Miistakis Institute

Planning to Connect:

A Guide to Incorporating Ecological Connectivity into Municipal Planning

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Introduction

What is the Purpose of this Guide?

Municipalities face challenges in finding practical guidance for integrating ecological connectivity into the structures and practical realities of municipal planning.

This guidebook is intended to help municipal personnel address that dilemma, by providing:
- Clarity on what ecological connectivity might mean for a municipality
- Clarity on which plans and policies to target, and how
- A searchable catalogue of example clauses from other jurisdictions[*1]
- A document library of sample plans, reports, strategies, and cases from which to learn[1*]

As well as supporting municipal planners, this guide is intended to help those working with planners or who are affected by municipal plans. Understanding the way ecological connectivity is viewed through the lens of municipal planning will help others (including municipal councilors, wildlife biologists, conservation groups, land developers and builders) better understand the decisions and options that emerge in the planning realm.

[1] Contained in an Appendix under separate cover

Ecological Connectivity

What is Connectivity and Why is it Important?

What 'Ecological Connectivity' Means

In the simplest terms, ecological connectivity is the ability for animals, plants and water to get from A to B. Their health, and that of the systems they inhabit, depends on it. Young animals can disperse to new habitats, genes can flow between communities keeping them resilient to disease, animals can get from summer ranges to winter ranges, flowing water can recharge ponds, evolving plants can find new habitats as the climate changes. Etc.

Connectivity can be a make-or-break part of a species' survival or of an ecological function (like water cycling) to actually function. The challenge is that the needs of species can vary dramatically, and there is rarely a clear threshold for 'disconnectedness.'

So while it may be clear at a high level *what connectivity is*, the question on your desk is what do you need to know about ecological connectivity as a planner? In practical terms, that would include two things:

- A sense of why connectivity is important to ecological conservation in your community, and;

- The different types of connectivity for which you will need to plan.

For a municipality, connectivity can be thought of happening at several scales:

- Regional connectivity — movement and connections of species that take place across large landscapes, but which might take those species through your community

- Local connectivity — movement and connections of species within and immediately surrounding your community

- Micro connectivity — movement and connections of species that take place over very limited areas due the small size of the species or its habitat, and which may exist entirely within a small part of your community

> ### *'Connectivity'* in this Guide
>
> 'Connectivity' is a well-used term in municipalities, with several different meanings (transportation connectivity, human connectivity, etc.)
>
> In this document, connectivity will always refer to ecological connectivity – the state or effort of connecting the pieces of ecological systems

- Hydrological connectivity — the linkages between rivers, streams, wetlands, and aquifers, both above and below ground.

Why Connectivity is Important

The key to why connectivity is important for ecosystem health lies in the 'system' part of ecosystem. A system works only to the extent that it's internal connections and relationships do. For that reason, understanding and maintaining landscape connectivity has become a key ecological conservation strategy in the face of unprecedented land use intensification.

Despite often being characterized in a linear way, connectivity refers to the numerous connections across the system. 'Habitat fragmentation' is simply the degree to which those numerous interconnections are lost or stressed. Think of stretching a knit sweater; what once appeared as a solid surface now shows spaces, and underscores the importance of the strands that connect it. Now imagine cutting the strands and see what happens to the sweater. The more you stretch (stress) the sweater, the more fraying happens.

The main concern with habitat fragmentation is it can separate species from important resources; animals can't find mates, plants can't migrate to climate-suitable conditions, young can't find new territory, birds can't find winter habitat. This has a range of implications at multiple levels. The most concerning is when fragmentation leads to genetic isolation within or between populations, meaning connectivity is lost to the point where animals are no longer able to exchange genes, and become isolated from each other. At that point they become more susceptible to disease in the short term and lose genetic resilience in the long term.

Ripple Benefits

Within a municipal landscape, the local government has perhaps the biggest influence on how stretched the sweater gets, and how many strands get cut. For that reason alone municipalities are increasingly playing a role in protecting biodiversity generally and connectivity specifically. However, planning for connectivity also has several positive associated ripples or 'co-benefits', including:

- Managing for ecological connectivity increases connectivity for humans. When we create a physically connected system, we create a physically connected community including parks and greenways that span and connect neighbourhoods.

- Connected landscapes provide other ecosystem services on which we rely, such as sense of place, pollinator habitat, green spaces, aquifer re-charge, and oxygen production.

- Promoting ecological connectivity helps landscapes be more resilient in the face of a changing climate by allowing for species to adapt, carbon to be sequestered, heat island effect mitigation, and accommodation of flood events.

- When we plan for connectivity around transportation routes, we can reduce human-wildlife conflict, decreasing traffic accidents, property damage, injury, and loss of life.

