species. As natural barriers are already numerous in mountain environments (e.g. rapid changes in elevation, aspect, slope, and substrate) cumulative human impacts in valley corridors will create even greater habitat fragmentation and connectivity problems. Map 16 provides a spatial summary of the information presented in this section.

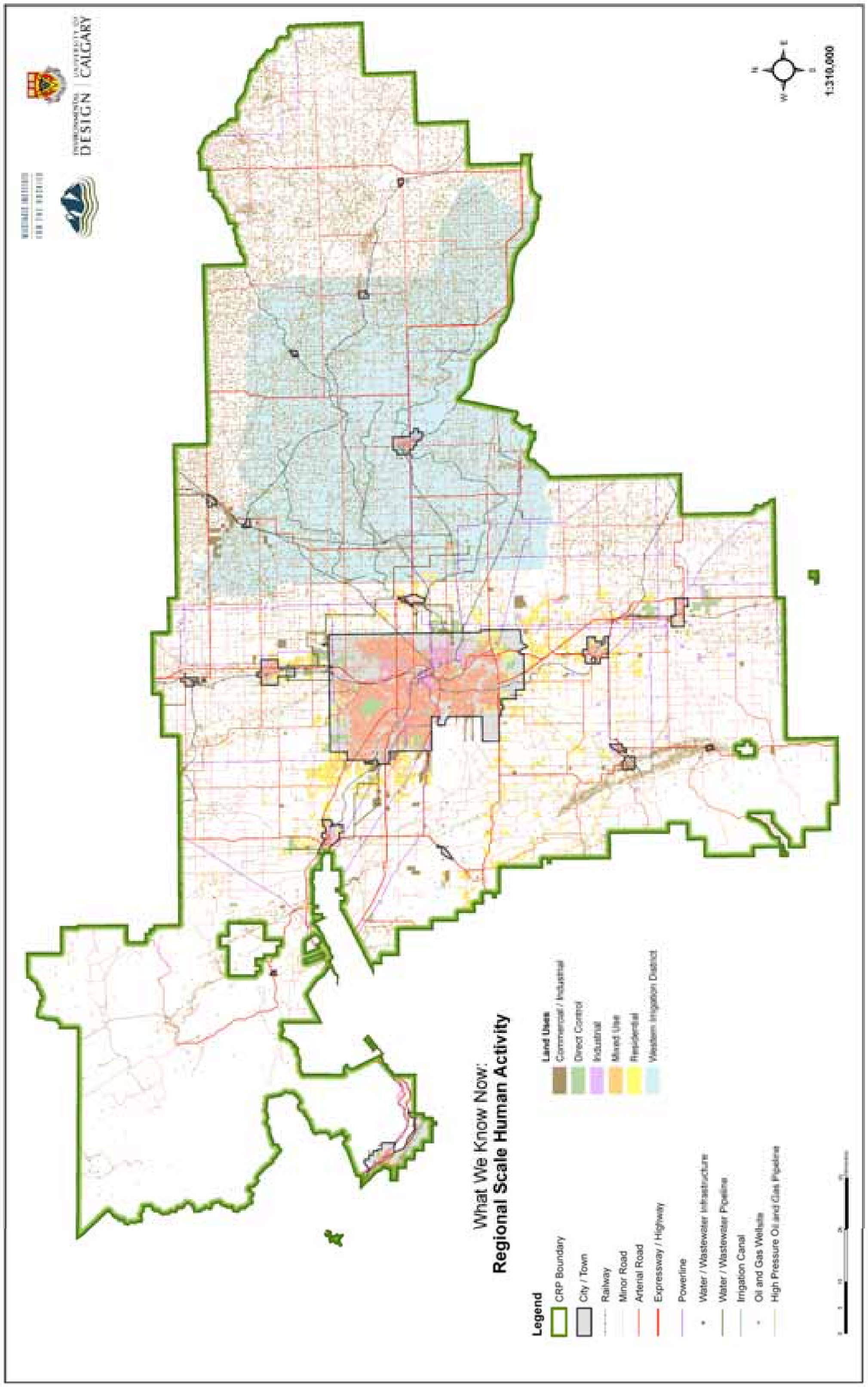
**Linear disturbances**

The energy and forestry sectors require a network of access roads, seismic lines, pipelines, and other infrastructure. The extent and intensity of these disturbances affects spatial connectivity at a regional scale. Busy roads are infrequently used as movement corridors by most species. Roads and major highways create major barriers to landscape connectivity for wildlife movement if they intersect or fragment habitat areas. Linear infrastructure such as electrical and pipeline rights of way can also increase the spread of invasive species. Habitat degradation also results from point and non-point pollution sources associated with different types of linear infrastructure and related activities.  Edge conditions can also result from linear disturbances. Herbivores tend to favor the abundance and variety of vegetation present in edges, which in turn attracts opportunistic predatory species to the edges.  As edge species increase in abundance, they impact the natural diversity of species, and may influence population viability and trophic relationships.  Land use decisions can have effects on the presence and abundance of edges in the landscape.  For example the building of a road through a forest patch will create more edge in the patch, parts of it occurring alongside the road.

**Regional Climate Change**

The predicted effects of climate change on the regional landscape encompassed by the Calgary Regional Partnership are for generally warmer and drier conditions.  The Intergovernmental Panel on Climate Change suggests increases in globally averaged surface air temperatures of 1.4 to 5.8 ºC by 2100.  Warmer temperatures are likely to have detrimental effects on many aspects of the hydrological cycle, wetlands, river flows, evapotranspiration rates and the amount of water retained in glaciers and snow pack.  Climate change is also likely to have an impact on forestry and forest management in the Waiparous, Ghost and Canmore areas.  