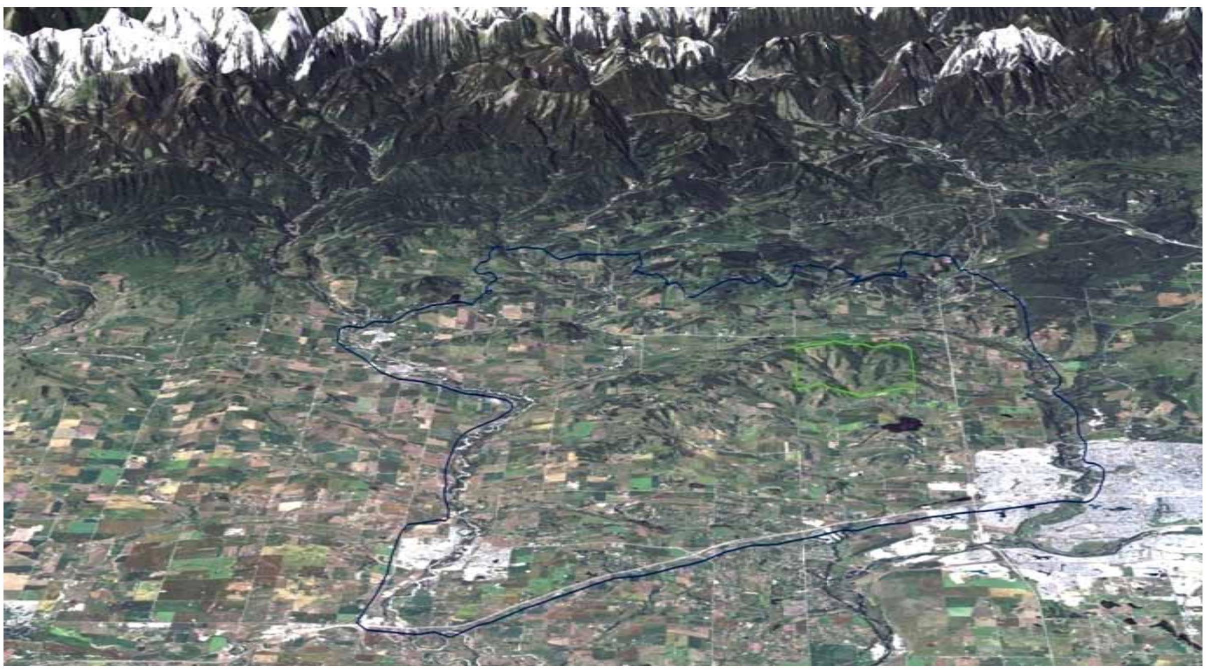
Considering Connectivity:

Maintaining Critical Landscape Connections for the Ann and Sandy Cross Conservation Area in a Regional Context



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2008

ENVIRONMENTAL DESIGN | UNIVERSITY OF CALGARY

MIISTAKIS INSTITUTE

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Prepared for the Sandy Cross Conservation Foundation
By the Miistakis Institute and the Faculty of Environmental Design
University of Calgary, Calgary, Alberta, Canada
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Executive Summary

The Ann and Sandy Cross Conservation Area (Conservation Area) is valuable natural and cultural heritage asset that provides a suite of social and ecological benefits within the rapidly changing landscape of the Municipal District of Foothills southwest of Calgary, Alberta. Planning and management decisions that are made over the next decade regarding regional *ecological infrastructure* will determine the extent to which the full potential of the Conservation Area can be realized. Maintaining functional connections for ecological processes (such as the movement of water, nutrients and wildlife) provide direct and indirect economic benefits that are essential to the health and long-term sustainability of the region.

The Conservation Area manages and protects 4800 acres (1943 ha) of the Foothills Parkland Natural Subregion. This is one of the most vulnerable natural subregions in Alberta wherein only 20% of the provincial preservation targets are currently met.

Connecting the habitat of the Conservation Area to the surrounding landscape is essential for two primary reasons. First, although the Conservation Area is relatively large, the long-term viability for many wildlife species requires a flow of animals from larger habitat areas, especially from the foothills and mountains to the west. Second, the Conservation Area provides a source of wildlife, plants, water and nutrients that can move out into the surrounding landscape providing critical ecological goods and services as well as valuable natural amenities. Maintaining landscape connections helps to prevent the Conservation Area from becoming a disconnected island and provides for the continuance of the special character that make the region so desirable as a place to reside.

The report expands the focal area and updates a previous wildlife movement study conducted in 1996. The authors used high resolution imagery (aerial photographs and satellite imagery) to identify existing landscape features and vegetation patterns conducive to landscape connectivity. The selection of these features was made based on available literature for the habitat of large mammals native to the region. It was assumed that this approach would provide habitat coverage for a wide array of other species such as small mammals, amphibians and birds as well as for hydrological processes. The focus was primarily on forested vegetation because of the lack of remaining native prairie. This s*tructural approach* to examining landscape connectivity was consistent with the goals, timeline and budget available for the research and has been shown to be effective for regional planning. A more quantitative *functional* approach would require detailed data and modeling based on the movements of specific animals (e.g., through telemetry) that was beyond the scope of the project.

Remote wildlife cameras were used to verify wildlife use of identified landscape features. Although the camera data do not provide comprehensive, quantitative grounds for detailed habitat mapping, the data are valuable to show the presence and relative abundance of animals currently using the area. Over a one year period, ten cameras were deployed at 86 locations resulting in over 39,000 hours of operation and the detection of 3,593 unique wildlife events. The ten medium to large mammals species detected, in order of abundance, were: white-tailed deer, elk, mule deer, moose, coyote, fox, black bear, cougar, skunk and badger.

The report makes extensive use of maps and figures to illustrate both the current landscape conditions, including the wildlife camera results, and the rapidly changing nature of land-use in the region. Final maps provide a working estimation of high priority areas for maintaining landscape connectivity.

The areas identified on the map are deliberately demarcated by dashed lines to indicate the permeability of these features. In other words, ecological processes are not entirely confined within these boundaries. The identified areas are <u>not</u> intended to define areas entirely unsuitable for development, but do provide valuable input into spatial planning processes that aim to consider ecological values as an important part of decision-making. Planned development within and around the identified areas should include design principles that maintain the potential for ecological connectivity.

The report identifies 18 patches of habitat that provide for landscape linkages within the study area. In addition, the maps depict linear landscape features such as riparian areas and ridgelines that are known to provide critical movement areas for wildlife. Finally, the analysis identifies several constrictions or barriers that appear to be limiting landscape connectivity.

Roads, particularly Highways 22X and 22 are creating a regional barrier effect to wildlife movement. The authors recommend that transportation design principles for wildlife mitigation be incorporated into any future plans for highway upgrades.

This would likely include the placement of mitigation measures such as fencing and crossing structures to increase both human safety (vehicle-wildlife collisions) and landscape connectivity. Priority areas include Highway 22X near the northeast boundary of the Conservation Area (i.e. near 144 Street), the intersection of Highway 22X and 22, and Highway 22 near the crossings of Pothole Creek and Three Point Creek.

The maps and analysis provided in this report constitute valuable input into immediate and long-term planning exercises for the M.D. of Foothills, the City of Calgary and the Calgary Regional Partnership. For example, the results provide information that could be considered in the next update of the Municipal Development Plan and in the creation of the Calgary Region Land-use Plan, a priority area under the new Provincial Land-use Framework. Finally, the report provides a set of recommendations and 'next steps' to implement planning and management of landscape connectivity.

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Background

In 1996, the Ann and Sandy Cross Conservation Area (hereinafter Conservation Area) collaborated with students in the Faculty of Environmental Design, University of Calgary to conduct a study of wildlife movement in and around the Conservation Area. The resulting report, *The Ann and Sandy Cross Conservation Area Wildlife Movement Study*, provided valuable conservation and planning information to the Conservation Area and the immediate surrounding region.

In the decade since the report was completed Calgary has grown to a population of over 1 million people and the surrounding areas have seen equally significant rates of growth in rural residential development. In addition, the availability of computer technology and advances in the field of landscape ecology provide new approaches for understanding landscape change. The combination of these factors, and a commitment to proactive management by the Conservation Area, deemed it appropriate to revisit the 1996 Wildlife Movement Study. Once again, the Faculty of Environmental Design (EVDS) was approached to conduct the analysis and produce an updated report.

Drs. Michael Quinn and Mary-Ellen Tyler, in conjunction with the Miistakis Institute at EVDS, recognized the opportunity to link this initiative to a more comprehensive research program being conducted collaboratively with the Calgary Regional Partnership. Jonathan Schmidt and Christopher Selvig, both of whom are also conducting related graduate research for their Masters degrees in EVDS, conducted research for this report under the supervision of Michael Quinn.

The following report provides an update on the 1996 Wildlife Movement Study based on the best available information for the study area. As with any such undertaking, there are significant limitations and uncertainties that the authors make explicit throughout the document. It is hoped that the current report will provide useful input into future planning processes for the study area. *The Conservation Area is a natural and cultural heritage treasure that provides a suite of social and ecological benefits within a rapidly changing landscape. Planning and management decisions that are made over the next decade will determine the extent to which the full potential of the Conservation Area can be realized.*

Fig. 1 A cow elk and her calf in the Conservation Area

Ann and Sandy Cross Conservation Area

Location and Mission

The Ann and Sandy Cross Conservation Area is situated 1.5 km southwest of the City of Calgary within the Municipal District of Foothills No. 31. The current land area is 4800 acres (1943 ha) of largely intact Foothills Parkland. In 1987 Ann and Sandy Cross donated nearly 2000 acres of their land to the Province of Alberta followed by an additional donation of 2800 acres in 1996. Students from the Faculty of Environmental Design were involved in preparing the first Strategic Management Plan in 1987/88. The Sandy Cross Conservation Foundation was created to manage the Conservation Area in 1996. The area has an abundant and diverse flora and fauna including over 300 plant species, 140 bird species and 22 mammal species. Resource inventories and descriptions can be found in Gilson & Pittaway (1996), Reid & Heseltine (1997), Gilson (1998), Glasgow & Adams (1999), and Masterman (2002).

The Conservation Area conducts a variety of conservation and education programs. Conservation initiatives include: grassland management through scheduled and planned cattle grazing, invasive plant species eradication, wildlife corridor research and monitoring of native fescue grassland health. Over 62,000 students and youth have participated in the conservation education programs at the Conservation Area since 1993 (www.crossconservation.org). Education programs have focused on locally relevant issues such as native fescue grassland and its relationship to other native flora and fauna.

Regional Context

The Conservation Area is situated at the head of the Pine Creek watershed within the Foothills Parkland Natural Subregion (Figs. 2 & 3). The Foothills Parkland Natural Subregion is a regional *ecotone* as it constitutes the transition between the Foothills Fescue Natural Subregion to the east and the Montane Natural Subregion to the west. This diverse natural subregion contains some of the greatest biodiversity of any area of Alberta as it provides habitat for vegetation and wildlife species from both the prairie and mountain environments as well as for ecotone specific species that rely on the proximity of both environments for their survival (Fig. 4).

Although the area is nestled within a few minutes' drive of over 1 million people, it still provides refuge for an array of wide-ranging species including cougars, black bears, bobcats, and elk. Badgers, prairie long-tailed weasels, and thirteen-lined ground squirrels, all declining prairie mammals, also make their homes in the Conservation Area.

The rolling topography, highly productive Chernozemic soils, aspen copses and fescue grassland remnants all combine to make the Conservation Area a valuable representation of Foothills Parkland. *Currently only 20% of the provincial preservation targets are met in the Foothills Parkland making it one of the most vulnerable natural subregions in Alberta.*

The M.D. of Foothills is part of the **Calgary Regional Partnership**, a voluntary regional initiative dedicated to addressing issues related to managing the effects of regional population growth (e.g., transportation pressures, threatened environmental carrying capacity, low density suburban expansion, agricultural land consumption, infrastructure and servicing needs, etc.) that are optimally managed at a multi-jurisdictional regional perspective. Such a multi-jurisdictional regional perspective is seen as necessary to protecting the long-term integrity of the Conservation Area (Fig. 5).

