

Nisku Wildlife Corridor Report

Final Report

April 3, 2019

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Revision 3



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EXECUTIVE SUMMARY

The Nisku Wildlife Corridor Report is the culmination of a two phase studio project partnership between the University of Alberta's School of Urban and Regional Planning and Leduc County. Phase I consisted of a review of planning policy within the Nisku Area that recommended protecting and connecting Environmentally Significant Areas (ESA), and aligning all local, regional, and inter collaborative policies with those protections. The majority of ESAs were found to be along the Blackmud Creek Drainage Basin.

Phase II built upon these recommendations and findings by conducting further evaluation on the benefits and drawbacks of creating a wildlife corridor in Nisku. SWOT and community benefits analyses, wildlife corridor best practices and re-established sites reviews, and research into the merits of wildlife corridors in developed industrial and urban areas showed that there is adequate space, multiple regional connections, and justifiable biodiversity for a wildlife corridor to be built and maintained in the Nisku Area. Phase II further bolstered the recommendation for the Nisku Wildlife Corridor to follow the Blackmud Creek Drainage Basin.

The preferred route provides ample room for wildlife movement and ecological systems functioning, passive recreation and educational opportunities, and regional connections to Saunders Lake and the Beaver Hills Biosphere. The route aids flood mitigation and groundwater preservation efforts through the renaturalization of Blackmud Creek within the Nisku Area. Placing the majority of the proposed corridor within Blackmud Creek's 1:100 year

floodplain and proactively working with landowners and non-governmental organizations to naturalize flood prone areas encourages steady corridor development over time while minimizing potential conflicts with higher value properties. The agricultural benefits of wildlife corridors are also clear, providing both direct and indirect benefits by reducing soil erosion, enhancing pollination, increasing pest control and crop nutrients, and providing windbreaks.

Recommendations for implementing a wildlife corridor along Blackmud Creek include:

1. Completing a detailed biodiversity study for the Nisku Area;
2. Creating one, comprehensive Nisku Area Structure Plan that incorporates a wildlife corridor along Blackmud Creek within the 1:100 year flood plain; and
3. Partnering with private landowners, NGO's, and regional stakeholders to begin re-naturalizing the 1:100 year floodplain lands.

To aid with implementing this corridor, or any others that Leduc County may consider, the research team has provided a Wildlife Corridor Criteria List to serve as a kick-off document for any future wildlife corridor planning and execution.

Overall, the Nisku Wildlife Corridor Report lays the groundwork for creating a connected, biodiverse wildlife corridor in the Nisku Area by updating existing policy, following best practices, taking advantage of the recreational and agricultural merits of wildlife corridors, and promoting private and public cooperation and/or land acquisition.

1 INTRODUCTION

1.1 STUDY AREA

The study area for the Nisku Wildlife Corridor Report is shown in Figure 1. The study area consists of a wide mix of industrial, agricultural, and residential land uses. Boundaries for the study area include the Queen Elizabeth II Highway to the west, the City of Leduc to the south, the City of Beaumont to the east, and the City of Edmonton to the north. Major regional considerations include the Edmonton International Airport (west of the QEII) and the Nisku Business Area's status as a key economic driver for the Edmonton Metropolitan Region.

1.2 OVERVIEW OF PHASE I

Phase II of the Nisku Wildlife Corridor Report builds off of the findings and recommendations outlined in Phase I. Phase I found that a wildlife corridor following the Blackmud Creek drainage basin would be preferred and included recommendations for:

1. Creating local policy for connecting Environmentally Significant Areas;
2. Executing a mandatory review/update of all ASPs to align with Recommendation 1, the new Municipal Development Plan, and statutory regional documents; and
3. Embedding the protection and connection of Environmentally Significant Areas into Intermunicipal Development Plans and Intermunicipal Collaboration Frameworks.

For a detailed overview of Phase I, please see the complete Phase I Report attached in Attachment 1.

1.3 PHASE II DELIVERABLES

The scope of Phase II consists of the following deliverables as per the Terms of Reference (see Attachment 2):

1. Evaluating options for a wildlife corridor in the study area;
2. SWOT analysis for the study area;
3. Wildlife corridor best practices review;
4. A discussion on the merits of wildlife corridors in built-up industrial and urban areas;
5. Re-establishment considerations for areas where traditional wildlife corridors have been overtaken by urban development;
6. Analysis of the community benefits of a wildlife corridor, including
 - a. Agricultural benefits
 - b. Recreation, gathering space, and eco-tourism opportunities
 - c. Creating a sense of place
7. A Wildlife Corridor Criteria List to be used when evaluating and determining a wildlife corridor.

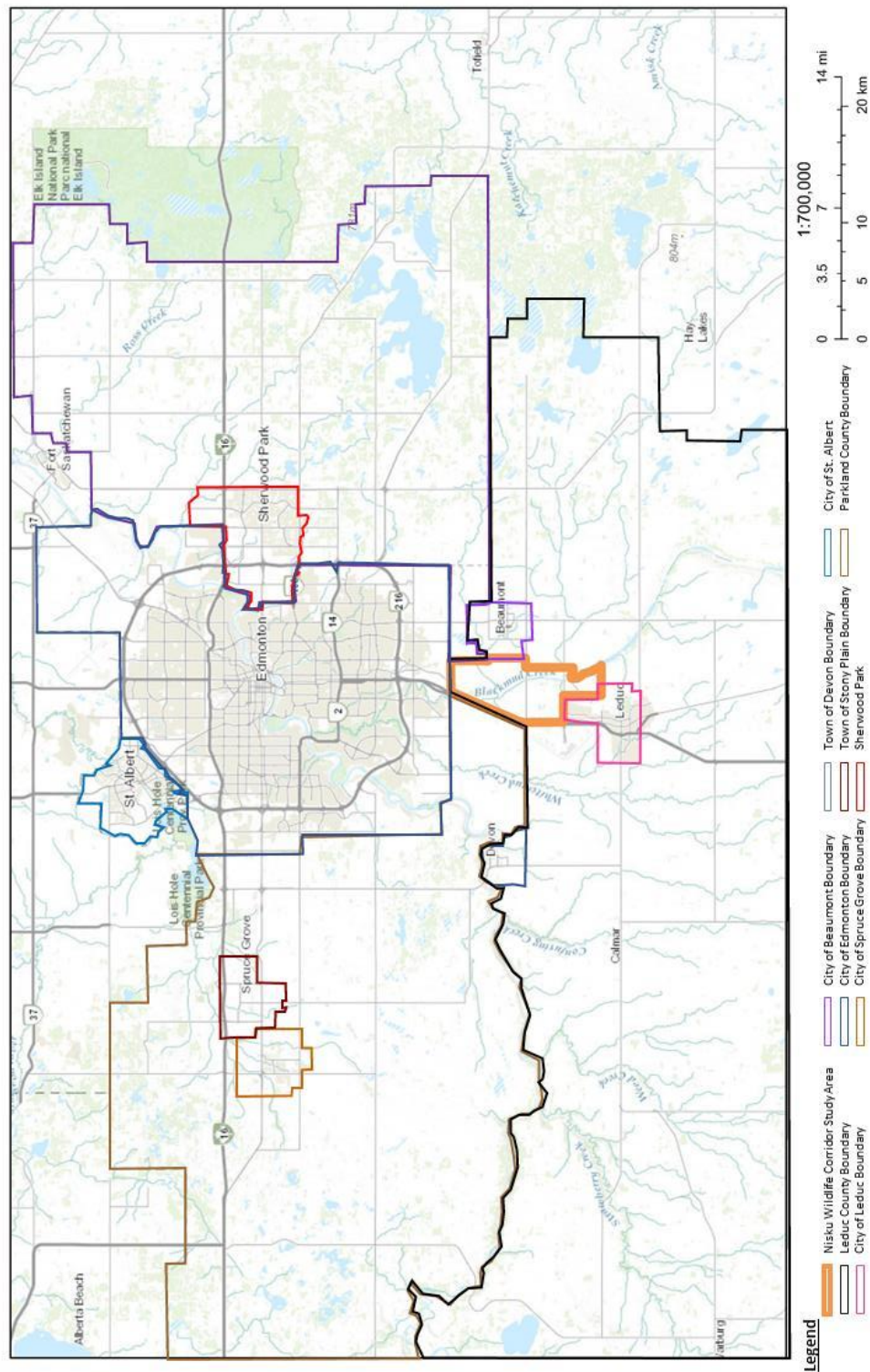


Figure 1 Study Area in the Regional Context

1.4 KEY FINDINGS

This report highlights eight key findings split over three categories:

IMPLEMENTATION

1. Leduc County has an opportunity to become one of the first well documented municipalities in Alberta to implement a wildlife corridor along a watercourse in a mixed urban industrial and rural agricultural setting;
2. Private land ownership and management is a central issue for wildlife corridors and there are well established planning tools available to make public and private partnerships successful;
3. Wildlife corridor implementation frameworks are critical in order to ensure collaboration and commitment between all public and private stakeholders;

NEEDS

4. The local and regional importance of the Environmentally Significant Areas and increased development pressures within the study area warrant the creation of a wildlife corridor, with a focus on connecting existing natural areas first;
5. Creating and implementing a wildlife corridor and restoring habitat are compatible processes that must be executed together within the study area;
6. Wildlife corridors are not just about establishing connections - they require consideration for ecological systems and functions as well;

BENEFITS

7. Passive recreation is compatible with wildlife corridors as long as it is done appropriately, and can lead to an increased sense of place through education, exploration, and interpretation; and
8. Biodiversity can increase crop yields under the right conditions;

1.5 GOALS AND RECOMMENDATIONS

The above findings resulted in the following two goals and four recommendations for a Nisku wildlife corridor. Please note that these recommendations build upon the policy updates suggested in Phase I and the preliminary recommendations for conservation and connectivity:

Goal 1: Connect Environmentally Significant Areas within the study area to regional wildlife systems, focusing on the Blackmud Creek Drainage Basin and the Beaver Hills Biosphere.

- a. Complete a detailed biodiversity study for Nisku in order to fully understand the range of wildlife and ecology that exist in the study area;
- b. Create one, comprehensive Nisku Area Structure Plan (NASP) that incorporates ESAs through a wildlife corridor along Blackmud Creek within the 1:100 year flood plain; and
- c. Update all local planning documents and applicable regional planning documents (statutory or otherwise) to reflect the new NASP.

Goal 2: Restore Blackmud Creek to its natural state within the 1:100 year floodplain in order to provide environmental, economic, and social benefits for residents, employees, and visitors of Leduc County;

a. Create a Blackmud Creek Working Group, inviting all landowners, regional stakeholders, and relevant Non-Governmental Organizations (NGO's), with the mandate to:

- i. Initiate discussions on the exact wildlife corridor alignment, determine project staging, and to incorporate stakeholder input;
- ii. Renaturalize the 1:100 year Blackmud Creek floodplain lands;
- iii. Provide passive recreation opportunities along the floodplain boundary; and
- iv. Evaluate, monitor, and manage wildlife corridor biodiversity and ecology within the corridor.

1.6 PREFERRED ROUTE AND JUSTIFICATION

Figure 2 shows the preferred route for the Wildlife Corridor and the opportunities for regional connectivity, and Figure 3 shows the Wildlife Corridor proposal in more detail.

The preferred route for the Nisku Wildlife Corridor runs along Blackmud Creek and its drainages. The main reasons for this approach are opportunities for:

- 1) Creating a wildlife corridor that is relatively development and barrier free;
 - a) Avoids major transportation corridors and human conflict areas (QEII, CP railway, Edmonton International Airport, and future economic development nodes) (see Figure 4);

- b) Linear corridor allows for multiple entry points, encourages wildlife to stay within the corridor boundary;
- 2) Building the widest corridor possible through the Nisku Business Park;
 - a) The Blackmud Creek floodplain is over 600m wide, exceeding the minimum recommended width of 100m based on existing studies;
 - b) Large width allows room to add recreation and sense of place opportunities where appropriate, as seen in Figure 5;
- 3) Flexibility
 - a) Land within Blackmud Creek's 1:100 year floodplain is not as commercially valuable as the land surrounding it, allowing for time to discuss conservation options with private landowners and operate on a case by case basis;
 - b) Can implement "easy wins" first and build momentum with other landowners from there;
 - c) Have options when considering regional expansion of the corridor. Not pigeon-holed if regional aspirations do not align with a wildlife corridor along a particular drainage route;
- 4) Increased local and regional surface and groundwater management;
 - a) Naturalizing Blackmud Creek within the study area could reduce maintenance costs and help adapt to future flood events;
 - b) Groundwater from Blackmud Creek already supplies groundwater to the Beaver Hills Biosphere, so further protecting Blackmud Creek is beneficial to the whole region; and
- 5) Connections to regional Environmentally Significant Areas;
 - a) Beaver Hills Biosphere and related parks network as seen in Figure 2;

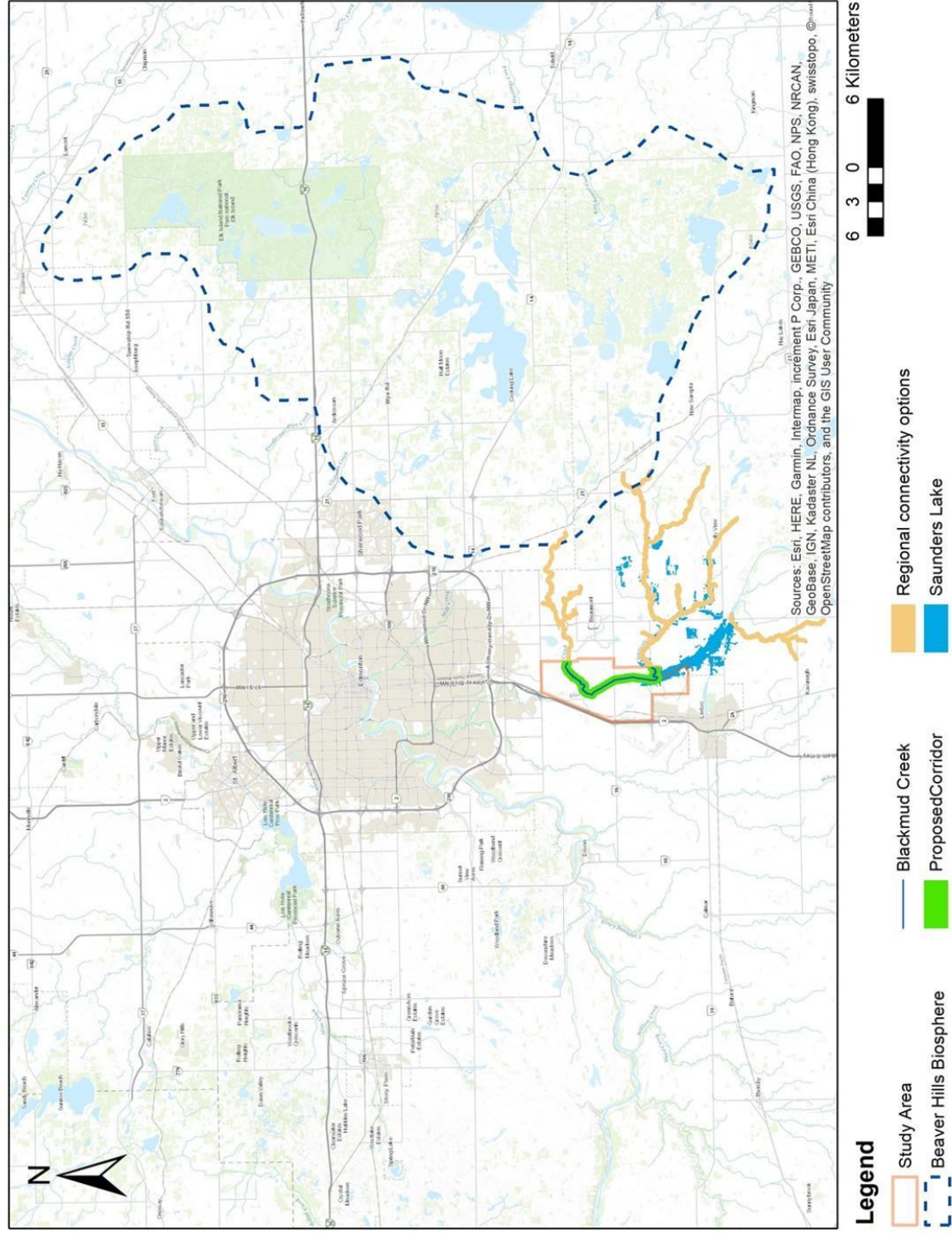
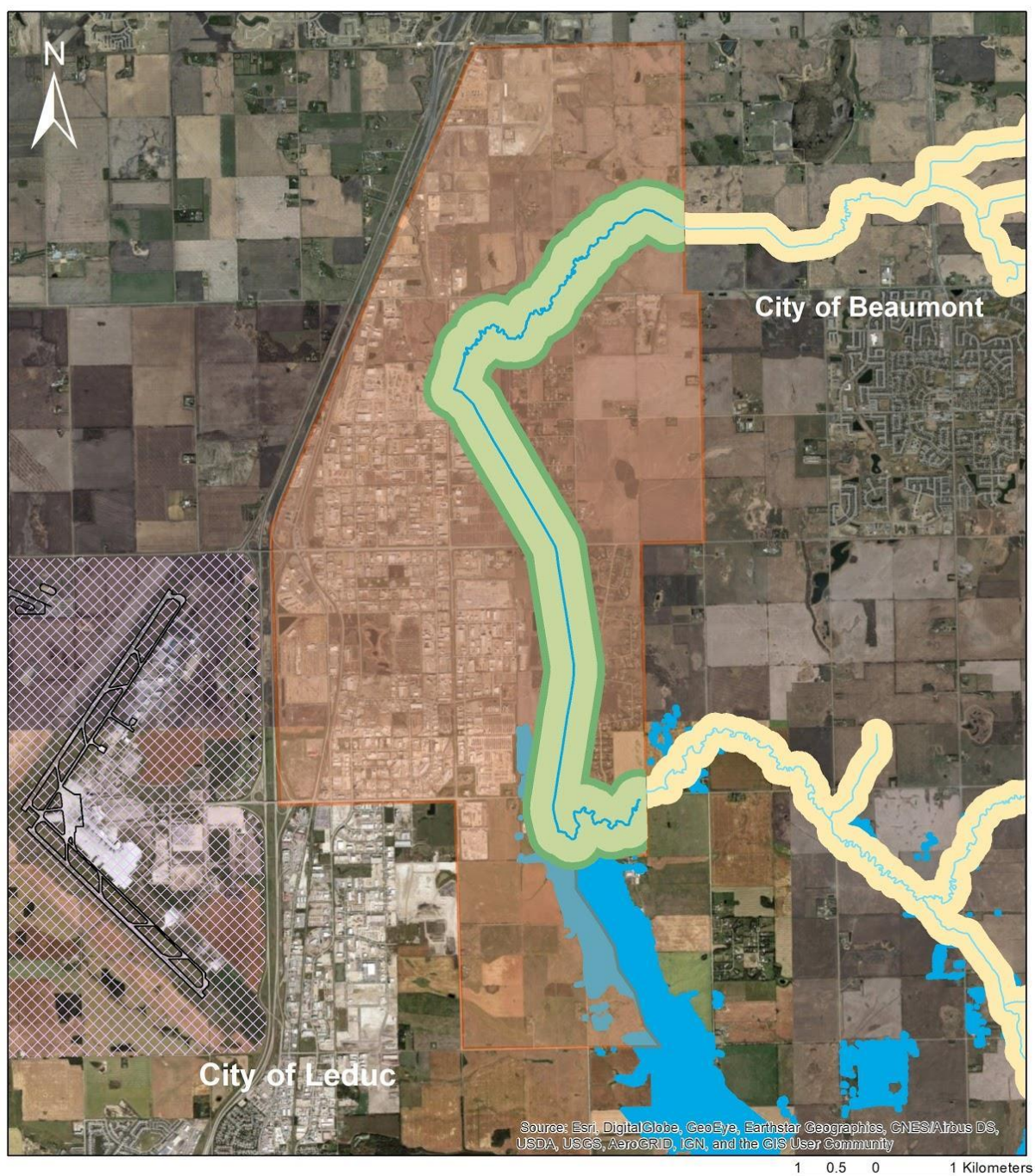


Figure 2 Preferred Route for the Nisku Wildlife Corridor and Regional Connectivity Opportunities



Legend









- | | | |
|--|---|---|
|  Study Area |  Blackmud Creek flood plain |  Regional connectivity options |
|  Edmonton International Airport |  Recreation buffer |  Saunders Lake |
|  Blackmud Creek |  Surface water regional connectivity | |

Figure 3 Nisku Wildlife Corridor Proposal within the Study Area

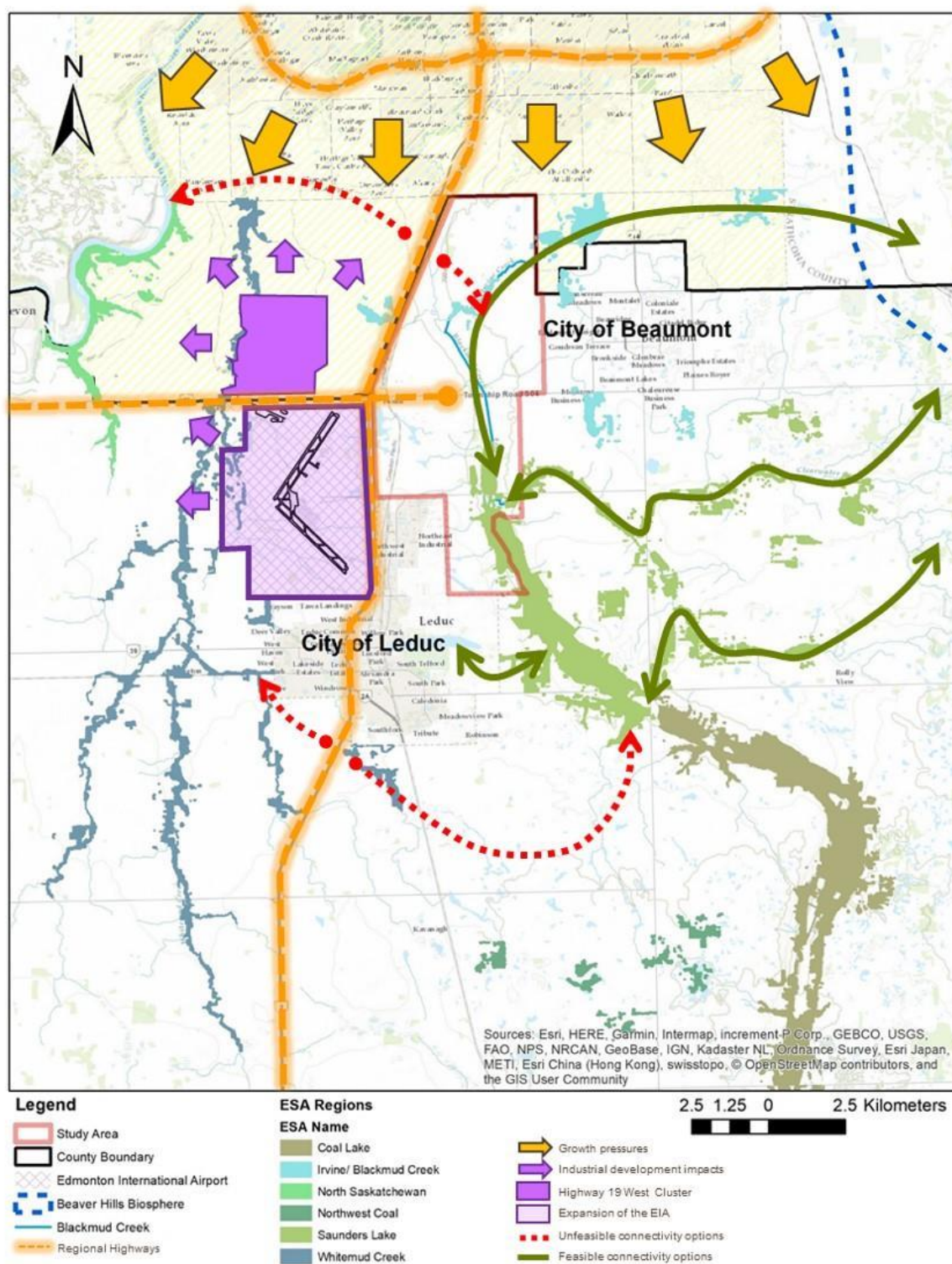


Figure 4 Feasible and Unfeasible Regional Connectivity Options



*Figure 5 Concept View of a Naturalized Blackmud Creek within the Study Area
(Concept Modified from City of Edmonton, 2015)*

Sections 2 through 6 of this report further discuss the justifications for this route selection and provide insight into the best approach for a wildlife corridor within the study area through a SWOT analysis, best practices and merits reviews, restoration considerations, and an analysis of how a wildlife corridor could impact agriculture, recreation, and a sense of place within the study area.

1.7 WILDLIFE CORRIDOR CRITERIA LIST

Attachment 3 contains a Wildlife Corridor Criteria list that was based off the findings and recommendations found within this report. The Wildlife Corridor Criteria List is a summary tool that can be used as a kick-off document when creating and implementing wildlife corridors. The Criteria List is designed so that the project team can identify what applies to their project and follow best practices accordingly.

2 SWOT ANALYSIS

A SWOT Analysis for the study area was carried out in order to form the foundation for any recommendations going forward. This analysis built upon the findings of Phase I.



Figure 6 SWOT Analysis (SWOT Diagram, n.d.)

3 BEST PRACTICES

A wildlife corridor best practices review was undertaken in order to assist Leduc County in determining how to successfully create and implement a wildlife corridor within the study area and overall region.

3.1 PRESERVING NATURAL HABITATS AND SUPPORTING BIODIVERSITY IN BUILT-UP AREAS

3.1.1 HABITAT ISLANDS

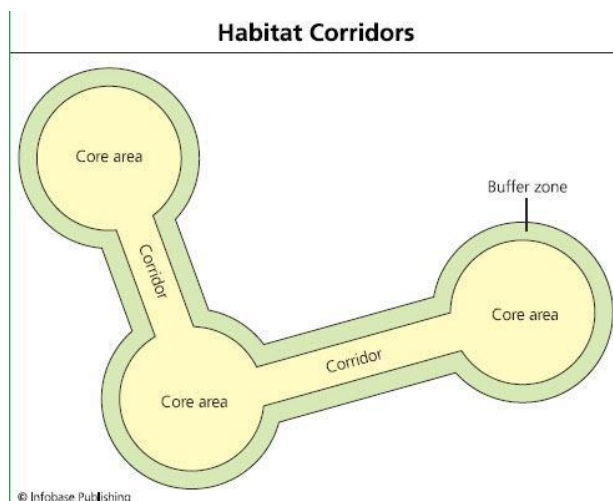
Urbanization can have serious impacts on biodiversity, affecting both the connectivity and the environmental conditions of natural

habitats¹. Many Environmentally Significant Areas with the study area are isolated from each other, creating “habitat patches”. The theory of island biogeography suggests that habitat patches behave like islands (see Figure 7): as the size of the patches and their connectivity increases, species richness improves². This theory also emphasizes that management plans of open spaces and environmental reserves cannot just consider connectivity alone, as the ecological functions and environmental services proposed in these spaces are just as important³. A properly designed wildlife corridors considers all of these factors.

¹ Conservation Corridor, 2018

² Adams and Dove, 1989

³ Conservation Corridor, 2017



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Figure 7 Habitat Island and Corridors (New Green Business Ideas, 2012)

3.1.2 IMPACT REDUCTION

Reducing the impacts of development on wildlife requires a solid understanding of the ecological processes that take place in natural habitats. Following the hierarchy outlined in environment impact assessments can aid in this understanding. The environmental impact assessment hierarchy relies on three main strategies, as shown in Figure 8: Avoid, mitigate, and offset.



Figure 8 Environmental Impact Assessment Hierarchy

3.1.2.a AVOID

Ecologically sustainable development and land use planning principles are the most useful tools to avoid the negative environmental impacts of development on wildlife. The precautionary principle is one such example that suggests that new developments should be environmentally justified by assessing if their gains outweigh their impacts on the environment. When the environmental impacts are larger than the benefits, better alternatives need to be researched.

Creating buffers around Environmentally Significant Areas or patches of wildlife habitat is another key tool. Since the interaction of wildlife with humans is one of the primary causes of disturbance, implementing effective programs and policies that modify human behaviour is extremely important. Examples of these programs include conducting educational activities, installing fauna crossing signs, and reducing vehicle speeds⁴.

3.1.2.b MITIGATE

Promoting the safe movement of fauna through and around urbanized areas is the first step in mitigating negative effects. The implementation of wildlife corridors plays an important role in this regard. Roads and rights-of-way in built-up areas disrupt habitat connectivity, so there is usually a need to consider options such as underpasses, escape routes, or fauna inclusion fences that are specific to the focus species in mind (see Figure 9). Reducing artificial lighting

⁴ British Columbia Ministry of Forests, Lands, and Natural Resources, 2014



Figure 9 An Example of Otter Fencing (Legacy Management Limited, 2019)

surrounding natural areas can also aid wildlife movement.

Invasive and exotic species that can greatly benefit from land clearance and the construction of permanent structures, creating a need to implement mechanisms for weed prevention and control. Revegetating and restoring ecosystems surrounding these cleared areas can also be important in terms of providing additional habitat for impacted species⁵.

3.1.2c OFFSET

Even after implementing actions to avoid and mitigate the negative impacts of existing and new development on wildlife and their habitat, there are usually residual impacts that are difficult to reconcile. Offsetting provides the tools to compensate for these impacts⁶.

Offsetting usually requires a more complex legislative framework to be implemented. In Canada, the Federal Government has put in place legislation with provisions for the use of Conservation Offsets to guarantee the protection of fish habitat, wetlands, and species at risk. In Alberta, the main piece of

legislation that regulates Conservation Offsets is the Alberta Land Stewardship Act (ALSA). The ALSA provides a very broad definition and regulations for offsetting, enabling its use for different purposes. The Alberta Wetland Policy is more specific, consolidating the use of Conservation Offsets to protect wetland habitats and species while sustaining their environmental services. Originally, the Wetland Policy was only to be used for conservation purposes on private land but was later applied to public land as well.

3.2 METHODOLOGIES TO DESIGN, IMPLEMENT, AND EVALUATE WILDLIFE CORRIDORS

3.2.1 CONTEXT

The most important thing to note about the design of a wildlife corridor is that it has to be context-specific. It depends on land-ownership patterns, socioeconomic factors, the policy framework, and available

⁵ British Columbia Ministry of Forests, Lands, and Natural Resources, 2014

⁶ British Columbia Ministry of Forests, Lands, and Natural Resources, 2014

resources⁷. International experience in wildlife corridor design has found that regional corridors are usually implemented to promote general ecological connectivity of natural land covers, while local corridor design responds to much more specific circumstances, such as focal species and their needs⁸.

3.2.2 WIDTH

Studies agree that a wider corridor is more functional, while recognizing that there are financial and practical constraints that may result in narrower corridors⁹. Different studies suggest different minimum widths, but it seems to be generally accepted that a corridor needs to be at least 100 m wide to foster biodiversity¹⁰. Smooth transitions between corridors and built-up uses are also recommended wherever possible.

3.2.3 SHAPE

Available literature highlights that straightforward corridors with irregular patterns incentivize wildlife to stay within the corridor boundaries. Corridors with too many bends can encourage wildlife to leave the corridor and enter developed areas, while extremely symmetrical systems do not resemble the heterogeneity and randomness of nature and are less effective as a result¹¹.

The effectiveness of a wildlife corridor also depends on creating the shortest connection possible between habitat patches to minimize travel time and providing multiple, easy-to-find entrances so that wildlife can

find a route regardless of any barriers or blockages¹².

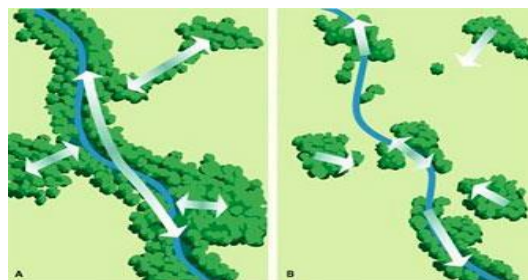


Figure 10 Ideal wildlife corridors are fairly straight, minimize travel time, and have multiple entrances and exits (Conservation Corridor, 2018)

3.2.4 BALANCING WILDLIFE AND RECREATION

3.2.4a INFRASTRUCTURE

Implementing wildlife corridors and creating new recreation opportunities are commonly lumped together due to their mutual reliance on nature and the limited availability of open space in urban areas. The most common type of recreation activities are passive, requiring only trails and less formal infrastructure in areas of environmentally significant features. The low impact perception of trails is misleading though, as research shows that trails can have negative impacts on wildlife corridors¹³. Trampling by walkers and runners triggers soil compaction and erosion, and the clearing of linear sections create hard edges that increase wildlife and human interactions, potentially affecting wildlife mortality. Pollution and the introduction of invasive species are other side effects of including trails in the design of a wildlife corridor.

⁷ Conservation Corridor, 2018

⁸ Beier, Majka, and Spencer, 2008

⁹ Beier, Majka, and Spencer, 2008

¹⁰ Hennings, 2010

¹¹ Holland and Hastings, 2008

¹² Hennings, 2010

¹³ Hennings, 2010

3.2.4b ANIMAL BEHAVIOUR

The presence of human activity causes some species to focus on avoidance instead of going about their normal activities, disturbing entire wildlife populations. There are some animals that can habituate to the presence of trails, with coyotes being a prime example. Coyotes adjust by becoming less active in recreation areas during the day, shifting their activities to nighttime hours when less people are present. Solutions to this issue include

re-distributing human disturbance by varying the number of visitors and areas of recreation.