Human Safety

Ensuring the smooth flow of wildlife through a community is also vital for human safety.

Where wildlife movement corridors and human transportation corridors intersect, there is always a significant risk of collisions. For community members, the results are, at best, significant financial and property loss; at worst, injury or death. When the design of human networks and systems is cognizant of wildlife movement networks, these risks can be dramatically reduced.

As well, while experience shows that human and wildlife can coexist on the same land base for the most part without conflict, human-wildlife interactions within the built environment can be dangerous if wildlife feel constricted. Facilitating wildlife movement *through* and out of a community can reduce this risk, and means reducing the unnatural attractants, bottlenecks, and inappropriate stopping points that can lead to unwanted human-wildlife encounters.

Ecological Connectivity in Plans and Policies

It is rarely the case that all ecological connectivity issues can be addressed in one policy. Even in the situations where there is a dedicated, wildlife-corridor-specific policy, this must still be set within a policy ladder, ranging from high-level goals to on-the-ground practices.

It can be helpful to think of ecological connectivity within municipalities in terms of the types of plans and policies where it needs to be enabled. These would include the following:

Policy / Plan Type	Examples	What They Do	How They Relate to Ecological Connectivity
Regional Plans	• South Saskatchewan Regional Plan (SSRP) • Biodiversity Management Framework (BMF)	• Sets out regional goals for ecological conservation and stewardship across the region • Identifies municipalities as the key player in delivering regional plan outcomes associated with private land • Requires compliance by municipalities within 5 years of plan approval	• Identifies connectivity priorities • Identifies the importance of Eastern Slopes for connectivity • Identifies connectivity as a key biodiversity indicator
Comprehensive Community Plans	• Municipal Development Plan (MDP) • Intermunicipal Development Plan (IDP)	• Sets out a community-wide vision for all municipal priorities • Sets the context for any and all policies and plans • References connections to any regional and intermunicipal plans. • Sets out conception of future land use, development, transportation, infrastructure, facilities, and servicing • Include broad-scale studies and analyses • Identifies corporate strategies	• Reference to environmental conservation priorities of the municipality could include connectivity • Can enable specific connectivity policies or strategies • Identification of Environmentally Significant Areas could include connectivity data or areas known to be important for connectivity • Municipality-wide connectivity studies and/or maps could be referenced here
Zoning and Districting	• Land Use Bylaw • Dedicated districts / zones • Ecological planning areas	• Divides the municipality into land use or planning districts • Prescribes permitted and discretionary uses in each district • Provides guidance for development permitting • Provides both general and	• Can include wildlife conservation as a permitted use for relevant districts • Can outline development standards required to conserve ecological values such as connectivity

Policy / Plan Type	Examples	What They Do	How They Relate to Ecological Connectivity
		• specific development guidelines • Identifies any requirements in site-specific plans • Identifies zone-specific planning priorities	• Can create 'conservation' zones related to connectivity • Can outline ASP requirements related to connectivity (development guidelines, setbacks, etc.)
Site-specific Plans	• Area Structure Plans (ASPs) • Area Redevelopment Plans • Conceptual schemes • Outline plans	• Outlines the subdivision and development concept for a specific area • Identifies the types of land uses planned for an area, and the proposed sequence of their development • Sets out population densities, and general location of utilities and infrastructure • Identifies 'reserve' lands available to the municipality • Identifies the specific locations of lots and facilities of a proposed development • Can address other matters identified by Council	• Can identify specific wildlife movement corridors spatially • Can require detailed identification of potential wildlife movement issues • Can specify required mitigation structures (culverts, bridge modifications, underpasses, etc.) • Can require more detailed, site-specific wildlife movement information • Can facilitate re-districting of areas important to wildlife movement • Can require specific ecological network design standards relevant to the site
Municipality-wide Policies	• Transportation policies • Open Space policy • Urban Wildland Interface policy • Green Infrastructure plans • Water Management Policies	• Non-site-specific policies created to address a specific, but cross-municipality issue or matter of concern • Provides guidance for specific items in site-specific-plans, or for operational practices	• Can be modified to include consideration of wildlife/ecological connectivity • Can integrate wildlife management practices with other operational practices • Can relate connectivity to other