Fig. 2 Natural subregions of the Conservation Area study area

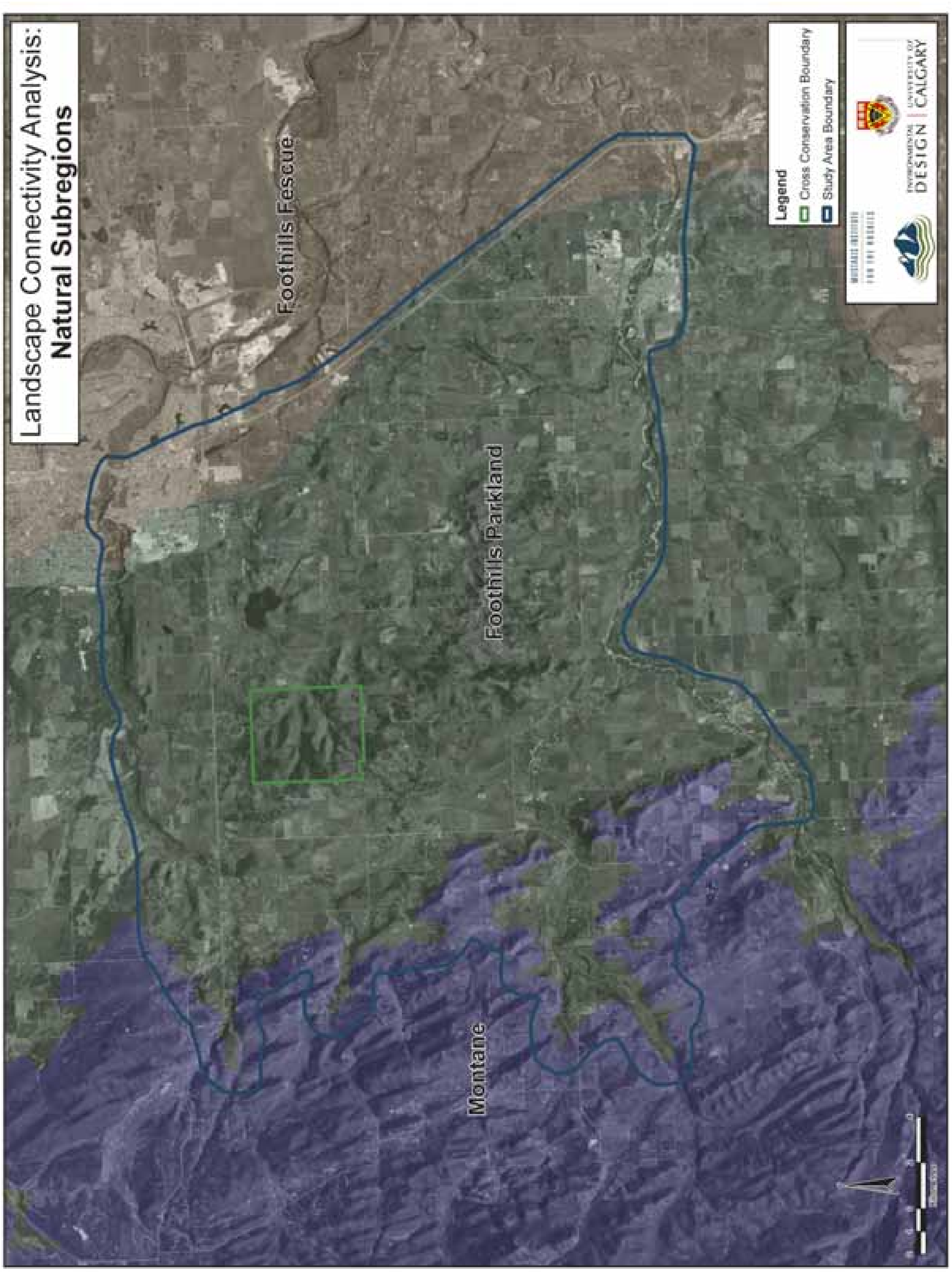


Fig. 3 Major hydrological features of the Conservation Area study area

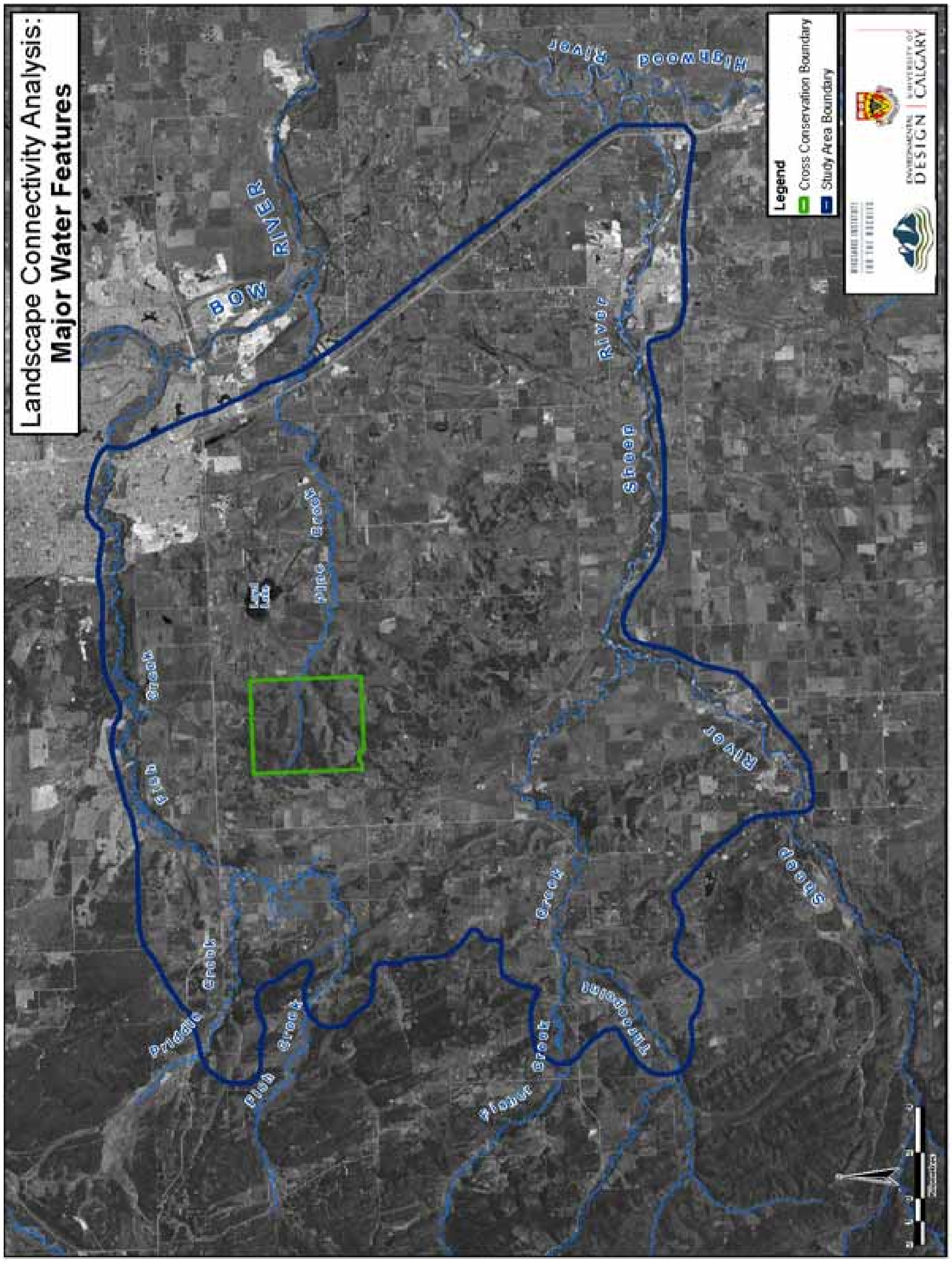


Fig. 4 Regional topography of the study area

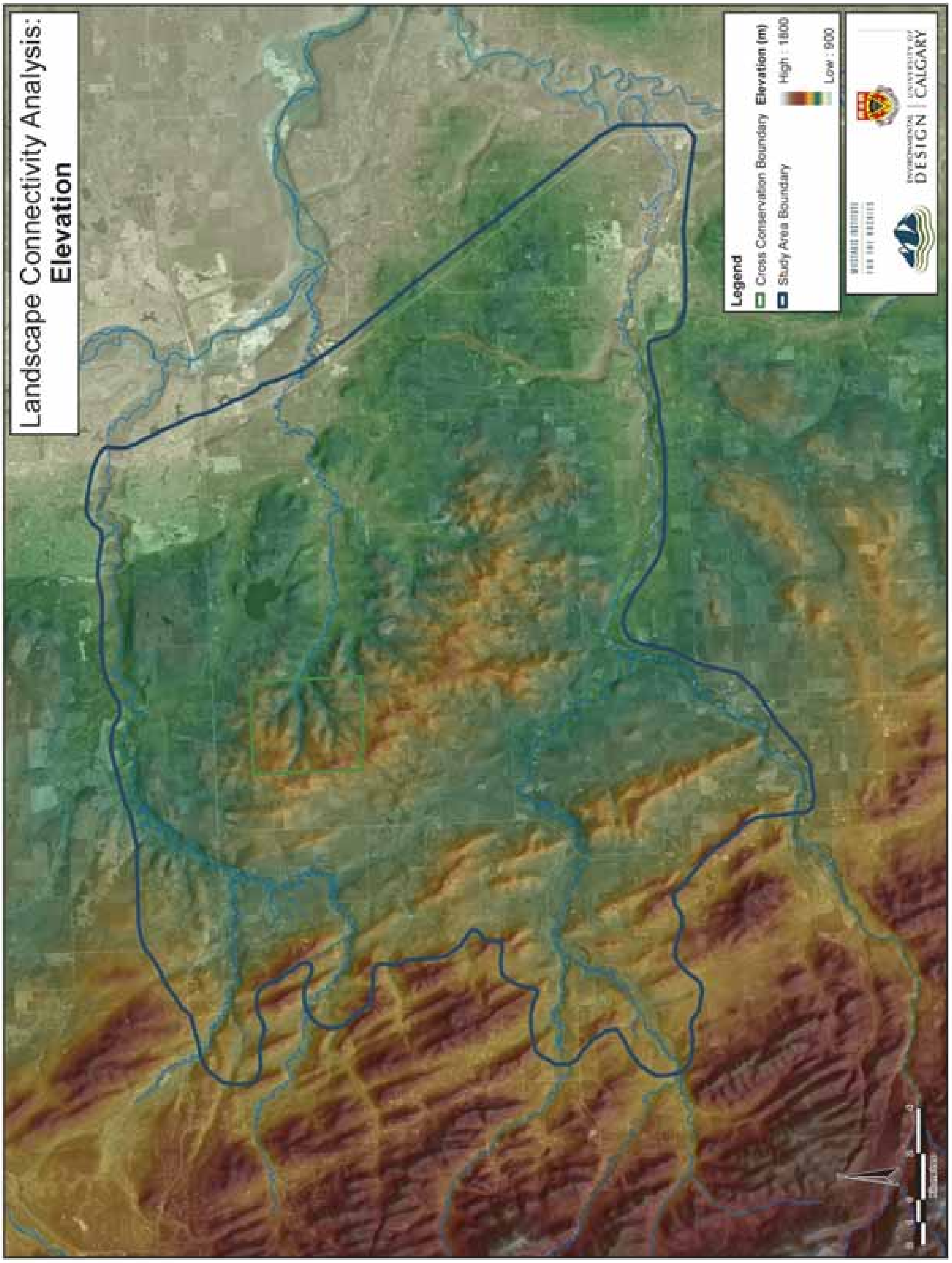
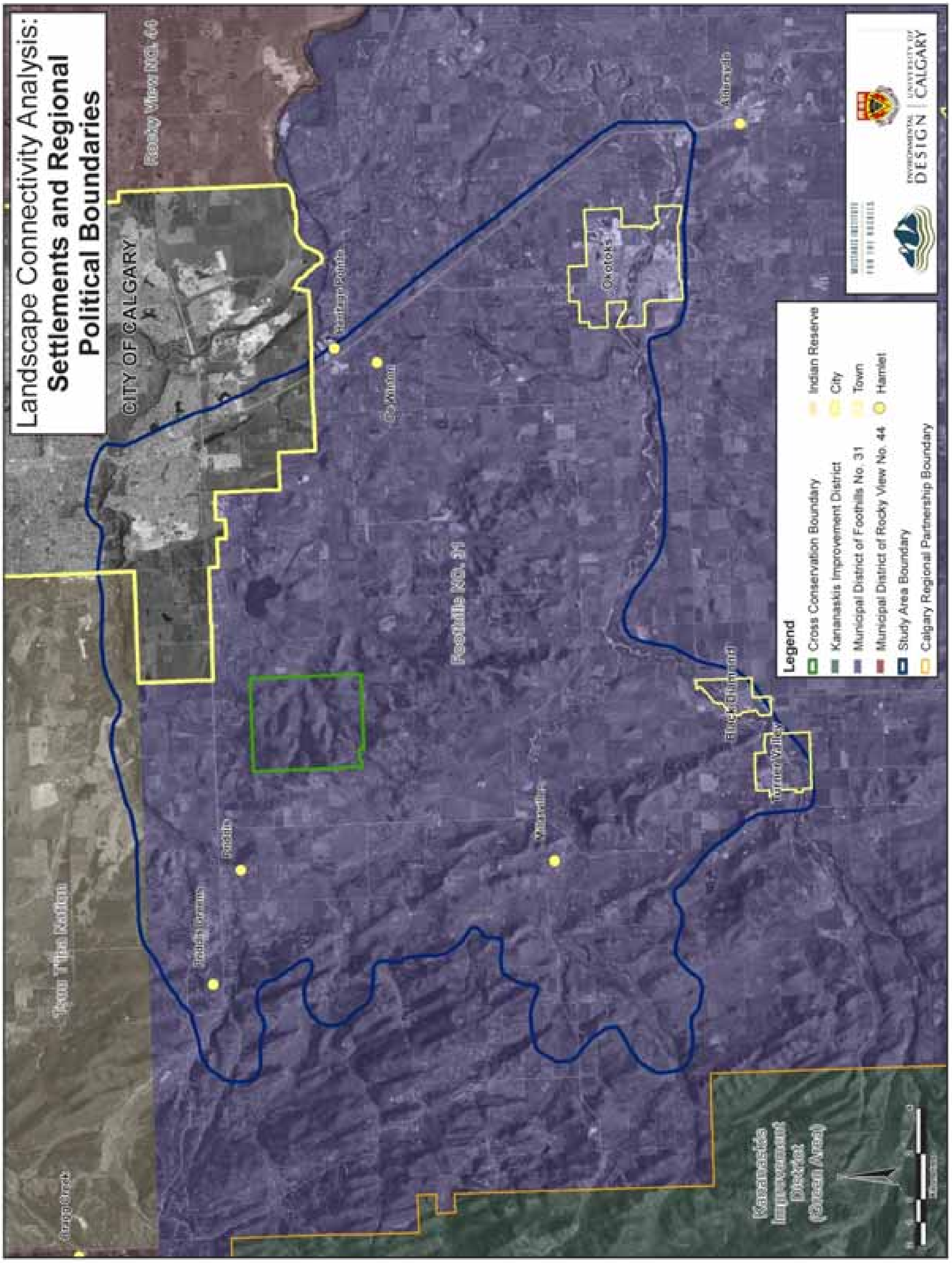


Fig. 5 Political and jurisdictional context of the Conservation Area study area



Land-use Change

Subsequent to a long history of indigenous presence and traditional use, ranching and crop agriculture has dominated the landscape surrounding the Conservation Area for much of the last century. More recently these historic land uses are waning as the area's proximity to both the City of Calgary and the Rocky Mountains make it a choice location for country residential development. Today the land values surrounding the Conservation Area are some of the highest in the province, and further land conversion from agricultural to rural residential is expected to continue into the future. In addition, the City of Calgary continues to expand southward and westward into the M.D. of Foothills. This type of landscape alteration has profound social and ecological effects including, but not limited to: increased traffic, changing population demographics and decreased native flora and fauna. Figure 6 illustrates the increasing density of rural residential housing within the Conservation Area study area. Figure 7 provides a snapshot of land cover change between 1926 and 2006. Figures 8, 9, 10 illustrate land-use, oil & gas and highways in the study area.

Fig. 6 Change in rural number of residential structures by decade (1940-2002) for the Conservation Area study area

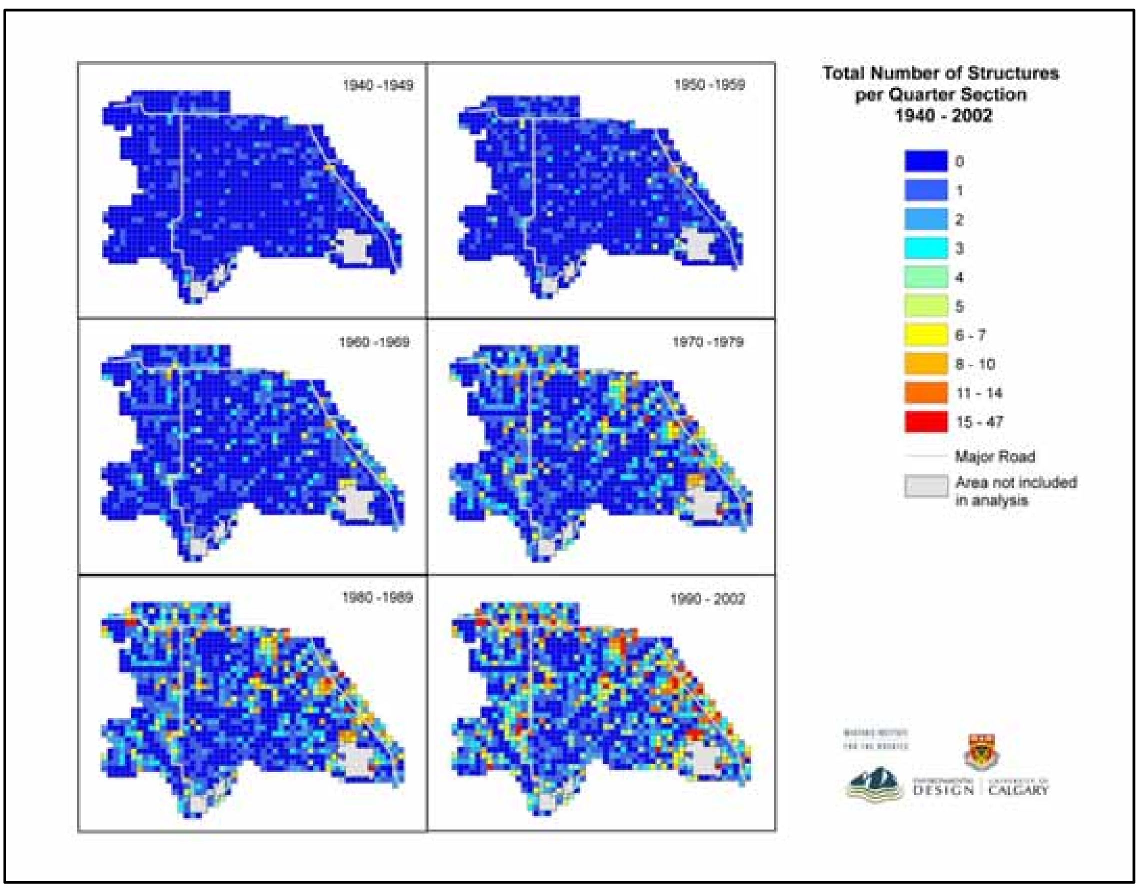


Fig. 7 Comparison of land cover change (1926-2006) northwest of the Conservation Area