However, the most significant consequences may be related to regional population growth and increasing water demand in a basin (SSRB) that is currently overcommitted in its ability to provide license allocations.  This possibility is a critical incentive for strategic regional land use planning and growth management that focuses protecting the green and blue flows in the regional hydrologic cycle and maximizing water use efficiency as a principle in land use planning.

**Map 16. Selection of human activities currently occurring on the CRP landscape**



**<u>Part 3:</u> What Do We Know Now About Regional Scale Ecological Infrastructure?**

**Ecological infrastructure and Land Use Planning "hot spots":**
Planned growth areas for most CRP members seem to occur primarily in natural amenity areas, such as the Bow Valley corridor to the west, the areas south and southwest of Calgary including the Sheep and Highwood River corridors, the areas east along Highway 1, and north along Nose Creek. These areas all overlap with areas of known or suspected ecological infrastructure that have been identified in this project. Some of the critical ecological infrastructure "hot spots" that need to be considered in strategic regional land use planning and growth management are described below:

1. North-south ridges southwest of Calgary, extending from highway 22x south towards the Porcupine Hills
    - The occurrence of ridge-top springs supports the growth of shrub communities and mixed forest patches, providing important wildlife habitat and movement corridors between the foothills and parkland ecoregions, particularly for elk and deer, but also for large carnivores. The springs provide high humidity and high soil moisture, which promotes diverse vegetative growth, providing food, shelter and a mild microclimate.
    - The ridges occur within the regional growth corridor along highway 22 which is an area experiencing among the highest amount of rural residential development in the CRP region. Excessive development could act as a barrier to wildlife movement along the ridge corridor, increasing water demands may disrupt the groundwater-surface water connections, and road/lot development could significantly alter surface water movement.