3.2.5 CREATING BUY-IN

Wildlife corridor creation depends on the social side of science just as much as the natural aspects. Studies suggest that creating buy-in for a wildlife corridor depends on the six criteria shown in Figure 11¹⁴.



Figure 11 Creating Buy-in for Wildlife Corridors

¹⁴ Keeley et al., 2018

3.2.5a WILDLIFE CORRIDOR CREATION

Figure 12 shows the recommended general steps to create a corridor based on available studies¹⁵. These studies recognize that corridor planning can be complex, and that if the process becomes too lengthy and complicated it is better to move on and get something in place rather than risking more land loss to human development¹⁶.

3.2.5b WILDLIFE CORRIDOR IMPLEMENTATION

A corridor cannot be successful without strong policy supporting its implementation and continued management. This includes

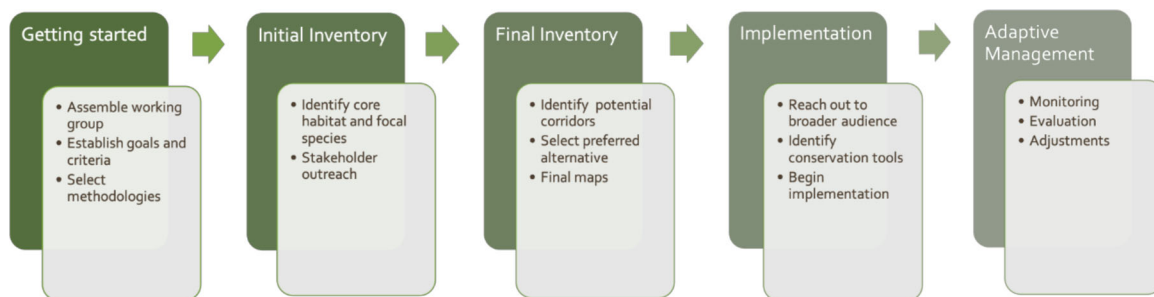


Figure 12 Steps to Create a Wildlife Corridor (Hennings, 2010)

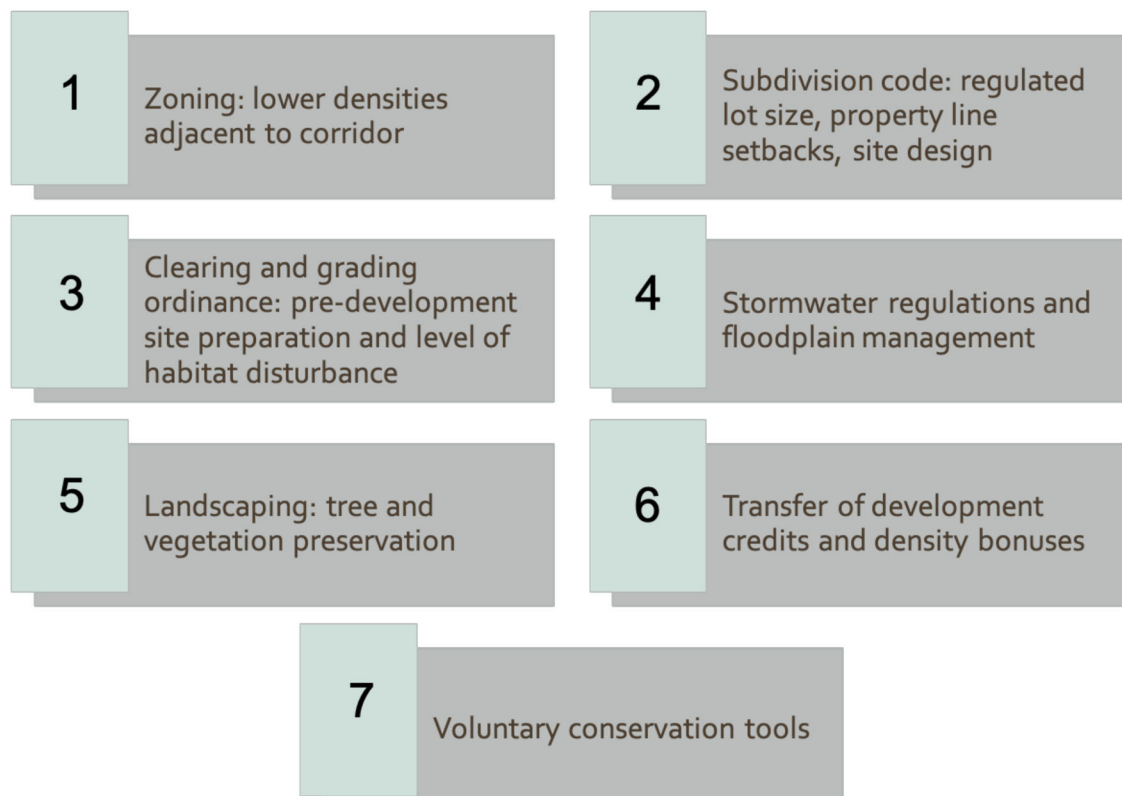


Figure 13 Planning Tools for Wildlife Corridors (Washington Department of Fish and Wildlife, 2009)

¹⁵ Herrera, Chassot, Monge, and Canet, 2016

¹⁶ Hennings, 2010



Figure 14 Left - Box Culvert Example (Parks Canada, 2018), Right – Overpass Example (Idaho Wildlife Federation, 2019)

policies for the conservation of public land and incentives for conservation and stewardship of private land¹⁷. Incorporating wildlife corridor policy into local statutory documents establishes consistency between election cycles and aids elected officials, County administration, and the public when identifying wildlife priorities¹⁸. Figure 13 on the previous page shows some of the planning tools that can be used.

3.3 INTEGRATION OF WILDLIFE MOVEMENT AND TRANSPORTATION INFRASTRUCTURE

Transportation corridors are a direct barrier to wildlife movement, but also have an impact beyond their physical footprint that can contribute to population decline. Negative impacts to wildlife include deterrence, avoidance, mortality from collisions, habitat loss and fragmentation, reduced connectivity, noise, light, and vibration pollution, the spread of invasive

species, and water pollution from vehicle chemicals¹⁹.

3.3.1 ROADWAYS

To avoid and mitigate these negative impacts, crossing structures are employed where necessary. The first step would be to avoid building roads in a wildlife corridor altogether²⁰. Since this is not always possible or the roads pre-date the corridor, mitigation would take the form of crossing structures. As seen in Figure 14, there are two main types of crossing structures: underpasses and overpasses. Underpasses come in two sizes - culverts, which are mainly used for amphibians or smaller wildlife due to size restrictions - and larger structures incorporated with other infrastructure. Wildlife culverts differ from culverts designed for water drainage as these are designed to stay dry except for periods of heavy runoff. Larger underpasses are used when a road structure crosses water or other roads and are designed to incorporate wildlife movement alongside this other infrastructure. Overpasses are mainly used for larger mammals on a longer migration

¹⁷ Ament et al., 2014

¹⁸ Washington Department of Fish and Wildlife, 2009

¹⁹ Beier, Majka, Newell, and Garding, 2008

²⁰ Beier, Majka, Newell, and Garding, 2008

route and include natural vegetation, making this the most expensive option.

In general, crossing structures should be designed with the following twelve best practices in mind²¹:

1. Design crossings for multi-species use;
2. Have suitable habitat on either side of the crossing, this includes providing cover in the form of vegetation;
3. Monitor crossings regularly for obstructions;
4. Build fencing to direct wildlife towards crossing structure;
5. Minimize human activity near structure;
6. Integrate the structures into local and regional plans;
7. Integrate the crossing structure alongside watercourses where applicable;

8. Locate the structure where wildlife have been documented crossing;
9. Design structure so wildlife can see the other side;
10. Temperature inside and outside the structure should be consistent, especially for amphibian species;
11. Air should flow freely; and
12. Natural light should be chosen over artificial light.

An innovative design called a 'dry path' (Figure 15), could be implemented in Leduc County alongside Blackmud Creek where the existing creek crosses a road²². Dry paths are an extension of the banks of a watercourse and are a low cost alternative to building separate wildlife crossing structures where infrastructure already exists.



Figure 15 Dry paths are provided on both sides of this stream crossing (Holopainen, n.d.)

²¹ Beier, Majka, Newell, and Garding, 2008

²² Beier, Majka, Newell, and Garding, 2008

3.3.2 RAILWAYS

Best practices for railways differ from roads because they focus on preventing animals from coming in contact with them in the first place. Studies have suggested seven recommendations to mitigate railroad impacts to wildlife²³:

1. Concentrate mitigation efforts on identified problem areas;
2. Implement a training program for employees with associated reporting of wildlife sightings;
3. Remove carcasses promptly to avoid attracting other wildlife to the area;
4. Remove spilled attractants (such as grain) promptly to avoid attracting wildlife;
5. Reduce chronic spillage through care and maintenance and handling procedures;
6. Manage right of way vegetation to reduce attracting animals; and
7. Share information between jurisdictions.

3.3.3 AIRPORTS

Airports can act as attractants for wildlife due to their nature as an island within an urban landscape. The area provides habitat, food, water, and is virtually predator free²⁴.

Best practices include:

1. Quantify species biodiversity and population numbers to understand the airport's role in the landscape;
2. Manage agricultural uses within airport lands to avoid attracting unwanted species;
3. Introduce buffer areas in and around the airport;

4. Manage stormwater so to meet water treatment requirements while reducing use by species that are aviation hazards; and
5. Develop and maintain datasets in order to assess the risk of current and future wildlife strikes

3.4 CASE STUDIES

Leduc County has an opportunity to become one of the first well documented municipalities in Alberta to implement a wildlife corridor along a watercourse in a mixed urban industrial and rural agricultural setting. Wildlife corridors in developed grassland and agricultural areas are largely understudied or implemented. There are also very few examples that have approached corridors along watercourses, with the ones that do concentrating on big river systems instead of local lakes and creeks. Cases addressing corridors in predominantly industrial areas could not be found.

The studies that do exist focus on areas that currently or are expecting to experience high residential development pressures. Given the loose connections to our study area, this section will focus on how these case studies have used planning instruments to implement wildlife and conservation corridors in their respective regions. The most important of these planning instruments involve how to go about implementing wildlife corridors on private land, since this is one of the main challenges of implementing a wildlife corridor both in the study area and most of the other case studies.

²³ Wells, Woods, Bridgewater, and Morrison, 1999

²⁴ Hesse, Rea, and Booth, 2010

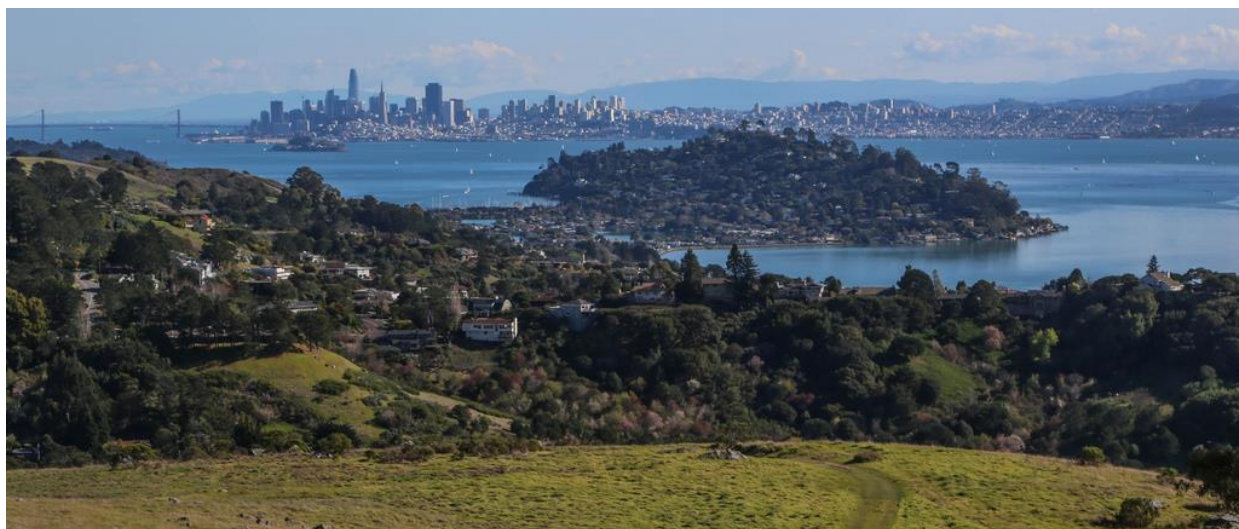


Figure 16 Ring Mountain (Picssr, n.d.)

3.4.1 OUTRIGHT PURCHASE

3.4.1a RING MOUNTAIN, CALIFORNIA

Outright purchasing is a mechanism primarily implemented by land trusts and other non-for-profit organizations dedicated to environmental protection. For instance, the California branch of Nature Conservancy purchased the majority of the land in Ring Mountain (seen in Figure 16), an important habitat patch of the Tiburón Península ecosystem, and the only part of that ecosystem located within an urban area²⁵. The importance of this area lies in the presence of Indigenous and endangered species, and its unusual geological features and biodiversity. Combining land ownership and management rights, Nature Conservancy acquired a total of 152.7 hectares.

3.4.1b WILLISTON, VERMONT

The town of Williston, Vermont provides an excellent example of a complex outright purchase of land for conservation purposes and cooperation between public and private actors. The Town of Williston, in partnership with the Vermont branch of Nature Conservancy, purchased a 119.5 ha property, including an important wetland known as Mud Pond (Figure 17) that provided habitat for a threatened species of salamander²⁶. The Conservancy underwent actions towards the restoration of natural habitat and the enhancement of connectivity between micro-ecosystems present in the land²⁷. Developers contributed money in exchange for mitigation services provided by Nature Conservancy. The Town later repurchased the land from the Conservancy and turned it into a natural reserve park. The Town is in charge of the operation and maintenance of the reserve, which is partially covered by user fees.

²⁵ Adams and Dove, 1989

²⁶ Adams and Dove, 1989

²⁷ Adams and Dove, 1989



Figure 17 Mud Pond, Williston, VT (Wild Burlington, 2016)

3.4.2 THIRD PARTY MANAGEMENT

The organization that purchases the land typically transfers management responsibilities to a third party in order to lower costs and maximize the funds available for purchase. This approach is used in some branches of the Nature Conservancy and the Missouri Department of Conservation. The former has turned a high percentage of its lands to local land-trusts and governments for protection, and the latter created an Urban Biology Program in 1978 to acquire environmentally significant lands in Kansas City and St. Louis, which have been handed over to local parks departments for

management and enhancement of their connectivity²⁸.

Another key example is the billion-dollar investment that New York City has put towards the protection of its water sources. The City has purchased large extensions of land adjacent to water sources and areas that are environmentally important to preserve water quality and quantity²⁹. The management of these areas is done in conjunction with several public actors, interest groups, and non-for-profit partners, which work together to guarantee that water quality remains high so that it does not have to be filtered³⁰.

²⁸ Adams and Dove, 1989

²⁹ Hu, 2018

³⁰ Hu, 2018

3.4.3 TAX INCENTIVES

Both Canada and the United States have an Ecological Gifts Program which encourages landowners to donate a portion of their ecologically-sensitive land to charities and land trusts in exchange for a non-refundable tax credit calculated based on the fair market value of the donation. In Canada, this program “is administered by Environment and Climate Change Canada in cooperation with dozens of partners, including other federal departments, provincial and municipal governments, and environmental non-government organizations”³¹. A significant percentage of the land owned by land trusts and nonprofits has been acquired through land donations under this program. One of the challenges is that since the donations are voluntary, it is difficult to generate connectivity between the protected area unless other mechanisms are used, such as land purchase or trade agreements.

3.4.4 EASEMENTS

Another legal instrument used to preserve land with environmental or agricultural value are conservation easements, a mechanism through which the landowner gives up development rights to a grantee while retaining the other rights in the property. The grantee then have the responsibility to ensure that the environmental value of the land is conserved. Easements are flexible in regards to the type of compensation that the landowner receives. According to the Alberta Land Stewardship Act, conservation easements in Alberta can be compensated with money or tax credits.

Easements can be used to create habitat connectivity when they are applied in a bundle of areas that have ecological potential. One local example is the Eastern Parkland County Conservation Easement. The Edmonton & Area Land Trust (EALT) entered into a partnership with the owner of a 100 acre old growth forest and wetland property in Parkland County that is part of a larger environmentally significant area known for its “corridor effect”³². The owner placed a conservation easement on the land title and still manages the property, while the EALT created an ecological inventory and committed to monitoring site to ensure that conservation values are permanently associated with the property³³. Conservation easements work well in areas where environmentally significant land not suitable for development is directly beside land that has a high property value, such as a wetland that is adjacent to an expanding suburb. Easements could apply to the study area since the main environmental features are wetlands, creeks, lakes, and riparian habitat.

3.4.5 PROTECTION OF ENVIRONMENTALLY SIGNIFICANT AREAS THROUGH BYLAWS

There are laws at the provincial or state level that require the protection of certain areas, such as wetlands, flood plains, and lakes. These areas are usually taken by municipalities upon subdivision of the land in the form of environmental reserves. Although this is a useful instrument to guarantee the protection of ecologically sensitive features of the land, it is not enough to guarantee connectivity in areas where subdivision has already occurred. The Alberta Land

³¹ Government of Canada, 2017

³² Edmonton & Area Land Trust, 2018

³³ Edmonton & Area Land Trust, 2018

Stewardship Act does have provisions that could enforce conservation in areas where further subdivision is not likely, but this tool is not recommended due to possible landowner opposition.

At the local level, zoning regulations are the most effective instruments to ensure adequate buffers and setbacks, compatible uses, and to ensure that there is a smooth transition between the protected and the built-up areas. In Lake County, Illinois the zoning bylaw states that communities may set aside between 3% and 8% of their developable land for the creation of “bufferyards” that enhance wildlife habitat while reducing noise, light and air pollution from nearby incompatible uses pollution³⁴.

Another bylaw instrument for the protection of environmental interests of the land is the Transfer of Development Credits (TDC). The use of TDC in Canada has been very limited, but examples do exist. A TDC program was implemented in Prince Edward Island for the conservation of 5 km of shoreline in the French River Area³⁵. In Alberta, this instrument has been used by the municipalities of Wheatland and Bighorn for the protection of agricultural land³⁶. These municipalities used TDC’s to cluster development in certain areas, keeping the continuity and large size of agricultural parcels. It is important to highlight that protecting agricultural land is a complementary measure to the implementation of wildlife corridors and should be pursued by the County not only as a strategy to boost agricultural operations, but also as an environmental strategy to

preserve open spaces and natural land cover.

3.4.6 LOCAL WILDLIFE CORRIDOR EXAMPLE: STURGEON REFINERY

A similar example of a wildlife corridor in the Edmonton Metropolitan Region is located at the Sturgeon Refinery in the Industrial Heartland³⁷. As shown in Figure 18, North West Refining set aside land to act as a wildlife corridor connecting the region south of the project to the North Saskatchewan River valley.

3.4.7 LESSONS LEARNED

These case studies demonstrate that the successful implementation of a wildlife corridor is dependent on the ability of the municipality to create partnerships with multiple actors, primarily conservation organizations and private landowners. Unilaterally creating a wildlife corridor that is the scope and scale of the current study area is not recommended because of the financial burden that it would put on the municipal budget and because of the resources that are needed to manage the conservation of the land.

It is also clear that property ownership is a challenge and there needs to be a combination of implementation mechanisms available to win the support of landowners. A wildlife corridor cannot be accomplished without outlining and providing compensation for the rights, real or perceived, that property owners must give up in order to make a conservation project of this magnitude work. Given that wildlife

³⁴ Adams and Dove, 1989

³⁵ Greenaway and Good, 2008

³⁶ Greenaway and Good, 2008

³⁷ North West Redwater Partnership, 2016



Figure 18 Plan View of the Sturgeon Refinery Wildlife Corridor, Northeast of Fort Saskatchewan, Alberta (Google Maps, 2019)

corridors are not limited by political jurisdictions, it is important to get commitment and support from surrounding municipalities, especially for management schemes such as TDC programs.

4 MERITS OF A WILDLIFE CORRIDOR IN THE STUDY AREA

4.1 SOCIAL BENEFITS

The social benefits of wildlife corridors can be classified into three cultural ecosystem services³⁸: recreation, education, and aesthetics³⁹.

4.1.1 RECREATION

Recreation includes all forms of active transportation as well as wildlife viewing opportunities. Riparian corridors such as the one proposed for Leduc County are ideal for recreation because it includes the possibility for water related activities where suitable.

4.1.2 EDUCATION

Education includes opportunities to learn about nature either on your own or in a group setting, which is important as residents and employees within the County become more urbanized and lose their access to nature.

³⁸ Millennium Ecosystem Assessment, 2005

³⁹ USDA, 1999

4.1.3 AESTHETICS

Aesthetics include the spatial structure of the corridor, the sense of place and identity, and seasonal diversity.

These social benefits are achieved through natural spaces acting as public spaces, providing opportunities for people to gather and develop ties through social interactions⁴⁰. A corridor in Leduc County would contribute to the development of these social ties and a creating a sense of place, which will be discussed later in this report.

4.2 ECONOMIC BENEFITS

A wildlife corridor can provide economic benefits by meeting a human need or want⁴¹. While economic benefits of wildlife corridors are numerous, it is difficult to assign hard economic values to most ecosystem services other than increased property values for those bordering the corridor^{42,43}. Ecosystem services are defined as “*benefits people derive from ecosystems*”⁴⁴. There are four main categories of ecosystem services⁴⁵:

1. Provisioning services: food, water;
2. Regulating services: climate regulation, water purification, pollination, and pest control;
3. Habitat services: habitat for species, maintaining gene pools; and
4. Cultural services: spiritual enrichment, intellectual development, recreation, and aesthetic values.

A wildlife corridor within the study area could derive direct and indirect economic benefits from these four categories. Examples include carbon storage, flood protection, increased land value for parcels adjacent to corridor, recreation opportunities, and mutual benefits between wildlife and agriculture.

As an example, naturalizing Blackmud Creek within the study area could limit soil erosion, reducing the amount of sediment that flows into Blackmud Creek. This sedimentation decrease provides direct economic benefits by reducing the amount of dredging required (if any at all), enhancing water quality and stormwater capacity, and maintains the high quality residential, agricultural, and industrial land⁴⁶ above the 1:100 year floodplain.

The indirect agricultural economic benefits of a wildlife corridor are numerous^{47,48}. An increase in wildlife species can lead to enhanced pollination, pest control, and breakdown of organic matter to provide nutrients for crops. Windbreaks created by trees in the corridor can also lead to higher crop yields.

It's important to highlight that these economic benefits flow to the wider community and not just those who border the corridor⁴⁹. For example, the entire Blackmud Creek watershed could benefit from improvements. With this said, it will be important to highlight

⁴⁰ Kazmierczak, 2013

⁴¹ USDA, 1999

⁴² Nelson et al. 2009

⁴³ USDA, 1999

⁴⁴ Millennium Ecosystem Assessment, 2005

⁴⁵ Biodiversity Information System for Europe, 2010

⁴⁶ USDA, 1999

⁴⁷ Jesweit and Hermesen, 201

⁴⁸ USDA, 1999

⁴⁹ Lant and Tobin, 1989

the economic benefits to private landowners when proposing the corridor⁵⁰.

4.3 ENVIRONMENTAL BENEFITS

As noted throughout this report and in Phase I, the environmental benefits of a wildlife corridor are significant and well documented. The main purpose of a wildlife corridor is to reconnect wildlife populations and maintain/restore biodiversity, which humans ultimately benefit from through ecosystem services. Briefly, environmental benefits include increased genetic diversity, reducing heat build-up, reducing soil erosion, improving air quality, rainfall retention, and reducing pollution⁵¹. Wildlife corridors also help species adapt to climate change by allowing wildlife to move from their current habitat to areas that are more suitable over time⁵².

5 RESTORATION

Restoration is the action of re-establishing ecosystem functions by means of applying strategies that will return the land to its natural state⁵³. The ultimate purpose is to provide more and better habitats to wildlife and restore the natural conditions that support life and biodiversity. Restoration results in more and improved wildlife habitat, soil retention, and water management both at the local and regional levels.

When restoration occurs, wildlife are encouraged to move back to the affected area following temporary disturbance. A big

challenge of restoration processes is that they can take many years to yield visible results as some critical habitat components can take decades form, as shown in Figure 19⁵⁴. Restoration actions demand a deep understanding of the regional ecology and need to encompass strategies for enhancing species diversity, structural aspects of the land, and ecological processes.

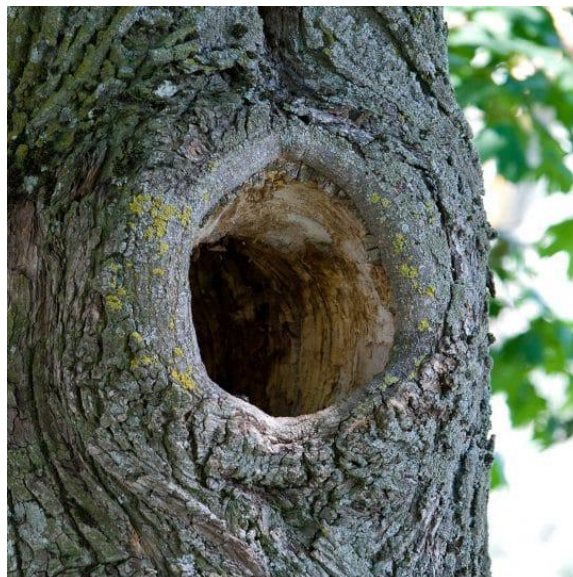


Figure 19 Critical habitat components such as tree hollows can take decades to form in restored areas (Elite Tree Care, 2017)

The most effective way of conducting restoration is by recreating the vegetative cover that existed before the disturbance, followed by active management practices. This process is very resource intensive, and is usually conducted in partnership with higher levels of government, communities, interest groups and conservation organizations. Figure 20 shows a proposed framework for the implementation of restoration strategies, specifying the actions that need to be taken and the important aspects to consider at each level.

⁵⁰ Nelson et al., 2009

⁵¹ Project EverGreen, 2019

⁵² Conservation Corridor, 2018

⁵³ Conservation Corridor, 2018

⁵⁴ Gleeson and Gleeson, 2012

Regional level	Landscape Level	Patch Level	Site Level
<ul style="list-style-type: none"> • Long-term vision • Ecological priorities • Monitoring programs 	<ul style="list-style-type: none"> • Identify Suitable habitat • Enhance connectivity • Ensure representation of ecosystems 	<ul style="list-style-type: none"> • Size and shape • Location • Diversity management 	<ul style="list-style-type: none"> • Indigenous species • Landform • Natural layers of vegetation • Fine-scale patchiness • Ground-layer components • Control of disturbances

Figure 20 Framework for ecological restoration (Gleeson and Gleeson, 2012)

It is important to note that since restoration processes are intentional activities, they can be undertaken from multiple perspectives:

“

From a **conservation perspective**, it recovers biodiversity in the face of an unprecedented, human-mediated extinction crisis. From a **socioeconomic perspective**, ecological restoration recovers ecosystem services from which people benefit. From a **cultural perspective**, ecological restoration is a way that we strengthen our communities, institutions, and interpersonal relationships by participation in a common pursuit. From a **personal perspective**, ecological restoration allows us to reconnect with the rest of Nature and restore ourselves as we restore impaired ecosystems.

Aronson and Andre (2013)

In Canada, there are guidelines for the restoration of protected natural areas. Figure 21 summarizes the process suggested for the planning and implementation of restoration programs.

5.1 RESTORATION WITHIN THE STUDY AREA

As shown in the County's ESA study (see Phase I Report in Attachment 1 for a detailed synopsis), Nisku is located within an important regional ecosystem characterized by the abundance of surface and groundwater, and riparian habitat.

5.1.1 GROUNDWATER

The numerous basins of the study area play an important role in filtering water, irrigating agricultural lands, regulating the temperature of microbiomes, and providing habitat for different species, among many other ecosystem services. The groundwater present in the study area contributes to the aquifer recharge of a larger UNESCO Beaver Hills Biosphere located to the northeast of Leduc County (see Figure 22).

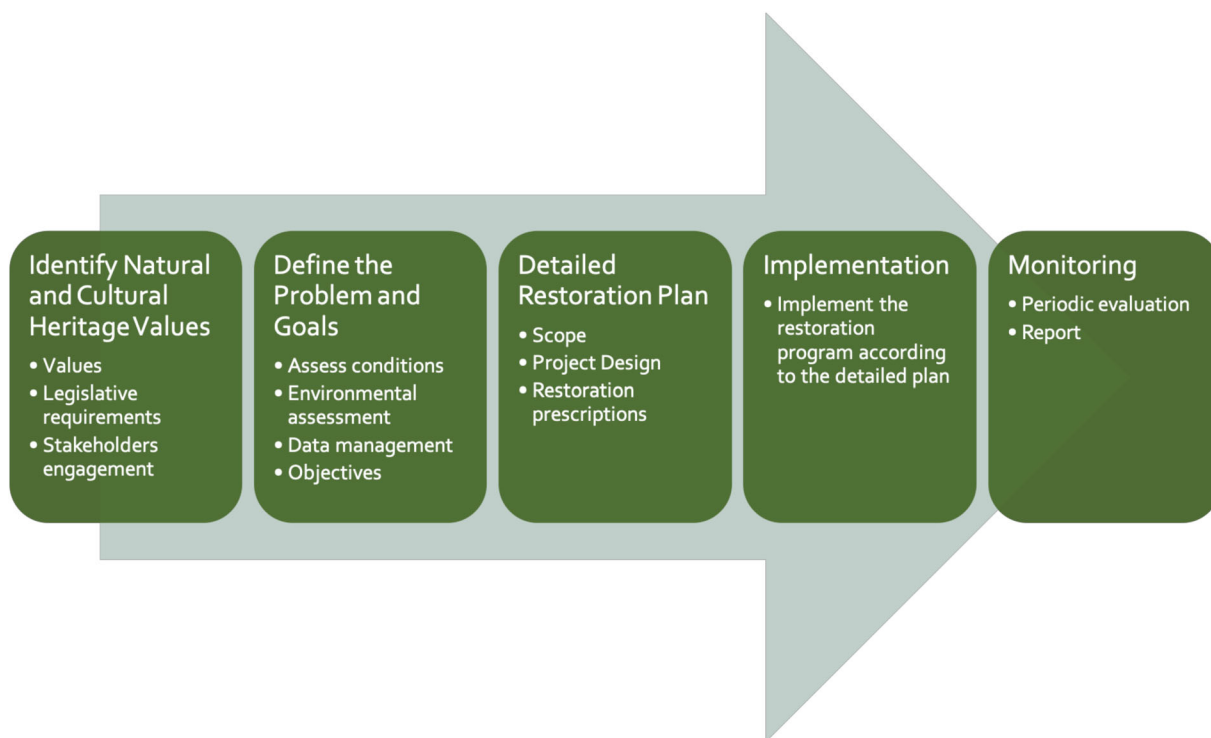


Figure 21 Process for the Restoration of Canada's Protected Natural Areas (Parks Canada and the Canadian Parks Council, 2008.)

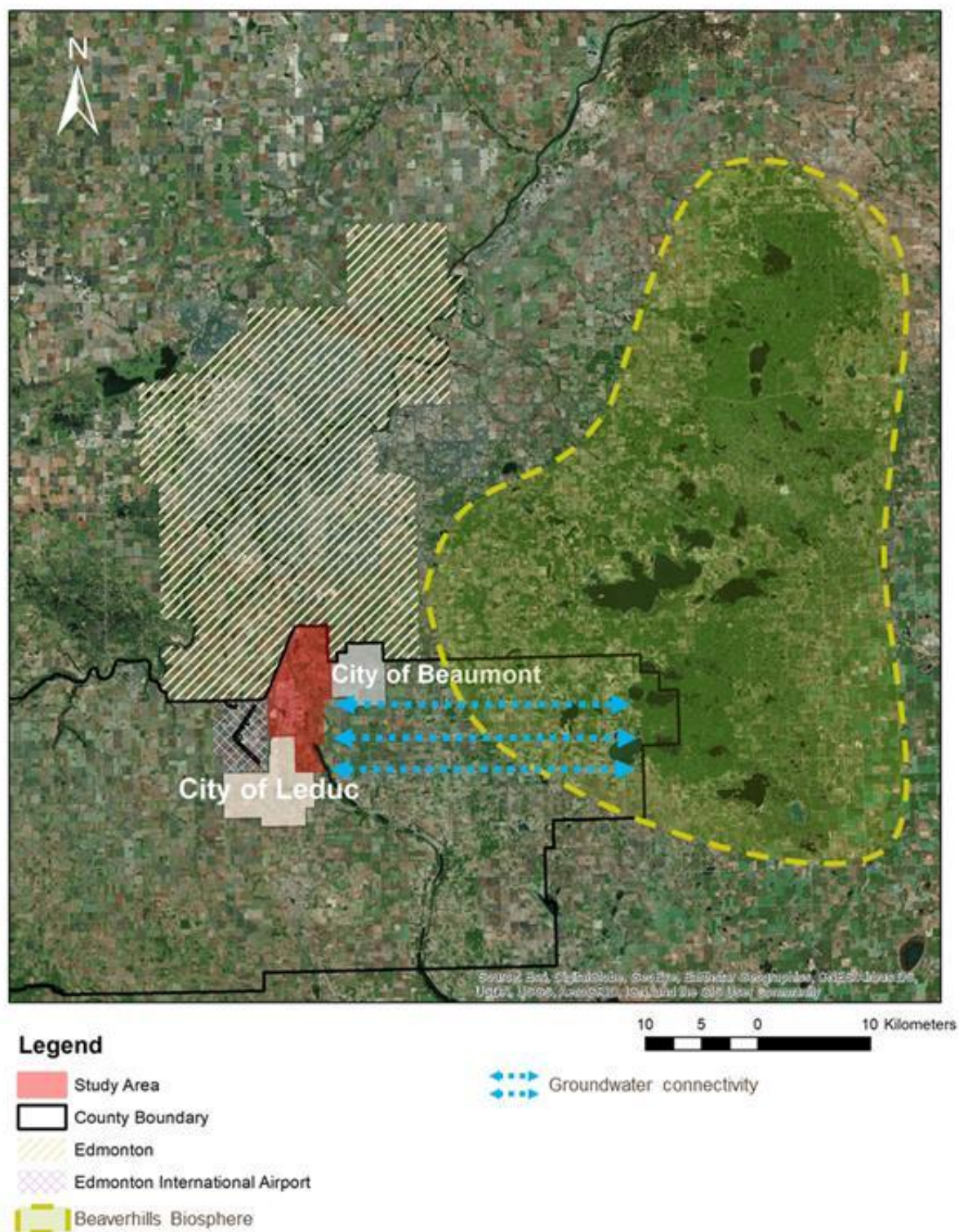


Figure 22 Groundwater Connections to the Beaver Hills Biosphere

5.1.2 CURRENT URBAN GROWTH

The regional ecosystem containing the study area has experienced different levels of disturbance throughout the years, mainly due to urban growth. Figure 23 shows the urban expansion that the study area has experienced from 1999 to 2019 (See Attachment 4 for more details). As available land gets converted from its natural state to developed uses, it loses its ability to support ecological processes to some extent, creating a disruption in the ecosystem. This disruption cannot be avoided completely since societies continuously grow and demand more space and infrastructure. This growth and demand is why the County's planning process must take an active approach to protecting the areas with the highest environmental importance and connectivity from human disturbance. While these protections have not yet been put into place within the study area, Leduc County has taken small steps towards ensuring the protection of ecological values. One of them was identifying the Environmentally Significant Areas and regions through the ESA study and officially recognizing them in the MDP.