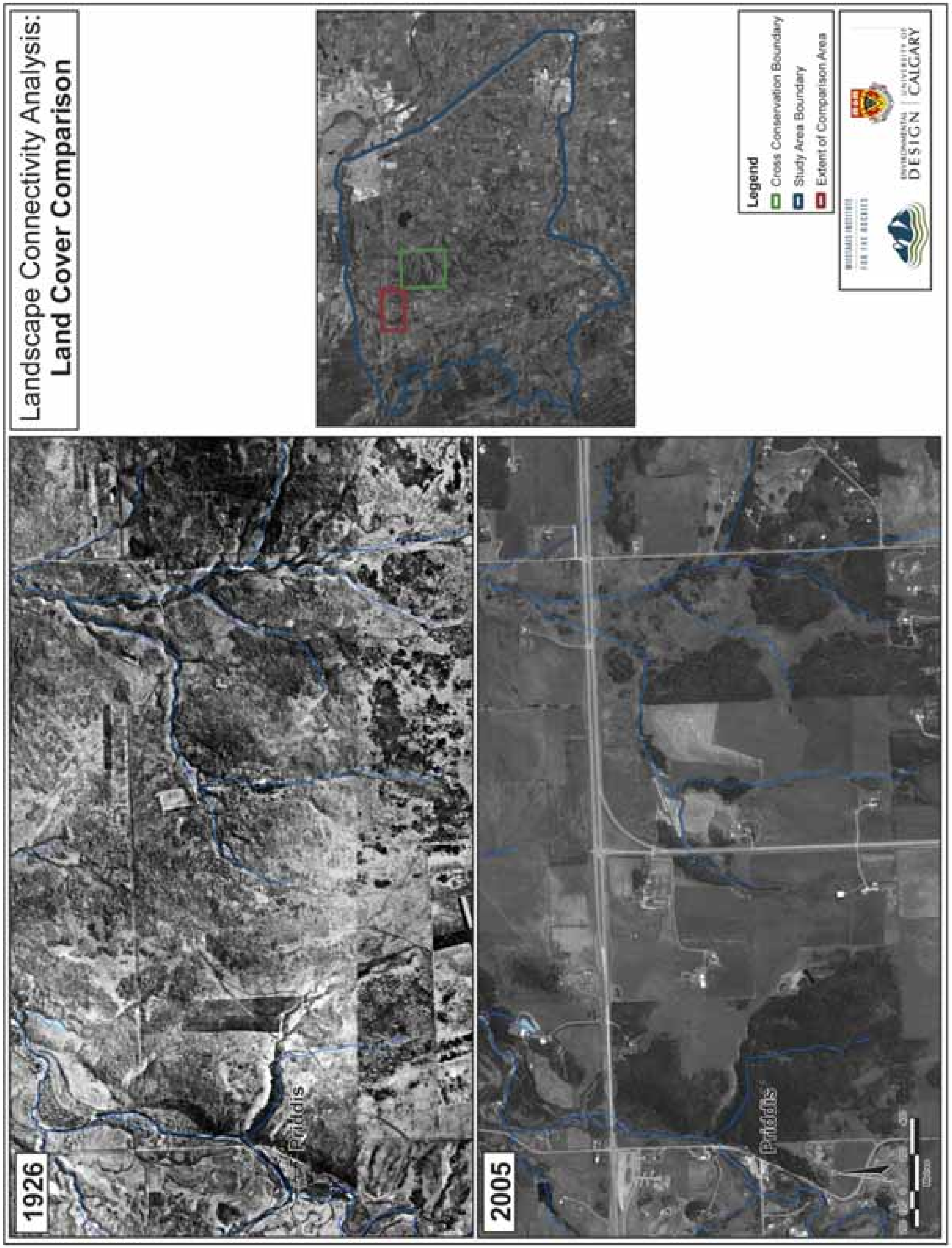


Fig. 8 Land use within the study area

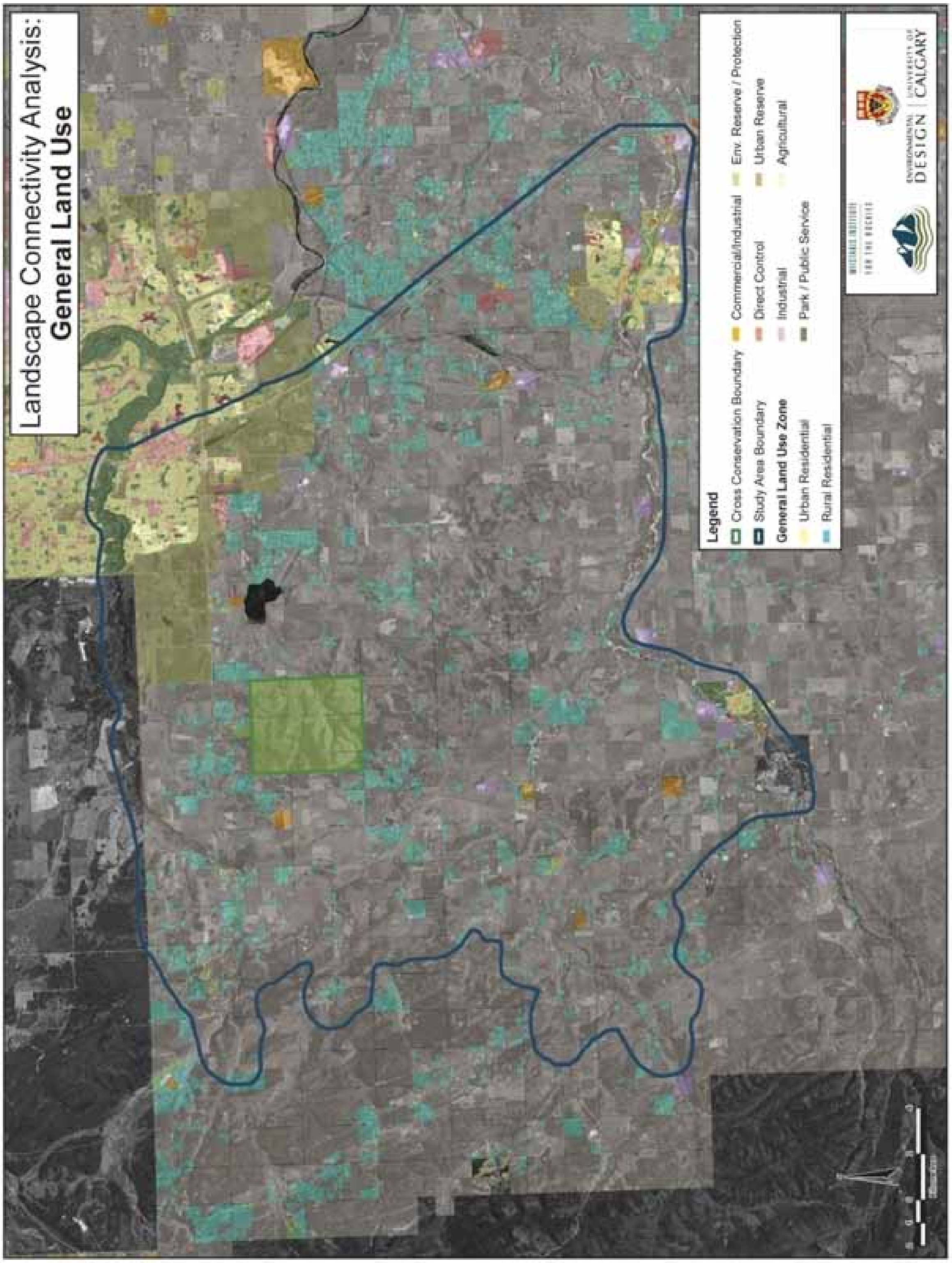


Fig. 9 Active and abandoned petroleum well sites in the study area

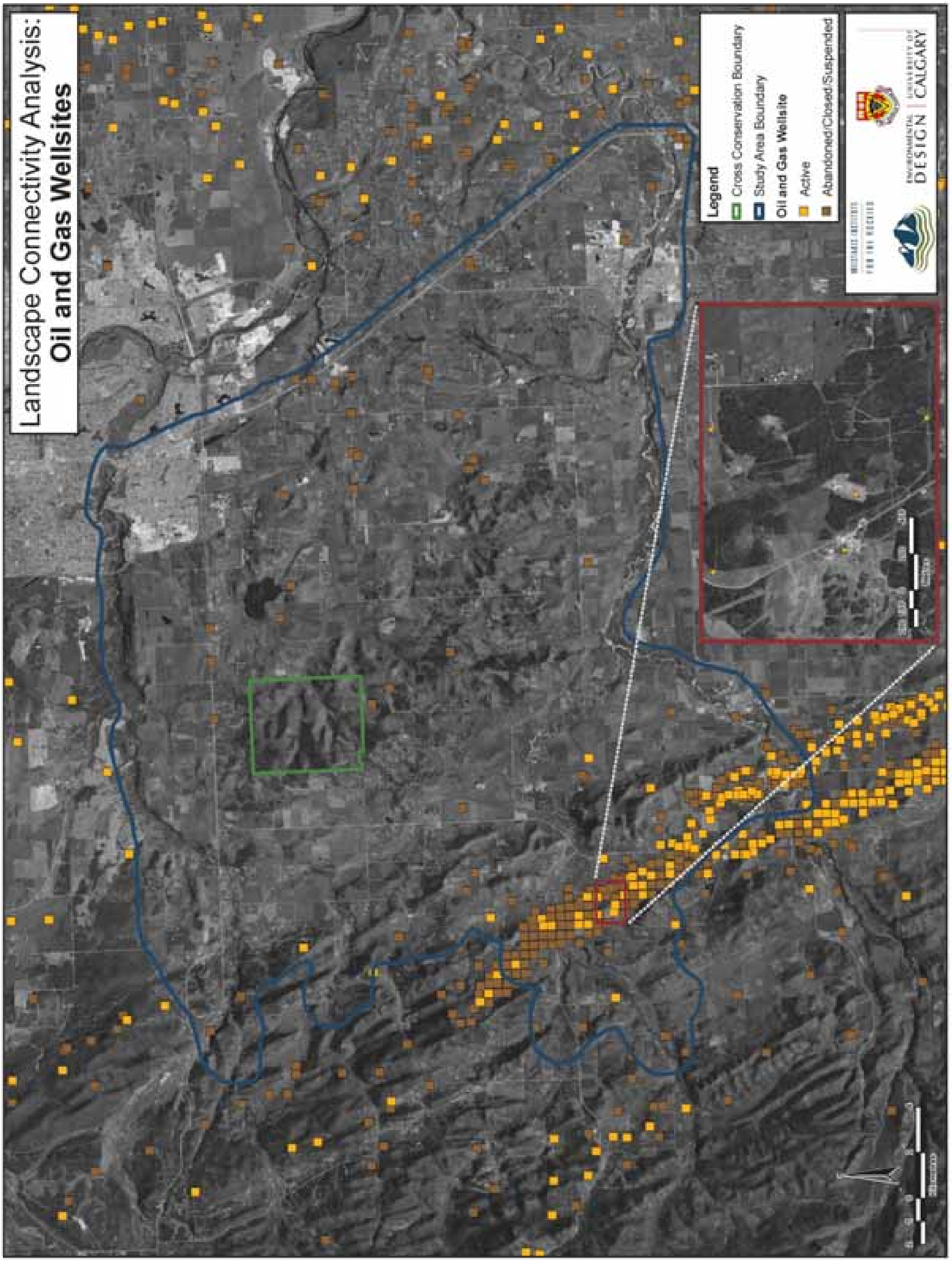


Fig. 10 Highways within the study area

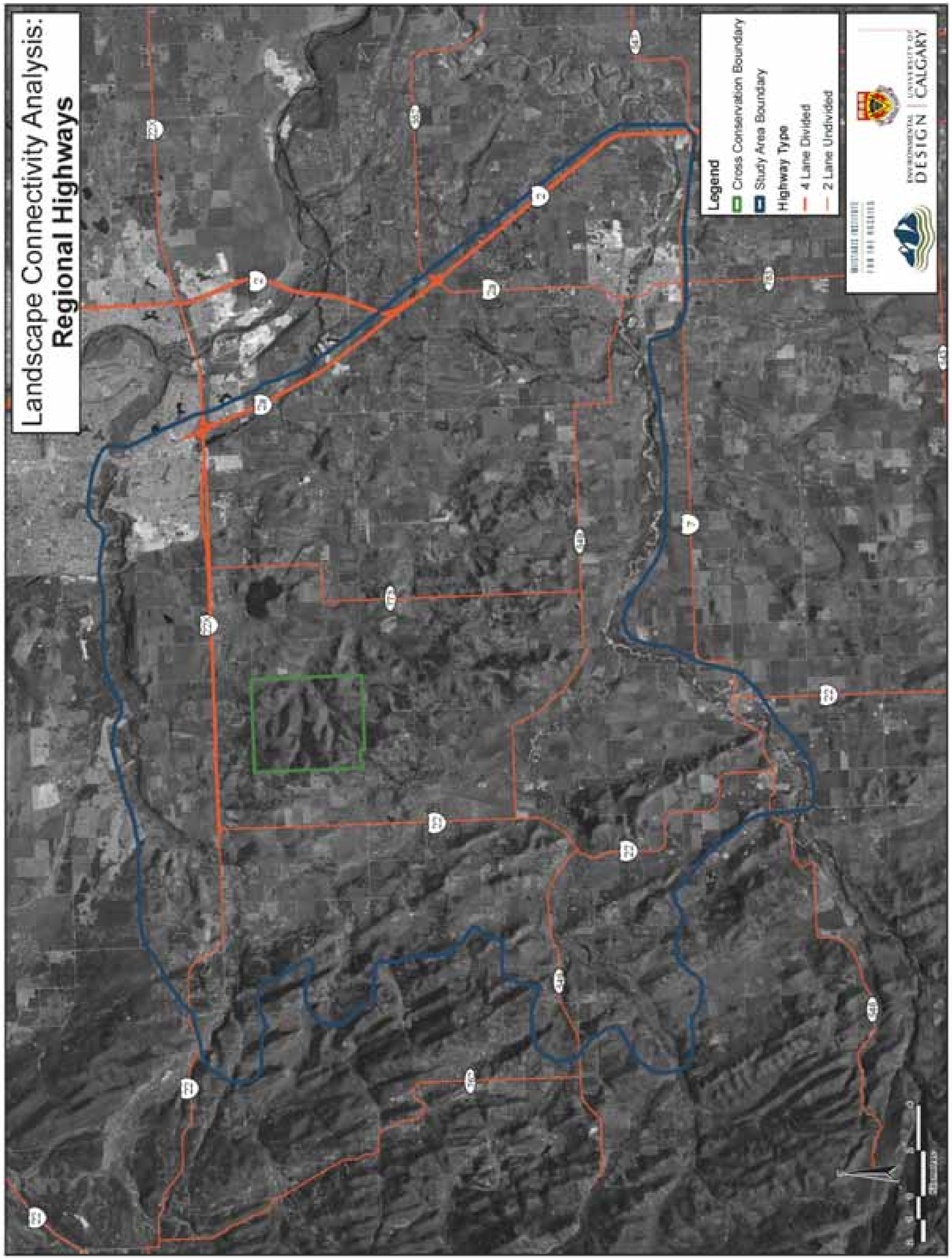


Fig. 11 View from near the Conservation Area looking northeast toward the City of Calgary illustrating landscape pattern

Fig. 12 A view of the Foothills Parkland west towards the Rocky Mountains

Purpose and Objectives

Purpose of the Conservation Area

The primary purpose of the Ann and Sandy Cross Conservation Area is to: ***Conserve wildlife and wildlife habitat in perpetuity.*** The Conservation Area continues to pursue an active management strategy to address this purpose including plans for habitat management, maintenance, and restoration (e.g., fescue grassland conservation program and wildlife camera monitoring). The ability of the Conservation Area to achieve this purpose as a protected area will continue to diminish unless appropriate multi-jurisdictional regional action is taken to manage the spatial location, intensity and mitigation of future development. Many of the wildlife species that inhabit the Conservation Area require ranges that extend well beyond the boundaries of the Conservation Area (e.g., deer, elk, moose, bear, coyote, cougar, sharp-tailed grouse and beaver). These wildlife species cannot be sustained in isolation by the Conservation Area and depend on the long-term maintenance of regional landscape connectivity with regards to their habitat.

Fig. 13 A cougar in the Conservation Area

Study Purpose and Objectives

The 1996 wildlife movement study provided information on wildlife movement patterns within a 1.5 to 6km range of the Conservation Area primarily using winter tracking data. The current report includes an expanded boundary to encompass a more regional look at wildlife movement patterns from a landscape connectivity perspective. The boundaries were chosen to be more congruent with the natural subregion and watershed boundaries in an effort to be more ecologically relevant (Fig. 14). Vegetation and landscape structure analysis along with data from remote cameras were used to identify areas for wildlife movement consideration.

The study is also intended to complement planning efforts by the Calgary Regional Partnership, the MD of Foothills, the Priddis-Millarville Residents Association, and provincial efforts through the Land Use Framework.

Objectives

- To identify and display wildlife (primarily focused on large mammals) movement patterns and potential in the region within and surrounding the Conservation Area.
- To identify and display important regional wildlife habitats and natural features which are linked to the Conservation Area.
- To identify potential areas of concern where future land use development may potentially have negative impacts on wildlife movement.
- To employ remote wildlife cameras to help confirm wildlife pattern movement while building relationships with local land owners.
- To identify major barriers to wildlife movement.

- To encourage the use of this information to be used with future planning efforts to help ensure the long-term sustainability of landscape connectivity.

Primary Limitations

The results reported in this report are based on a single year of data collection using 10 remote cameras and readily available remotely sensed data. The patterns of potential wildlife movement are based on inference rather than explicit tracking of individual organisms (e.g., as would be accomplished through radio-collaring). The research did not include the use of habitat models for selected species.

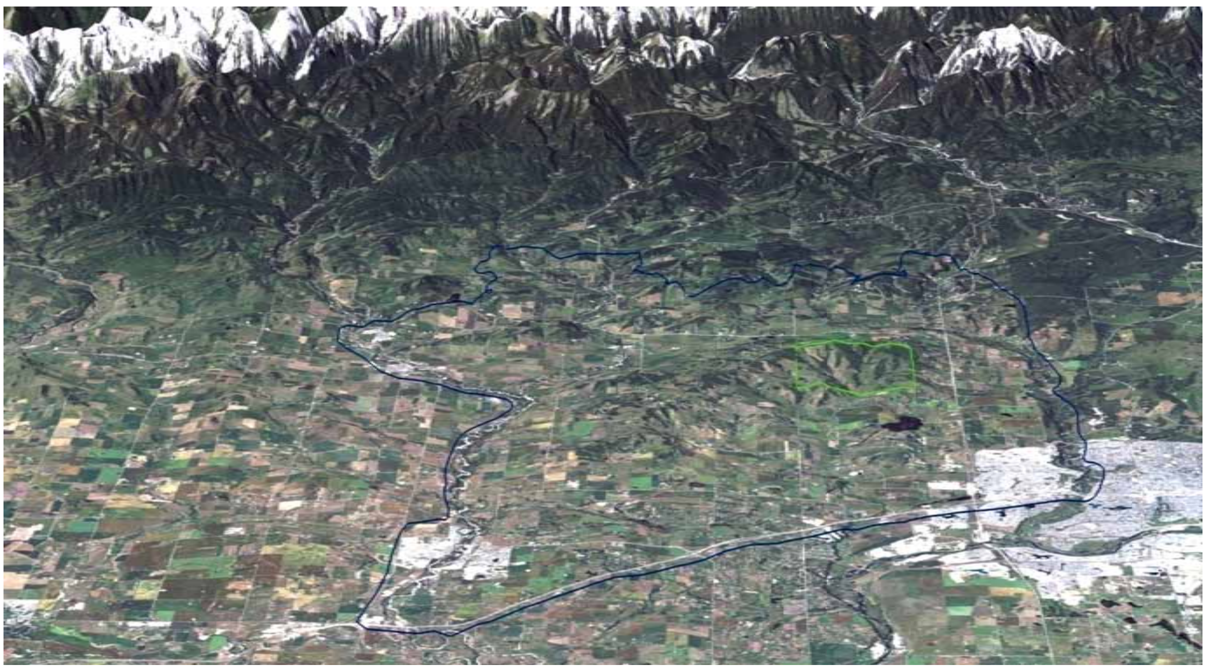


Fig. 14 Three dimension rendering of a satellite image (elevation exaggerated for illustration) of Conservation Area (green line) and study area (blue line) showing the regional context for the current report. View is from east to west with the City of Calgary clearly visible in the lower right quadrant and Okotoks towards the lower left. Note the ridge structure running north-south through the Conservation Area.

Key Concepts

Ecological Infrastructure

> *Infrastructure is defined as "the underlying foundation or basic framework (as of a system or organization)"*

Modern society relies on multiple engineered infrastructure systems, such as transportation systems for the efficient movement of people and consumer products, and utility systems that provide access to water, waste management, energy, and communication. A significant amount of public investment is required for initial capital costs, long-term maintenance, and strategic long-term growth and management of built infrastructure systems. The estimated current value of Canada's engineered infrastructure is $1.6 trillion (ACEC 2003). Failure to adequately plan, manage and maintain such systems results in a phenomenon known as *infrastructure debt.* The national infrastructure debt for Canada is estimated to be in excess of $57 billion (ACEC 2003).

There is, however, another form of infrastructure that is even more critical to the long term sustainability of society - *ecological infrastructure.* Ecological infrastructure consists of the spatial and functional interrelationships among terrestrial and aquatic landscape features and processes that capture, store and transport energy, water, nutrients and matter.

Ecological infrastructure provides ecosystem/ecological goods and services required for **all** biological existence. People depend upon such goods and services for everything from basic survival (e.g., provision of water) to maintaining and enhancing a high quality of life (e.g., landscape amenity). These elements consist of **provisioning services** such as food, freshwater and wood; **regulating services** such as flood regulation, climate regulation and disease regulation; **supporting services** such as nutrient cycling, primary production, and soil formation; and **cultural services** providing aesthetic, spiritual, religious, educational, recreational and other such benefits (Millennium Ecosystem Assessment 2005). Similar to engineered infrastructure, the failure to adequately maintain ecological infrastructure creates a 'debt' with significant societal costs.

In addition, the two infrastructure systems are linked such that incurring ecological infrastructure debt can create new engineered infrastructure costs. For example, alteration of hydrologic processes leads to increased water treatment facilities and costs. However, unlike engineered infrastructure, elements of ecological infrastructure may be virtually irreplaceable at any price.

Maintaining connectivity of landscapes is one of the critical factors in the maintenance of ecological infrastructure and the avoidance of ecological infrastructure debt.

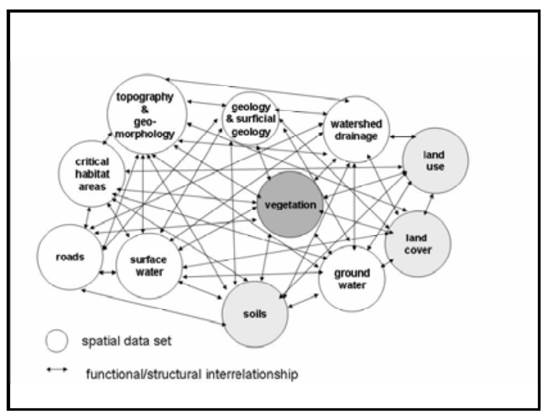


Fig. 15 Regional ecological infrastructure functional interrelationships

Growth and Landscape Modification

The type, amount and spatial distribution of human development greatly affects regional wildlife habitat.

While engineered infrastructure systems allow for the distribution of goods and services, their physical presence and operation may have direct effects on the supply of goods and services supplied by ecological infrastructure. Engineered systems are of little value if associated natural goods and services are impaired or absent (e.g., water). The connections between these infrastructure systems must be more explicitly recognized and addressed.

Landscape modification consists of any physical alteration of the landscape. The current primary agent of landscape change in the Conservation Area region is human residential and associated development. Population growth and economic prosperity in the Calgary Region are the ultimate drivers of this landscape modification.

The Calgary Region is experiencing an exceptionally fast rate of growth with the highest growth rates occurring outside the City of Calgary in the surrounding rural municipal districts, towns and cities (Table 1).

Regional Amenity Migration

Amenities provided by the surrounding natural landscape are significant factors for attracting growth in the Calgary Region. These amenities consist of recreational opportunities, scenic views, cultural and historical significance, and natural vegetation and wildlife. In today's information age, the metropolitan region has become the basic building block of the new economic order. People are highly mobile and locate wherever they expect to achieve lifestyle objectives. It is the provision of natural amenities that will help ensure the long term success of the Calgary Region. The paradox of Calgary's natural amenities is that while they may be a significant attraction in a decision to move to the Calgary Region, these features may be 'loved to death'. *Many of the desirable landscape amenities are associated with key movement features such as riparian areas and vegetated patches. Therefore managing for amenity quality can be consistent with managing for wildlife and associated ecological processes.*

Census Area	2001 Population	2006 Population	2001-06 Population Increase	2001-06 Yearly Average Growth Rate*
District 6	1,021,060	1,160,936	139,876	2.60
City of Calgary	879,003	988,193	109,190	2.37
District 6 minus Calgary	142,057	172,743	30,686	3.99
Foothills No. 31	16,602	19,736	3,134	3.52
Rocky View No. 44	29,925	34,171	4,246	2.69
Okotoks	11,689	17,145	5,456	7.96
Black Diamond	1,866	1,900	34	0.36
Turner Valley	1,608	1,908	300	3.48

Table 1 Population change in the Calgary region 2001-2006
***Equivalent to the compound annual growth rate (Source: www.statscan.ca)**

Cumulative Effects

While individual land-use impacts may not be seen to have significant effects, they often become significant as they accumulate through time and space. For this reason, understanding the cumulative effects (past, present and future) of human land-use development on the *ecological infrastructure* of the landscape is essential for the long-term sustainability of the ecosystem goods and services it provides. Impacts can consist of cumulative transformations of system functions over time and/or space.

Cumulative effects consist of "the complex additive and synergistic effects in time and space of multiple human actions and natural change" or simply put they are an aggregation of stressors that are considered to have significant effects. Cumulative effects are a result of the *tyranny of small decisions* or actions. The many incremental decisions, in time and space, from multiple entities and agencies combine both additively and synergistically in ways that result in significant environmental and social impacts.

Additive effects are the most obvious and easily identifiable of the two types of cumulative effects. They are a result of the simple addition of actions cumulating to create an action/effect of greater significance.

A spatial example is that of the effect of sub-urban development on in-stream flow. As an increasing amount of a catchment is paved for the development of residential housing there is an additive effect on in-stream flow of the catchment. Decreasing ground water infiltration and increasing overland flow during a storm can significantly increase the peak flow of the stream (potentially leading to an increase in number and/or severity of floods) while reducing its minimum flow during winter and dry summer months (potentially leading to significant fish kills).

Synergistic cumulative effects describe the results of interacting effects that would not necessarily be predicted from examining the individual impacts. Individual actions can set a chain of events into motion (e.g., butterfly flapping its wings leading to a hurricane half way around the world). Synergistic effects are characterized by surprise and are a result of the interaction within complex systems. It is only by further understanding these complex biophysical and biosocial ecological interrelationships through research and analysis that we can begin to predict potential synergistic effects.

The cumulative effects related to population growth and regional land-use are causing landscape fragmentation through habitat loss, habitat isolation and edge effects. As a result of their incremental nature, these effects may not come to our attention for some time in the future when the effects may be irreversible or very costly. In addition, the effects are likely to be further exacerbated as climate change plays an increasing role in the semi-arid climate of southern Alberta.

The complexities of cumulative effects and the uncertainties of dealing with complex systems call for a precautionary approach. The precautionary principle "states that in the case of threats of serious or **irreversible** damages, the simple lack of full scientific certainty cannot be used to delay measures to prevent those damages" (Corrado 2008, p. 4). It acknowledges the fact that it is much more cost-effective to prevent certain environmental degradation before it occurs.

It is the cumulative effects of land use decisions that have the most significant negative effects on biodiversity and connectivity in the Conservation Area region.

Landscape Connectivity

The Conservation Area makes a very important contribution to protecting ecological infrastructure and biodiversity in the Calgary region; however, its effectiveness is limited by its small size. For example, the home range of a female cougar in SW Alberta is at least 150 km^2 and a male cougar may occupy an area twice that size. These are sobering values when one considers that the Conservation Area is less than 20 km^2. This is certainly not unique to the Conservation Area and it is widely recognized that even very large protected areas cannot maintain viable populations of most species in isolation.

If the Conservation Area becomes an isolated island in a sea of development, its value will be greatly diminished. The greatest benefit to the region would be achieved through ensuring that habitats within the Conservation Area could function in concert with other areas beyond the immediate boundaries of protection. The field of *landscape ecology* addresses this issue through the concept of *connectivity*. A comprehensive review of connectivity is beyond the scope of the current report, but we provide a selection of key references at the end of the document.

Connectivity is simply a concept about the degree of movement of organisms or processes – the more movement, the more connectivity. Connectivity is an *emergent property* that is best understood as resulting from the interaction between an ecological process and the physical structure of the landscape. However, discussions of connectivity generally distinguish between *structural connectivity* and *functional connectivity*. Structural connectivity refers to the spatial arrangement of physical habitat elements on the landscape, while functional connectivity encompasses the behavioural components of the organism or process. A useful analogy to distinguish between the two types of connectivity is to envision functional connectivity as the players and structural connectivity as the field.

For a particular animal, functional connectivity is determined by such factors as: 1) degree of mobility, 2) behavioural requirements such as the need for cover, 3) the interaction between the first two factors and the landscape structure, 4) distance between habitat patches, 5) effects of other features that might impede movement (e.g., roads), and 6) interference from human or other predators.

Connectivity decreases when habitat is altered and fragmented. Fragmentation is the process of dividing contiguous habitats into smaller patches. When habitats are fragmented the total amount of habitat decreases and the remaining patches become more isolated. Fragmentation leads to loss of wide-ranging species (especially top carnivores), collapse of biological communities, impairment of remaining habitat fragments through edge effects, and disruption of critical ecological processes such as pollination and nutrient cycling.

One approach to lessening the effects of fragmentation is to maintain or enhance *corridors* between habitat fragments in order to facilitate the flow of ecological processes and species (i.e., maintain connectivity). *Corridors are spaces (often linear) in which connectivity between species, ecosystems, and ecological processes is maintained or restored at various scales.* Corridors may be narrow and clearly defined (such as a treed riparian zone along a prairie stream or a wildlife underpass to facilitate movement across a highway) or wide and less easily delineated *linkage zones* or *landscape corridors* (such as broad migration area for pronghorn antelope). Corridors can be defined at continental scales (e.g., migratory waterfowl flyways) or at a very local scale (e.g., highway wildlife overpass).

Vegetation within a corridor may be uniform and continuous or patchy in the form of *stepping stones.*

Although the concept of wildlife corridors is appealing and intuitively simple, there is much discussion in the literature and in professional practice about the design and functionality of corridors to lessen the effects of fragmentation. Ultimately, the design and utility of corridors depends on such factors as: the species of concern, topography, scale, extent of fragmentation, quality and amount of core habitat, human activity within and around the corridor, and landscape management objectives.