Policy / Plan Type	Examples	What They Do	How They Relate to Ecological Connectivity
			environmental or ecological priorities
Dedicated Plans / Policies for Conservation	• Environmentally Significant Areas (ESA) policy • Wildlife / ecological corridor policies • Biodiversity conservation plans • Habitat protection policies • Riparian / wetland policies	• Similar to 'municipality-wide policies', these are non-site-specific policies created to address specific concerns • Targeted specifically to conservation of environmental features (biodiversity, connectivity, habitat, riparian, wetland, etc.)	• Can gather into one place the disparate policy factors that affect connectivity • Can focus knowledge, resources, and activities on a connectivity issue(s) • Can provide more specific operational guidance for maintaining connectivity
Guidelines and Practices	• Development guidelines • Setbacks • Citizen-level actions	• Guidance that sits below policy and planning, and relates to specific development or operational practices • Facilitates quantifiable, pragmatic application of higher-level policies	• Connectivity metrics and practices can be incorporated into existing management practices • Specific mitigation options can be identified for various anticipated circumstances (e.g., roadways bisecting corridors, residences backing on connectivity zones) • Can facilitate lower-cost risk-reduction activities, versus higher-cost infrastructure approaches
Securement Tools	• Environmental reserve • Conservation reserve • Conservation easement • Land swaps • Transferable development credits	• Mechanisms that can be used to protect parcels important for various municipal priorities • May be used by the municipality alone, or via external	• Land securement tools can be used to protect critical connectivity areas and elements

Policy / Plan Type	Examples	What They Do	How They Relate to Ecological Connectivity
		partnerships	
Background Studies	• Connectivity modelling • Wildlife studies • Hydrology studies • Ecological threat assessments	• Science-based information that can be used to inform the development of municipal policies	• Can provide the more-detailed scientific basis behind ecological connectivity circumstances and needs • Can sit outside of the policy, and be updated as new information is developed

Conserving Connectivity vs Reactive Mitigation

When developing within ecological systems, and planning to ensure their on-going function, the concept of the 'Mitigation Hierarchy' often arises. This conceptual tool is intended to guide decision-makers when their regulatory approvals might have an unacceptable negative impact on the natural system (see sidebar, next page).

Municipal policy around ecological connectivity should be formed in a similar way, seeking first to 'avoid' and then secondarily to 'mitigate,' if necessary. In the context of municipal planning, it can be viewed even more simply: once areas important for ecological connectivity are identified, will the municipal approach be to conserve those areas (proactively mitigate), or minimize the impacts of the planned development and/or replace the function (reactively mitigate)?

Simply put, 'conservation' means the connectivity of the landscape is in place, and the municipality is trying to maintain it, while 'reactive mitigation' means connectivity is already (or about to be) disrupted, and the municipality is trying to minimize the intensity of that disruption. While conceptually they mean the same thing – helping animals, plants and water move through the system – functionally they are quite different, and therefore so are the approaches a municipality might employ.

Planning for connectivity conservation might involve using knowledge of important connectivity zones and associated patches in any of the following cases:

- Prioritizing the securement of undeveloped open spaces for municipal parks and natural areas;

- Supporting identification of high-value biodiversity areas to inform municipality-wide biodiversity conservation plans;

- Highlighting areas of importance for both wildlife and human/community connectivity;

- Comparing different scenarios for development to see which maintains the greatest amount of land important for connectivity;

- Aligning with connectivity outcomes identified in provincial regional plans;

- Supporting conservation-oriented planning tools such as Transfer of Development Credits; and/or

- Identifying areas within the municipality that may be of interest for private land conservation efforts (i.e., coordinating with local land trusts and conservancies).

Reactively planning for connectivity mitigation might involve using knowledge of important connectivity zones and associated patches in any of the following ways:
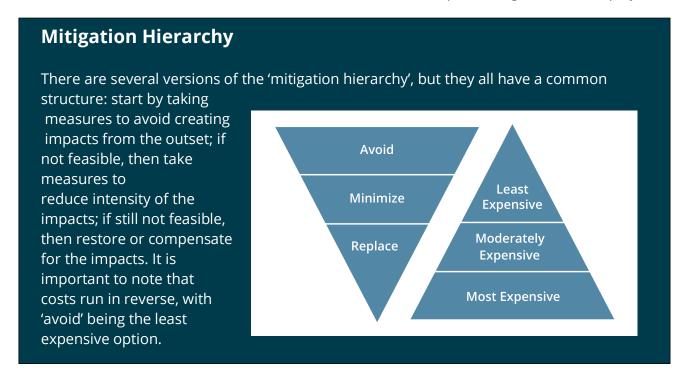
- Planning for transportation corridors to allow for animal, water, or plant movement;

- Retrofitting transportation corridors to allow for water, plant or animal movement;

- Comparing different scenarios for housing or infrastructure development to see which has the least impact on connectivity;

- Creating development guidelines that minimize the impact on wildlife movement;

- Identifying areas where humans and wildlife are most likely to come into conflict to prioritize education or active mitigation efforts;

- Prioritizing 'connectivity' areas that might see the greatest potential benefit from mitigative efforts; and/or

- Identifying ecological restoration zones where establishment or re-establishment of connectivity will aid species movement.