2. River valleys and riparian corridors in the CRP region
    - Valley bottoms and low, slumping slopes provide important coulee driven wildlife habitat areas due to nutrient-rich groundwater discharge and seepage that produce a positive soil moisture balance for vegetation growth. Riparian zones are linked to the landscape through groundwater as well as above ground tributary flows. Riparian zones play a critical role in maintaining spatial connectivity across the landscape and providing vital wildlife movement corridors and habitat. River valleys and riparian corridors also act as important recreational amenities.
    - Bow River Valley
        - The Bow River corridor west of Calgary hosts high habitat diversity and favorable climate due to the frequent Chinook winds that bring warm, dry weather. This, along with its variable topography and surface and groundwater flow regimes encourages wildlife to congregate here. Since deep snow prevents grazing, elk and deer prefer drier open areas exposed to sun and Chinook winds for their fall and winter ranges, such as windblown ridges and sunny south-facing slopes that occur in the Bow corridor. The Bow River corridor also provides a vital link for large

mammals moving between Kananaskis, Banff and areas to the north and south.

        - Vegetated coulees and draws leading up from the Bow River across the CRP region also provide important habitat for deer species and movement corridors from the river.
        - The Bow River valley is an increasingly important amenity area experiencing high levels of rural residential and commercial development, which could affect wildlife habitat availability and connectivity. As the Bow River supplies water for half of Calgary's population, increased development could also influence surface water flow regimes, supply and quality by increasing runoff and sedimentation, and creating downstream flood problems.
    - Elbow River Valley
        - The Elbow River supplies water for half of Calgary's population, and preservation of riparian functions west of Calgary is critical for maintaining quality water supply and downstream flood management.
    - Highwood River Valley
        - Maintaining the riparian functions of the Highwood River floodway is critical for downstream flood management.
    - Sheep River Valley
        - The Sheep River corridor provides key cougar, bighorn sheep and deer habitat, and important rainbow trout spawning areas.