The application of the corridor concept is most effectively applied with a strong working knowledge of focal species behaviour. A sole focus on structural connectivity is not sufficient since, for some species, habitat need not be structurally connected to be functionally connected and conversely, structural connectivity does not necessarily ensure functional connectivity. In other words, landscape connectivity is species (or process) specific.

In regions where core habitat patches are being fragmented and isolated by human activity, the maintenance of connectivity through the informed application of corridors may be one of the best options.

The designation of local and regional corridors has been incorporated into formal planning processes. The Oak Ridges Moraine in Ontario provides an excellent example of land use planning that includes corridor delineation on both public and private lands (Whitelaw & Eagles 2007, Government of Ontario 2002). Closer to home, the Bow Corridor Ecosystem Advisory Group (BCEAG 1999) has developed habitat patch and corridor design guidelines for use in the Bow Valley.

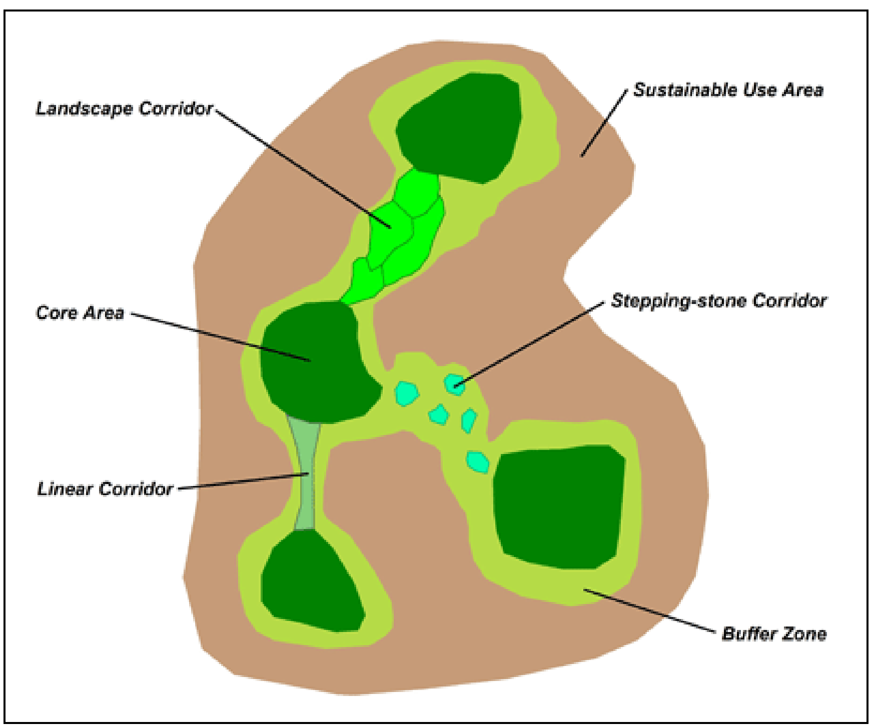


Fig. 16 A conceptual diagram illustrating types of corridors

Methods

The results presented in this report are based on a pragmatic approach that assumes:
1) landform and vegetation pattern at the scale of the study area can be used to infer suitable wildlife movement habitat for large mammals, and 2) large mammals are a useful surrogate for at least some of the critical ecological processes in the region (e.g., hydrological flow and nutrient transport). In particular, we focus on white tailed deer, mule deer, elk, moose, cougar, black bear, and coyote. We assume that relatively contiguous security cover in the form of forest vegetation is an essential habitat component for effective local, regional and dispersal movement of these species. In a human-dominated landscape, such cover is particularly important to the security of carnivores. Riparian corridors are assumed to be high quality movement corridors as they also provide surface water and relatively rich sources of food along with security cover as a result of topography and vegetation.

Potential wildlife movement corridors were identified using a heuristic, expert-based approach that included: mapping contiguous vegetation patterns visible in high resolution (1 m, 1999-2001) colour aerial photography in conjunction with 2005 SPOT satellite imagery (2.5 m, panchromatic), a 30 m digital elevation model and the other context mapping (human land-use) included in this report. Selection of features conducive to wildlife movement was made at a regional scale defined by the study area. Potential corridors were drawn on hard copy maps and validated through field visits.

Although advances in landscape ecology offer more sophisticated and quantitatively transparent spatial analysis methods, the current literature suggests that the approach we employed is still very useful for landscape planning. Habitat (forest) cover, along with some consideration of human disturbance (especially roads), has been shown to be effective in assessing overall value of wildlife habitat. This is especially true in the context of land-use planning and decision-making when resources, data and capacity are limiting (see for example: Sundell-Turner & Rodenwald 2008).

Special Note

The Foothills Parkland Natural Subregion is, by definition, a patchy environment historically dominated by copses of aspen in a matrix of fescue grassland. Continuous forest cover across the entire area would be an historic anomaly as the patchy conditions were maintained through the press and pulse disturbance vectors of grazing (e.g., bison) and fire respectively. Therefore, species inhabiting such an environment would be expected to have some tolerance to moving between habitat patches.

As an ecotone, it is important to consider that Foothills Parkland is inhabited by species extending towards the forest from the grassland (e.g., sharp-tailed grouse, badger) and species extending towards the grassland from the forest (e.g., cougar, black bear) while other species (e.g., elk, deer) thrive in the interface between the forest and grassland. The challenge for the Conservation Area is to maintain forested connections to the west and continuing east through riparian areas as well as maintaining grassland connections from the east with connections to the north and south. This ecological context differs significantly from much of the landscape ecology literature based on the fragmentation of once contiguous forests.

Fig. 17 A panoramic view from the Conservation Area showing the existing patchy configuration of Foothills Parkland as it trends toward Foothills Fescue (Photo: C. Selvig).

Wildlife Cameras

Cameras and Placement

We employed remote wildlife cameras to identify the presence of wildlife movement within and beyond the Conservation Area. The data obtained from the cameras were used to validate inferences made from vegetation and landform. We used 10 Reconyx© motion-triggered wildlife cameras. These cameras are designed specifically for wildlife research and capture digital images of any animal that passes within the detection zone. The use of this technology is non-invasive and allows for the collection of data with minimal disturbance to animals. The infrared illumination emitted by the cameras does not startle the animals and is invisible to humans, thus minimizing the chance of vandalism or theft. The cameras were placed at 80 different locations from June 2007 to March 2008 with an average deployment of 21 days at each location.

The wildlife camera field work began in June and July 2007 with an initial focus on verifying the potential corridors within the Cross Conservation Area property. Camera locations focused on a few key elements including: primary wildlife pathways along ridges and riparian areas, diverse habitat areas (deciduous, mixed and conifer forests) and border zones that capture the ingress and egress of wildlife from the Conservation Area.

Near the end of July 2007 the study was expanded to include the regional area surrounding Conservation Area. A public information meeting was held on 18 July 2007 to inform surrounding landowners and other interested citizens of the wildlife study and to request their permission to place a wildlife camera on selected properties. The public information meeting and preceding letter that was mailed to landowners received significant support and resulted in a long list of cooperative landowners and potential camera locations.

Following the public information meeting field researchers Chris Selvig and Jonathan Schmidt contacted landowners who expressed an interest in helping with the project and arranged site visits to these properties. During the site visits landowners were asked about their land and what they knew about the wildlife movement through and within their property. A regional aerial photo map of the area was used to facilitate discussions with the landowners and help identify potential camera locations.

Often the landowner would also provide a walking tour of his or her land. The walking tours provided a valuable opportunity to see the land and get a better sense of the intricacies of the landscape and how the wildlife might be moving through the area. At this time (or at a later arranged date) a camera would be placed on the land and arrangements made to access the camera in the following weeks. Landowners who did not have time or interest to meet with a researcher simply granted access permission to his or her land and cameras were installed at the best possible location. The final location of the camera was determined by observing sign of historic wildlife use along visible trails.

Fig. 18 A Reconyx digital infrared camera showing a typical tree-mounted deployment

Data Collection

We collected a number of parameters for each image captured by the wildlife cameras. Where possible, information was gathered on *camera number and location, date and time of movement, number of animals, species, direction of movement, age and sex.*

Camera number and location: locations were documented using a GPS using UTM coordinates in NAD 83.

Date and time: 24hr time and date are stamped on each image. Each animal movement sequence was recorded using two fields - photo in and photo out. For each animal movement sequence the *photo in* and *photo out* were each recorded with the date and time to the precision of one second.

Number of animals: the number of animals counted during the image sequence.

Species: Species recorded included whitetail deer, mule deer, elk, moose, coyote, black bear, red fox and cougar. Other animals such as hawks, badgers, squirrels, etc. were labeled in a field called "other".

Direction of movement: Eight directions (N, NW, W, SW, S, SE, E, NE) were used to determine the direction of movement. Although many animals moved in multiple directions during the photo sequence only the final direction was recorded. Where animals had no discernable direction, it was recorded as 'no direction'.

Age: Only two categories were used for age. Where identifiable, animals less than one year of age were recorded as fawns, calves or cubs. All other animals appearing to be greater than 1 year old were listed as 'adults' or not recorded, assuming a default of an 'adult' age.

Sex: Ungulates where only males have antlers make it easy to identify the males from the females. These include deer, elk and moose. Despite this supposed easy task of identification, it was made more difficult in the spring when antlers are just beginning to grow and within some juveniles, where antlers development is delayed for a year or two. Other mammals (cougars and bears) were identified as female when a cub was also photographed at the same time.

Results

Wildlife Cameras

Between May 2007 and April 2008 we deployed 10 Reconyx digital infrared cameras in 86 unique locations (both on and off the Conservation Area) for a total of 39,259 hours of operation (equivalent to 1635 days or 4.5 years of camera operating time). The cameras captured over 128,000 images comprising 3,593 individual animal movements (A movement is defined as one animal or a group of animals passing by a camera – individual movements often had many images). On average the cameras recorded an animal movement every thirty-one hours, but, eight cameras recorded an animal every five hours or less. Camera 10-Location 2, a spring nursery area for elk cows and calves, had the highest frequency of animal movements with one every 1.95 hours. A summary of camera data is provided in Appendices A & B.

A total of twelve small and large native mammal species were captured on the cameras including: badger, black bear, bobcat, coyote, cougar, elk, fox, moose, mule deer, white-tailed deer, skunk and snowshoe hare. White-tailed deer were by far the most frequent species captured on camera, with 61% of the total animal movements captured. Elk, mule deer and moose were the next most frequent species respectively. The following figures provide a summary of the captured images as well as a graphic representation of spatial distribution of images.

Table 2. Wildlife camera summary

Camera Summary Statistics	
# of Camera Locations	86
# of camera hours	39,259
# of animal movements	3,593
# of mammal species	12
# of photos taken	128,388
# of hours per animal movement	31.11
Most active camera (hours/animal movement)	1.95

Fig. 19 Relative percentage of images captured by species ('other' includes small mammals and birds)