5.1.3 FUTURE URBAN GROWTH

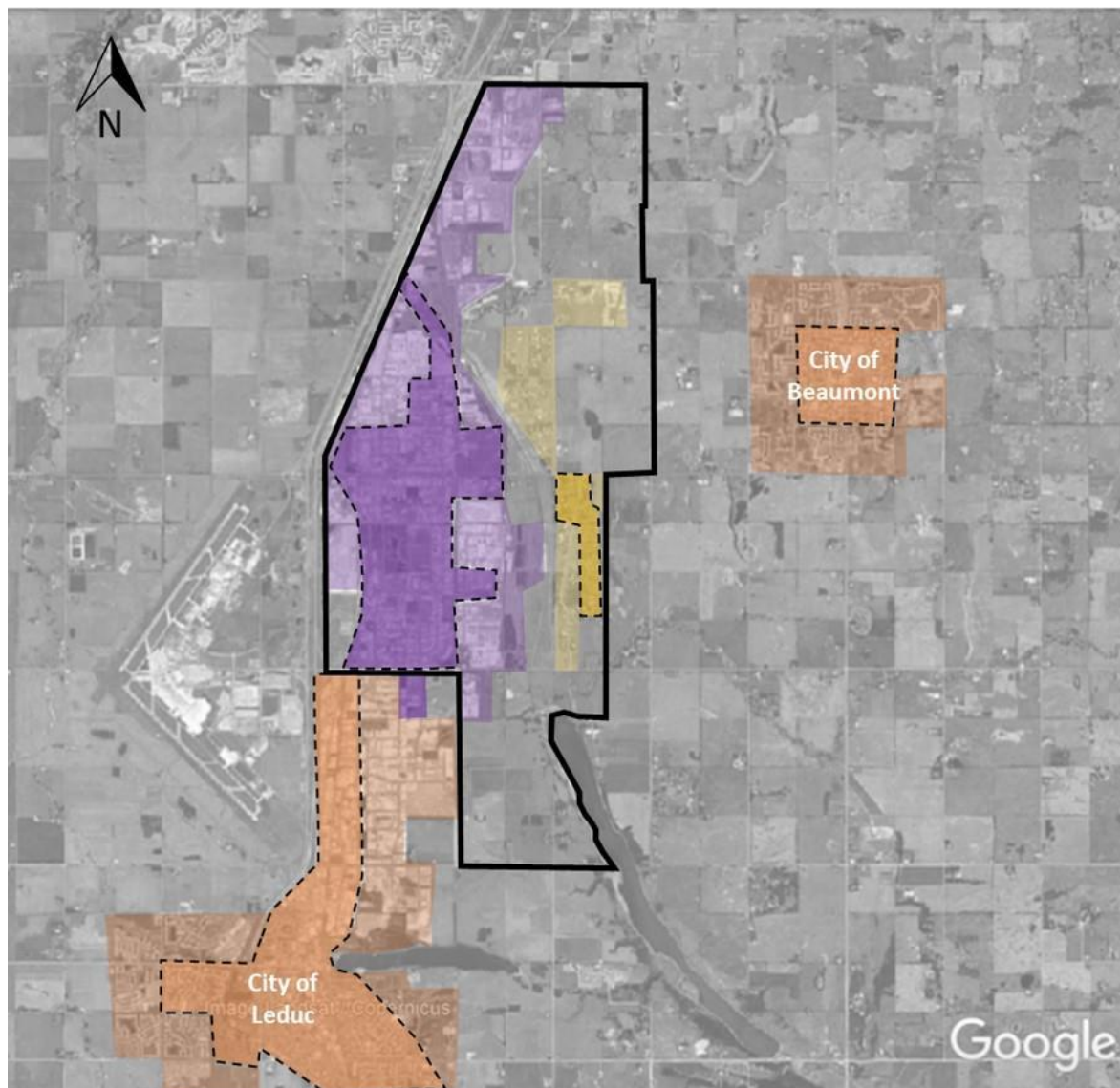
Planning for the conservation of ecological values requires an assessment of the disturbance risk incurred by the different elements of the regional ecosystem. Given the importance of the study area for ensuring adequate quantity and quality of surface and groundwater, undeveloped land itself is very valuable. Figure 24 shows the projected urban expansion within the study area and its

surroundings, based on the urban growth trends of the past 20 years and the planning documents that were reviewed in Phase I. It is important for the County to take measures not only to protect undeveloped land but also to restore lost ecosystem values to ensure the preservation of natural attributes, the continuity of environmental services, and the connectivity of preserved areas in the regional ecosystem.

5.1.4 BLACKMUD CREEK

Blackmud Creek is the key environmental linkage that has undergone significant alterations within the study area. In 1983 the County turned the creek into a canal between Highway 2 and Saunders Lake to improve drainage⁵⁵. Sediment build-up is a common challenge posed by canals and this is no exception. Two sediment maintenance reports have been commissioned for the canal since its inception, one in 2004 and one in 2014. Though the capacity of the canal has not changed, the 2014 report concluded that sediment deposition has slowed down 50% in the last decade compared to the first 20 years after construction

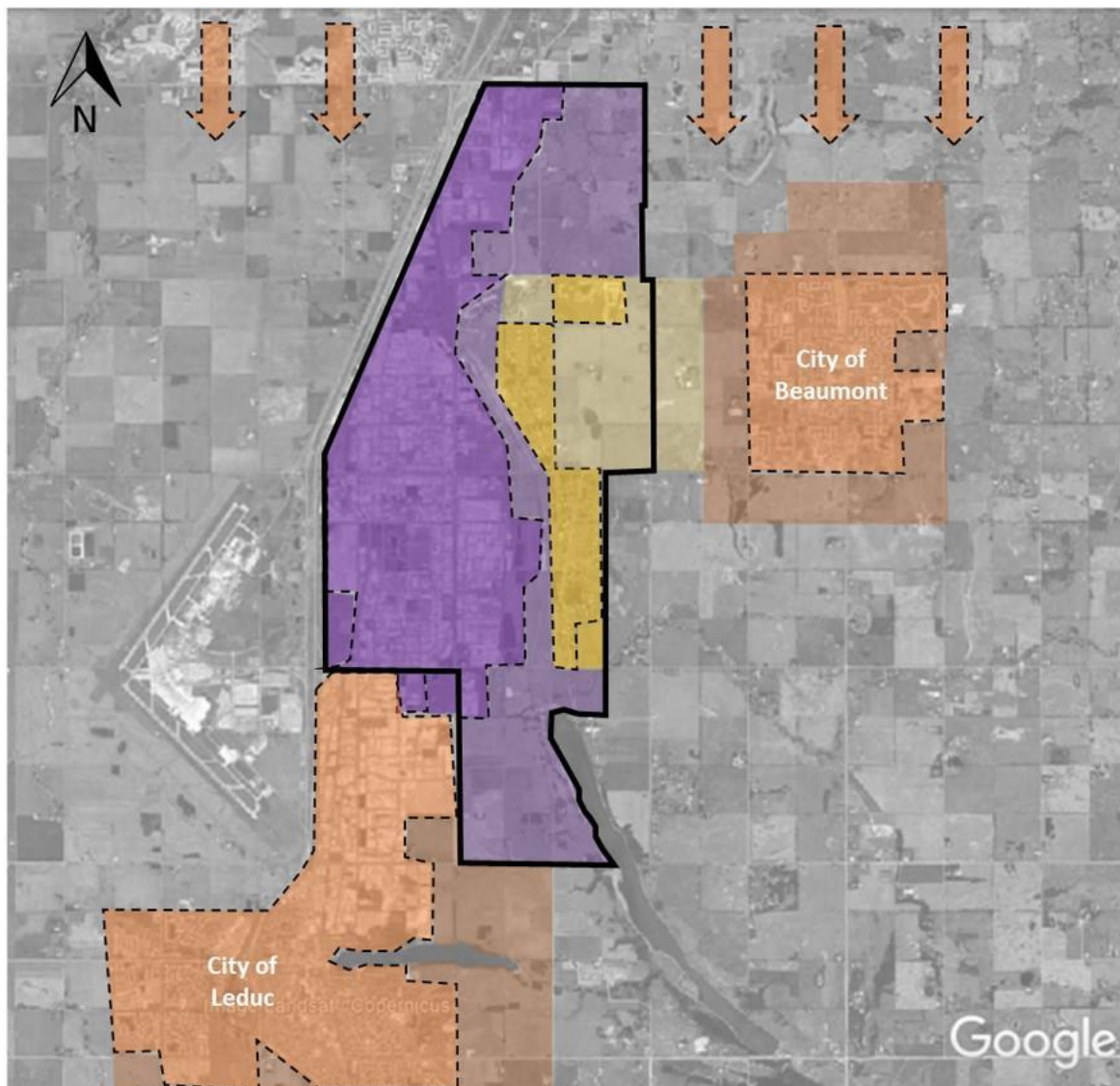
⁵⁵ Sameng Inc. (2014). Blackmud Creek 2014 Sediment and Maintenance Assessment.



Legend

	Study Area		Industrial expansion 1999 - 2019
	Residential land 1999		Urban land in surrounding municipalities 1999
	Industrial land 1999		Urban expansion in surrounding municipalities 1999 - 2019
	Residential expansion 1999 - 2019		

Figure 23 Urban Expansion in the Study Area and Surrounding Municipalities 1999-2019



Legend









- | | | | |
|---|---|---|--|
|  | Study Area |  | Projected industrial expansion 2039 |
|  | Residential land 2019 |  | Projected residential expansion 2039 |
|  | Industrial land 2019 |  | Projected urban expansion in surrounding municipalities 2039 |
|  | Urban land in surrounding municipalities 2019 |  | Urban growth pressures from the City of Edmonton |

Figure 24 Projected Urban Expansion in the Study Area and Surrounding Municipalities 2019-2039

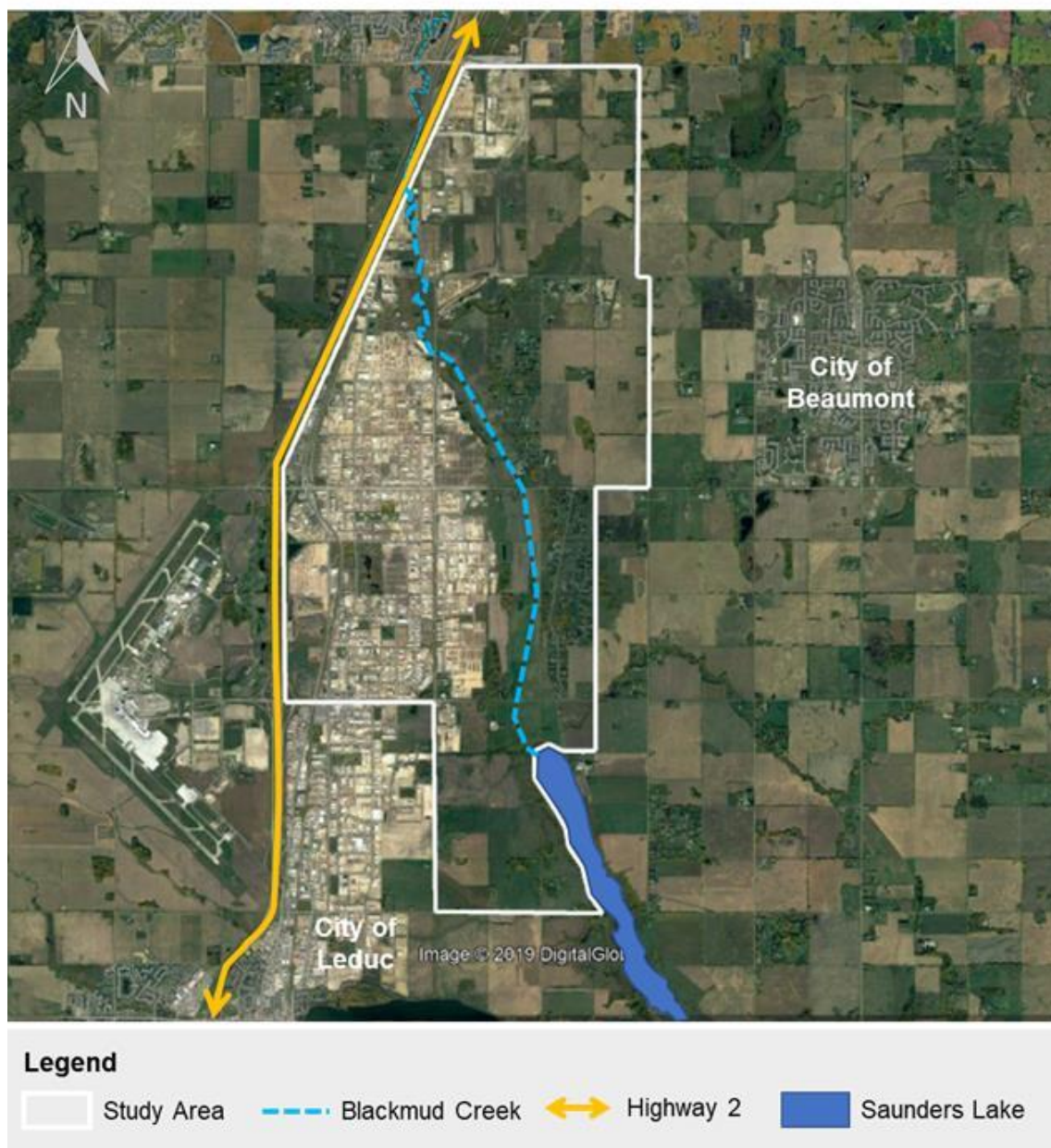


Figure 25 Location of Blackmud Creek within the Study Area

The construction of a canal has advantages and disadvantages. The biggest advantage is the mitigation of flood risk by having more direct control over the stream and volume of water⁵⁶. On the other hand, it also disturbs the ecosystem and can be a threat for the environment. Thus, a major step towards the

implementation of a wildlife corridor would be the restoration of Blackmud Creek, including naturalizing lands that fall within the 1:100 year flood plain.

Figure 25 shows the potential of Blackmud Creek for restoration. As explained before, Blackmud Creek is a critical feature of the

⁵⁶ Canal and River Trust, 2017

study area that provides the best opportunity for habitat connectivity, and is a prime candidate for restoration. Rivers, creeks, and water bodies in general play an important role not only in regulating ecological processes in natural environments but also in enhancing urban areas. The restoration of Blackmud Creek could improve the natural landscape of Nisku, making it more attractive for businesses and residents. It would also bring more biodiversity into an area that will eventually become predominantly urban. By restoring this important watercourse, the County would ensure an optimal recharge and discharge of groundwater in Nisku, the City of Leduc, Beaumont, south Edmonton and the Beaver Hills Biosphere. Other benefits include air purification, regulating the temperature of the immediate ecosystem, enhancing and supporting biodiversity, creating leisure, recreation and education opportunities, and fertilizing agricultural land⁵⁷.

The conversion of Blackmud Creek into a canal, and the fact that it has been neglected for decades, has compromised its ecological functions. Though there is no comprehensive ecological study of the creek available, it can be compared to similar cases in urban and in industrial areas. By channelling and altering Blackmud Creek, it has likely experienced:

- Bank erosion;
- Sedimentation build-up;
- Introduction of weeds and invasive plants⁵⁸;
- Partial destruction of riparian areas⁵⁹;
- Loss of oxygen within the water; and
- Fragmentation of the river banks.

Restoration programs have the potential of reinitiating the ecological processes and features that have been lost in Blackmud Creek, which is necessary to guarantee effective habitat connectivity between the environmentally significant regions of Saunders Lake and Irvine Creek, and further to the Beaver Hills Biosphere. Figure 26 shows the potential benefits that restoration actions have on a watercourse.

⁵⁷ Wlodarczyk and Mascarenhas, 2016

⁵⁸ Wlodarczyk and Mascarenhas, 2016

⁵⁹ Wlodarczyk and Mascarenhas, 2016



Figure 26 Potential Benefits of Watercourse Renaturalization

6 ANALYSIS OF IMPACTS

6.1 AGRICULTURE

Biodiversity is important for the regulation of ecosystem processes and delivery of ecosystem services. Increasing biodiversity, particularly wildlife populations, can benefit farmers by improving agricultural productivity potential⁶⁰. Farming approaches can be tailored to benefit wildlife and biodiversity, which in turn can increase ecosystem stability in the face of environmental change, without reducing the potential for agricultural yield.

There are two principal approaches to wildlife management which have been suggested:

- **Wildlife-Friendly Farming:** Agricultural practice is tailored to enhance populations of wildlife by creating a more integrated system⁶¹; and
- **Land Sparing:** Portions of agricultural land are managed intensively to increase yield, allowing other land to return to a semi-natural state, which can then act as reservoirs of biodiversity⁶².

These approaches do not need to be mutually exclusive, as the goal in both cases is to increase the availability of resources for wildlife such as food and shelter. The topography of a certain landscape may inform which system is most appropriate or feasible in a given situation, but overall this can best be achieved where the amount of land set aside for wildlife is increased.

One recent field based study showed the potential benefits of wildlife friendly agriculture on crop yields by comparing different amounts of land removed from production for the purpose of wildlife habitat creation⁶³. Measured yield was demonstrated to increase for the studied crops of wheat, beans, and oil seed rape, in fields with up to 8% of land set aside. The overall yield was similar compared with control fields that did not contain wildlife habitat patches.

This increase in crop yield effect is due to improvements in the delivery of natural services provided by wildlife and from the fact that the land sacrificed could be considered less productive or lower yielding. Examples of lower yield areas include field edges, where increased compaction, competition from trees and hedgerows for light and water, and greater stress from pest species is present⁶⁴.

Other studies have demonstrated increased yield in grassland as a result of increasing plant diversity by sowing species-rich seed mixtures⁶⁵. One experiment considered gradients of plant species richness and management intensity⁶⁶. The higher diversity crops were shown to be more effective in holding and increasing productivity than the higher management intensity, low-input crops.

These results are not to say that the agricultural benefits of increasing biodiversity are universal to all fields and landscapes. Context specific considerations need to include:

⁶⁰ Stiles, 2017

⁶¹ Schneider et al, 2015

⁶² Pywell et al. 2015

⁶³ Pywell et al. 2015

⁶⁴ Pywell et al. 2015

⁶⁵ Green et al. 2005

⁶⁶ Weigelt et al. 2009

- The costs associated with restoration;
- Field and soil preparation; and
- Soil nutrient status.

Overall, these studies demonstrate the potential for increasing habitat availability while reducing environmental impacts and the cost of production for farmers is possible, and should be considered in the evaluation of a wildlife corridor in the study area.

6.2 RECREATION

Developing a wildlife corridor in Nisku could allow for portions of the corridor to function as a park system and provide local passive recreation opportunities. Trail systems would be a large part of this recreation opportunity. Similar to wildlife corridor impacts, trail impacts are context specific, meaning they depend on the type and intensity of human use, the time of year, time of day, and the type of wildlife in the area. It is important to keep in mind that trails can have negative impacts on wildlife, as discussed in Section 3.4.2a, unless they are designed and managed properly⁶⁷. While there are many studies that focus on the wildlife aspect of corridors, few focus on corridors with multiple uses⁶⁸.

Trails should be designed with these seven best practices in mind:

1. Ban dogs or restrict them to on-leash only. The alternative would be to have designated off-leash areas in the least valuable land area⁶⁹;
2. Build trails along the edge of the corridor to minimize fragmenting the habitat further, including only building along the

edge of a riparian area at strategic points, such as for viewpoints or educational purposes;

3. Keep trail density lower in higher quality habitat;
4. Segregate uses (different activities in different zones along the corridor)⁷⁰;
5. Uses trees as screening to make wildlife more tolerant of human presence and to keep people out of where you do not want them to go;
6. Design for low maintenance; and
7. Provide a sequence of aesthetic experiences such as landmarks, facilities, and trail intersections.

6.3 SENSE OF PLACE

People perceive the same spaces differently⁷¹. A sense of place focuses on how you experience a place and what you associate with those experiences. A sense of place can involve ecological, social, economic, cultural, aesthetic, and historical aspects. Most importantly, a sense of place can evolve over time, with a space taking on different meanings as people and landscapes change around it.

Establishing a sense of place within a wildlife corridor can be attained through two main ways:

- Environmental education; and
- Activities that allow people to explore and interpret.

A wildlife corridor within the study area could provide a sense of place by giving Leduc County residents, employees, and visitors a place for outdoor education and exploration

⁶⁷ American Trails, 2018

⁶⁸ Briffett, 2001

⁶⁹ Conservation Corridor, 2017

⁷⁰ Briffett, 2001

⁷¹ Adams, Greenwood, Thomashow, and Russ, 2016

while respecting the main goal of wildlife conservation. Trails, boardwalks, and observation decks along the fringes of the corridor, and within the deeper reaches of the corridor where appropriate, could provide access to ecological opportunities that citizens would normally have to travel outside of the study area to access.

7 CONCLUSION

Phase I and II of the Nisku Wildlife Corridor Report support the creation of a wildlife corridor within the Nisku Area. The policy review conducted in Phase I found that current local and regional policy is limited, and that current plans should be updated to protect Environmentally Significant Areas (ESA) along the Blackmud Creek Drainage Basin. The analysis and reviews conducted in Phase II found that the ecology of Nisku warrants a wildlife corridor, and that Leduc County could be a leader in the creation of corridors in mixed urban and rural settings. Phase II further found that a wildlife corridor can be compatible, and in some cases beneficial to, continued industrial development, agricultural operations, passive recreation, and natural education. Implementing this corridor can be done through the creation of new wildlife habitat as well as the restoration of existing areas, using the existing national and provincial resources for corridor creation, focusing on ecological systems and functions rather than just connections, and most importantly, collaborating with public and private sector stakeholders.

The findings of Phase I and II have resulted in the below goals and recommendations:

Goal 1: Connect Environmentally Significant Areas within the study area to regional wildlife systems, focusing on the Blackmud

Creek Drainage Basin and the Beaver Hills Biosphere.

- a. Complete a detailed biodiversity study for Nisku in order to fully understand the range of wildlife and ecology that exist in the study area;
- b. Create one, comprehensive Nisku Area Structure Plan (NASP) that incorporates ESA's through a wildlife corridor along Blackmud Creek within the 1:100 year flood plain; and
- c. Update all local planning documents and applicable regional planning documents (statutory or otherwise) to reflect the new NASP.

Goal 2: Restore Blackmud Creek to its natural state within the 1:100 year floodplain in order to provide environmental, economic, and social benefits for residents, employees, and visitors of Leduc County;

- a. Create a Blackmud Creek Working Group, inviting all landowners, regional stakeholders, and relevant Non-Governmental Organizations (NGO's), with the mandate to:
 - i. Initiate discussions on the exact wildlife corridor alignment, determine project staging, and to incorporate stakeholder input;
 - ii. Renaturalize the 1:100 year Blackmud Creek floodplain lands;
 - iii. Provide passive recreation opportunities along the floodplain boundary; and
 - iv. Evaluate, monitor, and manage wildlife corridor biodiversity and ecology within the corridor.

Creating a wildlife corridor is a sensible approach to preserving ESA's and biodiversity within Nisku while also economic and social benefits along the corridor fringes. Implementing the above recommendations gives Leduc County the opportunity to become a provincial leader in developing wildlife corridors for mixed industrial, agricultural, and residential areas and can improve the quality of life for visitors and residents alike.

TEXT REFERENCES

1. Conservation Corridor. (2018). Urban connectivity: Recent research on species linkages in urban green spaces. Retrieved from <http://conservationcorridor.org/2018/07/urban-connectivity-recent-research-on-species-linkages-in-urban-green-spaces/>.
2. Adams, L.W. and Dove, L.E. (1989). Wildlife reserves and corridors in the urban environment: a guide to ecological landscape planning and resource conservation. National Institute of Urban Wildlife, Columbia, MD.
3. Conservation Corridor. (2017). Urban corridors: Research updates around the globe. Retrieved from <http://conservationcorridor.org/2017/04/urban-corridors-research-updates-around-the-globe/>.
4. British Columbia Ministry of Forests, Lands, and Natural Resources. (2014, November). A Compendium of Wildlife Guidelines for Industrial Development Projects in North Area, British Columbia. Retrieved from <http://a100.gov.bc.ca/pub/eirs/finishDownloadDocument.do?subdocumentId=9921>.
5. British Columbia Ministry of Forests, Lands, and Natural Resources. (2014, November). A Compendium of Wildlife Guidelines for Industrial Development Projects in North Area, British Columbia. Retrieved from <http://a100.gov.bc.ca/pub/eirs/finishDownloadDocument.do?subdocumentId=9921>.
6. British Columbia Ministry of Forests, Lands, and Natural Resources. (2014, November). A Compendium of Wildlife Guidelines for Industrial Development Projects in North Area, British Columbia. Retrieved from <http://a100.gov.bc.ca/pub/eirs/finishDownloadDocument.do?subdocumentId=9921>.
7. Conservation Corridor. (2018). Making habitat connectivity a reality. Retrieved from <http://conservationcorridor.org/2018/10/making-habitat-connectivity-a-reality/>
8. Beier, P., Majka, D.R., and Spencer, W.D. (2008). Forks in the road: Choices in procedures for designing wildland linkages. *Conservation Biology*, 22:4, 836-851.
9. Beier, P., Majka, D.R., and Spencer, W.D. (2008). Forks in the road: Choices in procedures for designing wildland linkages. *Conservation Biology*, 22:4, 836-851.
10. Hennings, L. (2010, April). Wildlife corridors and permeability - a literature review (technical report). Metro Sustainability Center, Portland, Oregon. Retrieved from https://www.researchgate.net/publication/265085554_Wildlife_corridors_and_permeability_-_a_literature_review
11. Holland M.D., and Hastings, A. (2008). Strong effect of dispersal network structure on ecological dynamics. *Nature*, 456, 792-795.
12. Hennings, L. (2010, April). Wildlife corridors and permeability - a literature review (technical report). Metro Sustainability Center, Portland, Oregon. Retrieved from https://www.researchgate.net/publication/265085554_Wildlife_corridors_and_permeability_-_a_literature_review
13. Hennings, L. (2010, April). Wildlife corridors and permeability - a literature review (technical report). Metro Sustainability Center, Portland, Oregon. Retrieved from https://www.researchgate.net/publication/265085554_Wildlife_corridors_and_permeability_-_a_literature_review
14. Keeley, A.T.H. et al. (2018). Making habitat connectivity a reality. *Conservation Biology*, 32:6, 1221-1232.
15. Herrera-F, B., Chassot, O., Monge, G., and Canet, L. (2016). Technical guidelines for the design and management of participatory connectivity conservation and restoration project at the landscape scale in Latin America. Retrieved from <https://portals.iucn.org/library/sites/library/files/documents/2016-059.pdf>.
16. Hennings, L. (2010, April). Wildlife corridors and permeability - a literature review (technical report). Metro Sustainability Center, Portland, Oregon. Retrieved from

- https://www.researchgate.net/publication/265085554_Wildlife_corridors_and_permeability_-_a_literature_review
17. Ament, R., Callahan, R., McClure, M., Reuling, M., and Tabor, G. (2014). Wildlife connectivity: Fundamentals for conservation action. The Centre for Large Landscape Conservation. Retrieved from <http://largelandscapes.org/media/publications/Wildlife-Connectivity-Fundamentals-for-Conservation-Action.pdf>.
 18. Washington Department of Fish and Wildlife. (2009). Landscape planning for Washington's wildlife: Managing for biodiversity in developing areas. Retrieved from <https://wdfw.wa.gov/publications/00023/wdfw00023.pdf>.
 19. Beier, P., Majka, D., Newell, S., and Garding, E. (2008). Best management practices for wildlife corridors. Retrieved from http://corridordesign.org/dl/docs/corridordesign.org_BMPs_for_Corridors.pdf
 20. Beier, P., Majka, D., Newell, S., and Garding, E. (2008). Best management practices for wildlife corridors. Retrieved from http://corridordesign.org/dl/docs/corridordesign.org_BMPs_for_Corridors.pdf
 21. Beier, P., Majka, D., Newell, S., and Garding, E. (2008). Best management practices for wildlife corridors. Retrieved from http://corridordesign.org/dl/docs/corridordesign.org_BMPs_for_Corridors.pdf
 22. Beier, P., Majka, D., Newell, S., and Garding, E. (2008). Best management practices for wildlife corridors. Retrieved from http://corridordesign.org/dl/docs/corridordesign.org_BMPs_for_Corridors.pdf
 23. Wells, P., Woods, J. G., Bridgewater, G., & Morrison, H. (1999, September). Wildlife mortalities on railways: Monitoring methods and mitigation strategies. In *Proceedings of the third international conference on wildlife ecology and transportation* (pp. 237-246).
 24. Hesse, G., Rea, R. V., & Booth, A. L. (2010). Wildlife management practices at western Canadian airports. *Journal of Air Transport Management*, 16(4), 185-190.
 25. Adams, L.W. and Dove, L.E. (1989). Wildlife reserves and corridors in the urban environment: a guide to ecological landscape planning and resource conservation. National Institute of Urban Wildlife, Columbia, MD.
 26. Adams, L.W. and Dove, L.E. (1989). Wildlife reserves and corridors in the urban environment: a guide to ecological landscape planning and resource conservation. National Institute of Urban Wildlife, Columbia, MD.
 27. Adams, L.W. and Dove, L.E. (1989). Wildlife reserves and corridors in the urban environment: a guide to ecological landscape planning and resource conservation. National Institute of Urban Wildlife, Columbia, MD.
 28. Adams, L.W. and Dove, L.E. (1989). Wildlife reserves and corridors in the urban environment: a guide to ecological landscape planning and resource conservation. National Institute of Urban Wildlife, Columbia, MD.
 29. Hu. (2018). New York City water filtration. Retrieved <https://www.nytimes.com/2018/01/18/nyregion/new-york-city-water-filtration.html>
 30. Hu. (2018). New York City water filtration. Retrieved <https://www.nytimes.com/2018/01/18/nyregion/new-york-city-water-filtration.html>
 31. Government of Canada. (2017). Ecological gifts program: overview. Retrieved from <https://www.canada.ca/en/environment-climate-change/services/environmental-funding/ecological-gifts-program/overview.html?fbclid=IwAR09WMTtgFrZ9mZ5zB6kPpsZ8hmm7DY70vdeFjd1CP0NqP-HcERkciBbvmk>
 32. Edmonton and Area Land Trust. (2018). Conservation Easements. Retrieved from <https://www.ealt.ca/conservation-easements>
 33. Edmonton and Area Land Trust. (2018). Conservation Easements. Retrieved from <https://www.ealt.ca/conservation-easements>
 34. Adams, L.W. and Dove, L.E. (1989). Wildlife reserves and corridors in the urban environment: a guide to ecological landscape planning and resource conservation. National Institute of Urban Wildlife, Columbia, MD.
 35. Greenaway, G., & Good, K. (2008). Transfer of development credits in Alberta: a feasibility review. Miistakis Institute.
 36. Greenaway, G., & Good, K. (2008). Transfer of development credits in Alberta: a feasibility review. Miistakis Institute.
 37. North West Redwater Partnership (2016, January). Wildlife corridor. Retrieved from