Clearly communicating this "proactive vs. reactive mitigation" context helps everyone involved understand what information is needed, and what options might come into play.

Mitigation Hierarchy

There are several versions of the 'mitigation hierarchy', but they all have a common structure: start by taking measures to avoid creating impacts from the outset; if not feasible, then take measures to reduce intensity of the impacts; if still not feasible, then restore or compensate for the impacts. It is important to note that costs run in reverse, with 'avoid' being the least expensive option.

Avoid

Minimize

Replace

Least Expensive

Moderately Expensive

Most Expensive

Sample Mitigations

In cases where it is impractical to conserve areas to provide for ecological connectivity, municipalities may have to incorporate reactive connectivity mitigations. As noted above this type of 'mitigation' means connectivity is already (or about to be) disrupted, and the municipality is trying to minimize the intensity of that disruption.

While determining which specific approach to take depends on the circumstance and requires expert assessment, it's important for municipal planners to know the range of mitigative techniques that are known to be effective in various circumstances. It's also important to keep in mind that mitigation:

- Does not necessarily mean large-scale infrastructure;

- Can also refer to changing practices;

- Might just occur in a municipality, but not be a municipality responsibility (and therefore must be done in partnership with the provincial authority);

- Can be aimed at assisting one species specific or be non-species specific;

- Can be engineered to provide for the safety of humans as well as the safety of wildlife;

- Might connect wildlife habitat, wetlands, natural drainage systems, or other ecological systems;

- Do not need to be expensive to be successful;

- Generally cost less when considered early in the planning process

Specific mitigative measures designed to reduce animal vehicle collisions and safety of wildlife movement across roads and through communities, include:

Animal detection systems (ADS) — wildlife mitigation aimed at altering human behavior, ADSs use sensors to detect large animals that approach the road, activating a warning (usually flashing lights) to drivers.

Bridges and culverts — wildlife mitigation aimed at physically separating wildlife from the roadway, bridges and culverts are built infrastructure that enable animals to move safely under the road. To optimize performance, wing fencing is installed to funnel animals toward the bridge or culvert and jump-outs are built to enable animals trapped in the right of way to escape.

Fencing — wildlife mitigation aimed at physically separating wildlife from the roadway, fencing (typically 2.0-2.4 meters high, and made of wire mesh) is the most common method for separating animals from drivers on a road. Fencing in isolation of safe crossing opportunities can result in roads acting as a barrier to animal movement and may be an undesirable ecological strategy.

Increasing visibility for drivers — wildlife mitigation aimed at altering human behavior, this includes techniques to improve drivers' ability to see animals near or on the roadway, such as vegetation removal or improved lighting. Vegetation removal has shown some promise while the effectiveness of improved lighting is inconclusive.

Landscaping – wildlife mitigation aimed at reducing attractants and providing cover, these techniques manage the vegetation associated with development, removing berry-producing bushes and ornamental fruit trees, and maintaining or planting trees and bushes capable of screening the corridor.

Lighting changes — wildlife mitigation along corridors aimed at preventing private or public lights from shining onto the corridor and alienating wildlife from the area, these techniques can be used either by advance design or by screening existing lighting.

Overpasses — wildlife mitigation aimed at physically separating wildlife from the roadway, overpasses are built infrastructure that enable animals to move over the road. To optimize performance wing fencing is installed to funnel animals toward the bridge or culvert and jump-outs are built to enable animals to escape trapped in the right of way.

Reducing attractants in yards and on roadsides — wildlife mitigation aimed at altering the animal's behavior by removing attractants (fruit trees, carcasses, vegetables gardens) that attract animals to the roadways. Carcasses of roadkill animals may act as attractants to other animals and lure them down to the road increasing risk of collision with a vehicle.

Reflectors — wildlife mitigation aimed at altering the animal's behavior, reflectors are installed on posts along edge of a road to visually repel animals. Extensively used as relatively cost effective to deploy most research on their effectiveness has been inconclusive or found no animal avoidance at sites with reflectors installed.

Signage — wildlife mitigation aimed at altering human behavior, driver warning signs are placed strategically in areas where wildlife tend to cross the road. Signage that is not static, set up seasonally, or includes variable features tend to be more effective at getting drivers attention.

Traffic speed— wildlife mitigation aimed at altering human behavior, these approaches either reduce the posted speed limit or implement traffic calming measures such as speed bumps, traffic circles and rumble stripes.

Development and Ecological Connectivity

'Connectivity' is a fundamental concept for human activity on a municipal landscape. All communities incorporate this concept in various ways in their plans: walkable communities, connected communities, transportation master plans, stormwater management, intermunicipal planning, pathways systems, utility corridors, etc. Each of these represents a unique network, but not a unique land base.