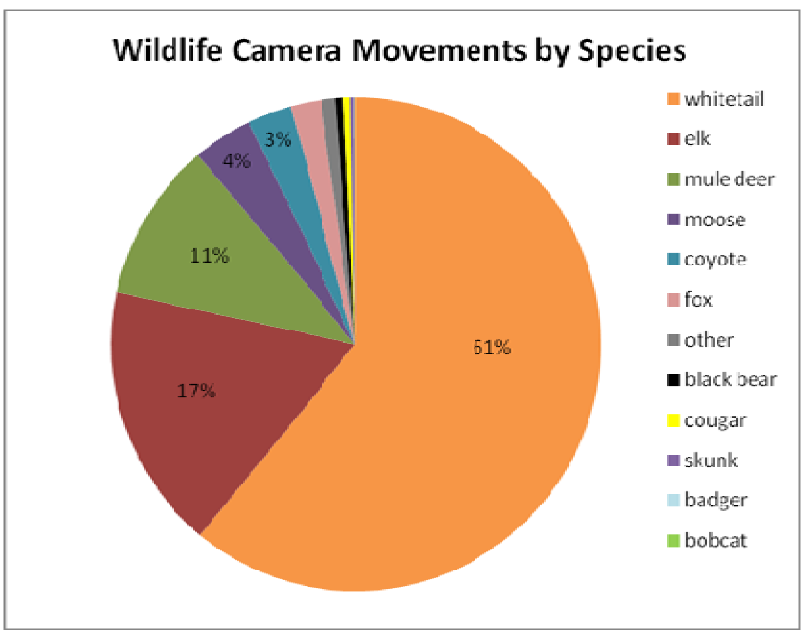


Fig. 20 Relative frequency of detected wildlife species within the study area

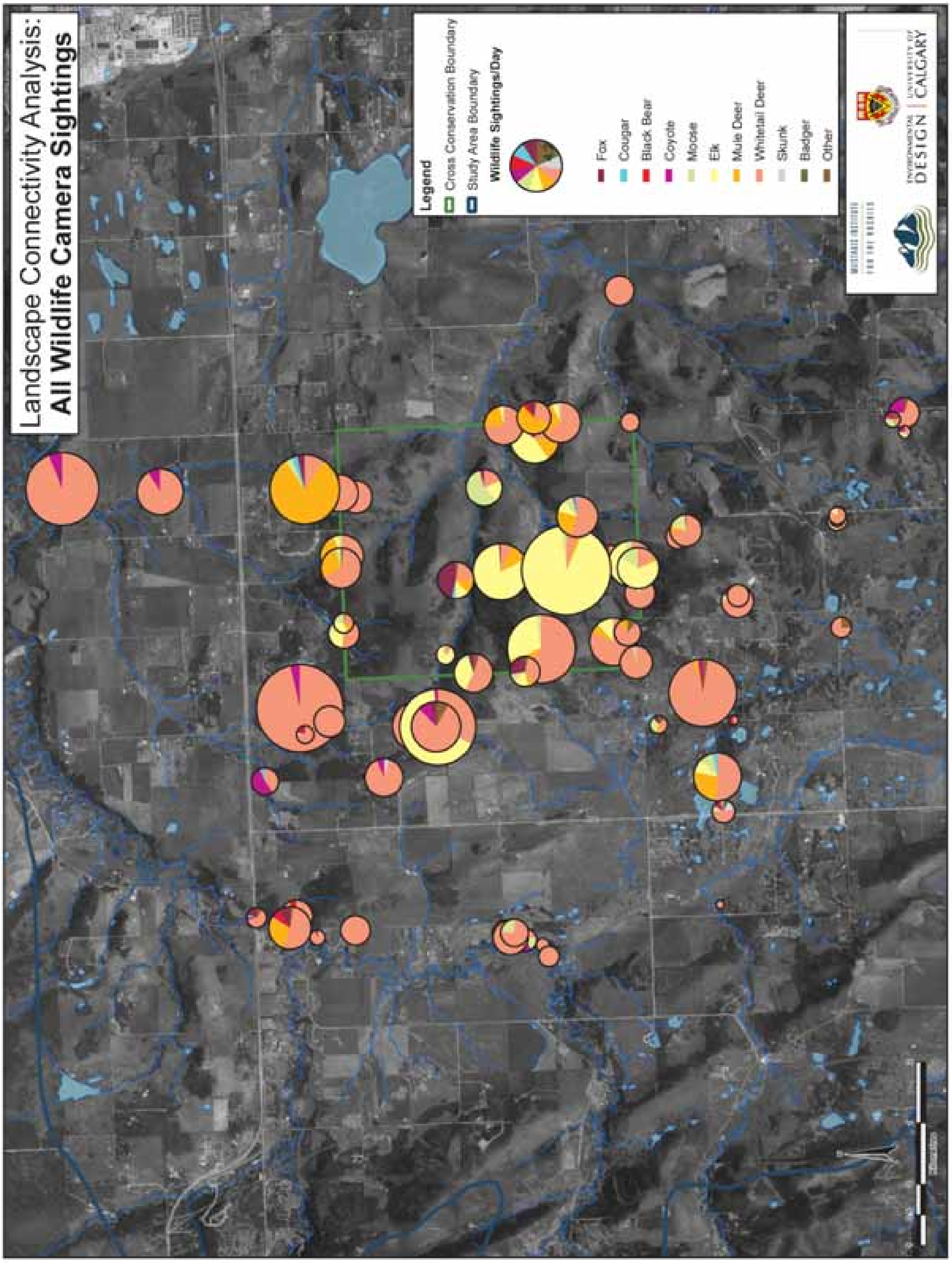


Fig. 21 Relative frequency of elk detections within the study area

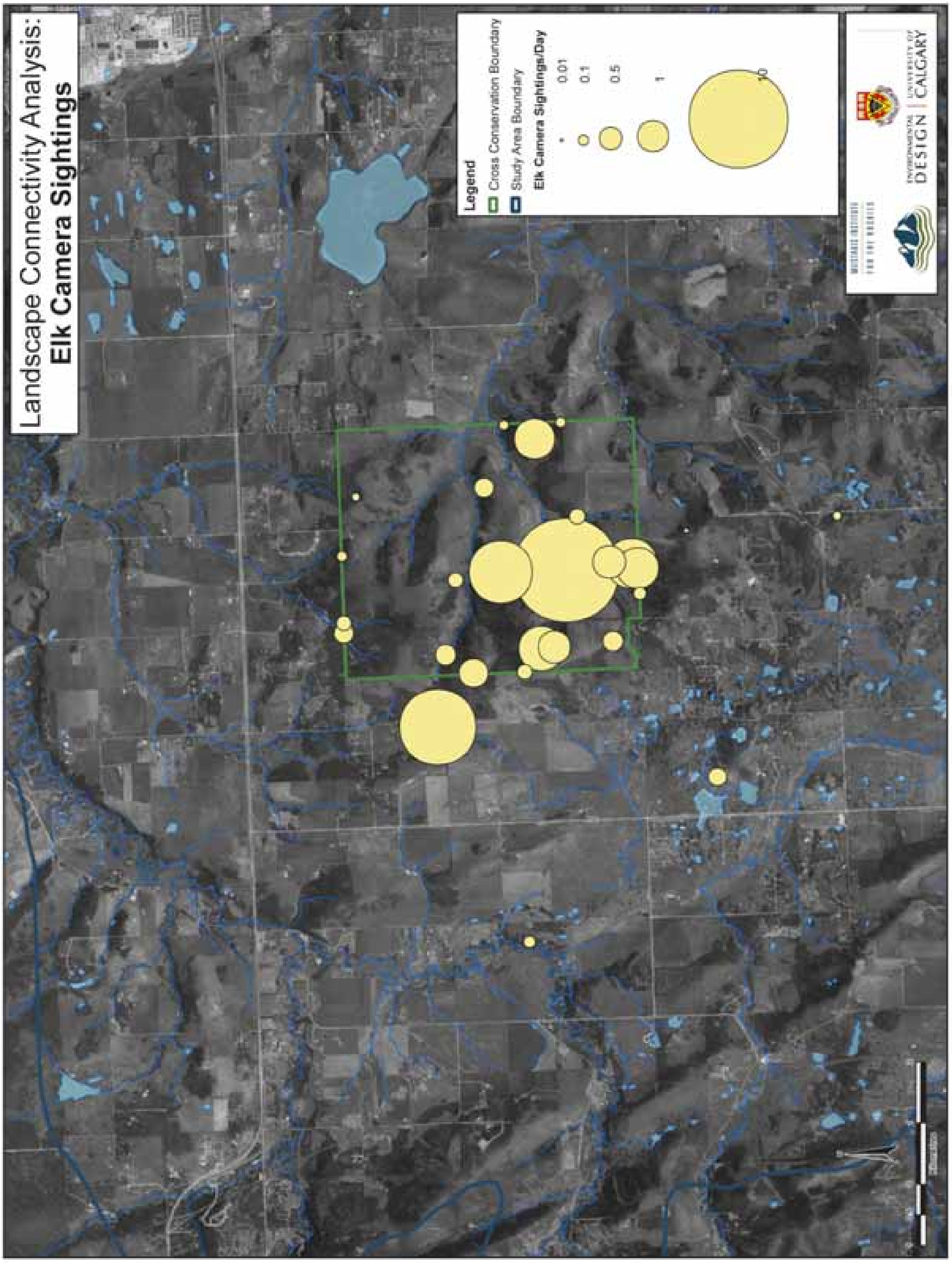


Fig. 22 Relative frequency of white-tailed deer detections within the study area

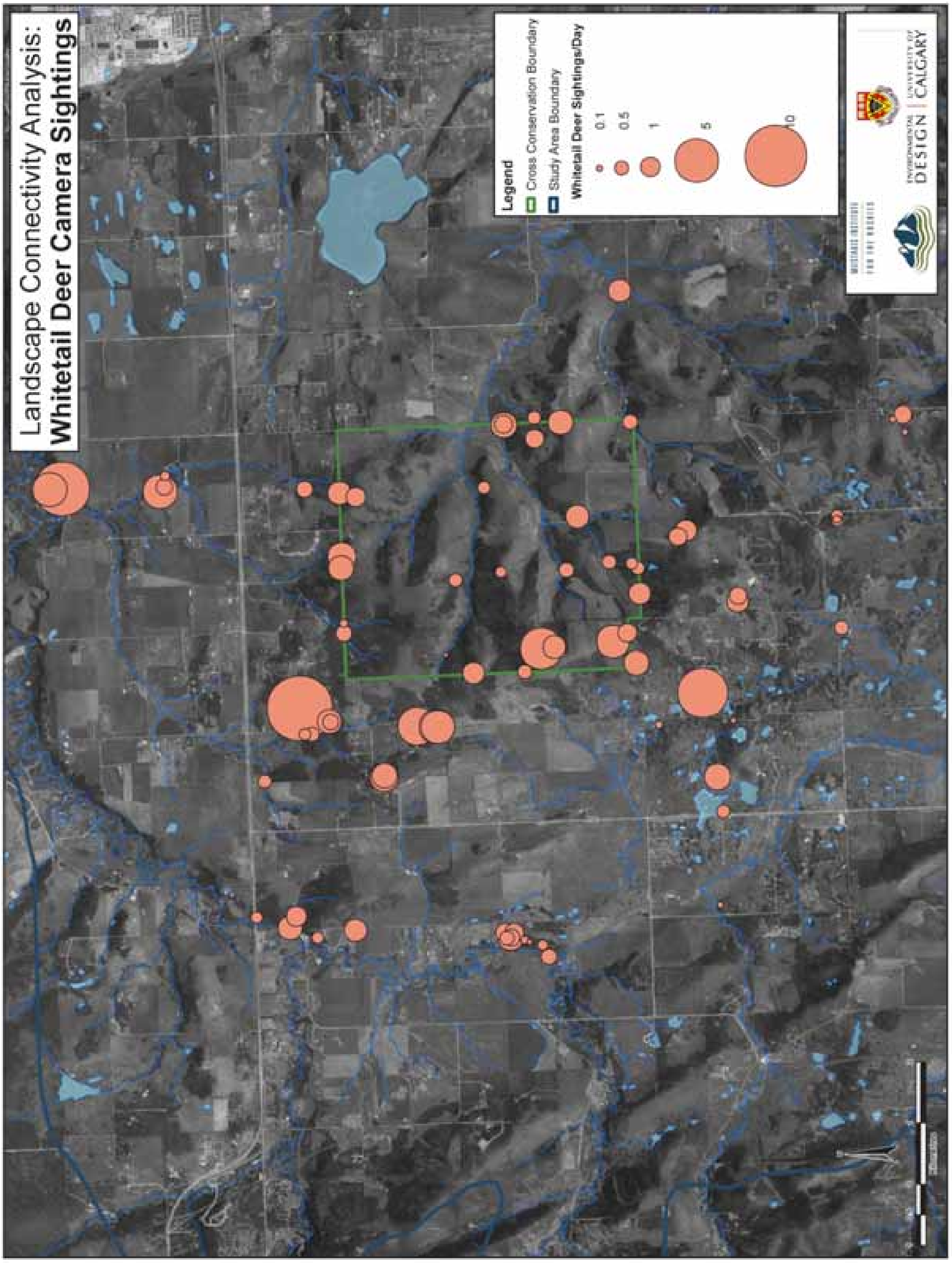


Fig. 23 Relative frequency of mule deer detections within the study area

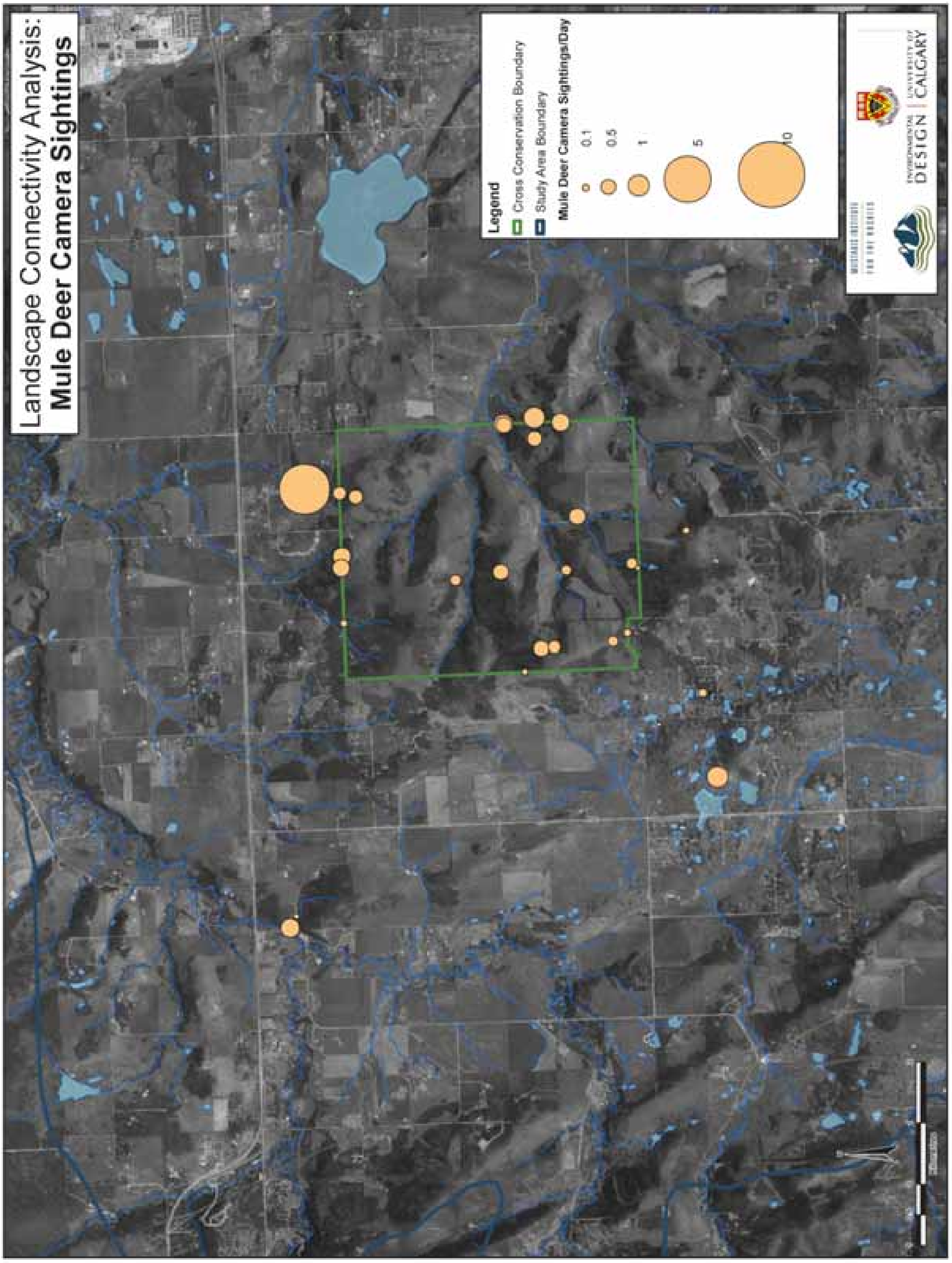


Fig. 24 Relative frequency of coyote detections within the study area

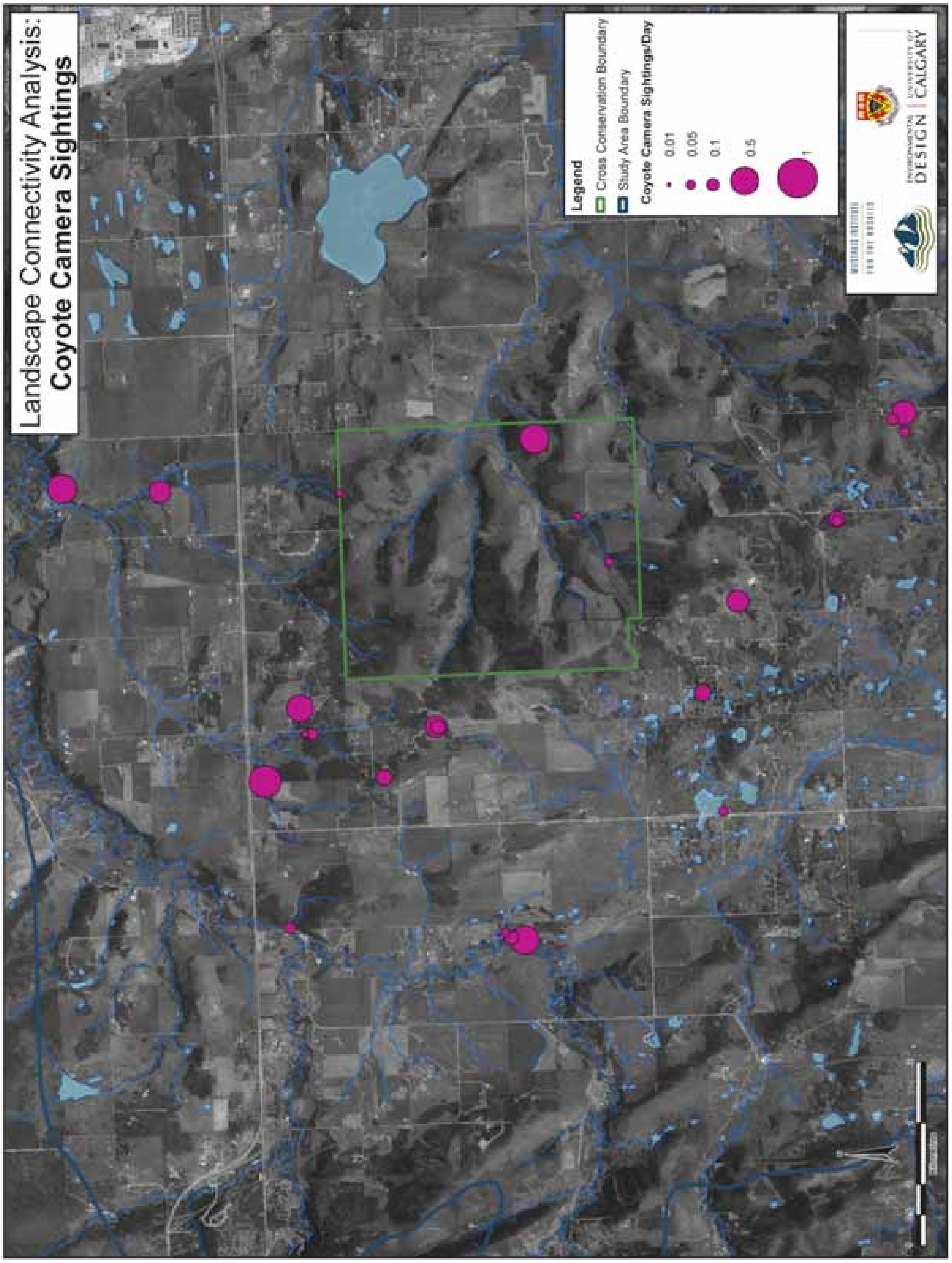


Fig. 25 Relative frequency of fox detections within the study area

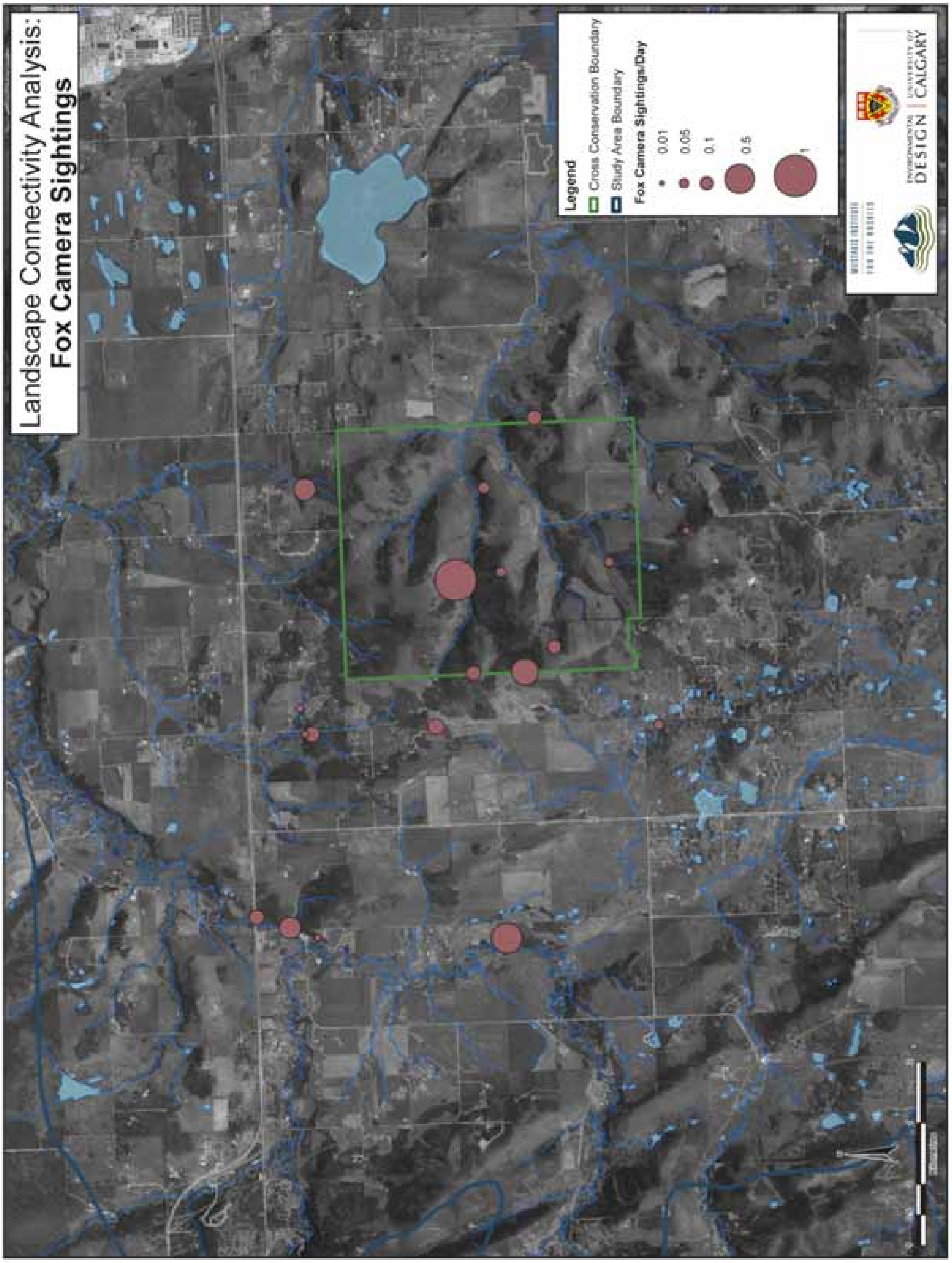


Fig. 26 Relative frequency of black bear detections within the study area

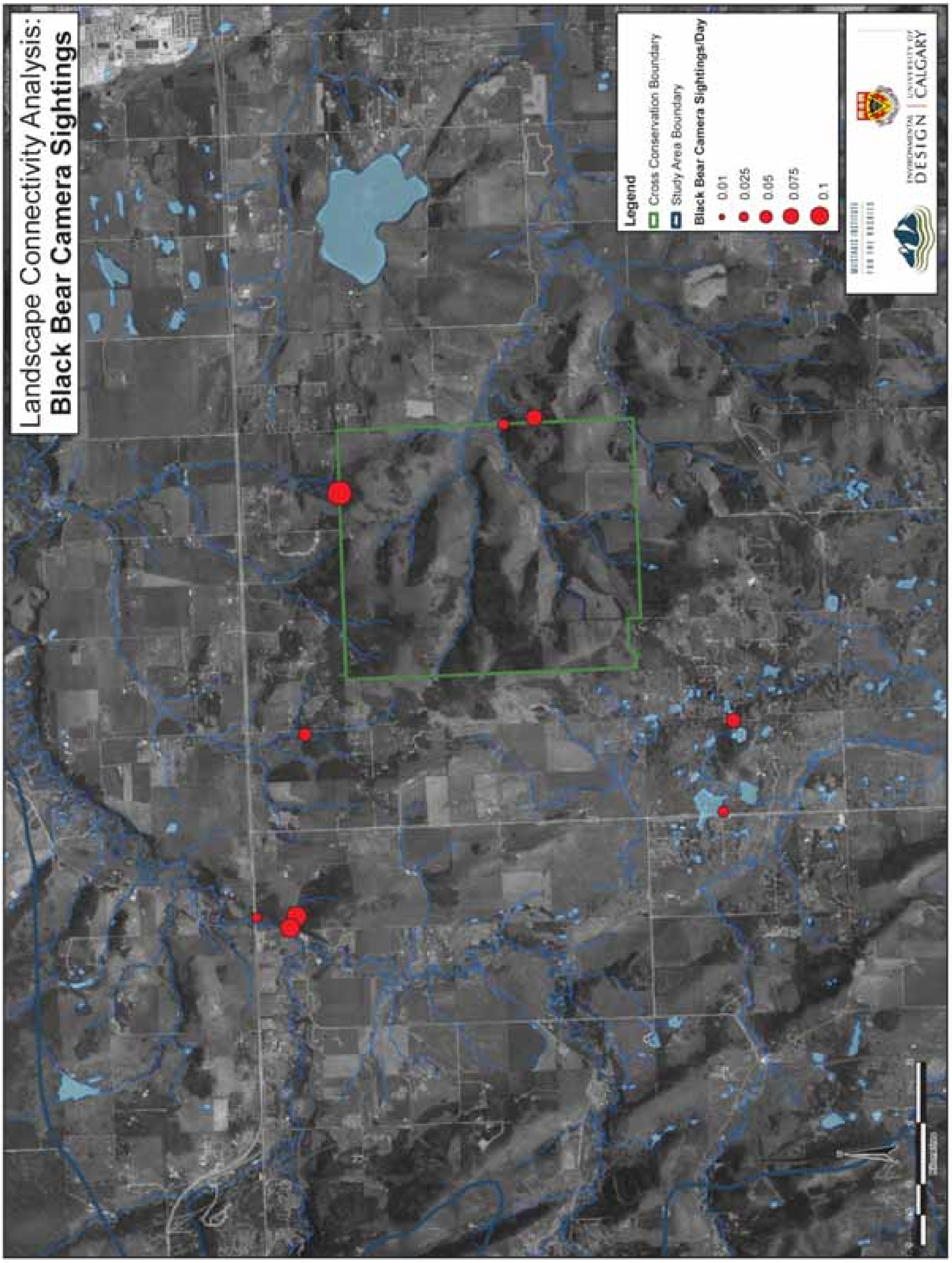


Fig. 27 Relative frequency of cougar detections within the study area

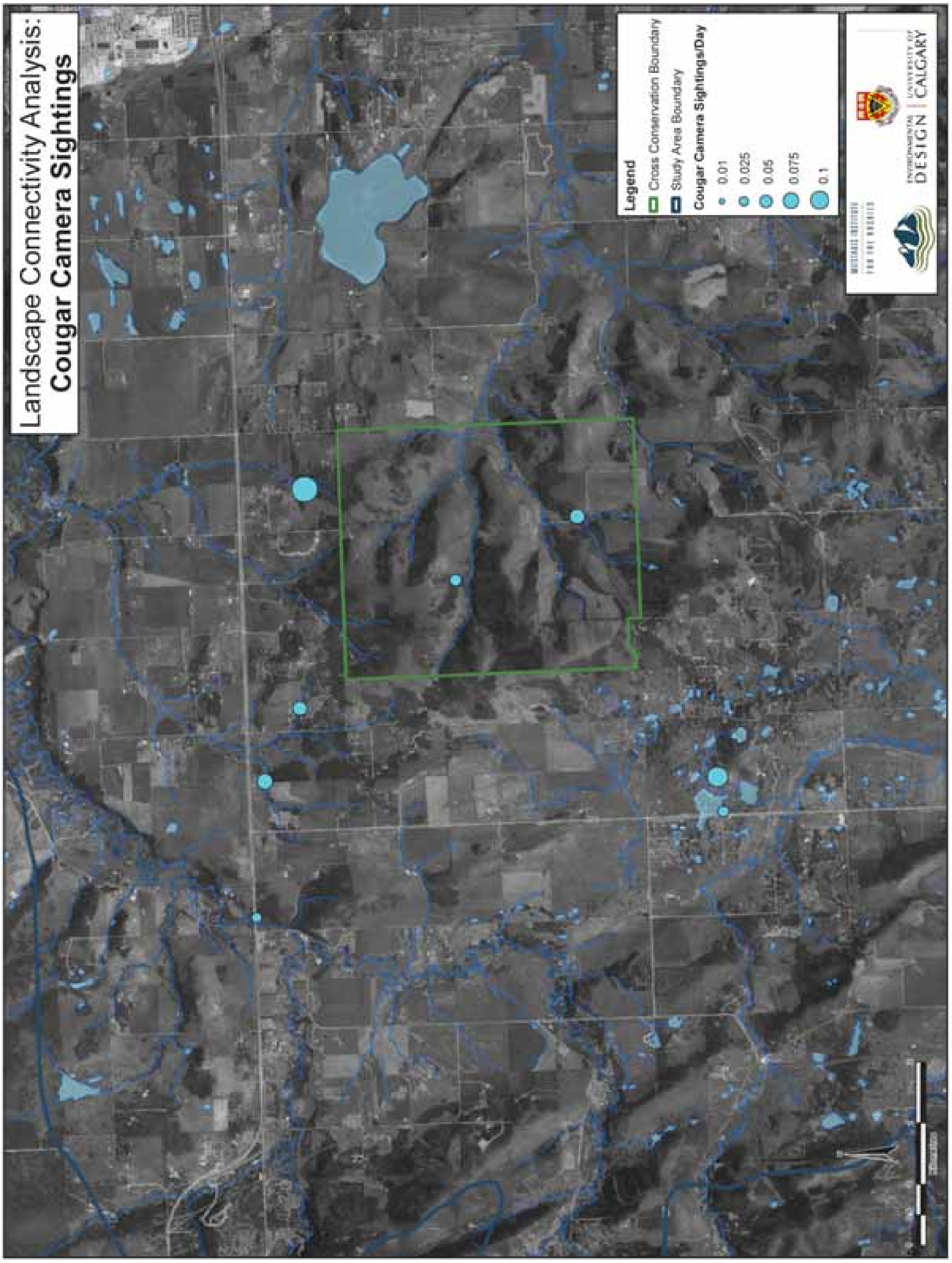


Fig. 28 A selection of images captured by the wildlife cameras within the study area

Landscape Linkages

The following section provides a summary of the linkages/movement corridors identified by analyzing structural landscape features in conjunction with wildlife camera imagery. Particular attention is given to existing forested vegetation patches, riparian areas and significant ridges.