- <https://nwrsturgeonrefinery.com/initiative/wildlife-corridor/>
38. Millenium Ecosystem Assessment. (2005). Ecosystems and human well-being: Opportunities and challenges for business and industry. Retrieved from <http://www.millenniumassessment.org/documents/document.353.aspx.pdf>.
 39. USDA: Natural Resources Conservation Service. (1999). Chapter 4: Corridor Benefits. Retrieved from https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs144p2_014927.pdf
 40. Kazmierczak, A. (2013). The contribution of local parks to neighbourhood social ties. *Landscape and Urban Planning*, 109:1, 31-44
 41. USDA: Natural Resources Conservation Service. (1999). Chapter 4: Corridor Benefits. Retrieved from https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs144p2_014927.pdf
 42. Nelson, E. et al. (2009). Modelling multiple ecosystem services, biodiversity conservation, commodity production, and tradeoffs at landscape scales. *Frontiers in Ecology*, 7:1, 4-11.
 43. USDA: Natural Resources Conservation Service. (1999). Chapter 4: Corridor Benefits. Retrieved from https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs144p2_014927.pdf
 44. Millenium Ecosystem Assessment. (2005). Ecosystems and human well-being: Opportunities and challenges for business and industry. Retrieved from <http://www.millenniumassessment.org/documents/document.353.aspx.pdf>.
 45. Biodiversity Information System for Europe. (2010). Ecosystem services. Retrieved from <https://biodiversity.europa.eu/topics/ecosystem-services>
 46. USDA: Natural Resources Conservation Service. (1999). Chapter 4: Corridor Benefits. Retrieved from https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs144p2_014927.pdf
 47. Jeswiet, S. and Hermsen, L. (2015, March 30). Agriculture and wildlife: A two-way relationship. Statistics Canada. Retrieved from <https://www150.statcan.gc.ca/n1/pub/16-002-x/2015002/article/14133-eng.htm>.
 48. USDA: Natural Resources Conservation Service. (1999). Chapter 4: Corridor Benefits. Retrieved from https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs144p2_014927.pdf
 49. Lant, C.L., and Tobin, G.A. (1989). The economic value of riparian corridors in corn belt floodplains: A research framework. *The Professional Geographer*, 41:3, 337-349.
 50. Nelson, E. et al. (2009). Modelling multiple ecosystem services, biodiversity conservation, commodity production, and tradeoffs at landscape scales. *Frontiers in Ecology*, 7:1, 4-11.
 51. Project EverGreen. (2019). Environmental benefits of green space. Retrieved from <https://projectevergreen.org/resources/environmental-benefits-of-green-space/>
 52. Conservation Corridor. (2018). Connectivity and the IPCC Special Report on Global Warming. Retrieved from <http://conservationcorridor.org/2018/10/connectivity-and-the-ipcc-special-report-on-global-warming/>
 53. Conservation Corridor. (2018). Connectivity and the IPCC Special Report on Global Warming. Retrieved from <http://conservationcorridor.org/2018/10/connectivity-and-the-ipcc-special-report-on-global-warming/>
 54. Gleeson, J., & Gleeson, D. (2012). Reducing the impacts of development on wildlife. CSIRO PUBLISHING.
 55. Sameng Inc. (2014, March). Blackmud Creek 2014 Sediment and Maintenance Assessment. Prepared for Leduc County. Retrieved from <https://www.leduc-county.com/public/download/documents/12112>
 56. Canals: Canals and Rivers Trust. (2017). Biodiversity, ecology, and green infrastructure. Retrieved from <https://canalrivertrust.org.uk/specialist-teams/planning-and-design/planning-policy/the-values-and-benefits-of->

- waterways/environmental-wellbeing/biodiversity-ecology-and-green-infrastructure
57. Włodarczyk, A.M. and Mascarenhas, J.M.R.D. (2016). Nature in Cities. Renaturalization of riverbanks in urban areas. *De Gruyter Open*, 6, 681-690.
 58. Włodarczyk, A.M. and Mascarenhas, J.M.R.D. (2016). Nature in Cities. Renaturalization of riverbanks in urban areas. *De Gruyter Open*, 6, 681-690.
 59. Włodarczyk, A.M. and Mascarenhas, J.M.R.D. (2016). Nature in Cities. Renaturalization of riverbanks in urban areas. *De Gruyter Open*, 6, 681-690.
 60. Stiles, W. (2017). The importance of biodiversity and wildlife on farmland. Farming Connect. Retrieved from https://businesswales.gov.wales/farmingconnect/sites/farming/files/documents_and_files/LIuniauw_2017/technical_article_-_farmland_biodiversity_final.pdf.
 61. Schneider, M.K. (2014). Gains to species diversity in organically farmed fields are not propagated at the farm level. *Nature Communications*, 5:4151.
 62. Pywell R.F., Heard M.S., Woodcock B.A., Hinsley S., Ridding L., Nowakowski M., and Bullock J.M. (2015). Wildlife- friendly farming increases crop yield: evidence for ecological intensification. *Proc. R. Soc. B* 282: 20151740. <http://dx.doi.org/10.1098/rspb.2015.1740>
 63. Pywell R.F., Heard M.S., Woodcock B.A., Hinsley S., Ridding L., Nowakowski M., and Bullock J.M. (2015). Wildlife- friendly farming increases crop yield: evidence for ecological intensification. *Proc. R. Soc. B* 282: 20151740. <http://dx.doi.org/10.1098/rspb.2015.1740>
 64. Pywell R.F., Heard M.S., Woodcock B.A., Hinsley S., Ridding L., Nowakowski M., and Bullock J.M. (2015). Wildlife- friendly farming increases crop yield: evidence for ecological intensification. *Proc. R. Soc. B* 282: 20151740. <http://dx.doi.org/10.1098/rspb.2015.1740>
 65. Green, R.E., Cornell, S.J., Scharlemann, J.P.W., and Balmford, A. (2005). Farming and the fate of wild nature. *Science*, 307:5709, 550-555.
 66. Weigelt, A., Weisser, W., Buchmann, N., and Scherer-Lorenzen, M. (2009). Biodiversity for multifunctional grasslands: equal productivity in high-diversity low-input and low-diversity high-input systems. *Biogeosciences*, 6, 1695-1706.
 67. American Trails. (2018). Planning trails with wildlife in mind - wildlife and trails primer. Retrieved from <https://www.americantrails.org/resources/planning-trails-with-wildlife-in-mind-wildlife-and-trails-primer>
 68. Briffett, C. (2001). Is managed recreational use compatible with effective habitat and wildlife occurrence in urban open space corridor systems? *Landscape Research*, 26:2, 137-163.
 69. Conservation Corridor. (2017). Urban corridor research updates around the globe. Retrieved from <http://conservationcorridor.org/2017/04/urban-corridors-research-updates-around-the-globe/>
 70. Briffett, C. (2001). Is managed recreational use compatible with effective habitat and wildlife occurrence in urban open space corridor systems? *Landscape Research*, 26:2, 137-163.
 71. Adams, J., Greenwood, D., Thomashow, M., and Russ, A. (May 2016). Sense of Place. The Nature of Cities. Retrieved from <https://www.thenatureofcities.com/2016/05/26/sense-of-place/>

FIGURE REFERENCES

- Figure 5: City of Edmonton. (2015). Stage one rendering – viewing deck park. Retrieved from https://photos.edmonton.ca/Major-Projects-Development/Blatchford-Redevelopment/i-96vxG4G?fbclid=IwAR1vy6l5DzHJNpnR0xvqGdxn7DD2w_aJLwfBHyum4PxFYkSgbbMncPal6g
- Figure 6: SWOT Diagram (n.d.). Retrieved from <https://www.presentationgo.com/presentation/swot-diagram-powerpoint/>
- Figure 7: New Green Business Ideas. (2012, July). Maintaining migration corridors. Retrieved from https://newgreenbusinessideas.blogspot.com/2012/07/maintaining-migration-corridors_25.html
- Figure 9: Legacy Habitat Management Limited. (2019). Otter fencing. Retrieved from <https://www.legacy-habitat.co.uk/otter-fencing.html>
- Figure 10: Conservation Corridor. (2018). Making habitat connectivity a reality. Retrieved from <http://conservationcorridor.org/2018/10/making-habitat-connectivity-a-reality/>
- Figure 12: Washington Department of Fish and Wildlife. (2009). Landscape planning for Washington's wildlife: Managing for biodiversity in developing areas. Retrieved from <https://wdfw.wa.gov/publications/00023/wdfw00023.pdf>.
- Figure 13: Hennings, L. (2010, April). Wildlife corridors and permeability - a literature review (technical report). Metro Sustainability Center, Portland, Oregon. Retrieved from https://www.researchgate.net/publication/265085554_Wildlife_corridors_and_permeability_-_a_literature_review
- Figure 14: Parks Canada. (2018). Kootenay National Park. Retrieved from <https://www.pc.gc.ca/en/pn-np/bc/kootenay/gestion-mgmt/passage-93s-crossing>. Idaho Wildlife Federation. (2019). Highway wildlife crossings mean more animals, more hunting, more meat, more fur. Retrieved from <https://www.idahowildlife.org/wildlife-highway-crossings-mean-more-animals-more-hunting-more-meat-more-fur/>
- Figure 15: Holopainen, S. (n.d.). Dry path image. Retrieved from <https://encounterswithwildlife.wordpress.com/2014/07/07/use-dry-paths-and-survive/>
- Figure 16: Picssr, n.d. Ring Mountain.
- Figure 17: Wild Burlington. (2016, January). Field trip: Mud pond in Williston. Retrieved from <http://wildburlington.blogspot.com/2016/01/field-trip-mud-pond-in-williston.html>
- Figure 18: Google Maps, 2019. Retrieved from <https://www.google.com/maps>
- Figure 19: Elite Tree Care. (2017). What's a tree hollow and why it's important. Retrieved from <https://www.elitetreecare.com/2017/11/whats-tree-hollow/>.
- Figure 20: Gleeson, J., & Gleeson, D. (2012). Reducing the impacts of development on wildlife. CSIRO PUBLISHING.
- Figure 21: Parks Canada Agency and the Canadian Parks Council. (2008). Principles and Guidelines for Ecological Restoration in Canada's Protected Natural Areas. Retrieved from <https://www.pc.gc.ca/en/nature/science/conservation/ie-ei/re-er/pag-pel?fbclid=IwAR09WMTtgFrZ9mZ5zB6kPpsZ8hmm7DY70vdeFjd1CP0NqP-HcERkciBbvmk>

ATTACHMENTS

ATTACHMENT 1: NISKU WILDLIFE CORRIDOR REPORT PHASE I

Appendix A: ESA Methodology

Appendix B: ESA's in Nisku Area

Appendix C: Summary of Local Spatial Context Analysis

ATTACHMENT 2: NISKU WILDLIFE CORRIDOR REPORT TERMS OF REFERENCE

ATTACHMENT 3: WILDLIFE CORRIDOR CRITERIA LIST

ATTACHMENT 4: URBAN EXPANSION IN THE STUDY AREA 1999-2019

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ATTACHMENT 1: NISKU WILDLIFE CORRIDOR REPORT PHASE I

Nisku Wildlife Corridor Report

Phase 1: Assessment of Planning Documents to Determine Project Alignment

February 27, 2019

Prepared for Leduc County by Denise Baikie, Mandy Chan, Derek Macdonald, & Nathalia Osorio

Revision: 2

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Executive Summary

Phase I of the Nisku Wildlife Corridor Report seeks to understand whether current regional and local planning documents and policies for the Nisku Business Area are aligned or misaligned with the creation of a wildlife corridor, and to create preliminary recommendations as to how policy alignment can be improved. The history of wildlife corridors, what kind of wildlife would use a corridor, and existing local examples of wildlife conservation methods were all explored. Regional and local level planning documents, policies, and programs were then scanned for keywords and phrases, and a spatial context analysis was conducted in order to identify alignments and misalignments that could inform the type, extent, and location of a wildlife corridor in the study area. The following key points were identified:

- Wildlife corridors should have wildlife as the primary focus, but can incorporate opportunities for human recreation, water management, and public education where suitable;
- Wildlife corridors need to be context specific in order to be successful;
- Current regional planning policy is generally set up to incorporate and implement a wildlife corridor, but it could be stronger with less focus on recreation and open space;
- Current local planning documents are lacking specific policy for wildlife and natural areas;
- Locating wildlife corridors along major drainage routes in the region could serve multiple purposes: increase flood protections, upgrade stormwater management mechanisms, re-establish native species, create a natural buffer between residential and industrial development, and prevent erosion; and
- Tools for implementing a wildlife corridor are in place (planning policy allows for Environmental Reserve, Conservation Easements), but are not as strong as they could be.

These key points were used to create preliminary policy recommendations for a wildlife corridor in the study area. These policy recommendations focus on embedding local and intermunicipal documents with implementable policies for conserving and connecting environmentally significant areas.

The most environmentally significant portions of the study area are located along Blackmud Creek. The location of a wildlife corridor must provide opportunities to connect these areas and integrate them with existing recreation and open spaces in the Nisku Business Area. When deciding the route, there must be also a consideration for the value of agricultural land, flood plains, and potential connections to other drainage systems and natural spaces in surrounding municipalities.

These preliminary policies and the suggestions to define a route for the wildlife corridor will be further refined and vetted in Phase II of this report, along with other potential options and recommendations as the project proceeds. Though an ideal wildlife corridor would put the conservation of wildlife first and foremost, Phase II of this project will put more of an emphasis on the financial and human benefits of creating a corridor that balances both wildlife and recreational needs in accordance with Leduc County's strategic vision and goals for Nisku.

Introduction to the Study Area

The study area for the Nisku Wildlife Corridor Report is shown in Figure 1 below:

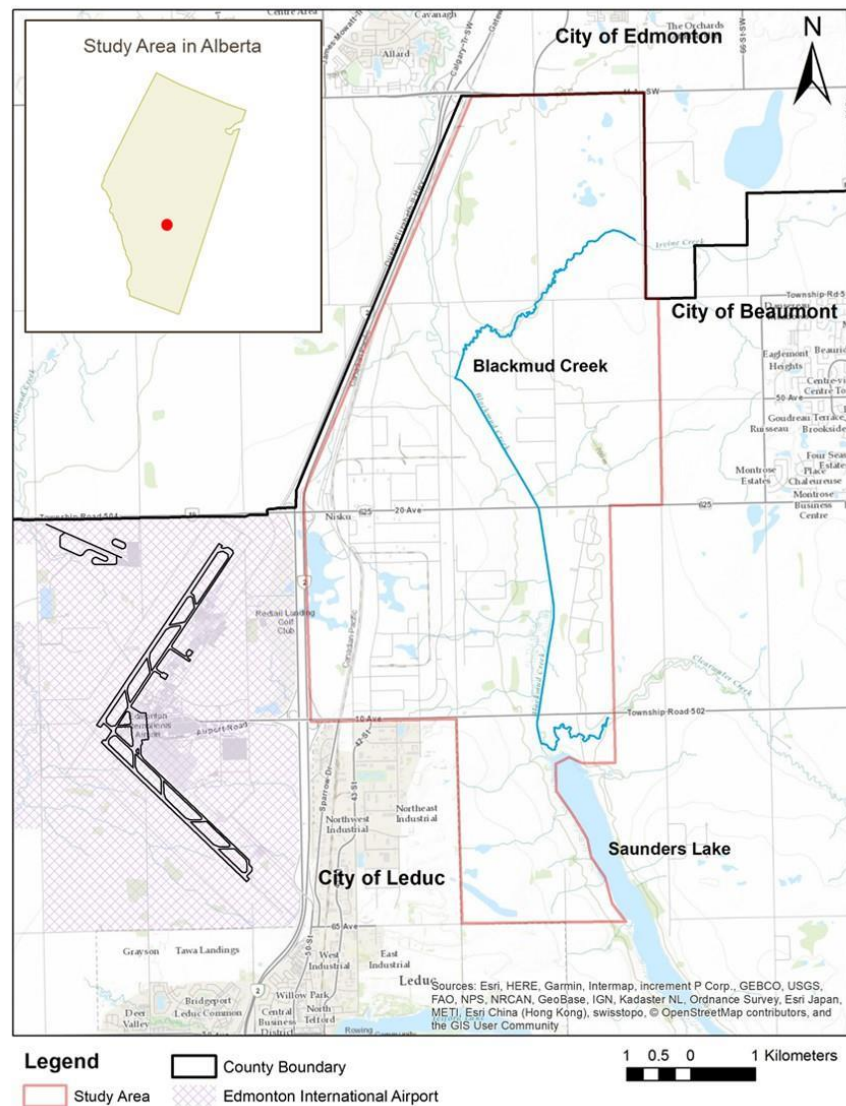


Figure 1: Study Area Boundary and Surroundings

The study area consists of a wide mix of industrial, agricultural, and residential land uses. Boundaries for the study area include the Queen Elizabeth II Highway to the west, the City of Leduc to the south, the City of Beaumont to the east, and the City of Edmonton to the north. Major regional considerations include the Edmonton International Airport (west of the QEII) and the Nisku Business Area's status as a key economic driver for the Edmonton Metropolitan Region.

Wildlife Corridor Background Research

Definition and Purpose

The general need for wildlife corridors arose from habitat fragmentation through the continued human alteration of the natural landscape, and associated decline in the presence of animals and general biodiversity. Habitat fragmentation occurs where a once continuous natural landscape is divided into habitat patches¹, resulting in a decreased presence of animal and plant species.² Fragmentation is generally caused by human modification to the landscape, leading to the loss of habitat, smaller habitat patches, and isolation of these patches³. Scientific evidence points to fragmentation as a leading cause of biodiversity decline in an area.

A habitat patch is an area that provides all the necessary resources for animal survival⁴. Corridors can be defined as links between, or connection of, habitat patches that allows for wildlife movement and can be wildlife habitat itself (for example large carnivores such as coyotes). This connection makes corridors an effective conservation tool since linking habitat patches can support the maintenance of wildlife populations in an area of human development.⁵

The traditional purpose of a wildlife corridor is to connect the habitat patches in a fragmented landscape for the movement of species, restoration and maintenance of biodiversity and ecosystem values. Corridors are mainly designed from the perspective of the field of conservation ecology⁶⁻⁷, to increase the biodiversity present in a human altered landscape, prevent the extinction of species, and restore and/or maintain ecosystem values in an area that has been degraded from its natural state⁷.

There are multiple criteria to consider in the design of a wildlife corridor. Corridors are generally created for a specific species as it is crucial to consider their territory size, home range size, shelter, food, nest, and den or breeding site³. As a general rule, the wider and more continuous the corridor is, the better⁸. However, these landscape connections between habitat patches are used in different ways by different species, so there are several ways in which they can be established. While some populations or individuals use them to move from one patch to another, others might spend some time in the corridor or even make it their permanent habitat. This variation means that corridors can be continuous or discontinuous, depending on the ecological integrity of the area and the opportunities for conservation, and they can serve different purposes according to their size and scale⁸. Whether a corridor is part of a regional reserve of pristine habitat or small stepping stones within a highly altered landscape, it plays an important role in the maintenance of biodiversity.

Another important characteristic of corridors is that they can be adapted to their specific context^{5,7}. In some cases, the best solution may be to design a wildlife corridor for more than just species movement. For instance, corridors can be used for public environmental education or can act as water storage areas during times of flooding⁹. In today's world, corridors are more about making room for wildlife within the human environment and less about creating/restoring large tracts of undisturbed land¹⁰.

Wildlife within the Study Area

Leduc County itself is dominated by agricultural land use¹¹. The smaller study area is dominated by a contrast of three different landscapes: industrial, agricultural, and residential. While natural habitats are limited and fragmented within the Nisku area, there have been sightings of wildlife in the vicinity¹. Reports of deer, beavers, and a variety of migratory bird species are common.

The agricultural and country residential landscapes consist of spruce and aspen groves interspersed with grasslands and residential buildings of different sizes. There are numerous wetlands and drainages, especially to the east of the Nisku Industrial Business Park, connecting with Blackmud Creek and Saunders Lake (see Figure 2). These habitats are home to beavers, muskrats, ducks, and a variety of amphibians. There are also a few small patches of forest, dominated by aspens, poplars, and some conifers. These patches provide a suitable habitat and stepping stones for rodents, small mammals, and birds.

Based on these landscape characteristics, the American beaver, white-tailed deer, coyote, and various bird species are the initial key target species for this wildlife corridor study. These species were chosen to be representative of all species present in the study area. Note that these target species will be further refined and adjusted as Phase II of this report is executed.

American Beaver: North America's largest rodent depends on ponds and wetland areas to survive and reproduce¹². Beavers are significant influencers on the landscape, as their dams flood surrounding woodlands and riparian areas. A stable source of food, consisting of the bark of poplars and other trees, grass, weeds, flowers, and connected wetlands that are protected and secluded from high-intensity human activity are critical for beavers to thrive. Wildlife corridors aid beaver populations by providing new food source areas once their existing habitat is depleted, and by giving young beavers the opportunity to move out of their home territory once they are mature enough to start their own colony.

White-tailed Deer: The white-tailed deer is the most abundant ungulate in Alberta¹². Deer are large mammals and their typical habitat consists of forests, aspen groves, and river flats. Deer eat forbs and shrubs, such as chokecherries and saskatoons. Deer need a mix of woodland and open grassland to thrive. While deer spend most of their days grazing, they are very wary and need woodlands to feel protected and feed during the winter. Deer are a migratory species, so they benefit from habitat connectivity, especially forested corridors.

¹ D. Martin, Personal Communication, January 23, 2019

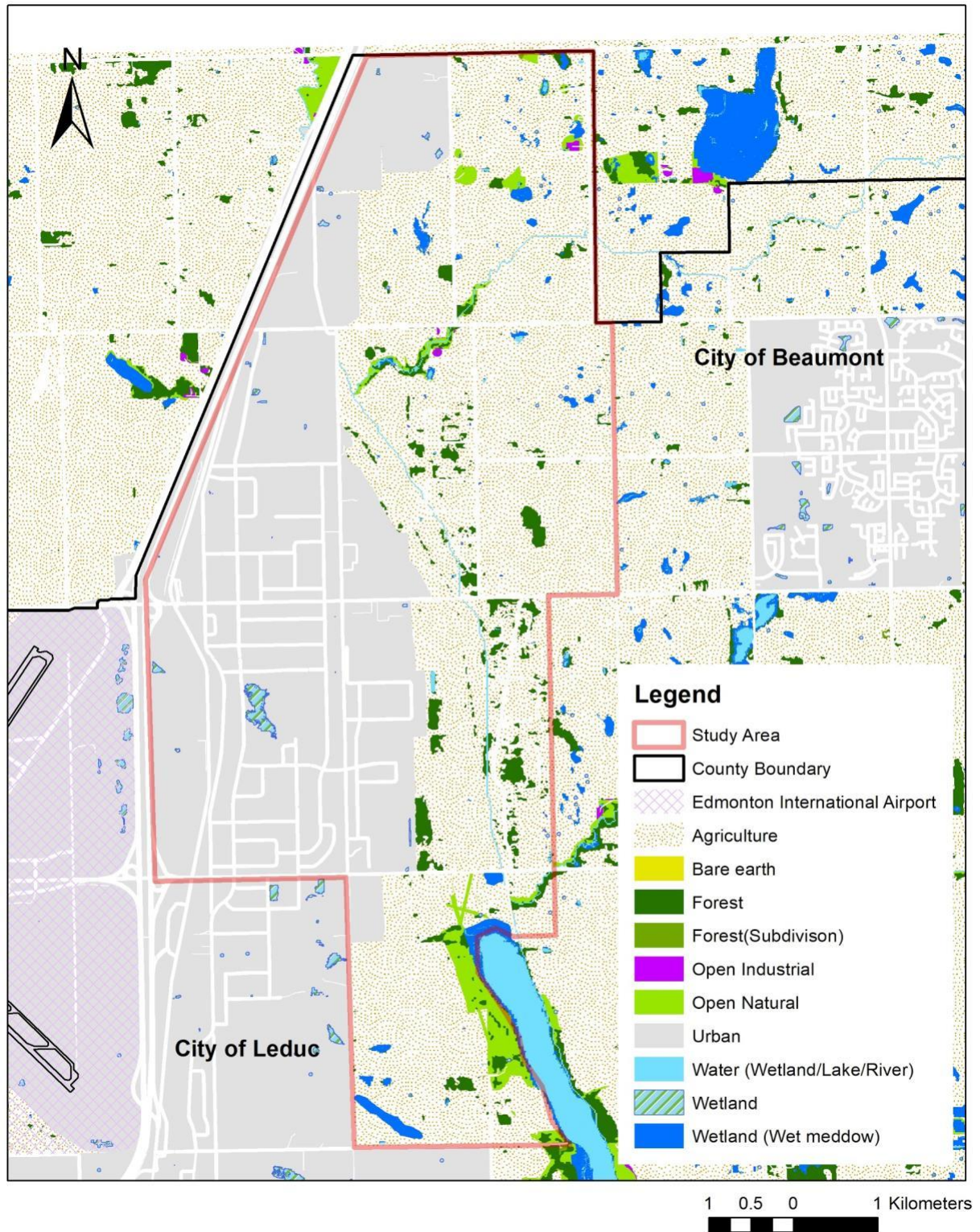


Figure 2: Land Cover in the Study Area

Coyote: Coyotes are highly adaptable to different types of terrestrial habitats¹². Mice and other small rodents are their main source of food, but they are known to be opportunists and will take advantage of the presence of livestock and other bigger mammals. Coyotes have a small range of movement during the winter and spring, and tend to travel longer distances in the summer and fall. Coyotes often venture close to human activity areas and will threaten house pets and livestock, causing conflict with residential communities. A wildlife corridor can help minimize the potential for conflict, providing a safe and secluded transient space for movement.

Birds Species: Birds play an important role in any ecosystem¹². They pollinate and disperse seeds, and help control the population of insects and rodents. Cranes, falcons, hawks, owls, geese, ducks, and a variety of songbirds, are all common in Alberta. Habitat needs varies among species, but in general birds benefit from mixed woods and dispersed wetlands. Fruit bearing trees provide food and nesting opportunities for small birds, while grasslands, meadows, and streams make a good habitat for ducks, geese, and other migratory birds. The migratory nature of most birds make wildlife corridors important for their wellbeing by providing suitable habitat for stopovers.

The Nisku-City of Leduc urban corridor does present a significant challenge to these species' natural habitats, but there are still plenty of conservation opportunities, especially through connecting existing water bodies and forest patches along the east portion of the study area.

Examples of Comparable Cases

A brief review of local wildlife corridor cases was conducted to help identify the general parameters for the design of wildlife corridors in Alberta and what kind of implementation mechanism can be used in the process. This review will be expanded upon in the Best Practices portion of Phase II of this report.

Wildlife Corridor Design - Canmore, 1999

Canmore encompasses a montane habitat that is not only rare in Alberta, but also a critical component of the Rocky Mountains ecosystem¹³. This habitat has the ability to support a wide variety of mammals and birds, and provides crucial connectivity between the Kananaskis Valley, Banff and towards the north of the Rocky Mountains. In 1999, when this wildlife corridor was proposed, Canmore was already experiencing urban growth and associated residential, commercial, and industrial pressures. The guidelines proposed by the Town of Canmore for the design of a wildlife corridor aimed to ensure the viability of the region's ecosystems by establishing a framework to guide and align development proposals with the environmental purposes of the municipality.

The subsequent wildlife corridor report suggests the following:

- A single, wide corridor is preferable to several narrower corridors;.
- Straight corridors are preferred over winding passages, arguing that curves and loops are more likely to lead wildlife to urban areas where they might experience conflict with humans;

- When designing long corridors, it is necessary to account for the total time that individuals and groups are going to spend there, as well as their needs related to food, water, and rest;
- Minimum width, length, topography, and vegetation cover should all be considered when starting the design of a wildlife corridor; and
- Corridor permeability to externalities and disturbances (noise, pollution) play an important role in determining corridor width

The report also highlights the importance of compatible uses:

- Scientific research and education;
- Power lines, road, sewage, and water pipelines;
- Vegetation management for fire, disease, and weed control; and
- Wildlife management and designated trails

Other parameters for the management and maintenance of a wildlife corridor that were identified include creating a spacious buffer around trails crossings, and closing the trails altogether during the seasons when wildlife is most susceptible to human disturbance. The report also advises to mandate having dogs on-leash at all times, establishing a monitoring system to ensure compliance, and erecting interpretive signage to educate people on the importance of corridors.

Conservation Easements - Strathcona County

Strathcona County has taken a different approach to conservation opportunities through conservation easements rather than a set corridor approach¹⁴. Their location between City of Edmonton and Elk Island National Park creates a variety of land uses. The dominant land use is agricultural, with residential, industrial, and commercial also being prevalent.

In order to create a conservation easement, the County enters into a legal agreement with a private landowner to keep the land designated in its natural habitat. The land is still owned by the private owner, but County bylaws place limits on what can happen with that portion of the property. These land restrictions are attached to the parcel in perpetuity. The County has approximately 100 conservation easements within the County, covering over 1,275 hectares of land.

Spatial Context Review

The following regional and local documents were scanned for content relating to wildlife, conservation easements, conservation reserves, environmental reserves, greenways, open space, and overall land uses.

Regional Level

Alberta Aerotropolis Viability Study Final Report

The Alberta Aerotropolis Viability Study (AVS) assesses the land adjacent to the Edmonton International Airport (EIA) boundary in order to see what kind of economic development would be feasible, and how that development could help the region create a diversified, multimodal transport hub¹⁵. The AVS does not address wildlife or environmental preservation or conservation directly, but does attempt to concentrate future development in four key areas as seen in Figure 3. These key areas comprise of 2,345 ha of land and focuses on creating economic clusters that have good odds of getting public and private funding. If fully implemented, Aerotropolis could supply anywhere from 52,000 to 86,000 jobs, or 5% of the Edmonton Metropolitan Region's workforce by 2044.

The Highway 19 West cluster northwest of the airport is the largest and most desirable economic development area in the study. The addition of a third runway at EIA, the expansion of Highway 19, extension of the 170 Street Goods Corridor, and future LRT connections makes this area undesirable for a future wildlife corridor.

The clusters adjacent to Saunders and Telford Lakes are much more amenable to a wildlife corridor. The Saunders Lake North District is directly south of the Nisku Wildlife Corridor study area, and proposes a mix of light industrial uses with wide streets and large building setbacks in order to cater to the energy industry. The Telford Lake Southern District proposes more campus style office parks and a community hub with retail, services and public uses. Both districts are identified as having easy access to servicing, and could be fully developed sooner than the other development areas as a result.

These two districts could conform to having a North-South oriented wildlife corridor along Saunders Lake, connecting to the potential Saunders-Telford Wildlife Corridor to the south. The main threats to a wildlife corridor are the plan to create waterfront business campuses on Telford Lake, and the extension of the Nisku Spine Road (identified as a major barrier in the Saunders-Telford Wildlife Corridor Study done in 2017).

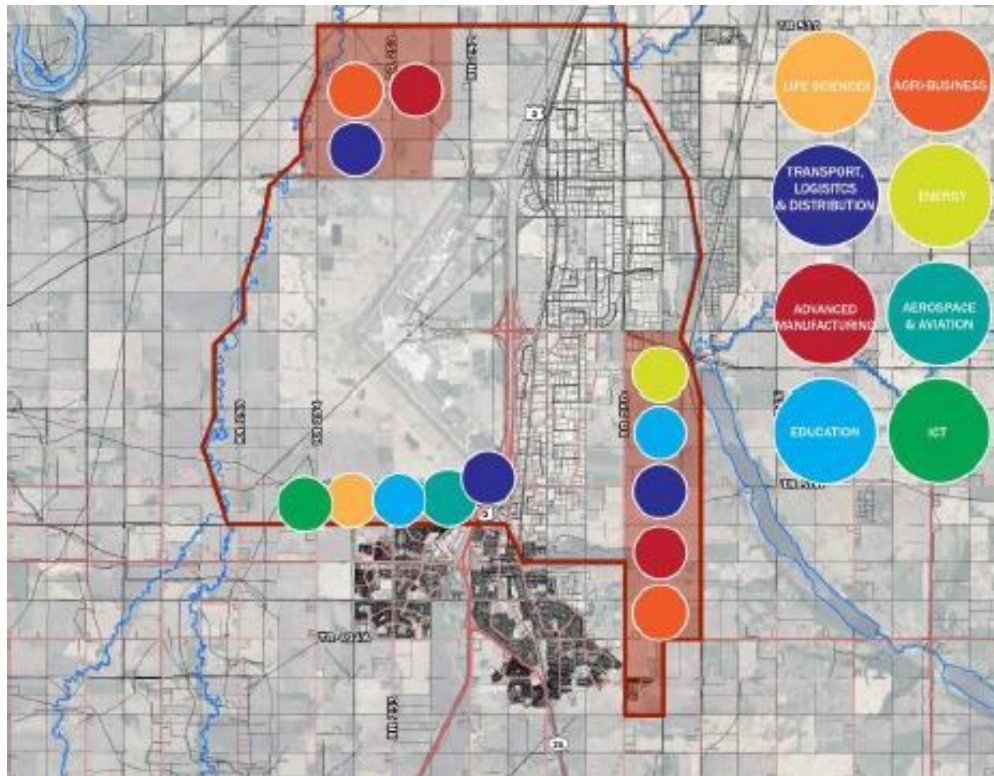


Figure 3: Key Development Nodes (Alberta Aerotropolis Viability Study Final Report, 2015)

Edmonton Metropolitan Region Board Growth Plan (2017)

The Edmonton Metropolitan Region Board Growth Plan (EMRBGP) is the dominant regional planning document in the study area¹⁶. The Plan sets out land uses, density targets, and overall regional priorities for Leduc County and its partners. The EMRBGP directly supports environmental protection, conservation, and connectivity through its guiding principles, goals and objectives. Highlights of these policies include:

- *Guiding Principle 7: Protect Natural Living Systems and Environmental Assessments:*
 - *We will practice wise environmental stewardship and promote the health of the regional ecosystem, watersheds and environmentally sensitive areas.*
- *Policy Area 2: Natural Living Systems*
 - *Conserve and restore natural living systems through an ecological network approach (2.1);*
 - *Protect regional watershed health, water quality and quantity (2.2);*
 - *Plan development to promote clean air, land and water and address climate change impacts (2.3);*
 - *Minimize and mitigate the impacts of regional growth on natural living systems (2.4); and*
 - *Conserve and restore the function, integrity, and connectivity of natural living systems for the long term ecological and social benefit of the Region, including but not limited to...key wildlife and biodiversity zones (2.1.2-H)*

Both the Beaver Hills Biosphere and the North Saskatchewan River Valley are noted as key natural living systems and provide potential opportunities for a wildlife corridor connection. Though Saunders Lake, Telford Lake, and the Blackmud Creek watershed are not directly mentioned, they are definitely areas that can be focused on within the structure of this Growth Plan.