These networks are not incompatible. When we look down on the built landscape, we see a network of roads overlain on a network of sidewalks overlain on a network of power lines overlain on a network of water pipes, on a network of communities, on a network of recreation facilities, and so on. We don't assume that if we have sidewalks, then we can't have roads, or that having roads means we can't have sewers.

It is true that these different types of networks can come into conflict, but community planning works to reconcile them. Sometimes we approach this by reserving parts of the land for critical pieces of a given network: a transformer station, a water treatment plant, a major roadway interchange. Sometimes we operate these networks in three dimensions: power lines above, roads on the surface, sewer pipes below. Sometimes we manage activities in these areas to maintain the connections: snow removal from roads, bylaws against blocking sidewalks, fencing of power lines. All these approaches assume that no one of these networks occupies the whole landscape, but we recognize the fundamental truth that their viability depends on maintaining their connectedness. So we make maintaining the connectedness the priority.

Ecosystems are no different.

They do not need to occupy the whole landscape, and they do not need to preclude other networks and land uses. But their viability is dependent on maintaining their connectedness. Sometimes we need to protect critical pieces of those networks: movement hotspots, important or multi-species habitats, vulnerable pinch points. Sometimes we need to go in three dimensions to ensure connectedness, providing underpasses, overpasses, or surface passages. Other times we need to ensure that where network corridors pass through the built environment we manage activities: limiting wildlife attractants, development setbacks, seasonal closures, protective fencing.

In urbanized environments that exist adjacent to wildlands, and which are embedded in regional ecological networks, it is not a question of "development or conservation"; it is

more a question of how we integrate those ecological networks with the various other networks that we are maintaining.

Policy and Planning

Establish Your Goals and Your Path

It can be tempting to dive into that 'problem' plan, or zero in on that 'known conflict area' as these tend to be the obvious places where a municipality needs to address connectivity. However, it's critical that you have answered a number of connectivity-related questions first, and use those to plot a path to maintaining ecological connectivity in your municipality.

Asking the Right Questions

The report *Connecting the Dots* includes a complete guide to posing and answering the fundamental connectivity-related questions. On the next page is a summarized version of that guide, as reflected in its 'Planner's Connectivity Worksheet.'

When you have answered these questions, you can better target your limited resources to the places where they will make the most difference. It's important to note that despite being called the 'Planner's' worksheet, filling it in will require support from several people, including biologists familiar with your community, your GIS staff, development proponents in the community, conservation groups, Council, etc.

Drafting Connectivity Objectives and Principles

You will notice that some of the questions in the Planners Connectivity Worksheet are hard to answer if you have not first articulated what you hope to accomplish. A discrete set of connectivity objectives will both help to answer some of those questions, and guide your subsequent actions.

The most helpful objectives will be those that relate to what the municipality will do, rather than simply the ecological vision you have. For example, "maintain ecological connectivity through the entire community" is a good vision statement, but provides little substantive information to guide policy development.

To help you zero in on what your objectives might be, consider these possibilities about what might be motivating your municipality:

- A desire to conserve wildlife habitat in the municipality

- Opportunities to incorporate mitigation in new developments

Planner's Connectivity Worksheet

What decision will this support?
- Conservation? (maintaining connectivity)
- Mitigation? (restoring connectivity)
- Plans / policy level? (MDP, LUB, sustainability plan, dedicated policy or bylaw, drainage plan, transportation plan, design guidelines, parks plan, ASP, outline plan); Where in the planning process is information needed?

What scale are you considering?
- Provincial, regional, intermunicipal?
- Whole municipality, part of the municipality?

Connectivity for what?
- Specific species, guild, community?
- Water? (groundwater, surface water)
- Landscape connectivity? (maintaining general connectedness and maximizing naturalness for the greatest number of species)
- Data or modelling limitations?

Connectivity to where?
- Specific 'patches'? (protected areas, natural open spaces, ecological network nodes, water bodies)
- Unknown 'patches'? (green space, undeveloped areas, entire perimeter)

What's in the way, what's helping?
- Potential barriers? (roads, built areas, waterways)
- Potential assistance? (mitigation structures, wide-span bridges, culverts, protected corridors, greenways, stepping stone parks/ponds)

What outputs do you need?
- A new policy?
- A set of criteria / guidelines?
- A map? A GIS data set?
- A scenario comparison?
- A prioritization?

What input information is required?
- Species-specific habitat data or behaviour information?
- 'Patches' data? (location of parks, open space, undeveloped areas, wetlands, etc.)
- Ranking information? ('better/worse' for barriers, mitigations, habitats, patches)
- Development plans?