The primary consideration in identifying these corridors was for movement of large mammals, especially large carnivores, which require relatively continuous security cover to facilitate movement. This focus is assumed to provide considerable connectivity benefits for a wide array of other species and ecological processes (e.g., hydrological connectivity, movement of smaller mammals, amphibian and birds). We have also identified points where there are considerable restrictions or barriers to movement, such as where wildlife movement corridors intersect busy roads.

The maps are provided to show the spatial arrangement and extent of potential movement corridors. ***We have intentionally indicated the location of the corridors with a dashed line – this is meant to indicate an approximate rather than absolute boundary.*** We have also indicated larger patches (landscape corridors) as well as more linear features based on our field observations and camera images of wildlife movement.

Figure 29 illustrates the corridors for the entire study area. The following pages provide a more descriptive narrative and maps for the corridors surrounding the Conservation Area. This includes both the 18 identified habitat patches and the linear ridge and riparian features.

Fig. 29 Summary of wildlife movement corridors for the entire study area

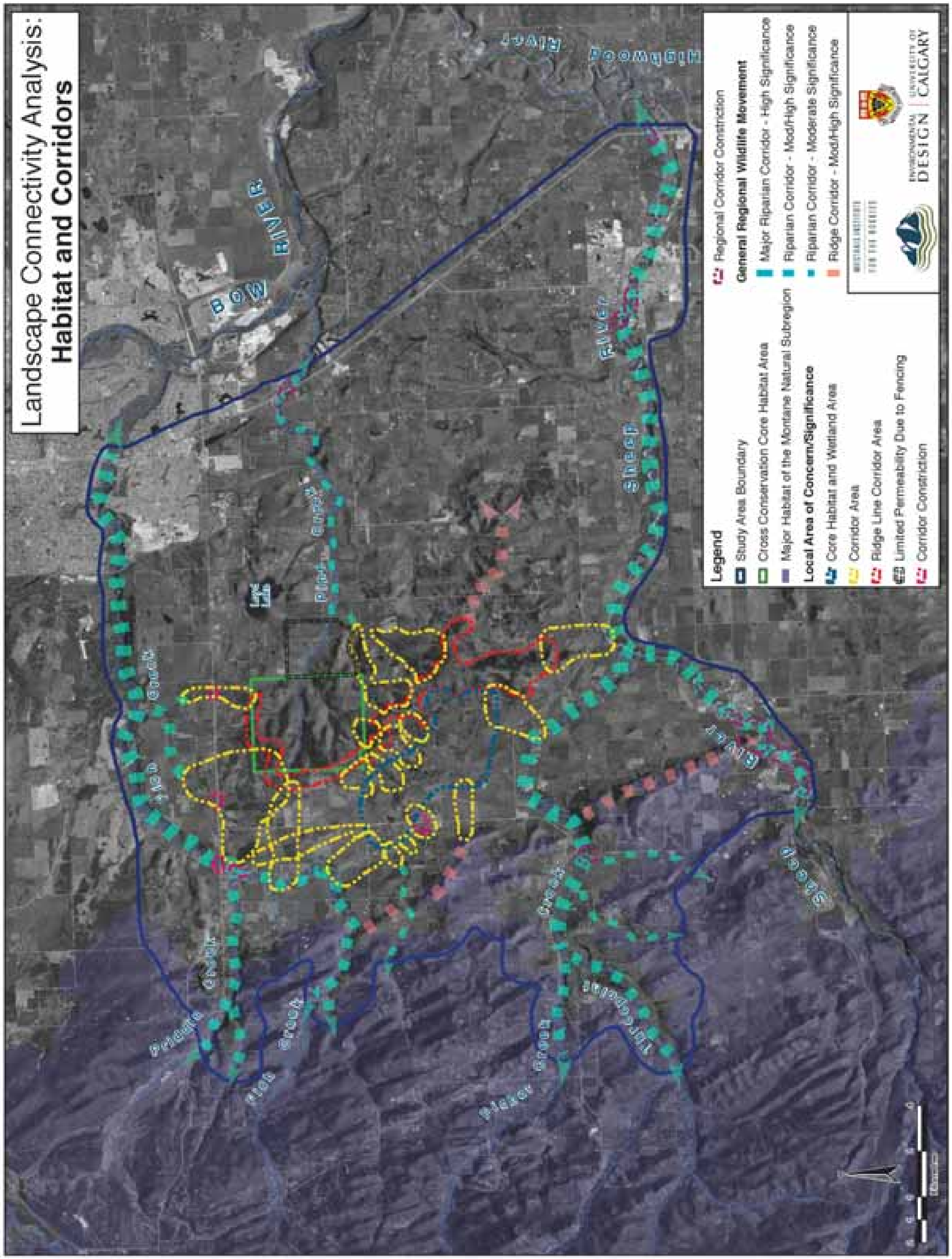
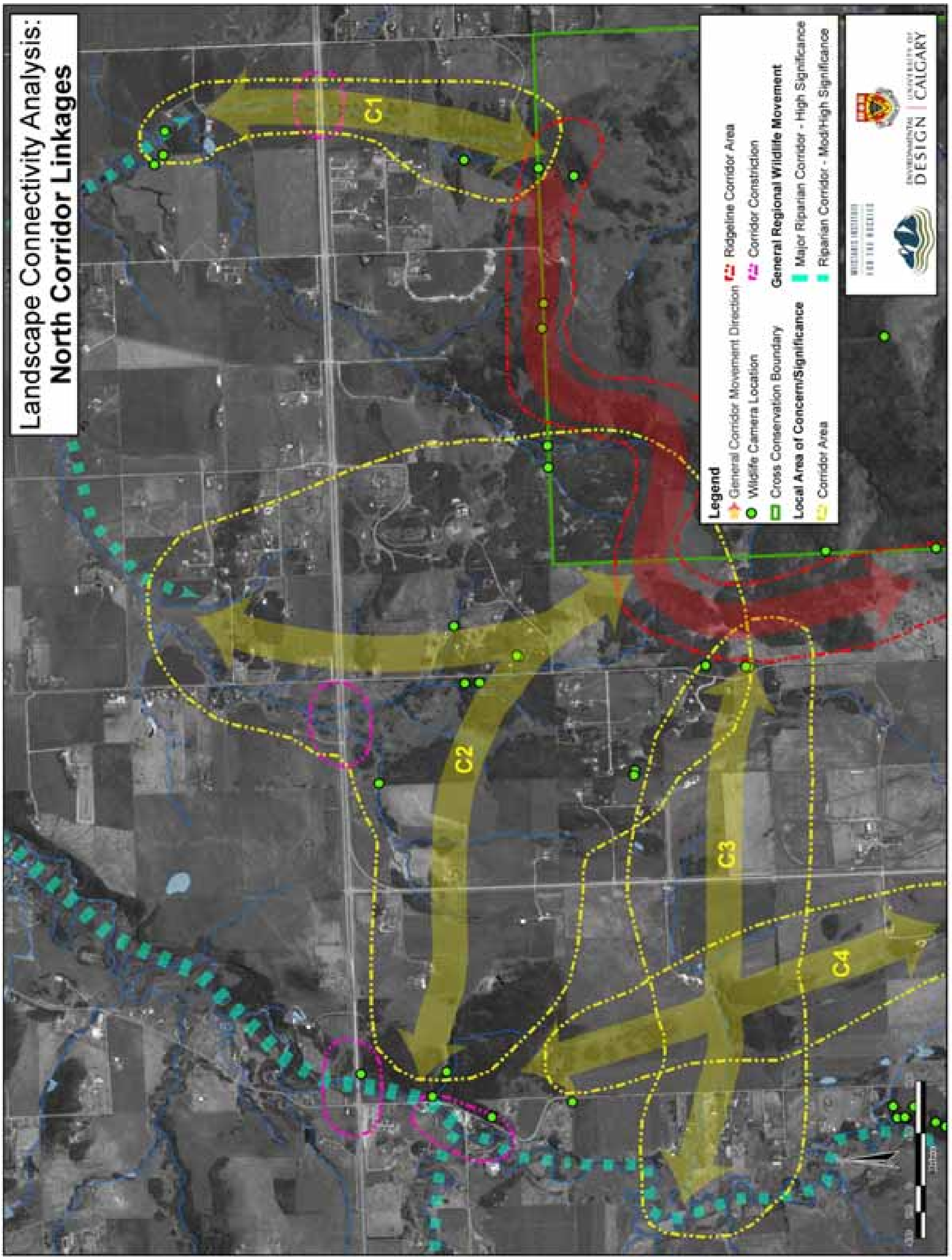


Fig. 30 Wildlife movement corridors north and northwest of the Conservation Area



North & Northwest

C1

Corridor C1 is a riparian corridor along an intermittent stream that drains from the Conservation Area north into the major riparian corridor of Fish Creek. The predominantly aspen and willow vegetation is continuous as it enters the quarter section north of the Conservation Area and becomes more sparse towards Highway 22X. The remainder of the corridor, largely surrounded by agricultural land, consists of some smaller patches of aspen and willow as well as a diversity of brush, forbs and grassland species associated with the stream moisture.

Camera #8 at location 3 and camera #3 at location 4 on the South end of the corridor show a significant diversity of wildlife sightings consisting of black bear, cougar, coyote, fox, moose, whitetail deer and mule deer. Camera 3 at location 4 recorded the highest total (116) and per day average (5.97) count of mule deer sightings of all the camera locations. On the north side of the corridor camera 5 location 20, camera 6 location 20 and camera 9 location 20 showed a significantly lower diversity of wildlife sightings consisting of coyote, moose, and whitetail deer. These 3 cameras also had a lower frequency of daily detection of between 0.33 to 3.31 compared to 1.97 and 7.26 for the two cameras to the south. The difference in wildlife detection frequencies and diversity are likely the result of the seasonality of the sightings, the barrier created by Highway 22X and the lack of significant forested patches on the north side of the highway.

The two cameras (Cam-08-L20, Cam-10-L20) further to the north along the stream riparian corridor, in close proximity to where the stream joins the major riparian corridor of Fish Creek, had an average daily wildlife detection rate of 3.22 and 8.26. Although the sightings were of low wildlife diversity (coyote, moose and whitetail deer) the high average wildlife sightings per day of these two cameras and those of the two cameras in close proximity to the Conservation Area in comparison to the 3 cameras at the North portion of the outlined corridor further indicates that the flow of wildlife along the corridor is currently being restricted.

The functionality of this corridor would be greatly enhanced by the provision of a formal wildlife crossing structure across Highway 22X. This would provide good connectivity between the Conservation Area and Fish Creek.

C2

C2 consists of 2 adjoining habitat linkages from the Conservation Area. The first linkage consists of forested and riparian habitat leading north across highway 22X and linking up with the major riparian corridor of Fish Creek to the north. The second linkage consists of discontinuous forested and riparian habitat potentially creating a stepping stone corridor linkage to the major riparian corridor of Fish Creak directly to the west. The western corridor linkage may act as an important connection from the Conservation Area to the major habitat of the Montane Natural Subregion to the West via the Priddis Creek or Fish Creek riparian corridors.

Both corridor linkages share a core of moderate to large aspen habitat patches directly adjacent to the Conservation Area. The north end of the North C2 corridor linkage is Similar to C1with small patches of aspen and willow surrounded by agricultural land. No cameras were located to the north end of this C2 corridor linkage, but observation suggests that there is a barrier effect occurring as the result of Highway 22X.

The west end of the West C2 corridor linkage consists mostly of agricultural land with interspersed aspen forest patches likely acting as stepping stones for wildlife movement.

There is a relatively large and intact aspen/spruce patch on the west end of the corridor that joins up with the major riparian corridor of Fish Creek. This patch acts as an important wildlife refuge for movement between the Conservation Area and the Montane Natural Subregion. Cameras within this large forested patch (Cam-05-L05, Cam-05-L04, Cam-04-L06, Cam-04-L05) captured a high diversity of wildlife including black bear, cougar, moose, mule deer, and whitetail deer. While less wildlife diversity was captured by other local C2 camera clusters (e.g., Central C2 cameras consisting of: Cam-10-L06, Cam-03-L06, Cam-10-L07, Cam-04-L08, Cam-10-L05), spread throughout the remainder of the west C2 corridor the diversity of wildlife sightings remained high. This further indicates that the east-west C2 corridor, albeit broad and patchy, is providing an important linkage for multiple species including black bear and cougar.

Both Highway 22 and Highway 22X, as well as their intersection, cross directly through the C2 corridor and likely constitute a significant barrier effect for wildlife movement as well as a safety/mortality issue with regards to wildlife automobile collisions. *Future transportation planning should take this barrier effect into consideration and identify potential design interventions to improve connectivity.*

C3

C3 is comprised of large aspen habitat patches along the ridge in close proximity to the Conservation Area in the east to the riparian corridor of Fish Creek or the forested ridge habitat of C4 to the west. The majority of C3 consists of crop and forage agricultural land with interspersed small to moderate forested patches and long linear patches of forest creating a shelterbelt that runs from the east portion of the corridor to the C4 forested ridge habitat. There is also a minor riparian corridor along an intermittent stream that cuts through the C4 ridge and drains into Fish Creek. It is the linear forest patches that are likely the greatest contributors to C3 wildlife movement as they create visual/perceptual security.

Cameras 06-L04, 10-L08, and 08-L09 on the eastern edge of the corridor had an average daily wildlife detection rate of between 3.77 and 8.94 consisting of elk, coyote, whitetail deer, and red fox. A large number of elk tracks observed in the snow during the winter also confirmed the use of the corridor by elk (Fig. 31). It is likely that C3 with its minimal forested land cover provides the minimal habitat attributes necessary for wildlife movement by species such as elk, white-tailed deer, and coyote while restricting movement by species such as cougar, mule deer and moose that have greater habitat requirements. Highway 22 crosses directly through the C3 corridor and likely creates a minor to moderate physical and perceptual barrier to wildlife movement as well as a safety/mortality issue with respect to wildlife automobile collisions.

C4

C4 consists of a corridor of aspen and willow patches that run along a ridge line between the riparian area of Fish Creek to the north and the core habitat and wetland area outlined to the south. The forested habitat is surrounded by crop and forage land as well rangeland. The south end of the corridor contains fewer forested habitat patches where the ridge line tapers off but contains an increase in brush, forbs and grassland species as it merges with a low lying intermittent stream area. No cameras were located along the ridge, but the presence of wildlife similar to C3 is a safe assumption. The ridge consists of a SW facing slope, which also provides important winter forage habitat for ungulates.

Fig. 31 Extensive evidence (tracks) of winter elk use in corridor C3

South & Southwest

C5

C5 is a corridor of small to moderate aspen and willow patches that run along a ridgeline from the core habitat and wetland area outlined to the south to the moderate coniferous patches adjacent to the riparian corridor of Fish Creek to the north. The forested habitat is surrounded by agricultural forage and rangeland land with a significant portion of semi-riparian brush, forbs and grass species to the south end of the corridor.

Cameras in the north end of the C5 corridor (Cam-08-L04, Cam-01-L05, Cam-08-L05, Cam-01-L06, Cam-08-L06, Cam-01-L07, Cam-08-L07, Cam-01-L08, Cam-01-L09) had average daily detection rates of between 0.21 to 1.86 consisting of white-tailed deer, elk, moose, coyote, and red fox. Cameras to the south end of the C5 corridor within the north end of the outlined core habitat and wetland area (Cam-01-L04, Cam-03-L02, Cam-07-L05, Cam-07-L04, Cam-09-L04) had average daily detection rates of between 0.07 and 7.10 with a high diversity of wildlife consisting of mule deer, white-tailed deer, elk, moose, coyote, black bear, cougar, fox, skunk, and badger. It is likely that C5 with its stepping stones of small to moderate forest patches creates the necessary habitat for wildlife movement by species such as elk, white-tailed deer, and coyote while restricting movement by species such as cougar, mule deer and moose that have greater habitat requirements. Rural residential development at the South end of C5 may potentially discourage wildlife corridor movement as it creates a minor to moderate physical and perceptual barrier.

C6, C7, C8, and C9

C6, C7, C8 and C9 consist of linkages between the core habitat and wetland area outlined to the east and small to moderate forested habitat patches to the west that eventually link up to the major habitat of the Montane Natural Subregion further to the west. The valley of brush, forbs and grassland species created by Pothole Creek is a naturally occurring habitat break between forested patches to the east and those to the west. C8 has the added physical barrier created by Highway 22 that cuts through it. While none of the 4 corridors provide ideal security cover for the movement of large mammals, the structure and riparian conditions likely provide habitat and connectivity for small mammal, amphibians and hydrological processes. Taken together, this corridor complex may function as an important linkage between the habitat of the Montane Natural Subregion and the outlined core habitat and wetland area that further links to the Conservation Area.

C10

C10 provides a connection between the ridgeline corridor and core habitat of the Conservation Area to the east and the core habitat and wetland area outlined to the west. The area consists of mostly medium to large aspen and willow patches that are somewhat isolated by agricultural forage and pasture lands. The intermittent stream and water bodies provide for an added diversity of vegetation types including brush, forbs, grassland and wetland species.

Cam-03-L02 on the west side of C10 and Cam-03-03 on the east side of C10 had average daily detection rates of 0.49 and 1.64 with a moderate diversity of wildlife consisting of white-tailed deer, mule deer, moose, and red fox. The western camera in close proximity to the wetland area captured a higher diversity of wildlife than the eastern camera. It is likely that the lack of strong topographic features such as deep riparian gullies or strong ridge lines within the corridor results in a dispersed wildlife movement across the area making it difficult for any one camera to capture a large proportion of total movement through the corridor. The intersection of Plummer's Road and 192 Street combine to create a significant physical and perceptual barrier at the narrow western edge of the corridor.

C11

C11 is a corridor between the ridgeline corridor to the east and the core habitat and wetland area outlined to the west. The area consists of an almost continuous line of moderate sized deciduous patches along the north side of a ridgeline that trends from NE to SW. There is a significant number of water features contributing to habitat diversity, including brush, forbs, grassland and wetland species, in the western half of the corridor.

Cam-05-L07 and Cam-07-L08 on the west side of C11 had an average daily detection rate of 0.66 and 7.1 with a moderate diversity of wildlife consisting of white-tailed deer, mule deer, coyote, and black bear. The country residential development and associated roads are likely acting as a deterrent to wildlife movement in this corridor; however, more detailed work would need to be conducted to test this assertion.

C12

C12 is similar to C11 in that it connects the ridgeline corridor to the east with the core habitat and wetland area outlined to the west. The area consists of moderate to large aspen and willow patches along a slight ridge line, descending from NE to SW, that are somewhat isolated by country residential and agricultural forage and pasture lands.

Cam-01-L04 and Cam-09-L04 at the centre of C12 had an average daily detection rate of 1.2 and 0.7 respectively with a moderately low diversity of wildlife consisting of white-tailed deer, moose, and coyote. The country residential development and associated roads in combination with the isolation created by the forage and pasture lands are likely discouraging wildlife corridor movement as they create a minor to moderate physical and perceptual barrier.