The EMRBGP predicts a population increase of 1,365 people in Leduc County by 2044, requiring 12 quarters of land (0.1% of overall population growth and 1.6% of land for the region). The Growth Plan also states that Leduc County is expected to meet a minimum residential density of 35 dwelling units per net residential hectare, along with an aspiration density target of 100 dwelling units per net residential hectare for urban and sub-regional centres. These density targets are higher for the region of Leduc County West of QEII to Whitemud Creek as there is the potential for Transit Oriented Development (TOD) surrounding the South LRT extension.

The plan also seeks to limit future country residential growth until existing supply in the Metro Region is almost fully absorbed. The country residential supply in the County should be ample for the time-being, allowing for the preservation of the County's high value agricultural land. A Regional Agriculture Master Plan (RAMP) is currently in development with the EMRB's partner municipalities in order to follow through the EMRBGP's desire to preserve large parcels of agricultural land in the Metro Region. This preservation of agricultural land could apply to some parcels on the east side of the Wildlife Corridor Report study area, but the western side's status as an existing employment area makes the preservation of large agricultural plots unlikely.

Airport Accord (2017)

The aim of the Airport Accord is to set out the principles, guidance, and Terms of Reference for the City of Edmonton and Leduc County annexation lands agreement so that EIA will be able to achieve its full economic potential¹⁷. The framework for the accord was based off of the EMRBGP and the Metro Mayor's Alliance initiative. The plan requires consultation and the completion of other airport joint land planning prior to any land use changes west of the airport (where the most prime agricultural land is located), and allows for the creation of agriculture reserves or similar protections. The Airport Accord directly affects the study area by mandating that the County, City of Edmonton, and City of Beaumont work collaboratively on the interfaces between North Nisku and East Vistas.

Blackmud and Whitemud Creek Surface Water Study (2017)

The Blackmud and Whitemud Creek Surface Water Study is comprehensive assessment of the Blackmud and Whitemud Creek drainage areas that encompasses portions of the County, City of Edmonton, City of Leduc, Strathcona County, and the City of Beaumont¹⁸. The aim of the study is to prepare a Surface Water Management Plan (SWMP) for the Region. The Nisku Wildlife Corridor study area is located within the Blackmud Creek portion of the drainage area, and includes the convergence of Blackmud Creek with Clearwater and Irvine Creek. The recommendations and objectives for the SWMP include several initiatives that could support the creation of a wildlife corridor. Highlights include:

- *Retain and adapt existing wetlands for wildlife habitat and water quality enhancement;*
- *Protect floodplain land within the Blackmud and Whitemud basins from further development with a floodplain overlay in the municipal lands use bylaws and dedicate them as Environmental Reserves at the time of subdivision. A policy for protecting floodplains that recognizes the flood risk and the environmental values that floodplains provide should be developed;*
- *Where extensive overland flooding is found to occur, it is not always practical to sterilize large areas from development, and these locations should be considered as possible sites for stormwater management facilities or wetlands;*
- *Promote the construction and use of wet ponds and wetlands (not dry ponds) within the basins, except in the EIA exclusion zone; and*
- *Coordination planning between municipalities within the basins by adopting a water management plan for the basin and ensuring their stormwater management design criteria are consistent.*

The objectives and recommendations could aid the creation of a wildlife corridor surrounding the wetlands in the study area, especially Blackmud Creek and Irvine Creek. Restricting development within the 1:100 year floodplain, and restoring land within 100m of the creeks could provide wildlife opportunities, as well as supporting natural stormwater infrastructure, preventing the spread of invasive species, and limiting erosion issues. The Surface Water Study projects that a 1:100 year flood could raise water levels by as much as 4.1m, flooding the portion of the Nisku Business Area closest to the QEII in the far north section of the study area. The creation of drainage parkways, creating a regional wetland along northwest of Beaumont, and integrating stormwater management with wildlife habitat and migration corridors are all suggested within the study.

The Surface Water Study also identifies species at risk (mainly migratory birds), historic resources around Saunders Lake, and 13 rare plant occurrences that can be found within the drainage area.

Leduc County and City of Leduc Intermunicipal Development Plan (2017)

Environmental stewardship is one of five sustainability pillars used in the creation of the Leduc County and City of Leduc Intermunicipal Development Plan (IDP)¹⁹. The southern portion of the study area between the QEII and Blackmud Creek is included within the IDP. The policies in the IDP directly mention natural habitat/systems, wildlife corridors, and the protection, sustaining, and enhancement of the natural environment and agricultural operations. The IDP also commits the County and the City of Leduc to cooperating and collaborating on stormwater, wildlife corridors, and passive recreation. The wildlife corridor between Saunders Lake and Telford Lake is explicitly mentioned and directs further details of such corridors to be developed in finer grained planning documents, and when designing the Nisku Spine Road between 65th Avenue and Rollyview Road.

Land uses in the plan generally support natural spaces and passive recreation connections along Blackmud Creek, but the Business to Greenways Transition land use area stops short of

the Nisku Wildlife Corridor Study Area. The Nisku / Leduc Business Industrial Area also makes no mention of wildlife, greenspace, and recreational connections, leaving a gap between Saunders Lake and the Blackmud Creek drainage area to the north.

Beaver Hills Initiative Land Use Management Framework (Updated 2014)

The Beaver Hills Biosphere is a UNESCO recognized area that crosses the northeast portion of Leduc County²⁰. A Land Use Management Framework has been implemented by the Beaver Hills Initiative since 2007, having been last updated in 2014. The Framework states that Leduc County has done a good job of embedding environmentally significant areas into their planning documents. There is an opportunity for Leduc County to coordinate with the Cities of Edmonton and Beaumont to connect the Beaver Hills area through the North Major ASP lands.

City of Edmonton, Leduc County, and City of Beaumont: Intermunicipal Planning Framework Agreement (2018)

The City of Edmonton, Leduc County, and Town (now City) of Beaumont agreed to an Intermunicipal Planning Framework that commits the three municipalities to joint consultation, collaboration, and planning for the now-approved annexation lands²¹. This framework was critical to the annexation going through as it adjusted the original proposed annexation boundaries to allow Beaumont to retain nine quarter sections of land within their boundary in exchange for supporting the remainder of the annexation application. Current statutory plans, zoning policies, and development agreements currently in place will be respected. The main principles of the framework agreement include ensuring that the interests intermunicipal sub-region are considered over the individual municipalities, letting the best people for the job be in charge of those efforts, and minimizing duplication wherever possible. The main motivations for this agreement are as follows:

City of Beaumont:

- *A need to change the tax ratio from 95:5; and*
- *Settle the annexation.*

City of Edmonton:

- *Expedite the larger annexation by resolving the impasse with Beaumont over 9 quarters sections;*
- *Annex 50 Street right of way two miles south of 41 Avenue SW; and*
- *Doing sub-regional planning for compact, contiguous, complimentary growth.*

Leduc County:

- *Collaborative, cohesive, contiguous, growth in the sub-region (Intermunicipal Planning Framework Agreement, 2018).*

This framework agrees to a terms of reference for the municipalities to base their land use, transportation and servicing, cost and benefit sharing, and major transportation corridor

frameworks off of. The terms of reference also outlines how the coordination of timelines, funding, reporting, and engagement should proceed among other items.

Local level

Municipal Development Plan (Draft - 2018)

The Leduc County Municipal Development Plan (MDP) is a statutory planning tool intended to address population growth within the existing planned areas, and establish guidelines on future growth and development in the County for the next thirty years²². Leduc County is currently incorporating public engagement feedback into a revised draft that will be presented to Council for approval in the near future.

Leduc County's vision is to promote a sustainable and vibrant future for all areas of the municipality. Nine goals were established to provide strategic direction to planning and development. Wildlife aspects were not directly included as one of the plan goals, but there are related agricultural and environmental objectives. This section outlines the relevant content of the latest version of the MDP at the time of writing. Further assessment and analysis will be conducted in the final edition of this report.

The MDP highlights the importance of protecting and supporting diversity in the agriculture industry. This not only includes agricultural land, but rural communities as well. The MDP proposes the development of complete communities by connecting existing hamlets with the urban centres. One of the main purposes of this strategy is to take advantage of existing recreation opportunities, and to create new ones, so that all citizens of the County have proper access and resources. Leduc County is also interested in promoting a responsible use of natural resources within the municipality, with the goal of protecting and enhancing the natural environment while recognizing its economic assets.

The agricultural-related objectives focus on minimizing land use conflicts with existing agricultural operations, and preventing fragmentation and premature conversion of agricultural to non-agriculture uses. In line with the EMRB Growth Plan, the County requires that all proposed developments on agricultural lands conduct an Agricultural Impact Assessment. The MDP encourages urban agricultural activities within the Nisku Area, such as farmers markets and food processing and distribution in order to connect residents with local agricultural producers. Another important goal is to support community gardens for social and self-sufficiency purposes, and conserve soils, clay, and sand fill in agricultural area by preventing the spread of weed/pests, contamination, and degradation.

In terms of the environment and open spaces, the MDP requires that all new Area Structure Plans (ASPs), Local Area Structure Plans (LASPs) or Area Redevelopment Plans (ARPs) conduct environmental impact assessments to minimize the potential adverse impacts on the Environmentally Significant Areas (ESAs). The municipality also identified a need to provide adequate recreation and open space opportunities for its residents. Conflict minimization

between industrial and residential developments is encouraged through incorporating buffers and/or transitional land uses, connecting the green space network, and providing a variety of amenities, open spaces, and recreation opportunities. The MDP states that minimizing the disturbance of ESAs and wetlands is a priority, as well as encouraging the preservation of trees and vegetation within these areas. In line with these objectives, all subdivision and development applications need to consider and incorporate natural areas such as wildlife habitat and passageways, trees strands, wetlands, and watercourses into their design. Leduc County is interested in encouraging the restoration of sensitive ecosystems, natural areas, and habitat corridors that have been previously disturbed, and ensuring that no negative impacts on habitat, water quality, and water quantity are caused by developments enclosed by watercourses. The MDP strives to achieve these goals by developing a regional open spaces system that connects to environmental features such as wetlands, rivers, creeks, habitat areas, and tree stands that are critical to maintaining environmental functions.

Land Use Bylaw (Last Updated - 2018)

The Leduc County Land Use Bylaw (LUB) directly defines environmentally significant areas and wildlands, highlighting the importance natural migration links²³. Policy protecting agricultural operations from non-agricultural development pressures and emphasizing the environmental significance of any areas proposed for tree clearing are also included. Several industrial and urban commercial districts discuss the issue of bird habitat promotion within the vicinity of an airport and prohibit developments that include characteristics which increase wildlife and bird hazards in those regions.

The land use map only shows Environmental Reserve land around the Wizard Lake area, not near Saunders or Telford Lakes. The LUB does allow for the establishment of Conservation Easements, but County staff have mentioned that Conservation Easements are rarely used, and that Conservation Reserves are a very new policy that has not yet been implemented into the LUB. The LUB is expected to be updated after the Municipal Development Plan is carried.

Environmentally Significant Areas Study (2015)

The Environmentally Significant Areas (ESA) study identifies land with a critical environmental value on a quarter-section basis¹¹. The findings of this study are crucial to assess the current state of wildlife and habitat in the Nisku Wildlife Corridor study area, as well identifying critical areas that could potentially be part of the wildlife corridor, and proposing strategies to manage these lands. The study uses four criteria to assess the environmental importance of the land:

1. *Presence of focal species, species groups or their habitat;*
2. *Rare or unique geology or habitats;*
3. *Areas with ecological integrity; and*
4. *Areas that contribute to water quality and quantity.*

In terms of the presence of focal species, this study considers primarily rare, threatened or endangered species, and fish-bearing water bodies and water courses. This criterion makes up 20% of the total environmental significance of the land. Regarding rare or unique geology or

habitats, the study assesses the presence of surficial geology and landforms, high productivity soils and peatlands. This criterion was assigned only a 10% of the total environmental importance of the land. The third criterion, ecological integrity, refers to the presence of terrestrial and aquatic habitat cover, and the contribution of the land to different types of connectivity. Landscape, lake, wetland, and in-stream habitat connectivity were all factored in. This criterion accounts for 40% of the total environmental significance of the land. In regard to the contribution to water quality and quantity, the study looked at river and stream density, riparian habitat intactness, and water storage and discharge potential. This criterion was assigned the remaining 30% of the total environmental importance of the land. The study assigned greater value to water-related factors than any other predictor of environmental significance.

Every quarter section within the county's boundaries was assigned a score for each criterion to identify the areas that are relevant in each of the four categories. The scores were then multiplied by the corresponding percentage value (e.g. a 0.2 multiplier was used for the score of presence of focal species) and added up to produce a general ESA score. Based on the quarter sections with a high ESA score, the report identified regions with a series of elements of high environmental value and classified them in three categories (Figure 4):

1. Aquatic and riparian ESAs;
2. Upland ESAs; and
3. Mixed ESAs.

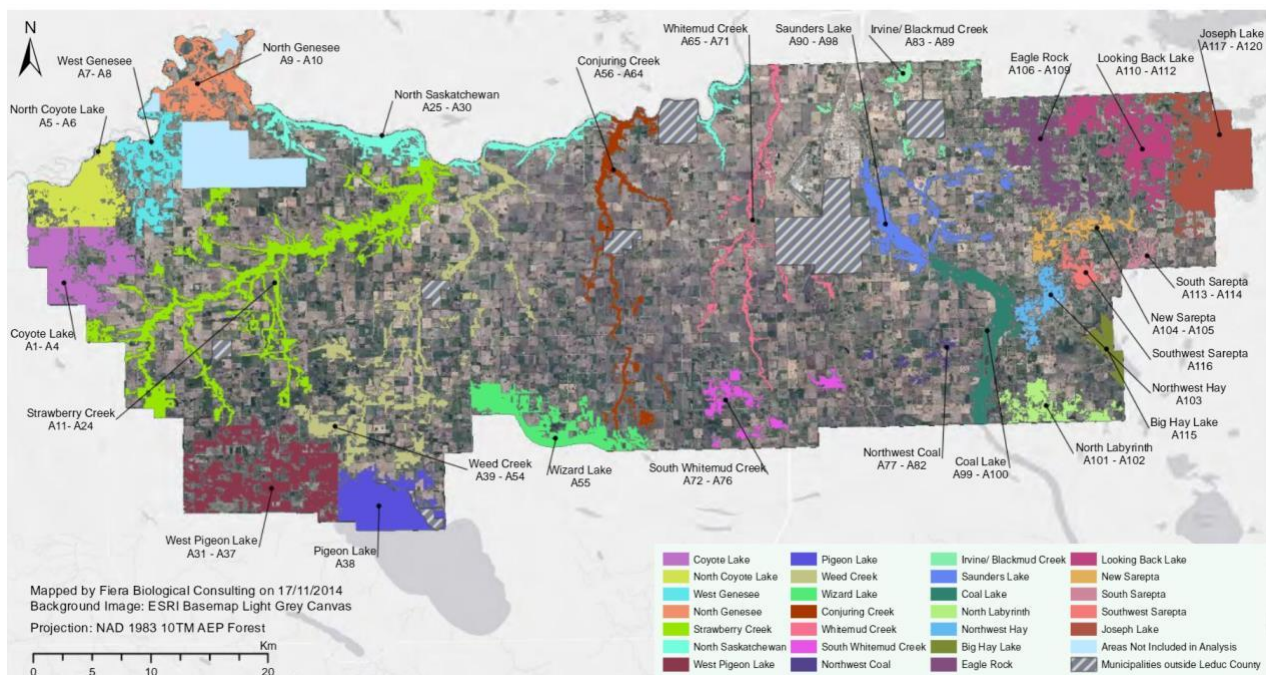


Figure 4: ESA Regions (Fiera Biological Consulting, 2015)

The study states that aquatic and riparian ESAs support a higher level of biodiversity, and contribute to ecological services such as water filtration and water treatment. Important

elements of these areas are wetlands, which are crucial to regulating surface and groundwater flows and to mitigating flooding risk. The study suggests that these ESAs should be prioritized in the formulation and adoption of ASPs given their high environmental importance for the municipality. Other recommendations for the management of these areas include dedicating the ESAs located in private land as Environmental Reserves or Easements upon subdivision approval to protect the most important water features. The report also recommends the use of a riparian matrix setback model to define the minimum buffer needed to protect these ESAs, and include development requirements that exceed these minimums. The use of low impact development principles to lower pollution and the minimization of intensive land uses adjacent to aquatic and riparian ESAs is also advised.

The study explains that Upland ESAs comprise important terrestrial habitat, provide a home to forest-dependent species, and facilitate the movement of terrestrial, semiaquatic and aerial species. Given that the predominant landscape in Leduc County is agricultural, undisturbed Upland ESAs are rare and there are limited conservation opportunities to guarantee that these habitats continue to exist. The study recommends land securement methods as a primary conservation means. These methods include land purchasing, Conservation Easements, Municipal Reserve dedication, restrictive covenants, transfer of development credits, and tax incentives. The study highlights the importance of maintaining good connectivity between Upland ESAs and other natural and semi-natural habitats at a local and regional level. This initiative requires regional efforts, but the study states that it is crucial for Leduc County to minimize intensive land uses in and around these areas in order to protect them.

In terms of the mixed ESAs, study explains that they represent a combination of the elements present in the previous two categories and require similar strategies to ensure their conservation as a result. As general recommendations for all Environmentally Significant Areas, the study suggests the promotion of contiguous development, the use of buffer zones to seclude ESAs from human activities, and the creation and restoration of natural corridors to ensure connectivity. The report also addresses the use of provincial legislation, such as the Land Use Framework and the Alberta Land Stewardship Act to minimize disturbances while recognizing the development needs of the municipality. These findings are of the utmost importance to justify the need for a corridor in the study area and to define the lands that should be preserved in an effort to create and maintain a functional and effective connectivity to ensure the preservation of biodiversity and ecosystem services in the municipality and region.

Parks & Open Spaces Master Plan (2006)

Leduc County developed a Parks and Open Spaces Master Plan in order to address the role of existing sites and provide direction for the future development of parks and open spaces²⁴. The Plan is non-statutory and takes its overall direction from the Municipal Development Plan and County Business Plan. This plan can be used as a form of foundation for other, more specific policies and plan for individual parks and programs. In 2010, a Parks Standards document was developed by the guidance of the Parks and Open Spaces Master Plan to ensure proper development of parks and natural areas in Leduc County.

The Master Plan prioritizes the development of new regional or district parks in the central portion of the County. Saunders Lake was identified as a potential site given that it is in an area of interest for recreation and environmental features. Additionally, the plan proposes to link County trails with the regional trail system. It is important to note that the Master Plan emphasizes that Leduc County will assist others but will not commence development of regional trails.

Several other strategies are outlined in Master Plan. First, to maintain the integrity of Environmentally Significant Areas, the County may employ land use planning for conservation purposes. Second, areas that provide environmental linkage and connections between existing and new environmental areas will be dedicated for Environmental Reserve. Finally, linear corridors that provide environmental benefits may also be designated as recreation trail linkages as long as the environmental values are maintained.

For new residential subdivisions, the Master Plan outlines additional dedications for Municipal Reserve will be required in the following cases:

- *To supplement environmental reserves along lakes and rivers;*
- *To protect habitat or vegetation not protected in environmental reserves;*
- *To provide ecological connections for vegetation continuity or wildlife corridors; and*
- *To provide linear connection to adjoining subdivisions*

Vistas Community Parks & Open Space Strategy (Draft - 2018)

The Vistas Community Parks and Open Space Strategy consists of a combination of goals, standards, and recommendations to ensure Leduc County provides appropriate and sustainable spaces for people to recreate across the community.²⁵ The Strategy's goals provide direction for the County to support and provide well utilized and sustainable parks and open spaces. Note that this strategy is a draft document that has not been officially approved as of the time of writing.

The vision of the strategy includes three important elements:

- *Access to parks and/or open spaces within 500m of all residences in the neighbourhood, providing a diverse range of passive and active recreation opportunities;*
- *Create a trail network to provide access for pedestrians, joggers, and cyclists to a variety of destinations within and around the community; and*
- *Full connection via walkways or greenways to open space areas, parks, stormwater management facilities, natural areas, and environmental reserves.*

The following is a summary of the relevant recommendations and tasks stated in the Strategy:

1. *Further stormwater planning be undertaken to better delineate where these facilities and coinciding parks may be located and connected;*
2. *Naturalization of the Blackmud and Irvine Creek banks would provide a natural separation between the Vistas residential development and the Nisku industrial and commercial areas;*

3. *A central park, which would include schools, around the large remnant woodlot will provide a focal point for recreation within the community and will also provide amenity for the town centre;*
4. *A trail link to Saunders Lake should be planned and designed to include a top-of-bank trail along the east edge of the Blackmud Creek corridor that will connect to the reservoir site and to the Irvine Creek top-of-bank. It will also connect through existing public reserves to the north end of Saunders Lake;*
5. *Trail connections to Beaumont will be provided through the Elan growth area as this expansion develops. A trail along Township Road (TP) 510 may be the first possible connection to Beaumont;*
6. *Trails, and specifically trailheads, will have suitable associated infrastructure such as benches, waste receptacles and trail-network signage. Interpretive signage for natural areas and locations of historical importance should be provided to add interest to the trail system;*
7. *The reservoir site represents the best opportunity for a district-level park that could incorporate a range of active recreation activities, including organized sports tournaments. A Concept Plan should be developed for this site to verify its potential and identify any environmental or other constraints;*
8. *The existing large park in Edda Vista could be enhanced with passive and small-scale active recreation facilities. Further public consultation and planning should be conducted for a future use of this site;*
9. *The Native Prairie Grass Reserve in Kayda Estates will be preserved as a significant natural area and as an area for nature interpretation and education. The existing partnership with the Alberta Native Plant Council will be fostered;*
10. *A comprehensive and sustainable Maintenance Plan will be prepared to clearly lay out maintenance standards for park and associated amenity maintenance. This will include an Enhanced Landscape Maintenance Program (ELM) and an optional amenity program; and*
11. *Given the different options available to Leduc County, a formalized Park Enhancement funding model be established to work with developers, community groups, school boards, and others to enhance open space.*

Leduc County Agricultural Strategy (2016)

The Leduc County Agricultural Strategy recognizes the development pressure facing agricultural operations in the region, and envisions a “*vibrant and resilient agri-food future built on a proud agricultural history*”²⁶. It identifies farming as the dominant land use in the County, and has four main principles designed to support that industry:

1. *Formally recognize and champion agriculture’s important role in Leduc County*
2. *Recognize and protect the priority agricultural land*
3. *Limit land fragmentation in priority agricultural areas*
4. *Implement multi-pronged support for long term success*

These principles are to be implemented through the MDP, LUB, and other relevant policies, regulations, and programs.

From a wildlife corridor perspective, the Strategy states that agriculture allows for a diverse range of wildlife habitat, and recognizes the Beaver Hills region as Environmentally Sensitive Agricultural Lands. These areas are still promoted for agricultural use, but only in a context appropriate way. The Nisku Wildlife Corridor Study Area is not listed in an environmentally sensitive land use zone, but consists of some of the best soils in the County that is recommended for large scale crop operations and soil preservation. Preservation of agricultural land in the region, as well as the Strategy's suggestion for less intensive country residential development in certain areas of the Nisku Wildlife Corridor study area, could provide an opportunity for a wildlife corridor to co-exist.

Area Structure Plans

Area Structure Plans (ASPs) are statutory planning documents that outline detailed policies for growth and future land use designations of specific areas in Leduc County. The ASPs contain information on the sequence of development proposed for the area, population density, proposed land uses (either generally or with respect to a specific parts of the area), and the general location of major transportation routes and public utilities. Leduc County has five ASPs located within and/or surrounding around the Nisku Wildlife Corridor study area. These ASPs were scanned for future development patterns and wildlife, environment, and agricultural related themes. Analysis of the scan's findings are contained in the Data Analysis section of this report.

Nisku Area Structure Plan (1981)

The Nisku Area Structure Plan was created to evaluate and identify areas that are suitable for the long term expansion of the Nisku Industrial Park²⁷. Other than business related development, the plan describes the existing water distribution system within the industrial park and in future expansion areas. The plan also provides a conceptual layout for the sanitary sewer system that could be developed in stages to serve the existing and future development in the park. In terms of environmental related areas, the plan addresses the importance to maintain of high environmental standards and the need to provide adequate services and recreational facilities for local industries and workforce.

The plan established an Agricultural Zone on the east and south boundary to protect the integrity of the adjacent creek and lake valley, and to buffer the non-compatible uses. This zone corresponds approximately with the valley formed by Blackmud Creek and Saunders Lake. Since the boundary quite often follows the quarter section lines for administrative conveniences, this zone is arbitrarily used as a boundary to the industrial area. However, a portion of the land under this designation may have potential for industrial development while other portions are undevelopable.

Nisku West Area Structure Plan (1980)

The Nisku West Area Structure Plan (ASP) was adopted in 1980²⁸. The land area was originally part of the Nisku Area Structure Plan, but was removed by Council in 2000 to create a

standalone ASP. The purpose of Nisku West ASP was to form a framework for industrial subdivision and development. The plan addresses business, light industrial, and park/open spaces land uses. The plan covers stormwater management, sewage collection, and water distribution systems. Environmental aspects of the plan include encouraging municipal servicing patterns that take full advantage of the natural features of the Plan Area wherever practicable. In addition, municipal park reserves are to be purposely located in most visible portions of the Plan Area in order to display an attractive landscape environment.

The Nisku West ASP focuses on this attractive landscape ideal in order to serve as a buffer and to be an important element of the park and open space system. The Municipal Reserve strip in the plan prevents direct access from any portion of the area to major roadways, forming a linkage between the municipal park reserve parcel located at the south end and near north end of the Plan Area. These park reserves are purposefully located to maximize the aesthetic, visual potential, and recreational potential for local employees, nearby business, and motorists entering or leaving Nisku West. Storm Pond Park Area is specifically designed to provide an interesting and varied park environment. All park areas and park reserves within this ASP are intended to function as passive parks.

North Major Area Structure Plan (2004)

The North Major Area Structure Plan was established in response to significant growth (both current and future) within the plan boundaries²⁹. This plan combines respect for the natural environment and existing heritage with the future aspiration and desire for residents to work, live and, recreate. The goal of this plan is to promote orderly development in the plan area with agricultural and sensitive resources in mind. Agricultural grain and cattle lands are dominant within the plan area. Additionally, this ASP contains the majority of the Nisku Wildlife Corridor study area's most significant natural features.

Conservation plays a critical role throughout the ASP, with Blackmud Creek being a key sensitive feature. The County seeks to conserve natural features along Blackmud Creek through Municipal and Environmental Reserves. The plan supports using land purchase and Environmental Reserve Easements if necessary. As per the guidelines of the Agricultural Code of Practice, agricultural practices along Blackmud Creek should prevent erosion and maintain water channels and sensitive slopes. Land within the 30 NEF contour of the 2040 Noise Exposure Forecast of Edmonton International Airport is restricted from residential development. Lands in the Agricultural Area are intended to remain as agricultural production due to their high quality soil noise restrictions, although the County may identify the land for other uses if appropriate.

Blackmud Creek Area Structure Plan (2004)

The Blackmud Creek ASP was extracted from the Nisku ASP in order to avoid any potential conflict between expanding industrial development and low-density country residential on either side of Blackmud Creek³⁰. This plan addresses future land use, utilities servicing, access, internal circulation, and implementation processes. The ASP's main objective is to establish a transitional land use area that is compatible to both adjacent industrial and residential areas.

Extensive agricultural uses continue to be permitted within the ASP. Areas below the 1:100-year floodplain boundary are designated for agricultural uses due to potential flooding. Passive outdoor recreation uses that are not adversely affected by flooding, such as golf courses and parks may be considered on a discretionary basis. The plan dedicates two relatively small areas as Environmental Reserve, but does encourage the retention of trees wherever practical. One of section of ER is located below the 1:100-year floodplain immediately south of the north boundary of the NE 18 and contains significant tree cover. The second area located north of Airport Road contains a stand of trees. These trees are preserved to help stabilize the slope within the 1:100-year floodplain.

Saunders Lake Area Structure Plan (2004)

The Saunders Lake ASP was split off from the Nisku ASP in order to the potential conflict between ongoing commercial and industrial development around the lake³¹. The ASP vision is to combine primarily business park development with significant areas of public open spaces around the lakeshore for low intensity recreation and environmental protection.

Twelve policies within the ASP address the natural area and open space designations. The plan recommends a minimum buffer from geotechnical top-of-bank, plus additional setbacks if required. Exceptions to the buffer are only permitted for recreation related development. The plan desires to have any open spaces and trails connect to adjacent areas and/or other regional recreational networks. Pedestrian access to any natural area and open spaces are suggested for approximately 400 meter intervals. Landscaping is permitted where required, and all land designated as Natural Area and Open Space is to be comprised of drought resistance species to minimize maintenance.

No parking or outdoor storage is allowed to be located within the designated setbacks from land zoned as Natural Areas and/or Open Spaces. Additional landscaping and lighting that minimizes impacts on wildlife is also required for land adjacent to these zones.

Local Area Structure Plans

Leduc County's Local Area Structure Plans (LASPs) provide another, more localized, statutory framework for the subdivision and development of an area of land. A LASP describes the sequence of proposed development for the area, general location of major transportation routes and public utilities, the land use and density of population proposed for the area, and reserves. A LASP must have land uses that are consistent with the applicable Intermunicipal and Municipal Development Plans. This section explores the four LASPs that apply to or surround the Nisku Wildlife Corridor study area, with a focus on wildlife, environment, agricultural, and related themes.

East Vistas Local Area Structure Plan (2010)

The East Vistas Local Area Structure Plan was established through an amendment to North Major ASP³². The East Vistas LASP was proposed in response to the demand for land to accommodate growth in the greater Metropolitan Region. A key feature of this plan is to create a

complete and sustainable urban community with a strong sense of place by applying Smart Growth principles to encourage sustainability by accommodating growth that make efficient use of the land and existing municipal services. The plan promotes healthy lifestyles by including infrastructure for walking and cycling, as well as aiming to make streets public amenities for non-drivers.

The plan addresses development concept relating to Municipal Reserve, natural areas, parks, and trails. The Irvine Creek Valley and its environments are to be protected as an Environmental Reserve. A geotechnical report is required at the time of subdivision that recommends the minimum setback distance for development from the top of bank. Sustainable treed areas are to be retained as Municipal Reserve, creating a network of smaller neighborhood park spaces. A linear pathway provides a linkage across the plan area, connecting natural areas like Irvine Creek and facilitating people and wildlife movements. Connections to future trail and park systems outside of the Plan area towards Blackmud Creek are encouraged. Stormwater facilities are encouraged to be built to mimic native wetlands and the natural drainage course, increasing the aesthetic appeal and the ecological integrity of the whole community. The Plan also notes that an existing transmission right-of-way could be an opportunity to create a new segment of the Waskahagan Trail, which remains incomplete through Leduc County north of Saunders Lake.

WAM Industrial Park Local Area Structure Plan (2008)

The WAM Industrial Park LASP was adopted for the purpose of defining the plan for servicing, transportation infrastructure, and for the industrial use development pattern as prescribed by the Leduc County North Major ASP³³. This plan has more emphasis on creating diversity and flexibility that enhances the strong industrial base that already exists in Leduc County, ensuring the region's future success.

A thirty-meter Municipal Reserve strip is located along the east boundary adjacent to future county residential land use. This strip creates a buffer identified as a "greenway buffer" in the between the business park uses proposed in the WAM LASP and future residential land uses proposed to the east in the North Major ASP. The LASP also calls for two stormwater management facilities to improve the water quality of any runoff before discharging into Blackmud Creek and the North Saskatchewan River. These facilities are designed to deter migratory birds.

Royal Cubera Local Area Structure Plan (2017)

The Royal Cubera LASP was adopted to provide a foundation for the development lands that were previously part of the North Major Area Structure Plan³⁴. The goal of the Royal Cubera LASP is to create a strong sense of place with comprehensive design and compatible development that supports and enhances adjacent land use. The LASP aims to create a well-connected, economically prosperous, and environmentally respectful, business, commercial, and light industrial complex. The plan also encourages social interaction and association with the natural environment by providing multi-use trails and green spaces that allow for both passive recreation and purposeful journeys.

The LASP lands are a mosaic of cultivated land, woodlots, and wetland features. The cultivated lands are dominated by canola crops. The woodlots are predominantly upland varieties that consist of trembling aspen and balsam poplar overstory, with a shrubby understory. Many wetlands are located in this LASP (22 wetland of various classifications) with six of them being rated as having high ecological value. Hydrophilic vegetation occurs in the wetlands that have standing water. The wetlands provide habitat for numerous waterfowl and shorebird species, such as the mallard, Canada goose, northern pintail, northern shoveler, red-winged blackbird, and killdeer. Additionally, the Fish and Wildlife Management Information System (FWMIS) identified other species such as short-eared owl, the swainson's hawk, and the northern leopard frog habitat in this LASP.