Adapted from *Connecting the Dots: A Guide to Using Ecological Connectivity Modelling in Municipal Planning* (Miistakis Institute 2016)

- Concerns about human safety on the roads and within the community

- A community-wide appreciation of biodiversity conservation

- The need to comply with new MGA provisions or the Regional Plan

- A desire to proactively conserve as a lower-cost alternative to restoring later

Once you have a sense of your connectivity objectives (what you will do), it is valuable to articulate a set of connectivity principles (the characteristics of how you will do it). This set of principles would be reflected in the wording and details of the related plans, bylaws, development guidelines, etc.

The following are three examples of how connectivity objectives and principles could be articulated.

Leduc Wildlife Corridor Study Principles
- Maintain a linear development edge with adjacent parcels to avoid entrapment of wildlife
- Design recreational uses to have minimal impact on wildlife and flora in the corridor as feasible
- Prioritize wildlife connectivity above all other uses
- Ensure minimal intersection of any anthropogenic feature with the wildlife corridor
- Maintain limited development within a 350 metre buffer of the wildlife corridor

Metropolitan Borough of Bury Guiding Principles
- Design to avoid harm to the link or corridor.
- Mitigation for the reduced integrity of the corridor.
- Compensation measures where a proposal would harm a link or corridor.
- Take appropriate measures if Protected Species are present on the site.

Bow Corridor Ecosystem Advisory Group Acceptable Activities
- scientific research (must be deemed appropriate for the area);
- designated, non-motorized recreational trails that cross perpendicular (to the extent feasible) to the direction of the wildlife corridor should only be permitted;
- linear service corridors that cross and are perpendicular to wildlife corridors (e.g., powerlines, roads, pipelines);
- vegetation management for fire, disease and weed control. These activities should not reduce the optimal average vegetative hiding cover to 40% or less; and
- wildlife habitat management activities designed to encourage or discourage wildlife use of site- specific areas (e.g., prescribed fire, enhance habitat by planting forage species and limiting human access or attractant management such as the removal of Canada buffaloberry to reduce bear-human encounters).

Each approach is perfectly valid, but each used a different technique. The Leduc Wildlife Corridor Study (commissioned by Leduc County and the City of Leduc) used design criteria; the Metropolitan Borough of Bury (in the United Kingdom) used general approach guidelines; the Bow Corridor Ecosystem Advisory Group (including the municipalities along the Bow River valley in the Rockies) identified land uses that might be considered compatible.

One of the most important parts of developing principles will be the degree to which your policies will tend towards, 'consider', 'encourage', and 'may' versus towards, 'will', 'must', and 'contribute.' The principles will also reflect where the responsibility for action and accountability will lie: Council? Ratepayer? Landowner? Proponent?

Comprehensive Community Plans

Every local government creates an overarching, vision-level plan for their community. In Alberta, this type of plan is called the Municipal Development Plan (MDP). This is the highest-level plan, laying out the vision for the municipality, including its future concept for land use, development, transportation, and services and facilities. Because the MDP guides every policy and activity in the municipality, all lower-level policies must be able to draw a line back to some part of this plan.

MDPs are also the place where a municipality would include cross-municipality policies for environmental matters, development constraints, infrastructure, and conservation, as well as reference any studies and analyses, or corporate strategies. Because these plans are extensive, and may not be reviewed for a decade, many municipalities create shorter-term strategic plans, which achieve a similar purpose but in a shorter-term, non-statutory plan.

Intermunicipal Development Plans likewise provide a higher-order policy frame, but in this case it refers to an area of interface between two municipalities, and helps to coordinate their policies for the region.

These comprehensive community plans offer the following opportunities for maintaining ecological connectivity.

Enabling Dedicated Policies

Because all municipal policies and plans must have a line of sight back to the Municipal Development Plan, even vague statements in the MDP can have the effect of enabling lower-level, specific policies. It is therefore important to have mention of the importance of ecological connectivity. Ideally this is in the form of policy statements that reflect the municipality's intention to conserve ecological connectivity and/or to mitigate development in favour of connectivity. To ensure that cascade down, these higher-order plans should

direct that lower-order plans must show how they will conserve or mitigate identified areas of importance for connectivity.

Incorporating Studies and Analyses

The development of these comprehensive plans generally involves undertaking background studies on complex or poorly understood topics to inform the associated policies. These studies often include analyses of environmental significance, in general or specifically. It is therefore advantageous to have situational assessments done on the existence and value of wildlife movement, habitat, and connectivity within the municipality. These studies can both inform the relevant policy, and also be attached as a recognized background report.