C13

C13 is a riparian corridor along an intermittent stream at the headwaters of the Pine Creek Watershed. The corridor creates a direct link between the core habitat of the Conservation Area to the north and the ridgeline corridor to the southwest. The area consists of an almost contiguous large patch of aspen with a single water body located near its centre.

Cam-02-L01, Cam-07-L02, Cam-01-L03, and Cam-07-L03 had average daily detection rates of between 1.4 and 3.4 with a moderate diversity of wildlife consisting of white-tailed deer, mule deer, elk, moose, fox, and coyote. These wildlife sightings confirm that the contiguous forest coverage, riparian conditions and minimal human activity or disturbance within C13 make it an important corridor for wildlife movement as well as an important habitat area, especially in combination with the large forested patches associated with the adjacent ridgeline corridor and the Conservation Area.

Fig. 32 Wildlife movement corridors south and southwest of the Conservation Area

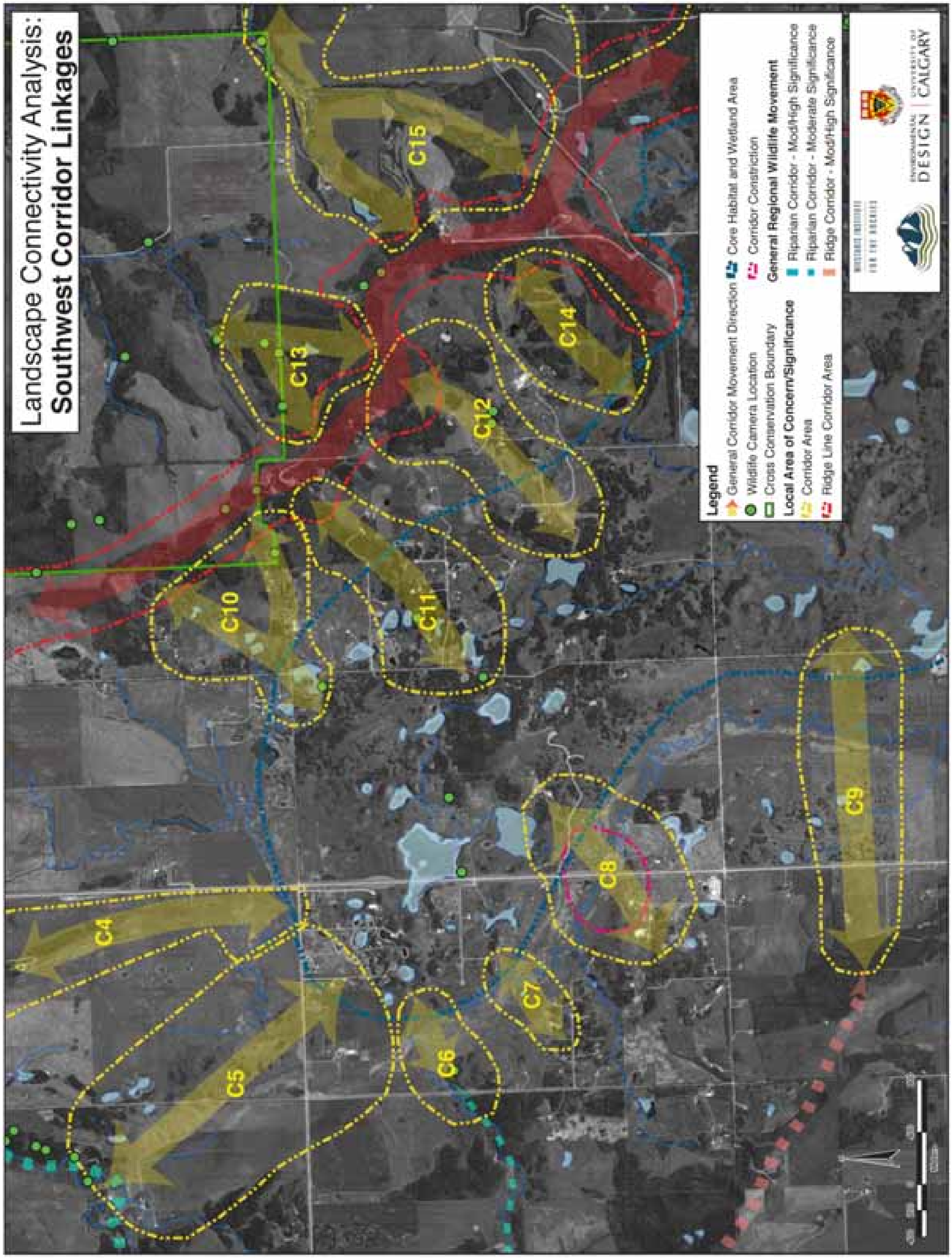
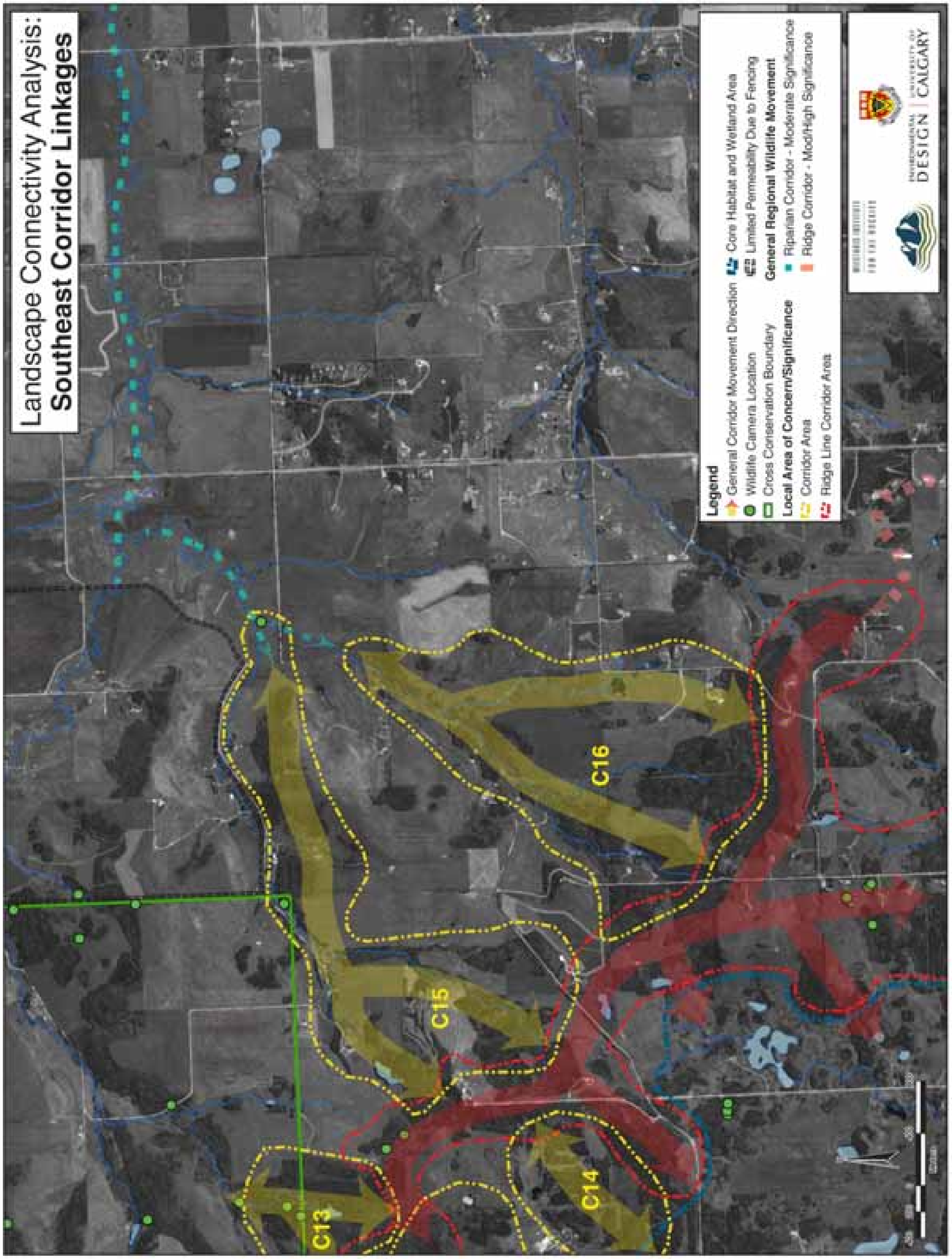


Fig. 33 Wildlife movement corridors southeast of the Conservation Area



Southeast

C14

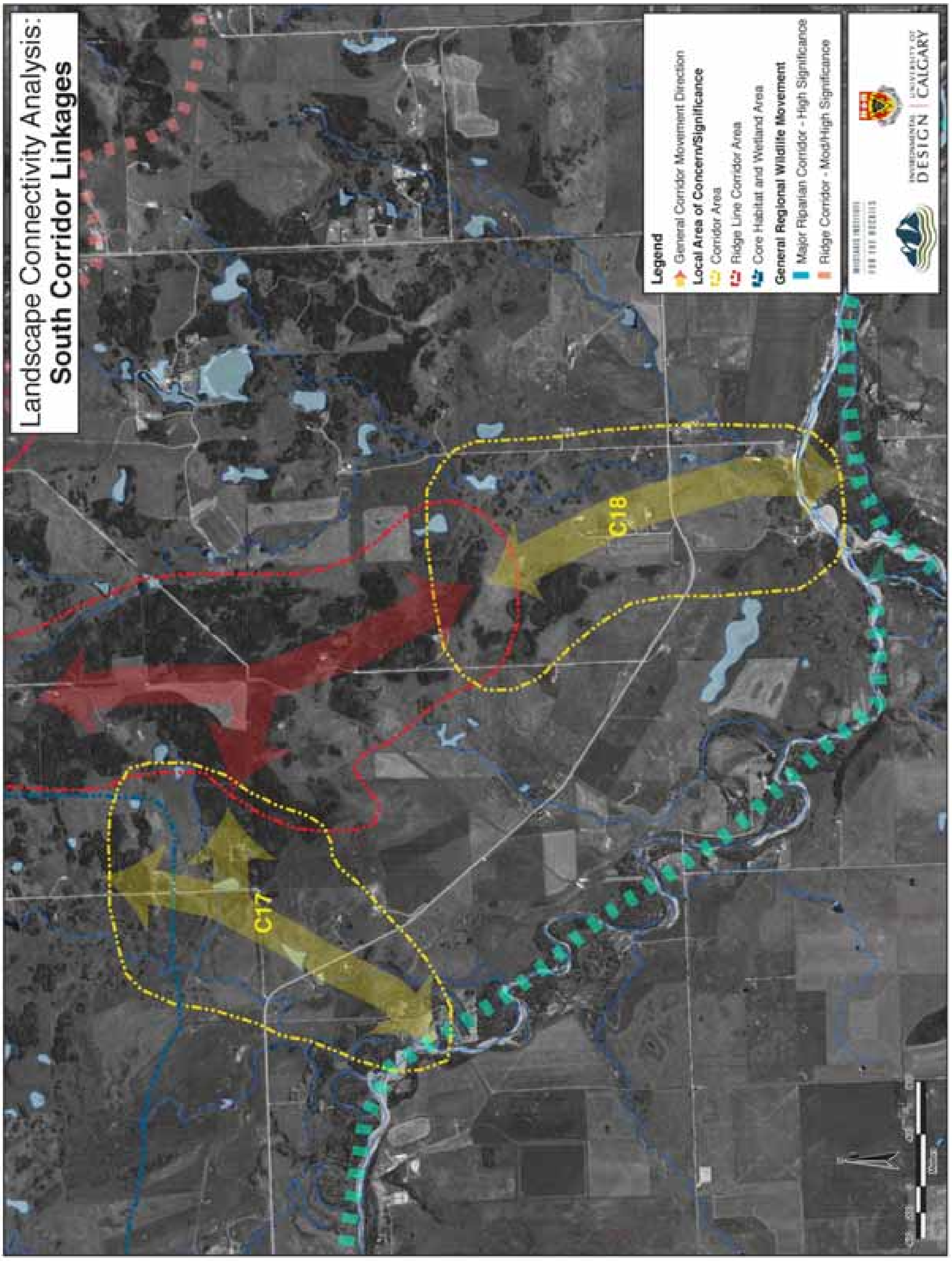
C14 also provides connectivity between the ridgeline corridor to the east and the core habitat and wetland area outlined to the west. The area consists of an almost contiguous large patch of willow and aspen with some minor water features that run from NE to SW. There were no cameras located within the C14 corridor. It is likely that the contiguous forest coverage and minimal human activity or disturbance within C14 make it a good corridor for wildlife movement as well as an important habitat area, especially in combination with the large forested patches associated with the adjacent ridgeline corridor to the East.

C15 and C16

C15 and C16 consist of riparian corridors along streams at the headwaters of the Pine Creek Watershed. The corridors link the ridgeline corridor in the SW to the riparian corridor of Pine Creek to the NE. The corridors consist of mostly small to moderate aspen and willow patches with brush, forbs and grassland species associated with the riparian conditions. The forest coverage is somewhat isolated by agricultural forage and pasture lands.

Cam-06-L01 and Cam-09-L05 at the centre and western edge of C15 had an average daily detection rate of between 0.5 and 1.3 with a low diversity of wildlife as the only sightings consisted of white-tailed deer. C16 contained no cameras, although wildlife use would likely be similar to that seen in C15. As there is no significant forested habitat areas to the East of the corridors it is likely that the corridors are best utilized by wildlife with minimal forest cover requirements such as coyote, white-tailed deer, and mule deer that extend eastwards into the prairies. A large game fence acts as a significant barrier to large mammal movement between the Conservation Area's core habitat and the riparian corridor of Pine Creek on the southeast corner of the property. C15 and C16 now likely function as an important indirect linkage between the two areas.

Fig. 34 Wildlife movement corridors south of the Cross Conservation Area



South

C17

C17 is a corridor that links both the ridgeline corridor and the core habitat and wetland area located to the north to the major riparian corridor of Three Point Creek and indirectly to the major riparian corridor of Sheep River and the major habitat of the Montane Natural Subregion. The corridor contains both riparian corridor movement areas along a seasonal stream and ridgeline movement area. Moderate to large patches of aspen can be seen to the NE of C17 with small to large willow patches along the centre portion and a mixed cover of deciduous and coniferous to the SW in association with Three Point Creek. Brush, forbs and grassland species can be seen in association with the intermittent streams, water bodies, and permanent creek. The forest coverage is partially isolated by agricultural forage and pasture lands. No cameras were located within C17. Some country residential development in combination with highway 542 that bisects the corridor likely create a moderate physical and perceptual barrier to wildlife movement as well as a safety/mortality issue with regards to wildlife automobile collisions.

C18

C18 consists of a linkage between the ridgeline corridor located to the north and the major riparian corridor of Sheep River and indirectly to the major habitat of the Montane Natural Subregion. Small to moderate patches of aspen and willow that are somewhat isolated by forage and pasture lands provide for both riparian corridor movement along a seasonal stream and ridgeline corridor movement. Brush, forbs and grasslands in association with the intermittent streams, water bodies, and river provide good habitat diversity. No cameras were located within C18. Highway 542 bisects the corridor and likely creates a moderate physical and perceptual barrier to wildlife movement as well as a safety issue with regards to wildlife automobile collisions. As a result of the lack of significant forest cover within C18, it is best suited to wildlife with minimal to moderate forest cover requirements.

Ridgeline Corridor

The ridgeline corridor is probably the most important corridor for regional movement of wildlife to and from the Conservation Area as it functions as a continuous link between the majority of the outlined corridors. The ridgeline corridor consists mostly of moderate to large aspen patches that are strongly linked with only minor topographic elevation changes that minimizes the effort required for movement through the corridor. The strongly linked forest patch cover along the corridor also provides significant habitat for wildlife, fulfilling more than just their movement requirements for cover.

The forest cover is only partially fragmented by agricultural pasture and forage lands in combination with some country residential development. Country residential development along the ridgeline corridor may be a significant concern in the future as these areas provide sites with scenic vistas. Twelve cameras located along the ridgeline corridor had an average daily detection rate of between 0.2 and 3.4 (overall average of 1.6) with a high diversity of wildlife consisting of white-tailed deer, mule deer, elk, moose, coyote, fox, and black bear.

The following is a finer summary of the 12 camera detection rates and species:

NE - Cam-08-L01 and Cam-08-L03 with average daily detection rates of 1.6 and 2.0 with white-tailed deer, mule deer, elk, moose, coyote, and black bear.

N - Cam-02-L02 and Cam-02-L03 with average daily detection rates of 2.9 and 2.5 with white-tailed deer, mule deer, elk, and moose.

SW corner of Conservation Area - Cam-03-L01 and Cam-04-L04 with average daily detection rates of 3.4 and 1.1 with white-tailed deer, mule deer, and elk.

Just South of Conservation Area - Cam-02-L04 and Cam-03-L07 with average daily detection rates of 0.9 and 1.6 with white-tailed deer, mule deer, elk, moose, and red fox.

Leighton Centre - Cam-01-L20, Cam-01-L21, Cam-02-L20 and Cam-03-L20 with average daily detection rates of 0.8, 1.4, 0.2 and 0.4 with white-tailed deer, moose, and coyote.

Core Habitat and Wetland Area

The core habitat and wetland provides a large diverse habitat area southwest of the Conservation Area. The area provides high quality security cover, forage and water for regional wildlife use. These are critical functions that link the Conservation Area, the major riparian corridor of Three Point Creek and the major habitat of the Montane Natural Subregion to the West. The area consists mostly of moderate to large patches of aspen and willow with the addition of multiple water bodies, seasonal and permanent streams. Forest cover in the area is perforated by agricultural pasture and forage lands as well as by some country residential development and associated roads. Country residential development within this area may be a significant concern in the future. Highway 22 bisects the area in the NE and creates a barrier to east-west wildlife movement.

Nine cameras located within the core habitat and wetland area had an average daily detection rate of between 0.1 and 7.1 (overall average of 1.5) with a high diversity of wildlife consisting of white-tailed deer, mule deer, elk, moose, coyote, red fox, skunk, badger, black bear, and cougar.

Conclusion

This report identifies structural connectivity features in the landscape based on remotely sensed imagery analysis. Areas of contiguous forested vegetation, linear riparian features and ridges were assumed to be important for the movement of the large mammals native to the region. Remote wildlife cameras were then deployed to provide a preliminary assessment of corridor functionality. The cameras proved to be very effective in capturing wildlife movement and the resulting images provide concrete evidence of corridor use. More extensive and species-specific monitoring and modeling would be required to develop quantitative relationships between corridor characteristics and wildlife movement. However, the results presented here provide compelling evidence for the value of corridors and remaining habitat patches surrounding the Conservation Area.

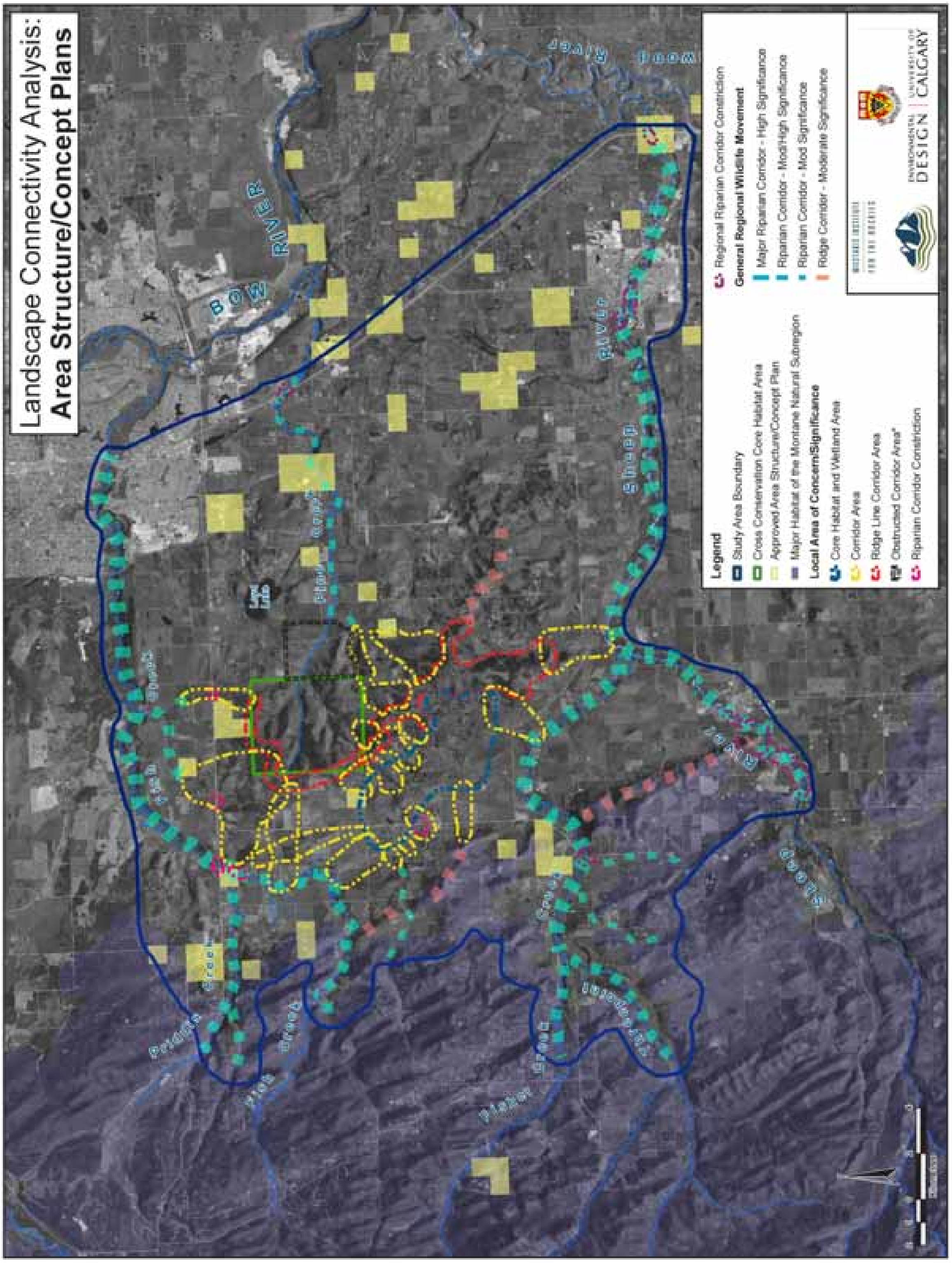
The presence of badgers, bobcats, black bears, cougars, elk and moose literally on the doorstep of 1 million people is testament to the health of the existing landscape. However, the continued growth of Calgary and surrounding rural residential development can quickly erode the ecological infrastructure of the region.