A variety of mammal species are found in this LASP, including the white-tailed deer, moose, coyote, porcupine, red fox, skunk, snowshoe hare, and white-tailed jackrabbit. Raptors such as the great horned owl, red-tailed hawk, northern harrier, and falcons are typically common when prey is abundant. Assortments of resident and migratory birds are also present within the Central Parkland Subregion. Resident and migratory songbirds such as the black-capped chickadee, American robin, red-breasted nuthatch, warblers, and sparrows are abundant across the landscape.

The land use concept proposes protecting the ecological integrity of natural features deemed to be of high ecological value. Municipal Reserve will be utilized first to provide connective trails, park spaces, and buffers around natural areas. Trails and park spaces are dispersed to provide logical connectivity between adjacent development. The LASP also states that the landscaping of parks, open spaces, and stormwater management facilities should incorporate indigenous plant species and xeriscaping to minimize landscape irrigation.

Queen Elizabeth II Business Local Area Structure Plan (2012)

The QE II Business Park LASP was developed to accommodate a range of compatible industrial and commercial uses³⁵. The Plan proposes that thirty-two-hectare eastern portion be rezoned from Agricultural to Industrial. Environmental considerations include wetland vegetation and naturalization of stormwater management facilities to consider passive bird hazard mitigation measures to ensure that birds do not use the site, especially large flocking waterfowl such as gulls and geese.

Surrounding Municipal Planning Documents

City of Beaumont

The City of Beaumont has several planning documents that could influence the placement of a wildlife corridor in Nisku.³⁶ Though the existing IDP formed in 1998 does not contain any relevant information, the policies, goals, and objectives of the City's MDP, ASP's, and NSP's provide some insight.

The existing MDP (1998, last updated in 2017) has several policies that promote strong linkages between new and existing open spaces, and the creation of larger parks and continuous open

space corridors within new developments. The Leblanc Canal and Irvine Creek are also listed as regionally significant features.

The new draft MDP (2017) goes farther, and identifies the Irvine Creek riparian area as a major East-West wildlife linkage. The creation and conservation of biodiverse habitat, the maintaining of Environmental Reserve Easements as natural areas, and the supporting of local and regional ecological connectivity are all directly stated in the proposed policy. Actions for implementing the Blackmud and Whitemud Surface Water Study recommendations, updating the Open Space and Trails Master Plan, and the development of naturalization studies are all included. The land use concept in the draft MDP shows the lands surrounding Irvine Creek and adjacent to Leduc County's border as mostly residential, with major parks and open space connections into northwest and southwest Beaumont.

The Elan ASP and NSP elaborate on this land use concept, showing the establishment of a drainage right-of-way rather than an Environmental Reserve along the LeBlanc Canal in the northeast of Beaumont, and recognizing that the canal is the primary outlet for Beaumont's stormwater system. The current land use is mostly agricultural, but would be almost exclusively residential in the future. Greenways and recreational connections are promoted, but few are actually shown. The ASP also follows the draft MDP's commitment to the Surface Water Study's recommendations.

Data Analysis

Policy Alignment for the Creation of a Wildlife Corridor

Regional Level

The overview of regional planning documents identified several opportunities to integrate wildlife habitat, sensitive ecosystems, stormwater management mechanisms, recreation and open space opportunities, and agricultural preservation. Overarching regional documents such as the EMRB Growth Plan, County of Leduc and City Leduc IDP, and the Whitemud and Blackmud Creek Surface Water Study all have policies embedding these objectives and emphasizing intermunicipal collaboration. Having relevant policies in these higher level documents provides strong direction for the local statutory plans, allowing them to create more implementable policy.

Comparisons of land use concepts throughout the regional documentation have indicated that a potential inter-municipal wildlife corridor could roughly follow the Saunders Lake, Blackmud Creek, Irvine Creek, and Leblanc Canal drainages through to the Beaver Hills Biosphere as shown in Figure 8. Much of this drainage land is within the 1:100 year flood plain, and is currently occupied by low-intensity agricultural land that requires crops to be hardy enough to withstand flooding². Leduc County has expressed that this land is seldomly productive due to tractors being afraid of getting stuck, and that the County has purchased lots within the area in the past. Revegetating these areas with native species could provide a wide enough corridor to

² D. Martin, Personal Communication, February 13, 2019

encourage wildlife movements, help absorb future floodwaters from expanding development, provide context appropriate recreation and wildlife education areas, and could buffer country residential and agricultural operations from more industrial works. All of these items can be explored and measured as Phase II of this report progresses.

Local Level

The MDP builds on regional statutory documents and local studies to provide general policy direction that supports the incorporation of a wildlife corridor into the environmental structure of Leduc County, even if it doesn't directly create wildlife corridor policy outright. The Environmentally Significant Areas identified in the 2015 study are officially recognized and incorporated into the MDP, but the purpose of including environmental guidelines seems to be the enhancement of the recreation opportunities for residents rather than the needs and benefits for wildlife. Despite the recreational focus of the MDP strategies, there are important policies for the treatment of ESAs. The MDP requires that all new Area Structure Plans, Local Structure Plans or Area Redevelopment Plans conduct environmental impact assessments to minimize potential adverse impacts on the ESAs. This approach highlights two important issues. First, there are a series of ASPs, some of which have been in place for more than a decade, and there's no clear instructions as to how these plans are going to be updated to incorporate more sustainable concept plans, if they even have to do so. Second, there are no specific details about what the standards and requirements for environmental impact assessments are. In any case, the use of this tool opens several opportunities to ensure that future development proposals at least consider the existence of environmental features and ecological services and incorporate minimum actions to protect them.

Another important aspect of the MDP is the stated interest in the restoration of sensitive ecosystems that have been lost to development and other anthropogenic disturbances. This objective especially applies to wetlands, water courses, and all areas that contribute to hydrology-related ecosystem services, as well as natural habitats. Most importantly, the MDP highlights the connection of natural ecosystems that are critical to maintaining environmental functions the incorporation of a wildlife corridor clearly responds to these intentions, and could be designed to match the expectations of the municipality in terms of the balance between the social, economic and environmental benefits that can be derived from it.

Most of the Area Structure Plans within the study area discussed or considered the environmental aspects concerning them. An important theme under this category was the creation and enhancement of the connection between open spaces, parks, and trails. However, ASPs are not a clear source of opportunities for the incorporation of a meaningful and functional wildlife corridor. Even though there is a certain degree of consideration for the environmental features of the land, there are no environmentally-focus strategies to manage them, let alone efforts to go beyond the minimum requirements for the sake of ensuring ecological connectivity. A reason for this might be the lack of a framework to align these efforts, which would make it pointless for individual ASPs to plan for the connectivity of ESAs.

An important characteristic of newer ASPs -the ones that were written within the past ten years- is that they have more regard for wildlife than the older ones, but many still are not fully

committed to direct policy statements on wildlife corridors. Many of the ASPs and LASPs took a similar approach to the MDP, where they mention wildlife, but still incorporate it into open space and recreation. The drafted Vistas Community Parks & Open Space Strategy mentions natural habitat and provides wildlife corridors under the Linear Park classification. A similar approach was found in the Saunders Lake ASP: the conservation of wildlife habitat was mentioned in the natural area/open space, transitional land, and stormwater management sections of the proposed concept. Out of all the ASPs and LASPs, the Royal Cubera LASP is the only one that speaks to wildlife policy in great detail. The plan not only recognizes the various species and animals inhabiting the plan area, but further identifies their desired locations and which species require attention for future development. The plan suggests creating a strong sense of place and protecting the ecological integrity of natural features.

Another aspect that works in synergy with the implementation of a wildlife corridor is the protection of agricultural land and operations. The MDP demonstrates that in general terms, the County is interested in maintaining the integrity of its agricultural industry, including the prevention of land fragmentation and conversion. This emphasis on agriculture is important for several reasons. First, agricultural land provides vegetative land cover which is important for the preservation of the integrity of the land and ensuring the continuous provision of water-related environmental services. Second, croplands provide safer passage for wildlife than areas with a higher anthropogenic disturbance. Finally, agricultural operations take place in large extensions of land, thus ensuring connectivity and continuity at a larger scale. Agricultural operations also provide food and habitat for wildlife, especially birds³⁷. Tillage (leftover crops in the field after harvest) often provides a food source for birds.

A large majority of older ASPs recognize the importance of protecting agricultural land through the designation of agricultural zones. Furthermore, some plans require the use of the Agricultural Code for practicing and conducting Agricultural Impact Assessments to minimize land use conflict with existing agricultural operations and to identify and mitigate the potential adverse impact. A few plans have proposed to minimize fragmentation and to conserve soils, clay and sand fill in agricultural areas.

Policy Misalignments for the Creation of a Wildlife Corridor

Regional Level

Proximity to Edmonton International Airport, regional transportation network expansions, and the Nisku Business Area's prominence as an industrial and commercial hub for the province all create policy misalignments for the creation of a wildlife corridor. Migratory birds are cited as one of the major species identified in the Whitemud and Blackmud Creek Surface Water Study, but several ASPs close to the airport specifically aim to deter birds from landing and settling in water bodies in their area. Any wildlife corridor in the region will have to take the potential for bird strikes at EIA into account.

The planned third runway at EIA, combined with the eventual widening of Highway 19, the Aerotropolis Highway 19 West Cluster strategy and future LRT expansion all pose a significant

challenge to wildlife corridor connections to the west of the Nisku Business Area (nevermind the existing QEII Highway). These proposed land uses are potentially too intensive and could create too many strong edges for a wildlife corridor to be effectively utilized.

On the eastern border of the study area, extension of the Nisku Spine Road as displayed in the Aerotropolis Study also creates a large potential barrier to wildlife movements, especially for those who may want to cross E-W or vice versa across Blackmud Creek and Saunders Lake. The northern edge of the Leduc County / City of Leduc IDP also does not provide a continuous connection for the Business to Greenways Transition land use zone up to the Nisku study area, leaving a gap in environmental policy for that portion of Saunders Lake.

Funding negotiations could affect the incorporation of open space and recreation opportunities alongside a regional wildlife corridor, as Leduc County's Parks and Open Spaces Master Plan does not support the County initiating regional trail building, but will only take an assisting role. It is important to note that the Master Plan emphasizes that Leduc County will assist others but will not commence development of regional trails on their own accord.

Local level

An outdated Land Use Bylaw, fencing, laydown yard locations, and misalignments between ASPs and the Environmentally Significant Areas Study are the main issues at the local level. The current Land Use Bylaw does not have a Conservation Reserve added to it, which could potentially be utilized when environmentally significant land needs protecting. It should be noted that the LUB is planned to be updated once the updated MDP is passed. During a site visit to the area, it was noted that there was a mix of fenced and unfenced lots in the Business Park, agricultural, and country residential areas. The effects of fencing on wildlife movement in the region is unknown at this time, but it could become a potential conflict with a future wildlife corridor. The placement of large laydown yards in the Business Park may eventually move elsewhere in the County and could free up the Business Park lands for future development. The massive size of these yard lands could mean there is an opportunity for wildlife, recreation, and open space corridors to be incorporated as a part any new developments.

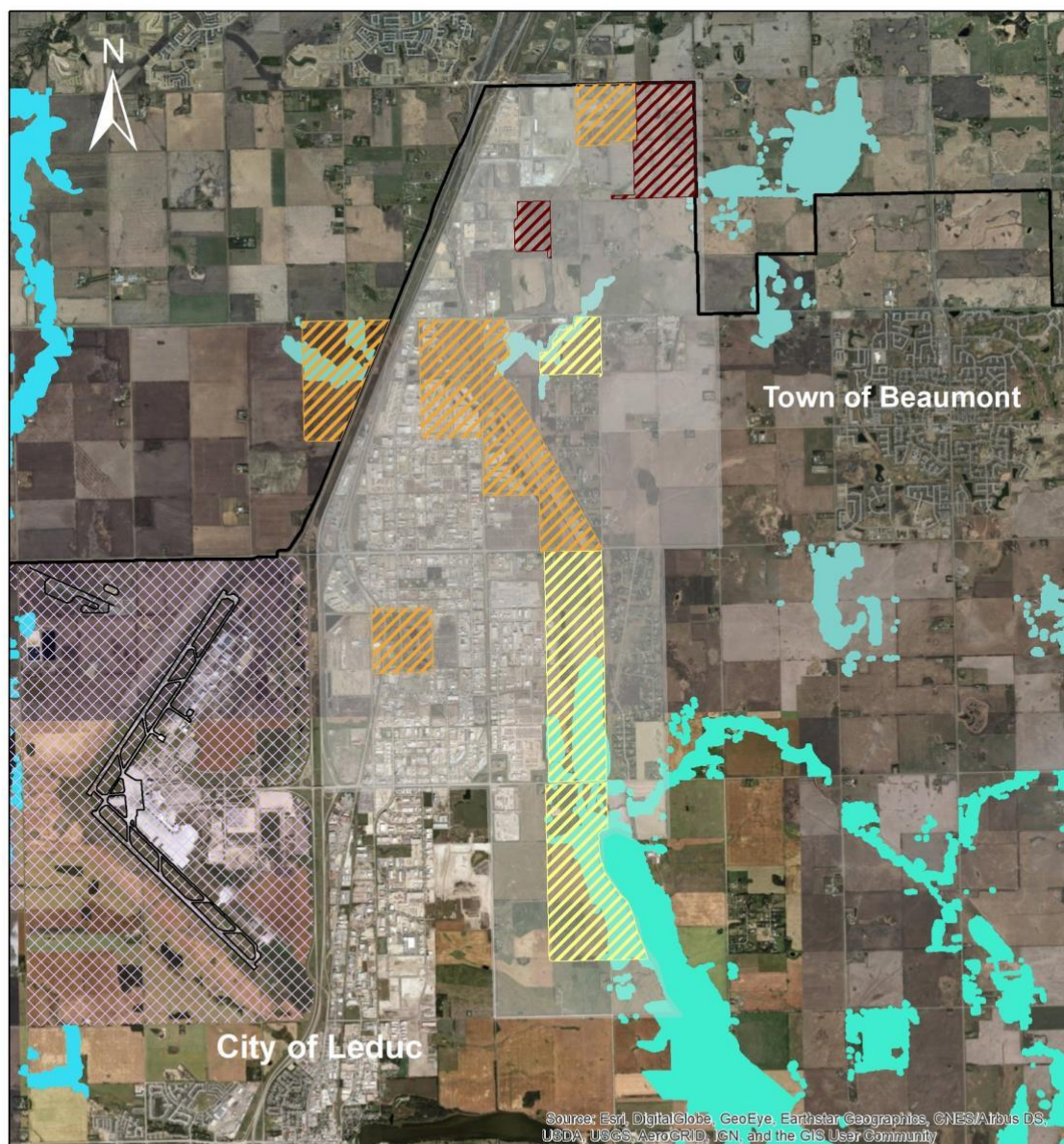
Using spatial analysis techniques (see Appendix A), the concept plans of the ASPs and LASPs were compared to the environmentally significant areas delineated by the ESA study. Figure 5 shows the areas where there are land use conflicts. Recognizing that a large portion of the study area is an industrial park with relatively high impact activities, the conflict areas were classified into three levels: low (conflict level of 1), medium (conflict level of 2) and high (conflict level of 3). Generally speaking, it was found that most ASPs do not present meaningful strategies to preserve or enhance environmental values. A high level of conflict was assigned to those areas with multiple environmental attributes that are not being considered, or even assessed in the ASPs. As shown in Figure 5, these conflict areas are concentrated around the Blackmud Creek channel and towards the north east corner of the study area, adjacent to important wetlands and riparian habitat.

Based on the threats that the approved concept plans of the ASPs pose to the environmentally significant areas in the study area, a set of conservation priority areas was identified (see Figure

6). These areas were also classified according to a priority score. Areas with a score of 6 to 9 were identified as medium priority, areas with a score of 9 to 12 are considered high priority, and areas with a score of 12 to 15 were identified as very high priority. It is important to note that even the parcels with a medium conservation priority still have a significant conservation score and should not be excluded from the conservation efforts. This classification system highlights the areas that are the most important for maintaining good ecological connectivity.

It is also important to consider that meaningful environmental connectivity cannot be achieved with local efforts alone. Even though this study has a defined study area, the priority conservation areas in Figure 6 cover a much broader portion of Leduc County and its surrounding municipalities. Accordingly, efforts to preserve natural connectivity should not be limited by political or administrative borders. An effort should be made to take a holistic and regional approach to guarantee the integrity of natural habitats and wildlife.

Finally, the information shown in Figure 5 and Figure 6 was combined to assess the disturbance risk of the parcels in the study area. Figure 7 shows the priority conservation areas that are most vulnerable to loss or significantly diminish their environmental attributes if no conservation action is taken. These areas should be given priority when assessing the location of a wildlife corridor because of their potential to contribute to the ecological integrity of the wildlife habitat, and support the continuity of environmental services enjoyed by the community.



Legend

Conflicts

Level



Figure 5: Land use conflicts in the study area

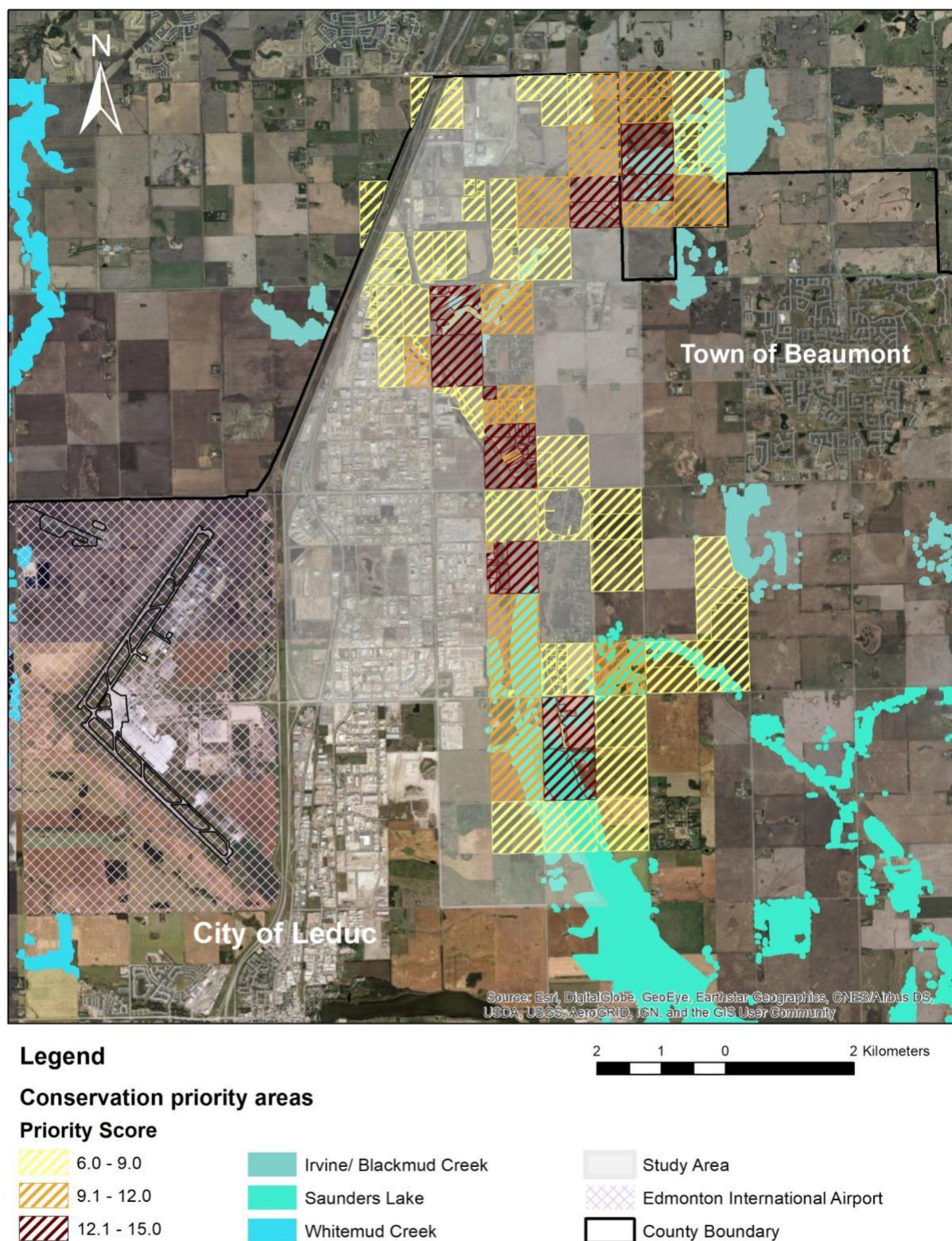
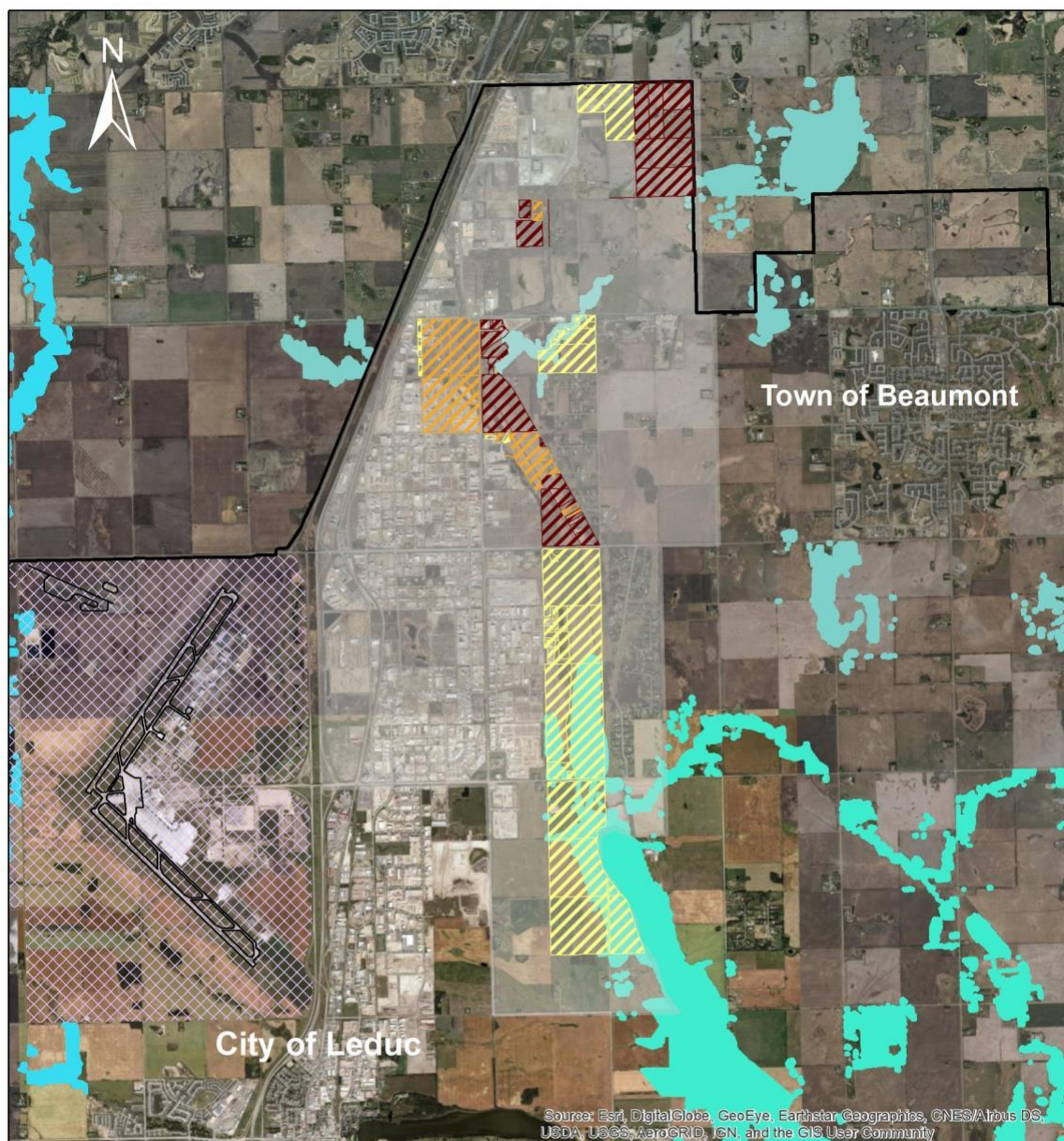


Figure 6: Areas with conservation priority



Legend

Disturbance risk of conservation priority areas

Risk score

6.0 - 15.0

15.1 - 24.0

24.1 - 33.0

Irvine/ Blackmud Creek

Saunders Lake

Whitemud Creek

Study Area

Edmonton International Airport

County Boundary

2 1 0 2 Kilometers

Figure 7: Disturbance risk of the areas with conservation priority

Data Gaps

A review of the applicable statutory and non-statutory plans and documents for the Nisku Wildlife Corridor Report study area identified the following data gaps:

- Wildlife focused policies and reports are common at the regional level, but are rare locally. Only one LASP within the study area identifies the importance of wildlife, and addresses concerns about the potential impacts of development in natural habitats and wildlife;
- The primary focus of local policies and reports is on the aesthetics, connectivity, and availability of trails and recreation areas for the community and not on the enhancement of natural habitats for wildlife;
- Policies that do address nature conservation and wildlife corridors are not being implemented effectively;
- Even when ASPs do have sufficient policies in place, the actual implementation of wildlife corridors is absent;
- The majority of local ASP and LASP documents have completed a very high level biophysical study on their respective area, but more detailed, focused studies and subsequent policies are needed in order to fully embed wildlife corridor planning at this stage;
- A detailed wildlife inventory as recommended in the 2015 EAS Study has not been completed. The lack of a detailed wildlife inventory makes it difficult for current wildlife policy to effectively implement wildlife corridors; and
- The proximity to the Edmonton International Airport creates conflicting priorities for migratory bird habitat in the study area.

Preliminary Recommendations

Policy Updates

The following three policy updates are being recommended in order to effectively create wildlife corridors in the study area:

1. Create local policy for connecting Environmentally Significant Areas that defines:
 - a. Areas that will be entirely conserved;
 - b. Areas where there needs to be buffers, transition areas, and other special considerations between built-up uses and natural habitats;
 - c. What types of wildlife;
 - d. The mechanisms required to implement the above;
2. Mandatory review/update of all ASPs to align with Recommendation 1, the new Municipal Development Plan, and statutory regional documents; and
3. Embed the protection and connection of Environmentally Significant Areas into Intermunicipal Development Plans and Intermunicipal Collaboration Frameworks.

Preliminary connectivity recommendations

Based on the analysis carried out in Phase I, the areas that are more suitable to create meaningful connectivity are located along Blackmud Creek, between Telford and Saunders Lakes. As suggested in figure 8, the priority conservation areas with a high disturbance risk identified in the previous section of the report present an important opportunity for conservation and connectivity. These areas have a high environmental significance, which make them ideal to create high-quality wildlife habitat. This general location will be considered as the main option to establish a more refined route for the Wildlife Corridor due to its location along the Blackmud Creek drainage area, potential for regional connectivity, and the relative lack of apparent misalignments and conflicts.

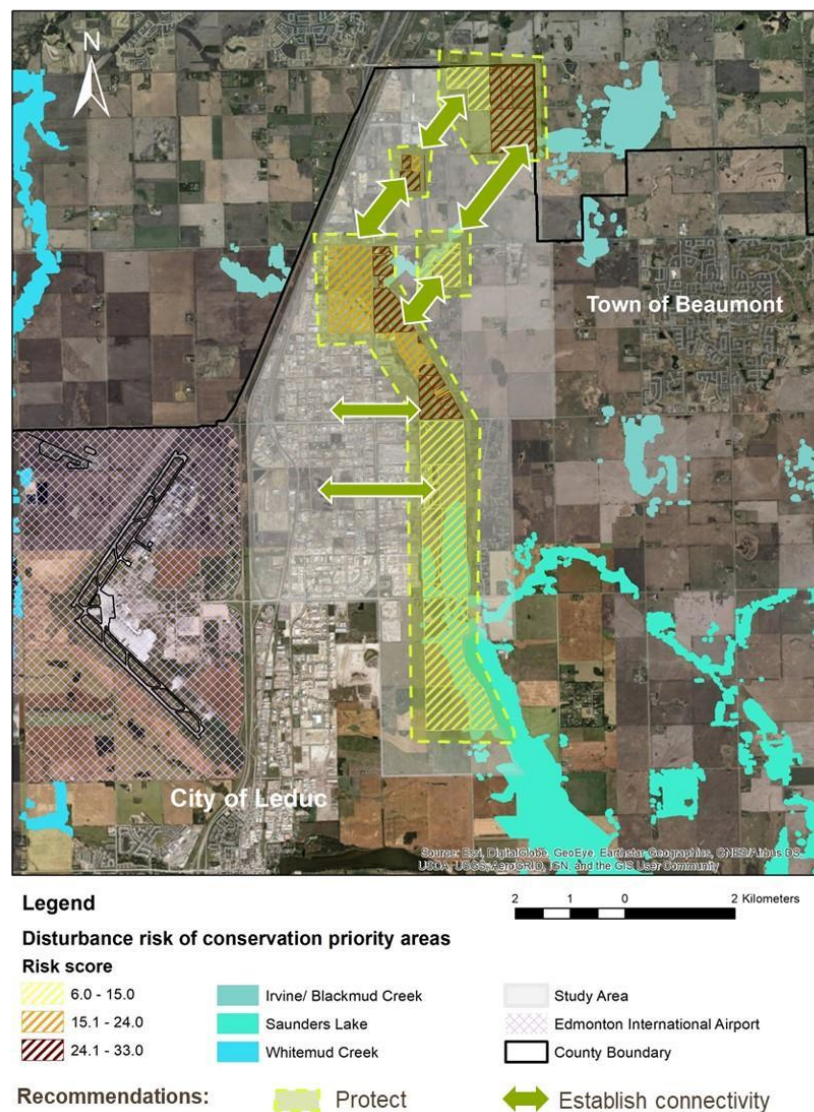


Figure 8: Conservation and connectivity opportunities to establish a Wildlife Corridor

Additional Commentary

An ideal wildlife corridor scenario would prioritize wildlife over enhanced community services, but Leduc County has indicated that a balance between the two is preferred. The 2018 Saunders-Telford Wildlife Corridor Study report recommends keeping uses completely separate, but the potential Nisku Wildlife Corridor is significantly larger in scope and exploring other options where some recreation, open space, stormwater infrastructure, education, and agriculture are included may be worth exploring. These options will potentially be explored and vetted in Phase II.

Since balancing of human and wildlife needs is desired, the incorporation of trails and recreation spaces provides a great opportunity for the interaction of people and nature. Ideally though, connectivity corridors must still give adequate space to wildlife and in some cases that means minimizing the disturbance as much as possible, including trails and other elements of recreation spaces.

References

1. Fischer, J., and Lindenmayer, D.B. (2007). Landscape modification and habitat fragmentation: A synthesis. *Global Ecology and Biogeography*, 16, 265-280.
2. Haddad, N.M. et al. (2015). Habitat fragmentation and its lasting impacts on Earth's ecosystems. *Sci. Adv.*, 1:e1500052.
3. Brenner, K. (2010). Corridor ecology and planning. Smart Cities Dive. Retrieved from <https://www.smartcitiesdive.com/ex/sustainablecitiescollective/corridor-ecology-and-planning/18365/>.
4. Rosenberg, D.K., Noon, B.R., and Meslow, E.C. (1997). Biological corridors: Form, function, and efficacy. *BioScience*, 47:10, 677-687.
5. Beier, P., and Noss, R.F. (1998). Do habitat corridors provide connectivity? *Conservation Biology*, 12:6, 1241-1252.
6. Evans, J.P. (2007). Wildlife corridors: An urban political ecology. *Local Environment*, 12:2, 129-152.
7. Soulé, M.E. (1991). Land use planning and wildlife maintenance: Guidelines for conserving wildlife in an urban landscape. *Journal of the American Planning Association*, 57:3, 313-323.
8. Department of Environment and Conservation. (2004)
9. Searns, R.M. (1995). The evolution of greenways as an adaptive urban landscape form. *Landscape and urban planning*, 33, 65-80.
10. Conniff, R. (2018, January 3). Habitat on the edges: Making room for wildlife in an urbanized world. Yale Environment 360 (Yale School of Forestry & Environmental Studies). Retrieved from <https://e360.yale.edu/features/habitat-on-the-edges-making-room-for-wildlife-in-an-urbanized-world>.
11. Fiera Biological Consulting (2015). Leduc County Environmentally Significant Areas Study. Retrieved from: <https://issuu.com/leduccounty/docs/2015esastudy>
12. Alberta Environment and Parks. (2015). Wildlife Species. Retrieved from <http://aep.alberta.ca/fish-wildlife/wild-species/default.aspx>.
13. Bow Corridor Ecosystem Advisory Group. (1999). Wildlife Corridor and Habitat Patch Guidelines for the Bow Valley. Retrieved from <http://biosphereinstitute.org/wp-content/uploads/2015/01/BCEAG-Wildlife-Corridor-1999.pdf>.
14. Strathcona County. (2019). Conservation Easements. Retrieved from: <https://www.strathcona.ca/agriculture-environment/environment-and-conservation/environmental-initiatives/easements/>
15. MXD Development Strategists and Stantec. (2015). Alberta Aerotropolis Viability Study Final Report. Provided by Client.
16. Edmonton Metropolitan Region Board. (2017). Edmonton Metropolitan Region Board Growth Plan. Retrieved from <http://emrb.ca/Website/media/PDF/Publications/EMRGP-Interactive.pdf>
17. City of Edmonton and Leduc County. (2017). Airport Accord. Provided by Client.
18. Associated Engineering. (2017). Blackmud/Whitemud Creek Surface Water Management Study Final Report. Provided by Client.