Explicitly identifying corridors

Some community plans will go so far as to spatially identify the areas important for connectivity across the entire municipality. In some cases, these are added to the Environmentally Significant Areas information as a features type. Such an approach needs to be cautious. Obviously, it relies on having access to accurate information. Also, information about connectivity may change much more quickly than the plan (which may not be revised for a decade or more). One way to insulate against these concerns if to have the higher-order plan direct that all lower-order plans must identify and map the corridor or connectivity information.

Identify specific tools that could be used

Comprehensive plans can also play an important role in identifying the possible tools that could be used to conserve connectivity. Again, this is an enabling provision, not a requirement. These plans can simply state that a range of tools can be used to conserve, maintain, or restore connectivity, without prescribing their use. This enables lower-order plans to focus on the implementation, rather than making the case. Examples that show up in Alberta Municipal Development Plans include environmental reserve, conservation reserves, conservation easements, land swaps, conservation offsets, and management plans and practices.

Setting Regional Direction

As noted, some comprehensive plans are actually transboundary, applying to the municipality and its partners. Several Intermunicipal Development Plans will use these plans to identify opportunities for maintaining regional connectivity and corridors. These can include references to existing park systems, ecological systems, watersheds, and

regional wildlife movement areas. These plans can also establish priorities for intermunicipal cooperation, including regional conservation priorities. Ecological connectivity is an obvious area for regional cooperation on environmental conservation.

Zoning and Districting[2]

Zoning and Districting is the process of identifying a collection of district types (e.g., Country Residential, Industrial, Agriculture, Highway Commercial) then dividing a municipality into spatially-distinct areas, attaching a unique district type to each one.

The primary mechanism for doing this is the Land Use Bylaw, which is used to define the land use districts in a municipality, and identify the *permitted* and *discretionary* uses for land and buildings in each. The Land Use Bylaw also prescribes the details of development permits, and number of homes per unit.

This standard municipal process offers the following opportunities for maintaining ecological connectivity.

Definitions

The Land Use Bylaw is a foundational policy for a municipality, and as such its list of definitions related to land use are similarly foundational. A great deal of clarity can be provided to the effort of maintaining connectivity by including a set of clear, enabling definitions related to ecological connectivity.

(See *Glossary* for suggestions of what this could include)

Permitted Uses

Each land use district must list its *permitted* uses (allowed without need for further approval) and *discretionary* uses (likely allowed, but subject to further approval).

A fundamental shift can be facilitated by listing 'Wildlife movement corridor' as a Permitted Use for all land use districts.

The shift involved is considering 'wildlife movement corridor' as a *land use*. Currently, areas necessary for wildlife movement are generally considered 'unused', and open to other land-

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[2] Though often referred to by its American term of 'zones' and 'zoning', in Alberta, this is referred to as 'districts' and 'districting'

based activities. Elevating this to a land use gets them on the radar as a viable use for a given piece of land.

It is important to note that such a shift bestows absolutely no requirement on any parcel or landowner — like other permitted uses, they simply provide an option that can be taken.

Wildlife Corridor Interface Guidelines

A Land Use Bylaw generally includes appendices that elaborate on specific planning and development considerations that arise often enough (or are contentious enough) to warrant more detailed guidance at the Land Use Bylaw level.

An opportunity exists to create Wildlife Corridor Interface Guidelines as an appendix to the Land Use Bylaw. This would be similar to existing FireSmart guidance, or Wildlands Urban Interface guidelines that outline the practices necessary to ensure (in those cases) building development and land use practices are modified in these areas to reduce risk to property from wildfire.

In the case of wildlife corridors, it would outline the practices necessary for development to effectively co-occur with wildlife movement areas.

Dedicated Districts

In some cases it may be more expeditious to create a dedicated land use district specifically for maintenance of ecological networks and movement.

There are several forms this could take. These could be broadly targeted at conservation of ecologically-important features, including connectivity elements ('e.g., 'Conservation' district) . These could focus specifically on connectivity, and be used where the primary intent of the area is to protect wildlife movement (e.g., 'Wildlife Movement Corridor' district). Or these could be used in areas known to be important for ecological connectivity more broadly (e.g., 'Ecological Connectivity' district), and include consideration of riparian corridors, wildlife movement areas, hydrological connectivity nexus points, etc.

Ecological Planning Areas

Another approach some municipalities have taken is to expand the concept of 'districts' or 'zones' beyond the concept within the Land Use Bylaw.

In this case, the municipality is divided into 'Ecological Planning Areas.' These areas would have a logical internal similarity (a drainage, a common land use type, an ecosystem type).

For each area, the important ecological features (natural assets, connectivity elements, important habitats, riparian areas, wetlands, etc.) are identified.

The Ecological Planning Area then receives a dedicated set of actions, development guidelines, planning principles, setbacks, reserves, etc. that reflect the needs and character of that area (both ecological and anthropogenic).