Figure 35 provides an illustration of the existing area structure plans and concept plans for new development in the vicinity of the study area and in relation to the identified wildlife movement corridors. If the maintenance of native wildlife is a desired future condition, then planning and management of land use change will need to explicitly address species requirements.
The source for many large mammals that currently utilize the Conservation Area is the foothills and Rocky Mountains to the west. As the highly developed Foothills Parkland and Foothills Fescue Natural Subregions are likely a sink (i.e., mortality exceeds birthrate), maintaining connectivity to the west is essential to the future presence of many species, particularly large carnivores, elk and moose. The functional connectivity of riparian corridors and ridges is an essential element in ensuring the future of these linkages.

Roads and increasing traffic volumes create a barrier effect for wildlife movement. In addition, the intersection of roads and wildlife corridors result in human safety concerns due to wildlife-vehicle collisions. Highways 22X and 22 should be evaluated to mitigate barrier effects and human safety risks. The camera data results presented in this report indicate a clear barrier effect of Highway 22X north of the Conservation Area to Fish Creek. Highway 22 in the vicinity of the intersection with Highway 22X and the region of corridor C8 should be priorities of mitigation consideration.

In a remarkable display of generosity, Ann and Sandy Cross donated their land for the citizens and wildlife of the MD of Foothills and the greater Calgary region. The Conservation Area provides an absolutely critical patch of Foothills Parkland habitat in a rapidly changing environment. The land use decisions that we make over the next decade will largely determine if we have the ability to follow the Cross' lead and ensure the long-term viability of our regional ecological infrastructure. Maintaining connections in the landscape is a cornerstone of that challenge.

Fig. 35 Existing area structure plans and concept plans



Recommendations and Next Steps

This report provides an assessment of landscape features conducive to wildlife movement and ecological processes surrounding the Ann and Sandy Cross Conservation Area. The information provided herein is a timely update to the previous Wildlife Movement Study and constitutes valuable input into regional planning processes. The following points are offered as suggestions for implementing and expanding the work on maintaining landscape connectivity.

- ✓ Make this report available to the public and to relevant planners, managers and decision makers through hard copies and Web-based distribution.
- ✓ Present (in person) the key findings to the media, interested public, regional planning authorities and public interest groups as opportunities allow.
- ✓ Encourage and collaborate with regional planners to designate landscape linkages and wildlife corridors in the Municipal Development Plan and the Calgary Regional Land-use Plan.
- ✓ Encourage and collaborate with regional planners to develop design guidelines for development within and surrounding identified wildlife corridors.
- ✓ Develop public education materials for rural residential residents on 'living with wildlife' and managing property to facilitate wildlife movement.
- ✓ Include priority landscape connectivity areas in the planning frameworks of regional land trust organizations for potential land securement and other private land conservation mechanisms.
- ✓ Continue to deploy wildlife cameras throughout the study area to monitor wildlife movement.
- ✓ Continue collaboration with EVDS at the University of Calgary to expand the current study to include a more quantitative landscape ecology approach to assessing landscape connectivity (e.g., landscape metrics and graph theory approaches).
- ✓ Examine opportunities and mechanisms to collaborate with landowners to minimize the barrier effects of game fencing (e.g., east of the Conservation Area in the Pine Creek valley).
- ✓ Communicate and collaborate with regional transportation planners to incorporate mitigation measures for landscape connectivity – especially in the barrier zone identified along Highways 22X and 22.
- ✓ Identify and explore opportunities to enhance connectivity through restoration activities and land stewardship initiatives.
- ✓ Develop and circulate an information package on landscape connectivity for land developers and real estate professionals.

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Appendix A - Individual Camera Summary Data

Camera Id #	Camera UTM Location	Camera Duration (Hrs)	Total Animal Movements	Hours per animal movement (hrs/animal movements)	On CCA?
Cam-10-L02	11 U 696167 5636686	412.35	212	1.95	Yes
Cam-09-L06	11 U 695365 5637511	794.00	390	2.04	
Cam-10-L08	11 U 698584 5635298	349.00	130	2.68	
Cam-03-L04	11 U 690580 5641092	466.00	145	3.21	
Cam-05-L02	11 U 691775 5640519	430.58	129	3.34	Yes
Cam-09-L04	11 U 695276 5639875	142.00	42	3.38	
Cam-04-L01	11 U 691350 5640324	450.87	93	4.85	Yes
Cam-06-L04	11 U 692988 5639800	632.00	102	6.20	
Cam-08-L09	11 U 694897 5635987	159.00	25	6.36	
Cam-01-L01	11 U 687718 5636449	424.07	65	6.52	Yes
Cam-07-L04	11 U 693642 5634966	363.00	55	6.60	
Cam-03-L01	11 U 688375 5640577	522.53	75	6.97	Yes
Cam-07-L02	11 U 693510 5633368	435.58	61	7.14	Yes
Cam-08-L02	11 U 694125 5635101	473.70	62	7.64	
Cam-02-L02	11 U 688144 5639615	477.72	58	8.24	Yes
Cam-05-L01	11 U 691578 5633434	525.88	63	8.35	Yes
Cam-05-L05	11 U 692371 5636843	1005.00	117	8.59	
Cam-07-L03	11 U 693604 5633357	335.25	37	9.06	Yes
Cam-06-L03	11 U 692857 5635401	690.53	76	9.09	Yes
Cam-02-L03	11 U 688185 5640682	520.18	55	9.46	Yes
Cam-06-L02	11 U 692770 5636363	501.85	53	9.47	Yes
Cam-10-L03	11 U 696387 5637190	263.48	26	10.13	Yes
Cam-10-L01	11 U 695413 5640186	433.20	42	10.31	Yes
Cam-08-L03	11 U 694152 5635465	670.43	60	11.17	Yes
Cam-07-L01	11 U 693153 5639806	310.85	27	11.51	Yes
Cam-04-L02	11 U 691468 5638268	531.42	45	11.81	Yes
Cam-01-L02	11 U 687905 5636552	694.35	54	12.86	Yes
Cam-01-L08	11 U 688028 5640230	142.00	11	12.91	
Cam-10-L04	11 U 696401 5637192	568.00	41	13.85	
Cam-02-L01	11 U 688110 5637170	519.12	37	14.03	Yes
Cam-05-L04	11 U 692352 5637684	358.00	25	14.32	
Cam-08-L01	11 U 694052 5639846	423.60	29	14.61	Yes
Cam-03-L03	11 U 690088 5633598	454.92	31	14.67	Yes
Cam-05-L07	11 U 692642 5638138	841.00	56	15.02	

Cam-03-L07	11 U 691345 5640436	987.00	64	15.42	
Cam-04-L08	11 U 691555 5640039	160.00	10	16.00	
Cam-09-L01	11 U 694909 5631737	437.12	27	16.19	Yes
Cam-01-L03	11 U 687958 5636770	301.98	18	16.78	Yes
Cam-05-L03	11 U 692024 5633938	551.52	32	17.23	Yes
Cam-08-L08	11 U 694853 5631743	142.00	8	17.75	
Cam-09-L05	11 U 695338 5640442	470.00	26	18.08	
Cam-01-L04	11 U 687989 5636845	366.00	20	18.30	
Cam-01-L09	11 U 688107 5637013	163.00	8	20.38	
Cam-10-L05	11 U 696432 5636260	310.00	15	20.67	
Cam-04-L04	11 U 691480 5638600	385.00	18	21.39	Yes
Cam-01-L06	11 U 688024 5637064	139.00	6	23.17	
Cam-01-L05	11 U 688023 5637139	858.00	34	25.24	
Cam-02-L04	11 U 688356 5641228	331.00	12	27.58	
Cam-01-L07	11 U 688027 5637079	196.00	7	28.00	
Cam-08-L07	11 U 694824 5631740	143.00	5	28.60	
Cam-03-L06	11 U 690655 5633695	907.00	31	29.26	
Cam-07-L05	11 U 693855 5637974	1293.00	43	30.07	
Cam-07-L08	11 U 694051 5634994	163.00	5	32.60	
Cam-07-L07	11 U 694020 5636167	144.00	4	36.00	
Cam-08-L05	11 U 694563 5634344	675.00	18	37.50	
Cam-10-L07	11 U 696506 5636695	676.00	18	37.56	
Cam-09-L02	11 U 695215 5639603	1149.12	30	38.30	Yes
Cam-04-L05	11 U 691503 5634657	787.00	20	39.35	
Cam-06-L05	11 U 693000 5635165	333.00	8	41.63	
Cam-06-L01	11 U 692742 5636576	352.60	8	44.08	Yes
Cam-04-L03	11 U 691474 5638294	763.00	17	44.88	Yes
Cam-03-L02	11 U 688567 5633652	437.03	9	48.56	
Cam-10-L06	11 U 696436 5635124	906.00	18	50.33	
Cam-07-L06	11 U 693991 5637236	332.00	6	55.33	
Cam-04-L06	11 U 691549 5640018	1009.00	15	67.27	
Cam-06-L06	11 U 693082 5631672	143.00	2	71.50	
Cam-08-L04	11 U 694243 5639835	173.00	2	86.50	
Cam-08-L06	11 U 694668 5634210	332.00	3	110.67	
Cam-05-L06	11 U 692518 5635023	473.00	2	236.50	
Cam-01-L21	11 U 696585 5630645	815.82	44	18.54	
Cam-02-L20	11 U 696274 5630634	673	7	96.14	
Cam-03-L20	11 U 696481 5630832	815.00	7	116.43	
Cam-04-L20	11 U 690677 5639139	550.00	34	16.18	
Cam-04-L21	11 U 691469 5632971	143.00	2	71.5	
Cam-05-L20	11 U 695556 5642724	498.00	7	71.14	
Cam-06-L20	11 U 695377 5642736	499.00	18	27.72	
Cam-07-L20	11 U 690641 5639145	550.62	44	12.51	
Cam-08-L20	11 U 695420 5644587	499.00	67	7.45	
Cam-09-L20	11 U 695582 5644611	550.00	68	8.09	
Cam-10-L20	11 U 695396 5644219	499.30	239	2.09	
Totals		**39,402.57**	**3,635**		

Appendix B Detailed Camera Data

Camera Id #	On CCA?	Camera UTM Location	Camera Duration (Hrs)	Total Animal Movements	Hours per wildlife movement (hrs/animal movements)	Average Wildlife Movements Per Day	whitetail deer	mule deer	elk	moose	coyote	black bear	cougar	fox	skunk	badger	other
Cam-10-L02	yes	11 U 696167 5636686	412.35	212	1.95	12.34	10	4	194	4							
Cam-09-L06		11 U 695365 5637511	794.00	390	2.04	11.79	**371**				14		2	1	1		
Cam-10-L08		11 U 698584 5635298	349.00	130	2.68	8.94	**42**		86		2						
Cam-03-L04		11 U 690580 5641092	466.00	145	3.21	7.47	**14**	116		5			4	5			
Cam-05-L02	yes	11 U 691775 5640519	430.58	129	3.34	7.19	**79**	10	36	3							1
Cam-09-L04		11 U 695276 5639875	142.00	42	3.38	7.10	**39**	1			1						1
Cam-04-L01	yes	11 U 691350 5640324	450.87	93	4.85	4.95	6	10	76					1			
Cam-06-L04		11 U 692988 5639800	632.00	102	6.20	3.87	**101**										1
Cam-08-L09		11 U 694897 5635987	159.00	25	6.36	3.77	**20**				2			1			2
Cam-01-L01	yes	11 U 687718 5636449	424.07	65	6.52	3.68	**16**	9	29	1	9						1
Cam-07-L04		11 U 693642 5634966	363.00	55	6.60	3.64	**28**	15	5	5			2				
Cam-03-L01	yes	11 U 688375 5640577	522.53	75	6.97	3.44	**61**	5	9								
Cam-07-L02	yes	11 U 693510 5633368	435.58	61	7.14	3.36	6	5	47	3							
Cam-08-L02		11 U 694125 5635101	473.70	62	7.64	3.14	**50**	8		3							1
Cam-02-L02	yes	11 U 688144 5639615	477.72	58	8.24	2.91	**40**	14	2	2							
Cam-05-L01	yes	11 U 691578 5633434	525.88	63	8.35	2.88	**30**	8	23					2			
Cam-05-L05		11 U 692371 5636843	1005.00	117	8.59	2.79	**62**	33			3	5		11			3
Cam-07-L03	yes	11 U 693604 5633357	335.25	37	9.06	2.65	6	1	24	6							

Cam-06-L03	yes	11 U 692857 5635401	690.53	76	9.09	2.64	**42**	18	7	6	1		2				
Cam-02-L03	yes	11 U 688185 5640682	520.18	55	9.46	2.54	**36**	15		3							1
Cam-06-L02	yes	11 U 692770 5636363	501.85	53	9.47	2.53	**34**	15	2	2							
Cam-10-L03	yes	11 U 696387 5637190	263.48	26	10.13	2.37	**19**	6	1								
Cam-10-L01	yes	11 U 695413 5640186	433.20	42	10.31	2.33	**22**		15	1				2			2
Cam-08-L03	yes	11 U 694152 5635465	670.43	60	11.17	2.15	**39**	11		4	1	5					
Cam-07-L01	yes	11 U 693153 5639806	310.85	27	11.51	2.08	5		5	1 6				1			
Cam-04-L02	yes	11 U 691468 5638268	531.42	45	11.81	2.03	10	6	5	1			1	21			1
Cam-01-L02	yes	11 U 687905 5636552	694.35	54	12.86	1.87	**24**	25	3	1		1					
Cam-01-L08		11 U 688028 5640230	142.00	11	12.91	1.86	10			1							
Cam-10-L04		11 U 696401 5637192	568.00	41	13.85	1.73	**11**	24				2		3			1
Cam-02-L01	yes	11 U 688110 5637170	519.12	37	14.03	1.71	**11**		23	1	1			1			
Cam-05-L04		11 U 692352 5637684	358.00	25	14.32	1.68	**16**	1		6		2					
Cam-08-L01	yes	11 U 694052 5639846	423.60	29	14.61	1.64	**17**	8	1	3							
Cam-03-L03	yes	11 U 690088 5633598	454.92	31	14.67	1.64	**30**			1							
Cam-05-L07		11 U 692642 5638138	841.00	56	15.02	1.60	**43**			3	10						
Cam-03-L07		11 U 691345 5640436	987.00	64	15.42	1.56	**47**	4	1	1 1				1			
Cam-04-L08		11 U 691555 5640039	160.00	10	16.00	1.50	10										
Cam-09-L01	yes	11 U 694909 5631737	437.12	27	16.19	1.48	**13**		7	6							1
Cam-01-L03	yes	11 U 687958 5636770	301.98	18	16.78	1.43	**16**		2								
Cam-05-L03	yes	11 U 692024 5633938	551.52	32	17.23	1.39	**12**	2	5	3				9			1
Cam-08-L08		11 U 694853 5631743	142.00	8	17.75	1.35	8										
Cam-09-L05		11 U 695338 5640442	470.00	26	18.08	1.33	**26**										
Cam-01-L04		11 U 687989 5636845	366.00	20	18.30	1.31	**11**	6				3					
Cam-01-L09		11 U 688107 5637013	163.00	8	20.38	1.18	6			2							
Cam-10-L05		11 U 696432 5636260	310.00	15	20.67	1.16	6				8		1				
Cam-04-L04	yes	11 U 691480 5638600	385.00	18	21.39	1.12	**14**	2									2
Cam-01-L06		11 U 688024 5637064	139.00	6	23.17	1.04	3							3			
Cam-01-L05		11 U 688023 5637139	858.00	34	25.24	0.95	**32**				2						
Cam-02-L04		11 U 688356 5641228	331.00	12	27.58	0.87	**11**			1							
Cam-01-L07		11 U 688027 5637079	196.00	7	28.00	0.86	6				1						
Cam-08-L07		11 U 694824 5631740	143.00	5	28.60	0.84	1			1	3						

Cam-03-L06		11 U 690655 5633695	907.00	31	29.26	0.82	**20**				3			5			3
Cam-07-L05		**11 U 693855 5637974**	**1293.00**	**43**	**30.07**	0.80	**23**			**4**	**3**	**2**	**2**		**6**	**1**	**2**
Cam-07-L08		11 U 694051 5634994	163.00	5	32.60	0.74	5										
Cam-07-L07		11 U 694020 5636167	144.00	4	36.00	0.67	3										1
Cam-08-L05		11 U 694563 5634344	675.00	18	37.50	0.64	**18**										
Cam-10-L07		11 U 696506 5636695	676.00	18	37.56	0.64	**18**										
Cam-09-L02	yes	11 U 695215 5639603	1149.12	30	38.30	0.63	7	5	10	7							1
Cam-04-L05		11 U 691503 5634657	787.00	20	39.35	0.61	**12**						1	4			2
Cam-06-L05		11 U 693000 5635165	333.00	8	41.63	0.58	4			3	1						
Cam-06-L01	yes	11 U 692742 5636576	352.60	8	44.08	0.54	8										
Cam-04-L03	yes	11 U 691474 5638294	763.00	17	44.88	0.53	2		13	2							
Cam-03-L02		11 U 688567 5633652	437.03	9	48.56	0.49	3	1		3				1			1
Cam-10-L06		11 U 696436 5635124	906.00	18	50.33	0.48	**13**			1	1	2		1			
Cam-07-L06		11 U 693991 5637236	332.00	6	55.33	0.43	5		1								
Cam-04-L06		11 U 691549 5640018	1009.00	15	67.27	0.36	**14**							1			
Cam-06-L06		11 U 693082 5631672	143.00	2	71.50	0.34	1				1						
Cam-08-L04		11 U 694243 5639835	173.00	2	86.50	0.28	2										
Cam-08-L06		11 U 694668 5634210	332.00	3	110.67	0.22	1		2								
Cam-05-L06		11 U 692518 5635023	473.00	2	236.50	0.10	2										
Cam-01-L21		11 U 696585 5630645	815.82	44	18.54	1.29	28	0	0	4	10	0	0	0	0	0	2
Cam-02-L20		11 U 696274 5630634	673.00	7	96.14	0.25	2	0	0	3	2	0	0	0	0	0	0
Cam-03-L20		11 U 696481 5630832	815.00	7	116.43	0.21	1	0	0	4	1	0	0	0	0	0	1
Cam-04-L20		11 U 690677 5639139	550.00	34	16.18	1.48	33	0	0	0	0	0	0	0	0	0	1
Cam-04-L21		11 U 691469 5632971	143.00	2	71.50	0.34	0	0	0	0	0	0	0	0	1	0	1
Cam-05-L20		11 U 695556 5642724	498.00	7	71.14	0.34	5	0	0	2	0	0	0	0	0	0	0
Cam-06-L20		11 U 695377 5642736	499.00	18	27.72	0.87	16	0	0	2	0	0	0	0	0	0	0
Cam-07-L20		11 U 690641 5639145	550.62	44	12.51	1.92	39	0	0	0	3	0	0	0	2	0	0
Cam-08-L20		11 U 695420 5644587	499.00	67	7.45	3.22	64	0	0	3	0	0	0	0	0	0	0
Cam-09-L20		11 U 695582 5644611	550.00	68	8.09	2.97	62	0	0	0	6	0	0	0	0	0	0
Cam-10-L20		11 U 695396 5644219	499.30	239	2.09	11.49	224	0	0	0	15	0	0	0	0	0	0