19. City of Leduc and Leduc County. (2017). Leduc County and City of Leduc Intermunicipal Development Plan. Provided by Client.
20. Spencer Environmental Management Services Ltd. (2006). Beaver Hills Initiative Land Use Management Framework. Retrieved from http://www.beaverhills.ca/media/resources/BHI_Land_Mgmt_Framework_Phase_1_Report_July_2006_final.pdf
21. City of Edmonton, Leduc County, and City of Beaumont: Intermunicipal Planning Framework Agreement (2018)
22. Leduc County. (2019). Municipal Development Plan Draft. Provided by Client.
23. Leduc County. (2018). Land Use Bylaw. Provided by Client.
24. Leduc County. (2006). Parks and Open Spaces Master Plan. Provided by Client.
25. Leduc County. (2018). Vistas Community Parks & Open Space Strategy Draft. Provided by Client.
26. Serecon, Toma & Bouma Management Consultants, and Stantec. (2016). Leduc County Agricultural Strategy. Provided by Client.
27. County of Leduc. (1981). Nisku Area Structure Plan. Provided by Client.
28. Sparrow Developments Ltd. (1980). Nisku West Area Structure Plan. Provided by Client.
29. Leduc County. (2004). North Major Area Structure Plan. Provided by Client.
30. Leduc County. (2004). Blackmud Creek Area Structure Plan. Provided by Client.
31. Leduc County (2004). Saunders Lake Area Structure Plan. Provided by Client.
32. Leduc County. (2010). East Vistas Local Area Structure Plan. Provided by Client.
33. Leduc County. (2008). WAM Industrial Park Local Area Structure Plan (2008)
34. Leduc County. (2017). Royal Cubera Local Area Structure Plan (2017)
35. Leduc County. (2012). Queen Elizabeth II Business Local Area Structure Plan (2012)
36. City of Beaumont. Planning Documents. Retrieved from <https://www.beaumont.ab.ca>.
37. Statistics Canada. (2015). Agriculture and wildlife: A two-way relationship. Retrieved from <https://www150.statcan.gc.ca/n1/pub/16-002-x/2015002/article/14133-eng.htm>

Appendices

Appendix A. Environmentally Significant Areas Methodology

At the local level, the conflicts between proposed or established land uses and the purpose of incorporating a wildlife corridor are mainly found in the Area Structure Plans. A spatial analysis assessment was carried out to further narrow down where these conflicts are, with the results of the Environmentally Significant Areas study being used as the basis for this assessment. The working files for the ESA study were unavailable, but were able to be recreated by comparing the maps from the study with the layers that were provided by Leduc County. The following five fields were added to the attributes table of the parcels shapefile, one for each criteria proposed by the ESA study, plus the general ESA score:

- Criterion 1: Presence of focal species, species groups or their habitat
- Criterion 2: Rare or unique geology or habitats
- Criterion 3. Ecological integrity
- Criterion 4: Water quality and quantity
- General ESA score

Parcels that were located within the areas that ranked medium to high in the first criterion were selected and assigned a value of 1 in the field of the attributes table corresponding to criterion 1. All other parcels received an assigned default value of 0. This process was repeated until the five new fields were completed. This binary system helped identify all the parcels in the study area with a significant environmental value and enabled them to be filtered according to the described criteria. The parcels with a value of 1 in the field corresponding to criterion 1 were selected and merged, creating a new shapefile of general areas for this criterion without the parcels' divisions. This process was repeated until a new shapefile was created for each of the criteria, plus one for the general ESA score. A buffer of 50 meters around each area was added to incorporate the adjacent portions of surrounding parcels (See appendix B).

This spatial information served as the basis for the analysis of land use conflicts. Leduc County provided the shapefiles of all the Area Structure Plans affecting the study area. The land use concept plan for each ASP was reviewed to identify the proposed land uses and evaluate the level of impact that they currently have - or will have - in the areas with high environmental values. A geoprocessing tool was used to identify where the ASPs intersect with ESAs and created new polygons corresponding to these areas. Two new fields were created in the attribute tables of these new shapefiles: one to describe the proposed land uses and another one to specify the level of conflict with the

ESAs in a scale of 1 to 3. A value of 1 was assigned to those conflict areas where the ASP provides at least a minimum mitigation strategy, or where the proposed land uses are not entirely incompatible with the nature of the affected ESAs. A value of 2 was assigned to the areas where the proposed land uses have a high environmental impact, but the environmental value of the affected areas is either given by a single criterion (e.g. presence of species only) or by a criterion with a low relative weight (e.g. unique geology). Finally, a value of 3 was assigned in cases where the proposed land uses have a high environmental impact, the concept plan does not provide a clear strategy to mitigate this impact, and the affected areas have a high environmental value (e.g. convergence of two or more ESA criteria). The resulting polygons were merged into a single shapefile showing the intersection areas with their corresponding level of conflict (see Figure 3).

This groundwork allowed for the identification of areas that need to be prioritized by Leduc County in terms of conservation efforts. First, the ESA criteria were ranked according to the environmental needs of a wildlife corridor and assigned them a numeric value:

- Contribution of the land to water quality and quantity (criterion 4): value of 5
- Presence of species and their habitat (criterion 1): value of 4
- Ecological integrity (criterion 3): value of 3
- Unique geology or habitats (criterion 2): value of 2

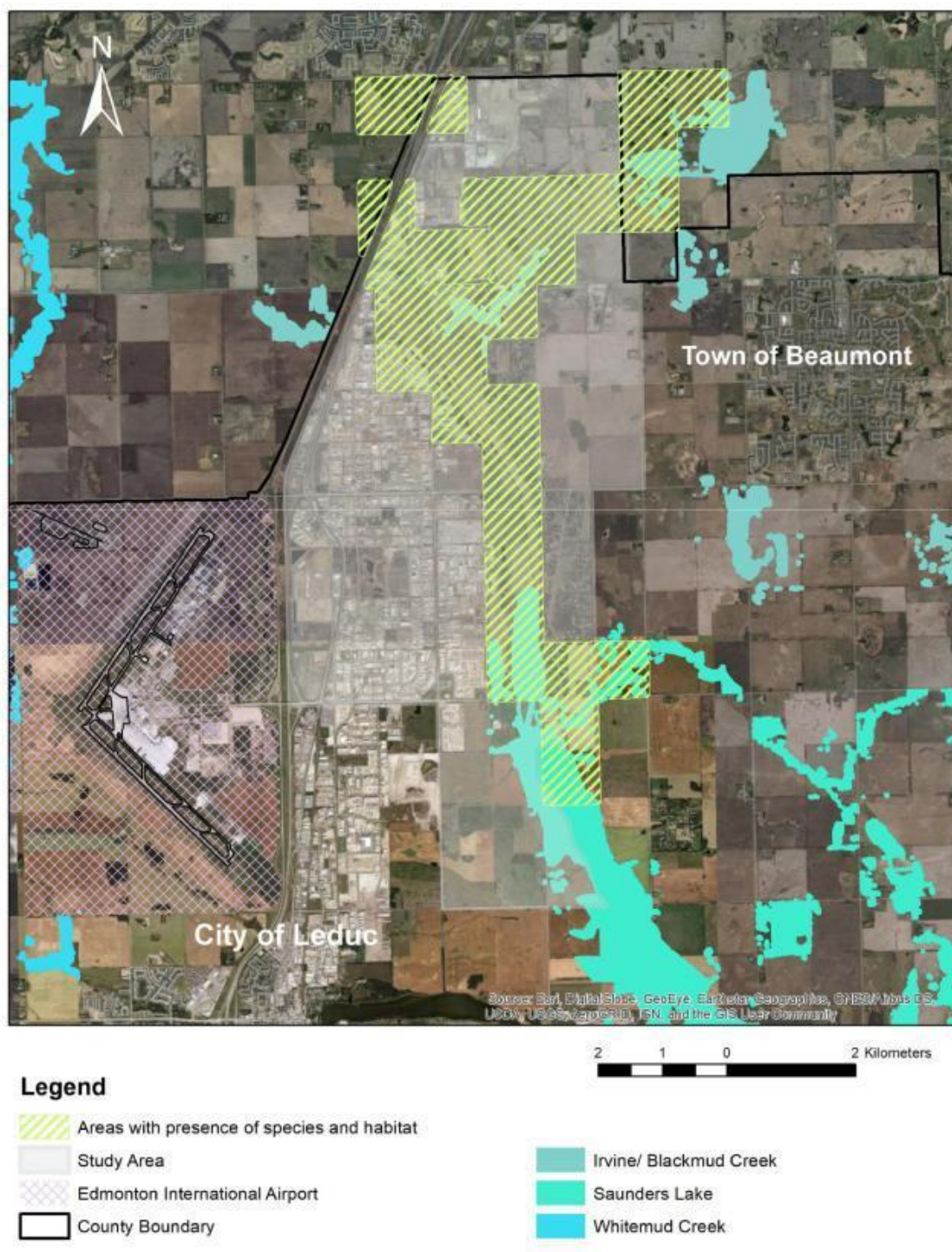
Since the criteria applied to each parcel was already identified, all that was needed was to create new fields in the attribute table of the parcels shapefile and assign the numeric values. Parcels that directly contained one or more of these environmental attributes, and their adjacent parcels, were included. The full numeric value was assigned to the former and a value of 1 was assigned to the latter. A value of 1 was assigned to those parcels that had a medium to high general ESA score. Yet another field was added to the table to add up all the values and produce a final score. The lowest score was 0, resulting for those parcels with no outstanding environmental significance, and the highest score was 15, assigned to those parcels that check positive for all the ESA criteria and have a medium to high general ESA score. Only the parcels with a score higher than or equal to 6 were considered to guarantee as much diversity of environmental attributes as possible, and to avoid including parcels that are only adjacent to areas that fulfill all four ESA criteria. As a result, the scores were distributed in a scale of 6 to 15 and grouped in 3 different brackets using a natural breaks classification method. Parcels with a score of 6 to 9 were attributed a low conservation

priority, parcels with scores from 10 to 12 were classified as medium conservation priority, and parcels with scores from 13 to 15 were identified as being high conservation priority (see Figure 4).

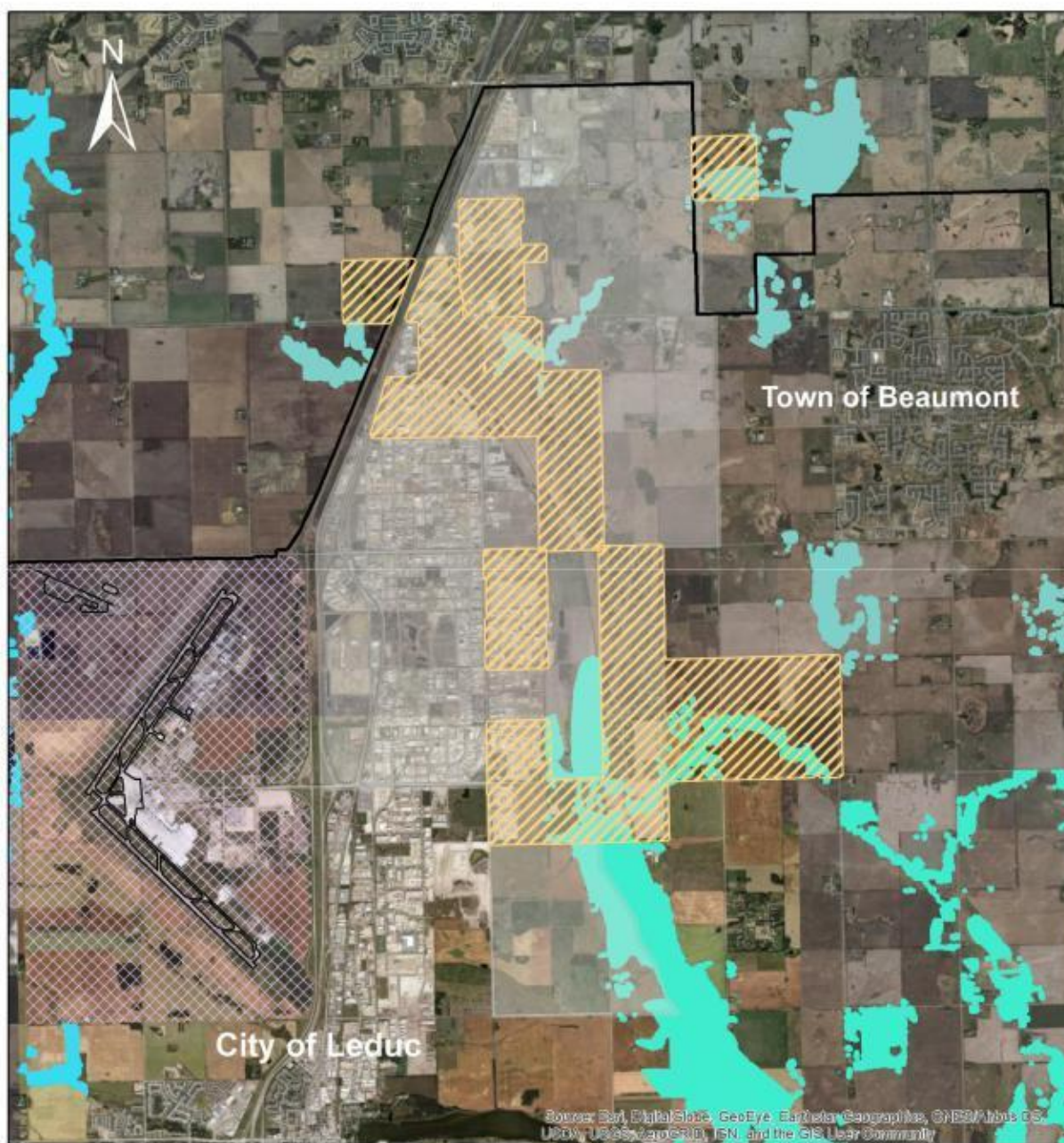
As a final step, it was necessary to assess the disturbance risk of these priority conservation areas to direct the efforts of the municipality where they are most needed. The conservation score of the parcels was multiplied by the conflict level assigned before, resulting in disturbance values ranging from 6 to 33. These scores were classified into three equal intervals, allocating a low risk label to those parcels with scores of 6 to 15, medium risk to parcels with scores of 16 to 24, and high risk to parcels with scores of 25 to 33 (see Figure 5). The scale was included for the purpose of prioritizing efforts, but it does not mean that the integrity of parcels labeled as “low risk” can be taken for granted. All the parcels included in Figure 5 are both environmentally significant and at considerable risk of being disturbed by the land uses that the County has already approved through the ASPs, so careful assessment of all parcels is required.

Appendix B. Environmentally Significant Areas in the Nisku Area





Areas with presence of focal species and their habitat



Areas with unique geology or habitat



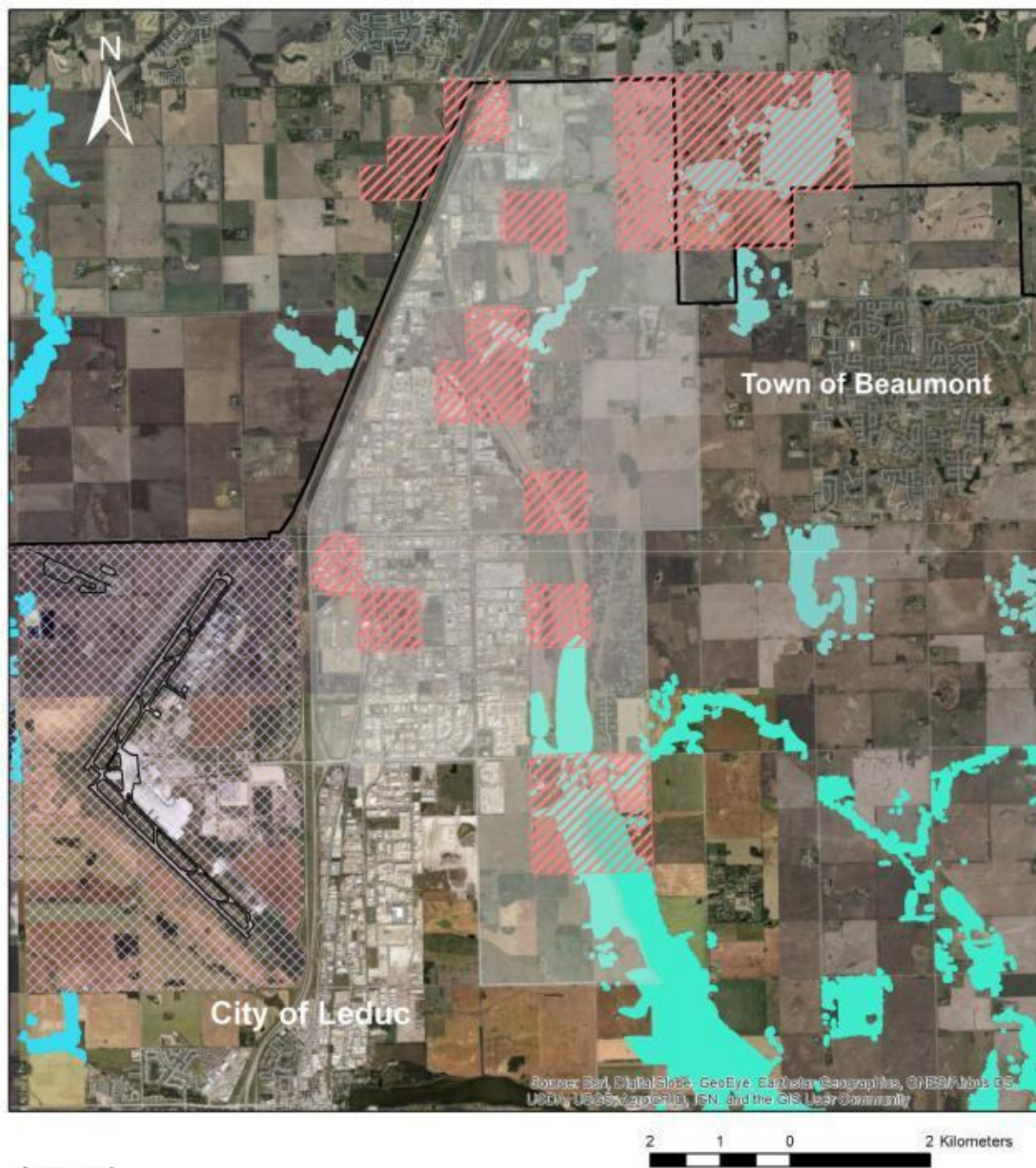
Legend





-  Areas with unique geology or habitat
-  Study Area
-  Edmonton International Airport
-  County Boundary

-  Irvine/ Blackmud Creek
-  Saunders Lake
-  Whitemud Creek

Source: edited by authors

Areas with ecological integrity

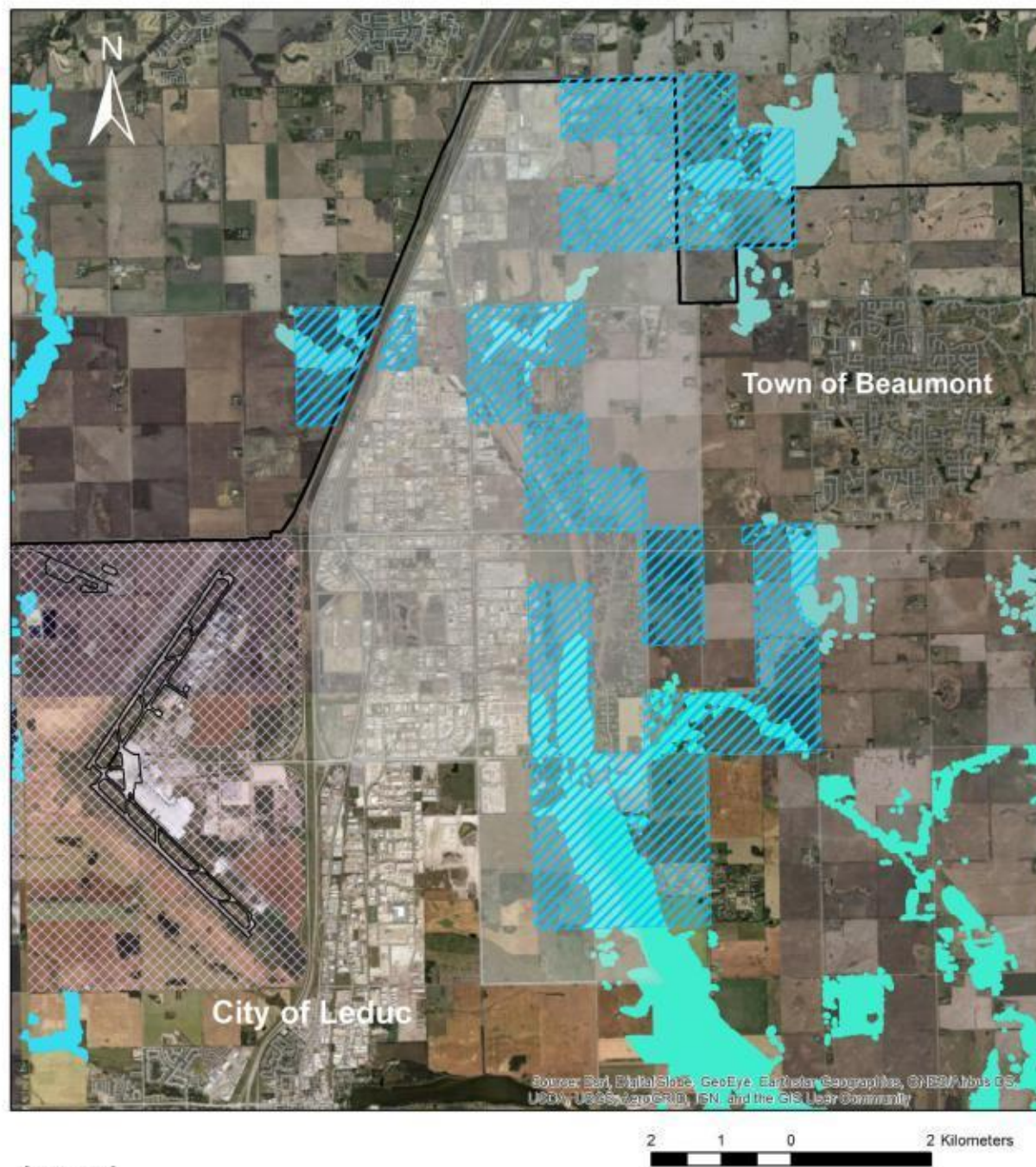
**Legend**

-  Areas with ecological integrity
-  Study Area
-  Edmonton International Airport
-  County Boundary

-  Irvine/ Blackmud Creek
-  Saunders Lake
-  Whitemud Creek

Source: edited by authors

Area that contribute to water quality and quantity



Legend

Areas that contribute to water quality and quantity

Study Area

Edmonton International Airport

County Boundary

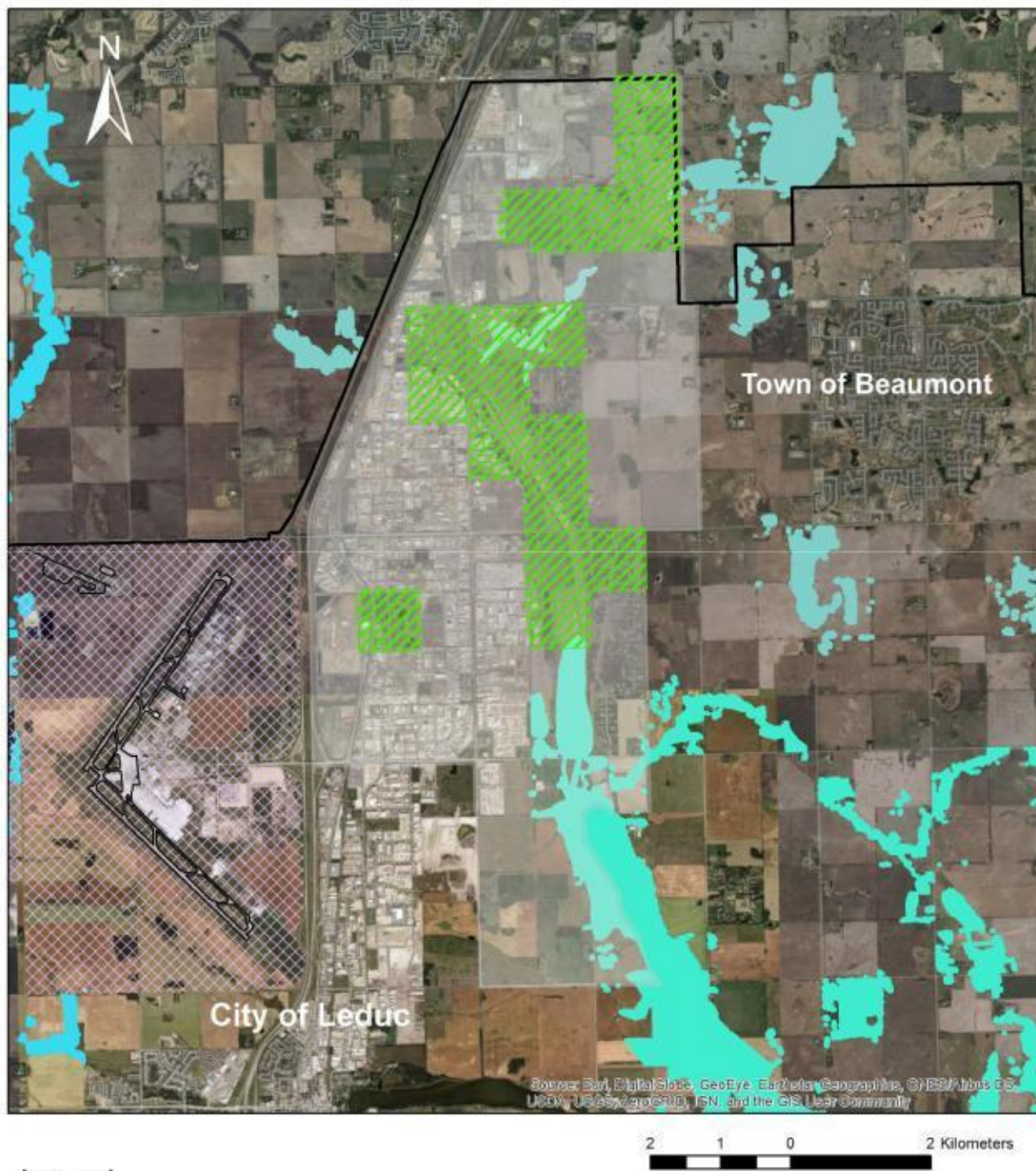
Irvine/ Blackmud Creek

Saunders Lake




Whitemud Creek

Source: edited by author

Areas with high ESA scores

**Legend**

-  Areas with high ESA score
-  Study Area
-  Edmonton International Airport
-  County Boundary

-  Irvine/ Blackmud Creek
-  Saunders Lake
-  Whitemud Creek

Source: edited by authors

Appendix C. Summary of the Spatial context analysis at the local level

	Mentioned Wildlife or Wildlife Corridor	Main goals and focuses area	Wildlife		Agricultural Land		Environmental Aspect	
			Mentioned about protected species	Proposed ways to protect and preserve wildlife	Suggest the importance of Agricultural Land	Proposed ways to protect and enhance Agricultural Land	Consider Environmental Aspect	Proposed ways to preserve the environmental aspect
Local Plans								
Municipal Development Plan	Yes	<ul style="list-style-type: none">- Protect and support agricultural land- Develop and create complete design communities- Promote, protect and enhance the natural environment- Identify and act on opportunities for recreation and tourism	N/A	<ul style="list-style-type: none">- Consider and incorporate natural areas such as wildlife habitat and passageways, tree strands, wetlands, and watercourses into the design- Ensure development adjacent to or near watercourses within the County does not impact on habitat, water quality and quantity-	<ul style="list-style-type: none">- To promote diversity and tradition in agriculture through urban agricultural practices- Recognize the importance of protecting the agricultural land base	<ul style="list-style-type: none">- Keep poultry or bees within the residential area- Consider and support community gardens- Provided four agricultural areas- Conserve soils, clay and sand fill in agricultural areas- Minimal fragmentation on agricultural land- Minimize disturbance of environmentally significant areas, wetlands.	<ul style="list-style-type: none">- Value Environmentally Significant Areas	<ul style="list-style-type: none">- Encourage retention of trees and vegetations- Development require Environmental Impact Assessment- Encourage restoration of sensitive ecosystems, natural areas, and habitat corridors that have been previously disturbed- Preserve natural areas within County through the dedication of reserves- Encourage landscaping practice to reduce the environmental impact of stormwater and lessen the need for irrigation
Environmentally Significant Area Study	Yes	<ul style="list-style-type: none">- The study used four criteria to assess the environmental importance of the land	Address the following: <ul style="list-style-type: none">- Presence of focal species- Rare or unique habitats- Ecological integrity- Water quality and quantity The importance to maintain good connectivity between Upland ESA and other natural areas at the local and regional level	<ul style="list-style-type: none">- The study suggests the ESA area that should be prioritized- Provide recommendations to protect the most important water features- Minimize pollution and intensive land uses- Consider land securement as a primary conservation means.- Promote contiguous development, use buffer zones, create and restore natural corridors to ensure connectivity	N/A	N/A	<ul style="list-style-type: none">- Addressed in the wildlife section	
Park & Open Spaces Master Plan	Yes	<ul style="list-style-type: none">- Supplement environmental reserves along lakes and rivers- Protect habitat or vegetation that are not protected in environmental reserves- Ecological connections for vegetation continuity or wildlife corridors- Provide linear connection to adjoining subdivisions	N/A	N/A	N/A	N/A	<ul style="list-style-type: none">- Saunders Lake was identified as a potential site as an area of interest of recreation and environmental features- Enhance environment benefit by creating recreation trails- Tree retentions	<ul style="list-style-type: none">- County may identify lands for protection to ensure conservation of environmentally significant areas- Provide environmental linkage and connections between existing and new environmental areas- Dedicate land for environmental reserves- Retain vegetation including coniferous, deciduous forest, and grasslands.
Vistas Community Parks &	Yes	<ul style="list-style-type: none">- Increase accessibility	N/A	N/A	N/A	N/A	<ul style="list-style-type: none">- Enhance the	<ul style="list-style-type: none">- Naturalization of Blackmud and

Open Space Strategy		<ul style="list-style-type: none"> - to parks/ open spaces for residences - Create a trail network - Full connection via walkways or greenways to open space, parks, natural areas, and environmental reserve 					<ul style="list-style-type: none"> - connection between open spaces and parks - Create connection trails 	<ul style="list-style-type: none"> - Irvine Creek - Trail link to Saunders Lake
Area Structural Plans								
Nisku Area Structure Plan	No	<ul style="list-style-type: none"> - Address business related development, existing water distributions system and future business expansions 	N/A	N/A	<ul style="list-style-type: none"> - Designation of Agricultural Zones 	<ul style="list-style-type: none"> - Proposed to established on the east and south boundary to protect the integrity of the creek and lake valley - Land under this designation may have the potential for industrial development while other portions are undevelopable 	<ul style="list-style-type: none"> - Important to maintain high environmental standards 	<ul style="list-style-type: none"> - Create a buffer to separate the non-compatible uses
Nisku West Area Structure Plan	No	<ul style="list-style-type: none"> - Established to form a framework for the industrial subdivisions and development of the lands - Plan address business, light industrial, park/open spaces 	N/A	N/A	N/A	N/A	<ul style="list-style-type: none"> - Strong focus on attractive landscape as a buffer - Maximize the aesthetic, visual potential, and recreational potential 	<ul style="list-style-type: none"> - Municipal servicing patterns should take full advantage of the natural feature - Municipal park reserve should be purposely located to in most visible portions of the Plan Area by showing the attractive landscape environment
North Major Area Structure	No	<ul style="list-style-type: none"> - Promote orderly development in the plan area with agricultural and sensitive resources 	N/A	N/A	<ul style="list-style-type: none"> - Agricultural lands are predominated within this planning area, farming operation is most extensive in nature, being grain and cattle. - most of the significant natural features are located within the plan area 	<ul style="list-style-type: none"> - Agricultural Code of Practice, agricultural practices along Blackmud Creek should prevent erosion, damage water channels and sensitive slopes - Agricultural area intended to remain as agricultural production although the County may identify the land is appropriate for other uses in certain locations 	<ul style="list-style-type: none"> - Key on conservations 	<ul style="list-style-type: none"> - Seek to conserve the natural feature along Blackmud Creek, municipal and environmental reserves
Blackmud Creek Area Structure Plan	No	<ul style="list-style-type: none"> - Establish transitional land use that compatible with both adjacent industrial and residential areas 	N/A	N/A	<ul style="list-style-type: none"> - Continue to permit extensive agricultural uses 	<ul style="list-style-type: none"> - Permit uses such as the cultivation of forage or cereal crops, or cattle grazing - Floodplain boundary is designated for agricultural uses 	<ul style="list-style-type: none"> - Encourages the retention of trees wherever practical 	<ul style="list-style-type: none"> - Two areas within the plan are proposed as an environmental reserve - Preserve trees to help stabilize the slope within the floodplain
Saunders Lake Area Structure Plan	Yes	<ul style="list-style-type: none"> - Recognized as a region of significant environmental feature and community asset - Develop open space around lakeshore for 	N/A	<ul style="list-style-type: none"> - Lighting within the plan area should be limited to minimize the impact on wildlife in the vicinity of Saunders Lake - Consider wildlife habitat 	N/A	N/A	<ul style="list-style-type: none"> - Majority of the land has significant environmental features 	<ul style="list-style-type: none"> - Provide minimum buffer from geotechnical top-of-bank and additional setback if required - Encourage to remain the natural state within the plan - Trails to connection open space

		recreation and environmental protection - Create a network for residents to have access to nature		through stormwater management, natural area/open spaces, and transition areas				for residents to gain access to the natural area
Local Area Structure Plans								
East Vistas Local Area Structure Plan	Yes	<ul style="list-style-type: none"> - Create a strong sense of place by promoting healthy lifestyles - Propose concept relates to municipal reserve, natural areas, parks and trails 	N/A	<ul style="list-style-type: none"> - Parks and trails, consider a linear pathway to provide linkage across the plan area between natural areas to facilitate people and wildlife movement 	N/A	N/A	<ul style="list-style-type: none"> - Protect the environment - Sustainable treed area 	<ul style="list-style-type: none"> - Irvine Creek Valley and its environments will be protected as an environmental reserve - Recommend setback distance from the top of the bank - Pathway to connect all natural areas - Encourage stormwater facilities to mimic natural drainage course and wetlands
WAM Local Area Structure Plan	No	<ul style="list-style-type: none"> - Emphasis on the diversity and flexibility to enhance industrial bases 	N/A	<ul style="list-style-type: none"> - Instead of protecting wildlife, the stormwater management facilities are designed to prevent birds from setting 	N/A	N/A	<ul style="list-style-type: none"> - Create a buffer to separate the business park and proposed future residential land uses 	<ul style="list-style-type: none"> - Uses "Greenway buffer" - Stormwater management facilities wetland landscaping concept will be designed to deter migratory birds from setting in the facilities
Royal Cubera Local Area Structure Plan	Yes	<ul style="list-style-type: none"> - Create a strong sense of place - Plan for social interaction and association with the natural environment - Protection on the ecological integrity of natural features 	<ul style="list-style-type: none"> - Recognize the variety of mammal species - Habitat species 	<ul style="list-style-type: none"> - Identify the location on where the mammal and species habitat 	<ul style="list-style-type: none"> - Recognize the area consist of cultivated land, woodlots, and wetland features 	<ul style="list-style-type: none"> - Identify the predominantly areas of cultivated land, woodlots, and wetland 	<ul style="list-style-type: none"> - Respect and preserve the environment 	<ul style="list-style-type: none"> - Municipal reserve be utilized first to provide connective trails, parks spaces, and buffers around natural areas
Queen Elizabeth II Business Local Area Structure Plan	No	<ul style="list-style-type: none"> - Mainly focus on compatible industrial and commercial uses 	N/A	N/A	<ul style="list-style-type: none"> - Propose zoned agricultural land to industrial 	N/A	<ul style="list-style-type: none"> - Propose wetland vegetation and naturalization of stormwater management facilities 	<ul style="list-style-type: none"> - Stormwater management facilities to be designed to prevent bird, especially large flocking waterfowl such as gulls and geese

ATTACHMENT 2: NISKU WILDLIFE CORRIDOR REPORT TERMS OF REFERENCE

Nisku Wildlife Corridor Report

Project Sponsor: Leduc County, Planning & Development
Term: 2019 Winter Semester

1.1 Purpose

The Nisku Area is located near the centre of Leduc County, east of the Edmonton International Airport (EIA), south of the City of Edmonton, north of the City of Leduc and west of the Town of Beaumont. It is currently the base of significant economic development and a growing urban community of East Vistas. The Nisku Area is an area where higher density, fully-serviced development is to be concentrated and provides a central location for a range of businesses, services, housing types, and amenities.