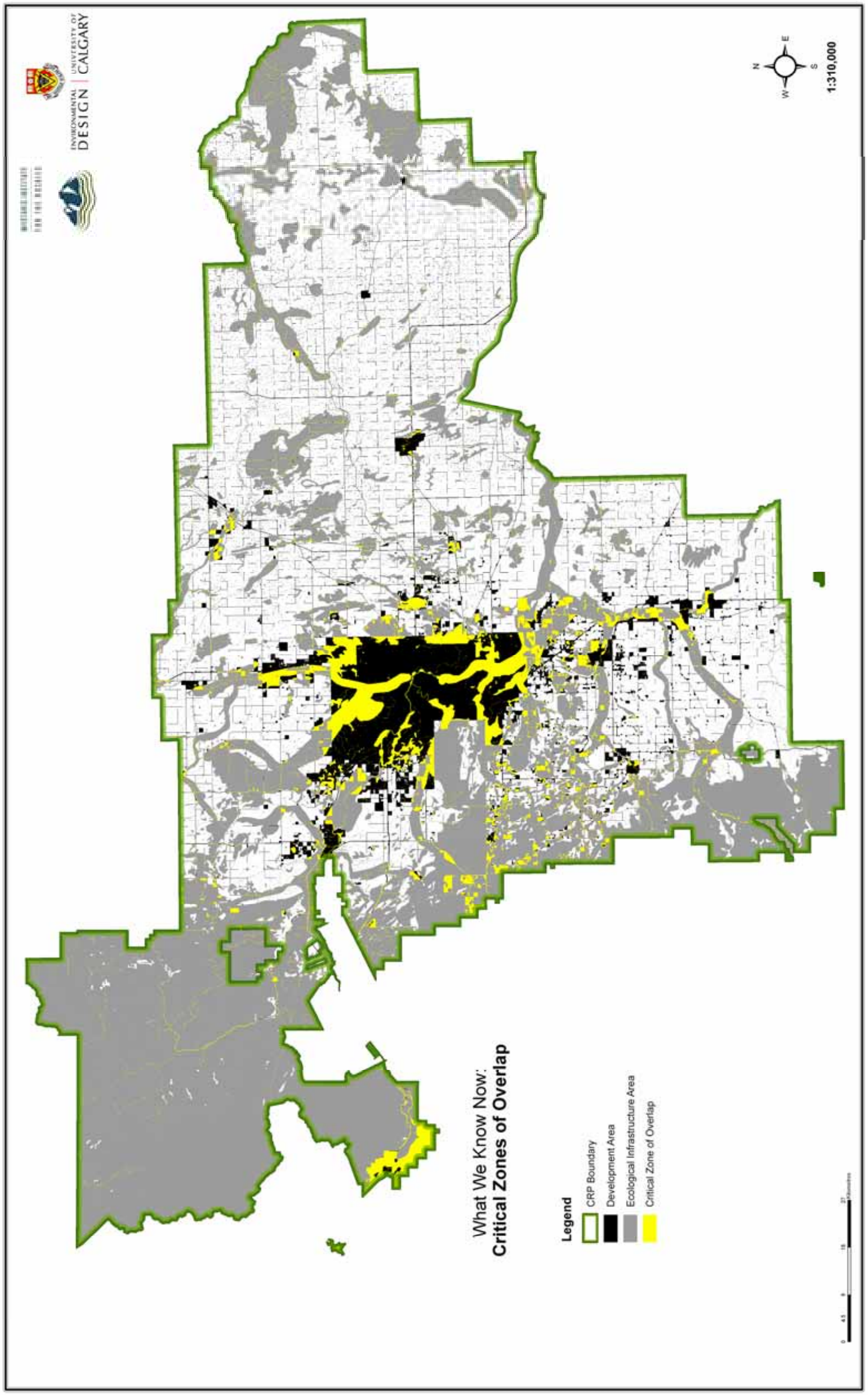
3. Wetland complex along the eastern edge of Calgary, extending along a slight northwest to southeast gradient
    - Important groundwater-surface water connections occur in this area, illustrated by the presence of wetlands occurring in groundwater discharge areas. These discharge areas are also associated with poorly drained soils, and are nutrient rich, supporting the presence of diverse, abundant vegetation. These wetlands function as prime habitat areas for waterfowl and migratory birds, and represent the regional flyway corridor for migratory birds.
    - Groundwater discharge areas are also important sources for wetlands and headwaters for tributaries, maintaining the base level of permanent streams and ponds, and regulating water temperature, providing critical spawning habitat for fish. This groundwater-surface water connection is critical to maintaining water supply and quality. The presence of functional wetlands play large roles cleaning and filtering water and regulating run-off and sedimentation across the NW to SE topographic gradient as water drains into the Bow River downstream. These are critical processes that provide clean water for human use.
    - The regional growth corridor east along highway 1 is considered a natural amenity area for rural residential development as well as industrial development. This increasing development could disrupt the green-blue flow interface. Because surface water features are relatively scarce in the CRP, special consideration needs to be given to the interrelationship between ground and surface waters and how human activities on the surface affect springs and streams.

4. Wetland complex along the eastern edge of Wheatland County
    - Wetlands that are connected to groundwater discharge areas and poorly drained soils provide important waterfowl and migratory bird habitat within the regional flyway corridor.

5. Large areas and patches of intact forest along the western edge of the CRP. The aspen parkand patch geometry provides a rich mixture of interior and edge habitat for a wide variety of species. The forested patch size increases towards the west and the natural patterns should be maintained as much as possible.
    - The ecological roles of intact forested areas include providing habitat to interior wildlife species sensitive to edge effects and disturbance; act as carbon sinks helping to modify climate change; protect water quality and regulate water flow; and reduce soil erosion and sediment loading.

***The objective of a spatial approach to strategic regional land use planning is to organize future growth patterns to support critical ecological infrastructure functional interrelationships between ecological and human processes and regional landscape. Map 17 provides a visual overview of where current development (and development pressure) overlaps with known areas of critical ecological infrastructure.***

**Map 17. Critical Zones of Overlap between Development and Ecological Infrastructure**



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