The heart of the Nisku area is the Nisku Industrial Park which is contained within the Nisku Area Structure Plan and the Nisku West Area Structure Plan areas. These plans have come up for review and revision and, as a part of that review, there is the opportunity to investigate wildlife movements in the area.

1.2 Scope

The Project will be divided into two Phases:

Phase 1: Assessment of Planning Documents to Determine Project Alignment

This phase will demonstrate alignment or lack of alignment of the Nisku wildlife corridor project with other key planning documents within Leduc County. A report will be generated outlining how the Wildlife Corridor Plan aligns with current planning documents and where misalignments occur. The report will include an analysis of the data gaps and recommend ways in which to alleviate the misalignments.

Phase 2:

1. **Best Practices** - Will identify research trends in identifying, evaluating, and defining wildlife corridors, the potential appropriate structures or methods to ensure safe and efficient movement of the fauna and the various modes of transportation, as well as mechanisms to support the maintenance and preservation of natural habitat to ensure biodiversity which is often lost in urban areas due to fragmentation of the natural landscape.
2. **SWOT Analysis** - Conduct a SWOT analysis associated with the integration of a wildlife corridor into the land use concept of the updated Nisku ASP and the potential impact within Leduc County as a whole.
3. **Merits of Wildlife Corridors** - A discussion on wildlife corridors in built-up industrial/urban areas.
4. **Re-establishment of corridor** - In some cases due to urban expansion traditional wildlife corridors have been lost. The project should give consideration on how to re-establish lost corridors within the Nisku area.
5. **Analysis** – An analysis on wildlife corridors and the impact it may have on agriculture and community life. This may include such items as:
 - How will these linkages assist in farming and what is the cost to benefit ratio?
 - Can the wildlife corridors be used for recreation and animal sighting agri-tours? What could be the economic impact for the farmer or business?

- Could a large park system be developed in Nisku connecting animal corridors for animal watching and could this park be designed for a community gathering place for Nisku events?

The big picture is, could a “sense of place” be developed where wildlife and the Nisku community coexist and build and learn for one another? What are some ways to develop this?

6. **Option Evaluation** - Evaluate the options for maintaining a wildlife corridor.
7. **Report Preparation/Recommendations** - Develop a report outlining similarly tried Best Management Practices (BMP's) for recommendations for wildlife corridor(s) in the Nisku Industrial Park and greater Nisku area.

1.3 Assumptions

- Students will have a working knowledge of ArcGIS and InDesign for the purposes for map design and to create high quality visual presentations, which will serve to increase the understanding of the overall project.
- Recommendations will consider the land use objectives and policies from the updated MDP and other pertinent County Documents.
- A long term vision will be developed.
- At any point during the project clarity and assistance will be offered by various professional bodies (as needed).
- Leduc County are the owners of the study and are not obligated to implement the outcomes.

1.4 Deliverables

- A Final Report
 - Which will be composed of two (2) Phases. A Draft Phase 1 Report and a Final Phase 1 Report. Plus a Draft Phase 2 Report and a Final Phase 2 Report.
- A summary of best management practices for wildlife corridors.
- An analysis of wildlife corridors and their effect within the subject area.
- A summary of criteria in the form of a checklist that would need to be evaluated in the choosing of a location and the preferred type of infrastructure for a wildlife corridor.
- How the findings of this report can be incorporated into the Nisku Area Structure Plan and other appropriate County documents.
- One presentation to Leduc County Council outlining the project and its recommendations.

1.5 Project Governance

Working Group – Role is to complete work identified in the project scope and deliverables.

- U of A Planning students
- Leduc County liaison (1 staff from P&D, with some support from GIS, if needed).

Steering Group – Role is to review and help direct the project as needed/required as well as facilitate the necessary connections for the working group between interested parties.

- Sandeep Agrawal, Planning Program, U of A
- Duncan Fraser, Seasonal Instructor, U of A
- Jordan Evans, P&D, Leduc County
- Benjamin Ansaldo, P&D, Leduc County
- Duncan Martin, P&D, Leduc County

1.6 Required County of Leduc Resources

- Planning, technical (spatial data, mapping support) or other staff from Leduc County.
- Assistance in organizing a Working Group site visit.
- Leduc County staff will use their best effort to review Draft Phase 1 and 2 reports within one week of receipt to help ensure the project remains on schedule.
- Assistance with scheduling of the team members to be placed on the Leduc County Council Agenda for presentation purposes.

1.7 Timelines

Date	Item
Prior to Wed. Jan. 9 2019	Leduc County FTP Site to be operating.
Wed. Jan. 9 2019	Project commencement (first day of classes).
TBD - but prior to January 18, 2019.	Steering Group to have kickoff meeting with Working Group
TBD - but prior to January 31, 2019.	Site Visit
Wed. Feb. 13 2019	DRAFT Phase 1 report to be completed. Review and comments on DRAFT Phase 1 report to be given to Working Group within one week of receipt, if possible.
Wed. Feb. 27, 2019	FINAL Phase 1 Report completed.
Wed. March 20, 2019	DRAFT Phase 2 Report completed. Review and comments on DRAFT Phase 2 report to be given to Working Group within one week of receipt, if possible.
April 10, 2019 or before	FINAL Phase 2 Report completed <u>prior</u> to Council presentation.
Prior to April 10, 2019	Council Presentation April 10, 2019 is the last day of classes for the Winter Term.

Note : The Graduate Studio Team will use their best efforts to complete the appropriate deliverables within the timeline specified above. However, unforeseen circumstances may arise necessitating mutually agreeable time extensions where necessary.

Date: November 13, 2018

Approved for Implementation

Duncan Martin, Senior Long Range Planner, Leduc County

Sandeep Agrawal, Professor and Inaugural Director, U of A School of Urban and Regional Planning

Duncan Fraser, Sessional Instructor U of A School of Urban and Regional Planning

ATTACHMENT 3: WILDLIFE CORRIDOR CRITERIA LIST

Wildlife Corridor Criteria List	Issued Date:
	Revised Date:
Project Name:	Page ___ of ___

Purpose:

While wildlife corridors are context specific, certain aspects can be generalized into criteria that are necessary for a well-functioning corridor.

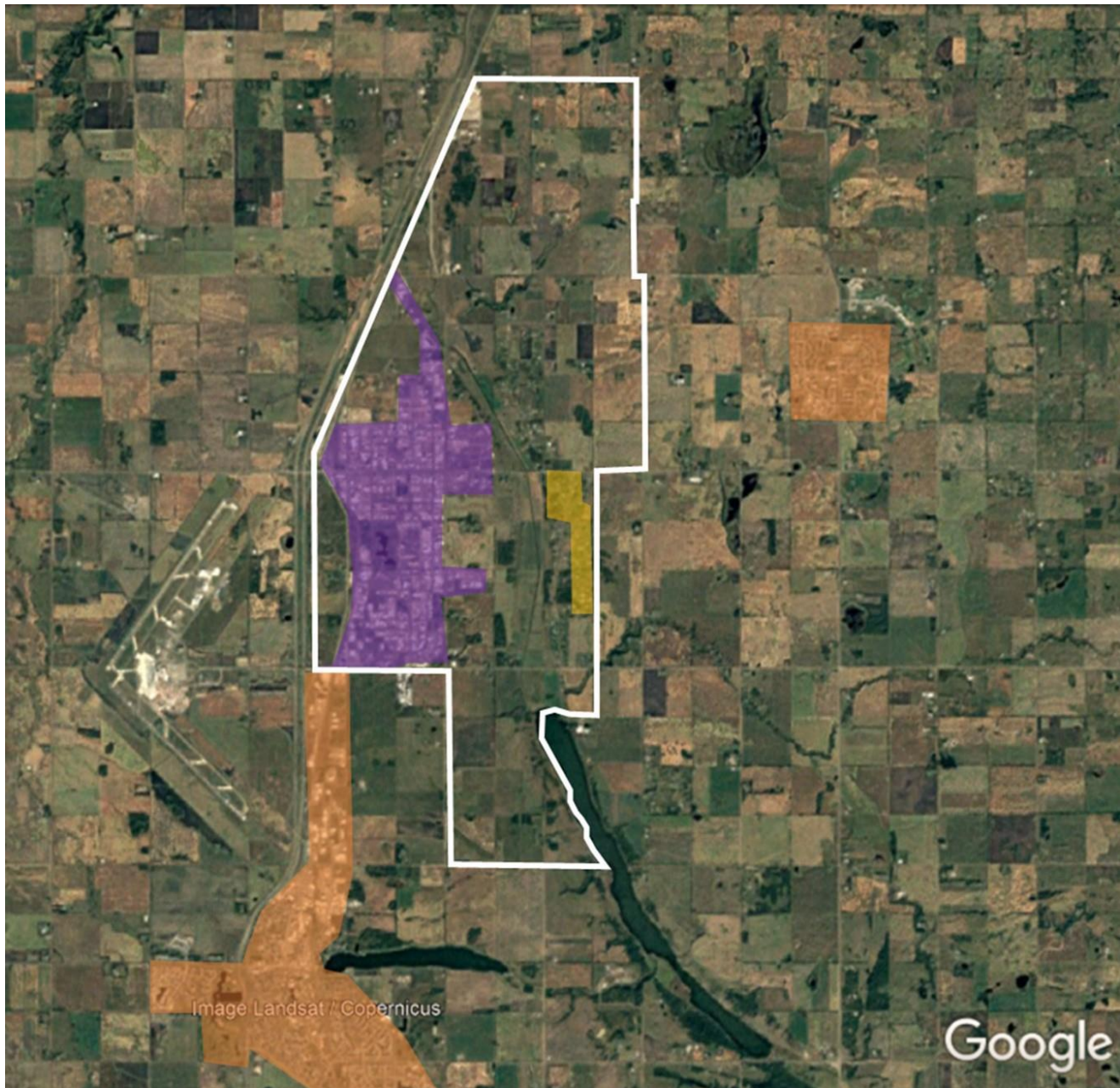
Considerations		Applicable/ Non- Applicable	Comments
Getting Started	Define the purpose of the corridor – strictly for wildlife use or a shared space for both wildlife and humans		
	Identify stakeholders – early involvement should be considered if people will be impacted. Involvement in the process would gain acceptance and provides opportunity for them to participate		
	Use scientific knowledge to inform the process – includes understanding and identifying the targeted species and associated protection status, core habitat, and habitat connectivity potential		
	Knowledge sharing via a multidisciplinary team-gain insight on different discipline point of views, bring together a multidisciplinary team to work on the project		
Process Related Considerations	Start with connecting undeveloped areas as it is easier to conserve a natural area then restore one		
	Re-naturalize areas by reintroducing native species		
	The transition between the corridor and human development should be gradual		
	The shape of the corridor should not be too uniform as nature is random		
	The width of the corridor - function increases as the width of the corridor increases		
	Continuous feedback loop - planning, implementing, and maintaining a corridor is not a linear process		
	Keep it simple - if the process is too complicated, the corridor may never be implemented		
	Avoid, mitigate, offset		

	Through public education highlight multiple benefits of a corridor		
Implementation Considerations	Schedule a time frame for revising and updating the manual		
	Instill a sense of ownership through volunteerism and business sponsorship		
	Encourage the use of wildlife friendly fencing		
	Encourage small building footprints on large parcels of land with a minimal road network		
Transportation Considerations	Identify where wildlife cross transportation corridors by looking at where wildlife move in the area and reviewing vehicle collisions history		
	First consider relatively low-cost adaptations such as fencing, planting vegetation and providing an appropriate walking surface to make passage structures suitable for wildlife movement		
	Mirror habitat conditions on both side of the road		
	Plant shrubs next to the passage structure to allow cover for approaching animals		
	Wildlife passage should be made available during non-flood conditions underneath bridge structures		
	Fencing is the most effective and preferred method to guide animals to passage in order to prevent intrusions onto the highway		
Trail Considerations	Trails should be carefully planned to minimize habitat damage and disturbance to wildlife		
	People should be encouraged to stay on trails and keep dogs on leashes		
	Discourage people from feeding wildlife		
	Install wildlife-proof trash and recycling receptacles		
	Use of vegetation as a shield to separate human-use from wildlife where practical		
	Recreational pathways should be confined to one side, leaving a dedicated corridor for wildlife uses on the other side		
	Provide a sequence of aesthetic experiences such as landmarks, facilities, and trail intersections.		


ATTACHMENT 4: URBAN EXPANSION IN THE STUDY AREA 1999-2019



Urban Expansion in the Study Area 1999 – 2019


Urban land cover in the study area and surrounding municipalities 1999



Urban expansion in the study area and surrounding municipalities 1999-2019

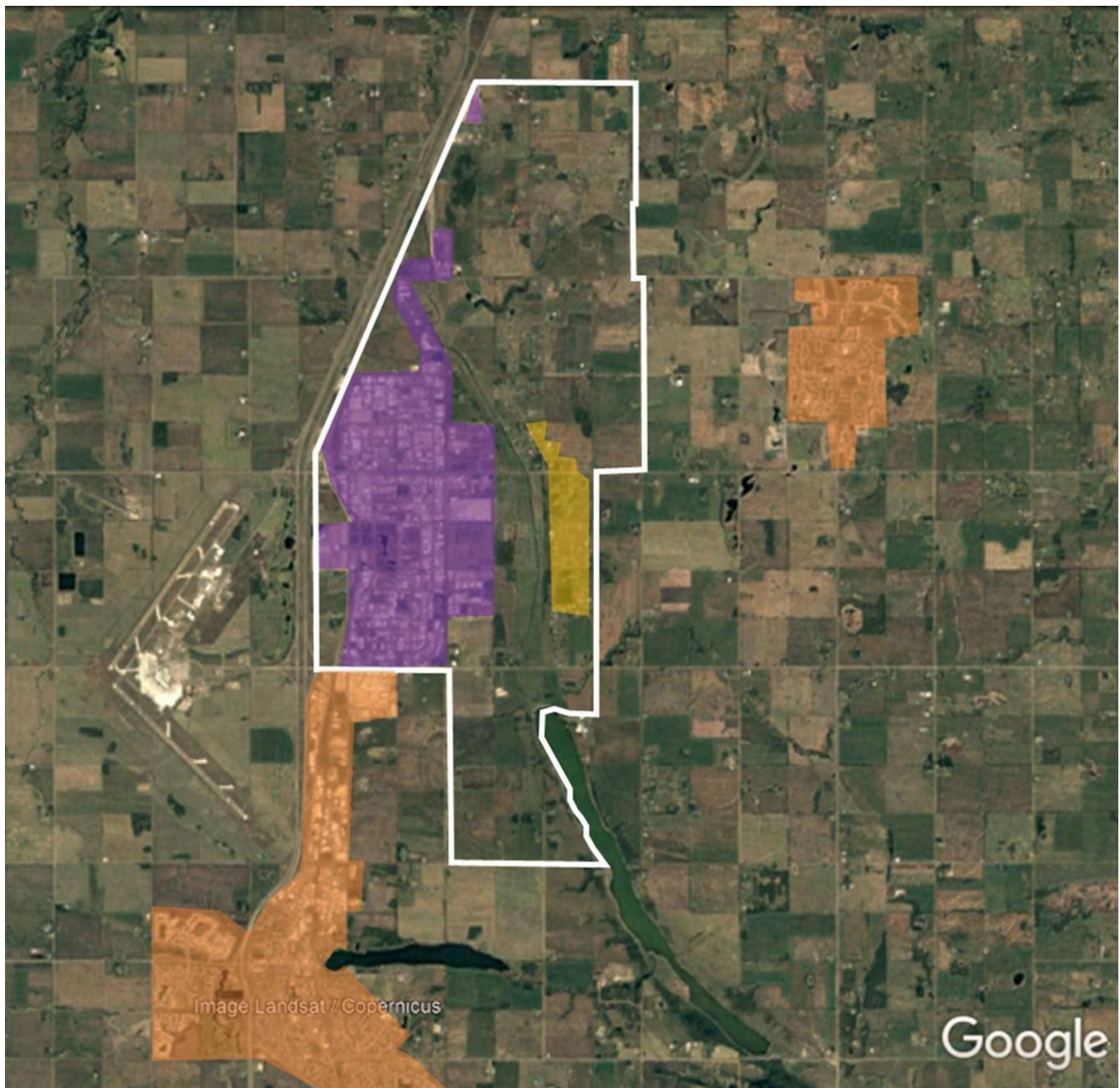
 Study Area

 Residential land
 Industrial land

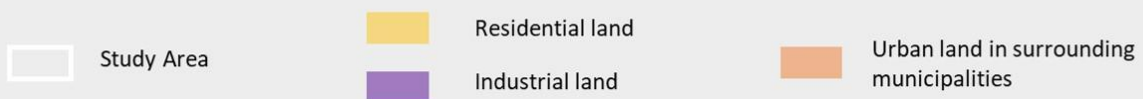
 Urban land in surrounding municipalities

Source: edited by authors

Urban land cover in the study area and surrounding municipalities 2004

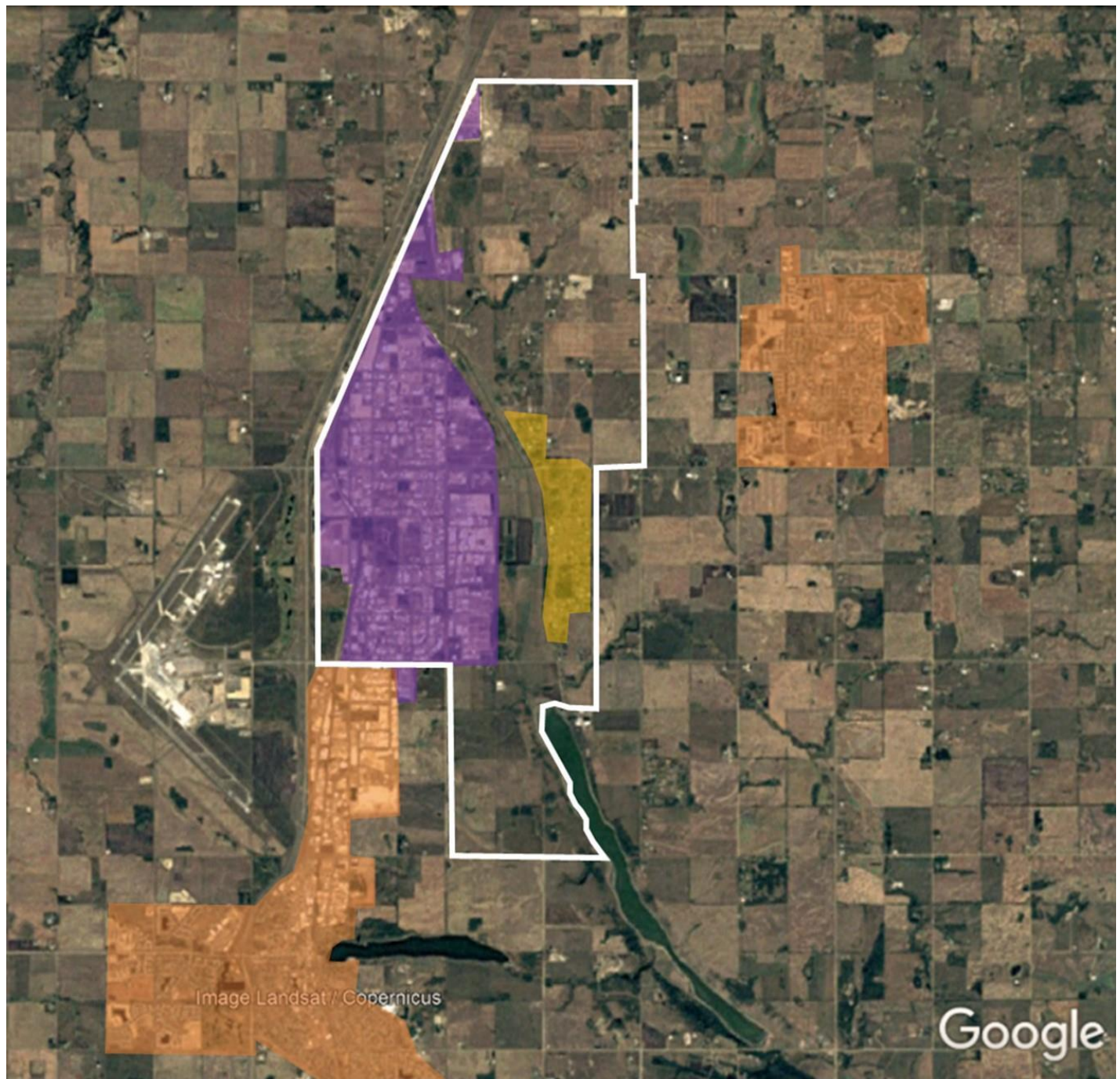


Urban expansion in the study area and surrounding municipalities 1999-2019

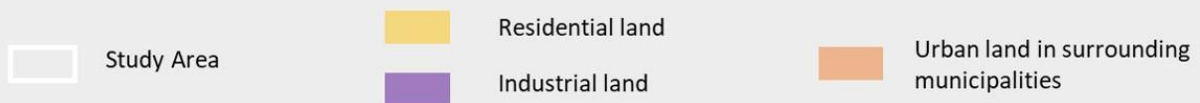


Source: edited by authors

Urban land cover in the study area and surrounding municipalities 2009

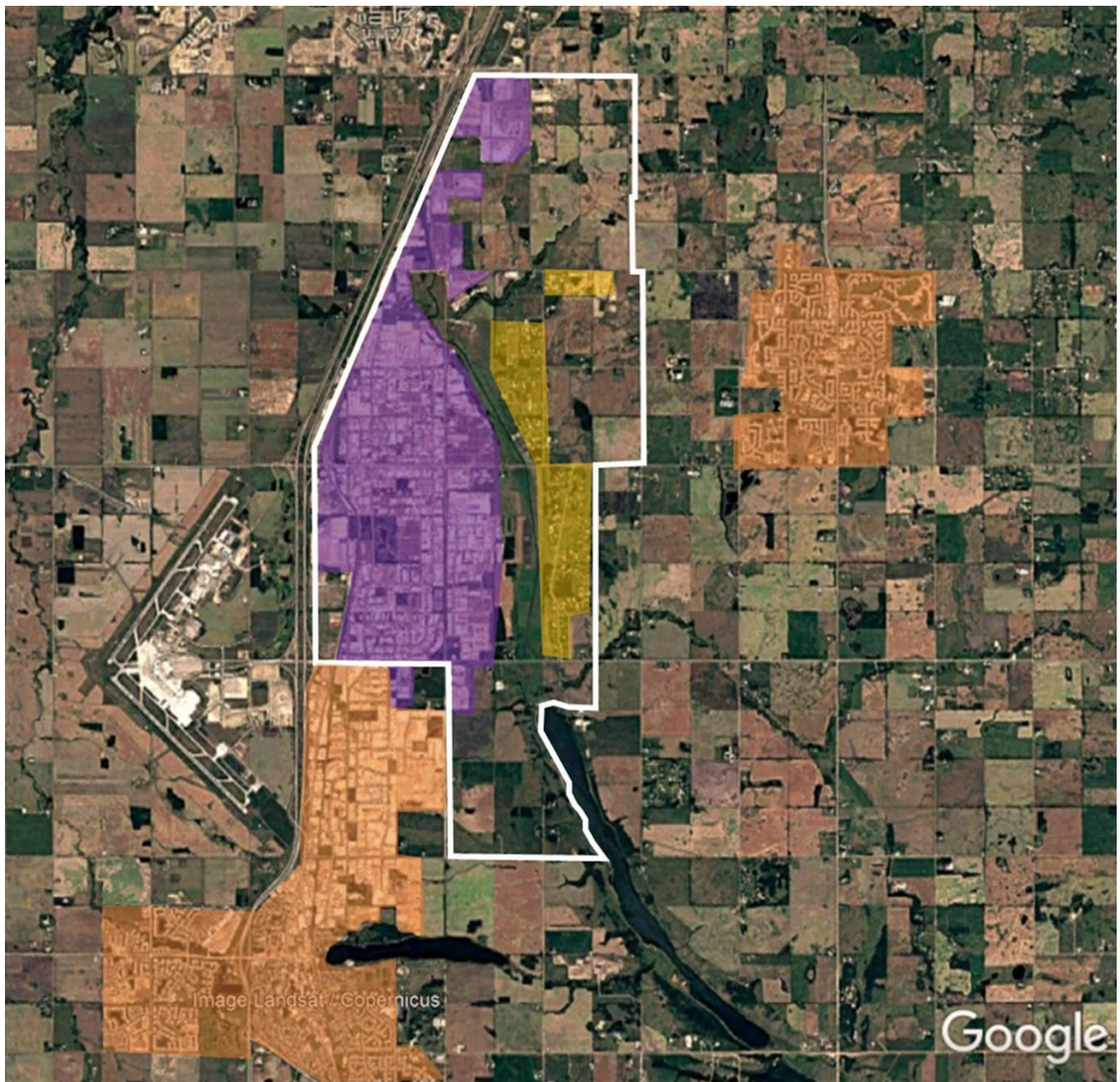


Urban expansion in the study area and surrounding municipalities 1999-2019

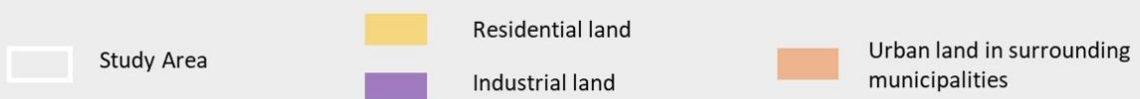


Source: edited by authors

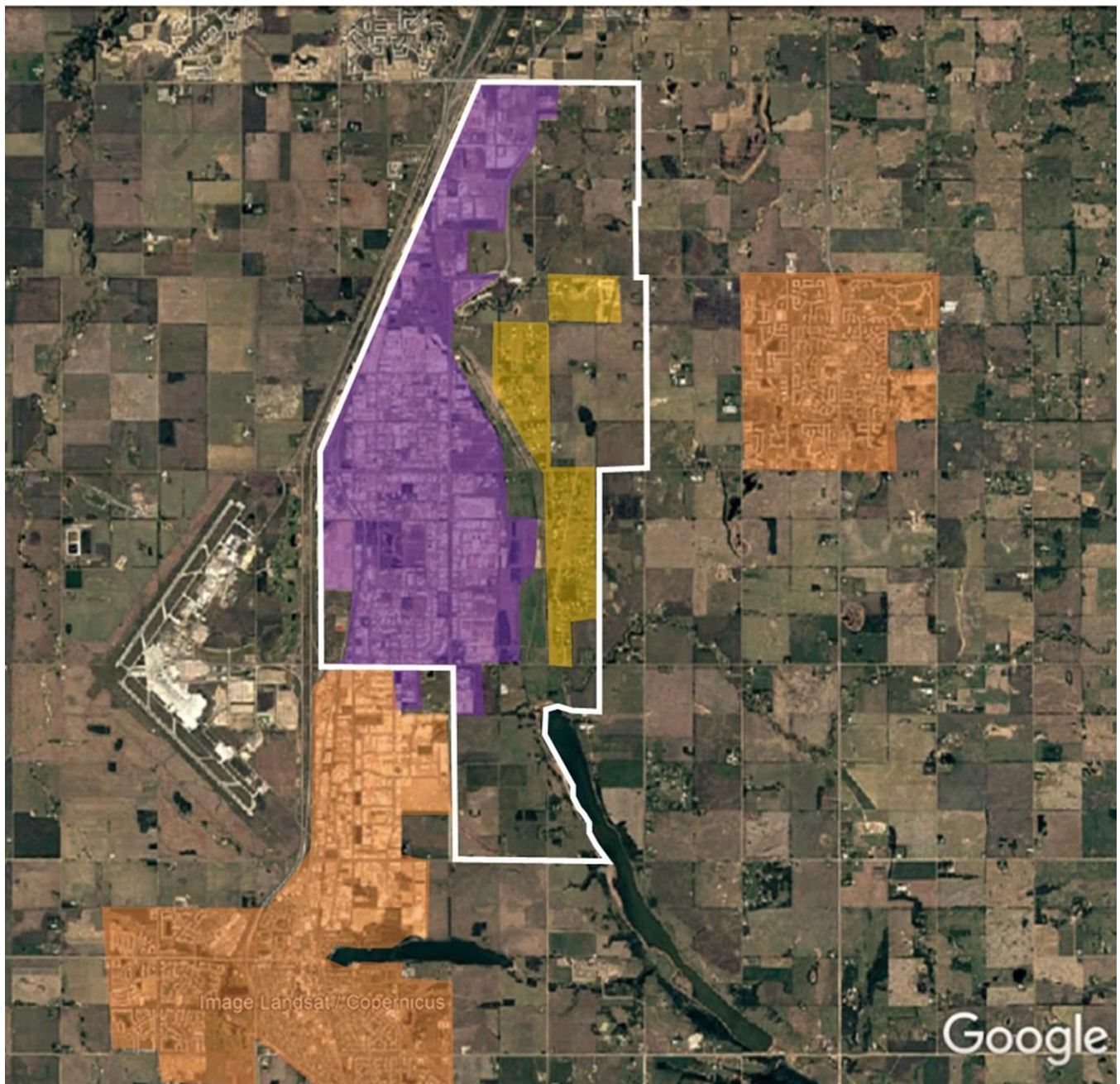
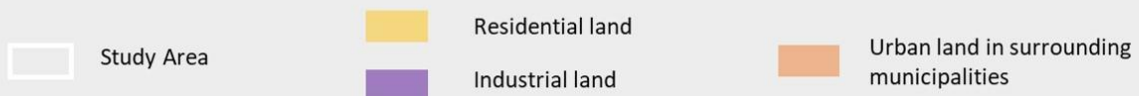
Urban land cover in the study area and surrounding municipalities 2014



Urban expansion in the study area and surrounding municipalities 1999-2019



Source: edited by authors

Urban land cover in the study area and surrounding municipalities 2019**Urban expansion in the study area and surrounding municipalities 1999-2019**

Source: edited by authors