With regard to ecological connectivity, a municipality could identify planning areas based on major regional corridors, or identified movement hotspots. In this case, the municipality need not cover the entire land base, as not all of it will be important for connectivity.

Practically, this delineation of Ecological Planning Areas could be added to the Land Use Bylaw as an appendix.

Overlay Districts

Overlay districts are commonly used in municipal planning to address special planning needs in an area. The overlay district is superimposed over the existing zoning or districting, and may in fact cross several underlying districts. The effect is to add a layer of safeguards, special requirements, or additional standards.

Overlay districts can be used to protect wildlife movement corridors, by requiring additional reviews, special development standards, or other special considerations in the identified area of the movement corridor (regardless of the existing underlying zoning).

Using historical conservation overlays as a model, wildlife movement overlays could require that all development applications for either a permitted or discretionary use must be circulated to an ecological advisory committee for comment, and then to the municipal planning commission for an ultimate decision.

Site-specific plans

Site-specific plans are those that reference, in a spatially-explicit way, a portion of the municipality. These can be plans created at a relatively-general level, outlining the subdivision and development concept for the area (intended land uses, sequence of development, etc.). Or they can be plans for a more specific level, outlining exactly where building lots would be located. An example of the more general is the Area Structure Plan (ASP), and an example of the more specific is the Outline Plan.

Site-specific plans offer the following opportunities for maintaining ecological connectivity.

Spatial Identification of Corridors

Area Structure Plans (ASPs) can be required to identify, spatially, where there wildlife movement corridors are in the area subject to the plan. This would occur in a similar way to ASPs identifying generally where the transportation corridors are proposed to be located.

Wildlife Movement Issue Identification

Site-specific plans can be required to specifically detail what the wildlife movement issues are likely to be, and what steps will be taken to address these. This can happen even in the absence of a detailed map of the movement corridors.

Required Mitigation Measures

An Area Structure Plan can be required to incorporate explicit consideration of mitigation measures to be used to address connectivity issues.

When speaking to 'mitigation measures' again it is important to be clear that this does not just mean large-scale infrastructure like wildlife overpasses. This can mean the placement of infrastructure such as culverts, extended bridge spans, and multi-purpose underpasses. It can also mean different approaches to the siting of transportation, servicing, and residential structures, or the avoidance and protection of certain critical nexus points.

Improved Connectivity Information

Often, ecological scientists are aware of an area's potential importance for wildlife movement or ecological connectivity, but have only coarse data for a specific location. With the right higher-level policies to guide it, the municipality can require the development of the ASP to include creation of more detailed, site-specific connectivity information.

Re-Districting for Conservation

The development of Area Structure Plans often involves re-zoning or re-districting of the affected land base. Generally, this is to facilitate more intensive land use, and/or a more complex varieties of land use. If the Land-Use Bylaw includes such Districts, the ASP can include re-zoning/re-districting areas that are known to have conservation value, such that the permitted uses conform with maintenance of the corridors or connectivity.

Ecological Network Design

If a municipality has a cross-municipality policy that speaks to (and identifies) ecological networks and systems that exist across the municipality, the Area Structure Plan can be required to adhere to the spatially-identified corridors, reducing the likelihood that the shepherds of the plan must defend protection of corridors only in the context of a stand-alone document. This can also ensure that corridor-friendly design standards articulated elsewhere (in a different policy) must be applied in the context of the ASP.

Outline Plans

Outline Plans, and other such detailed, lot-level plans, draw from the direction provided by the council-approved Area Structure Plan. Connectivity-friendly design standards and lot placement are unlikely to occur at this level if the ASP does not provide direction that it must.

It is important at this point to note, that not all development occurs subject to a device like an ASP, and design guidelines exist outside of these plans. Thus these guidelines have an importance of their own.

Municipality-wide policies

Municipality-wide policies are those that exist below the vision-level guidance of a Municipal Development Plan, but are not applied only on a specific spatial area. They might refer to a type of land use, a specific issue that could arise anywhere in the municipality, or provide greater direction for a higher-level goal identified in the MDP.

These policies usually have to work in conjunction with other policies and plans. For example, such a policy could lay out the goals for stormwater management, which Area Structure Plans would then be expected to operationalize. In general, these kinds of policies can be modified to include consideration of wildlife/ecological connectivity, can integrate wildlife management practices with other operational practices, or can relate connectivity to other environmental or ecological priorities.

More specifically, municipality-wide policies offer at least the following opportunities for maintaining ecological connectivity.

(*NB: It is important to note that each of these could be titled a 'Plan' or a 'Policy'. In general, a 'Plan' is 'what we are going to do'; a 'Policy' is 'how we are going to do it'. For the purposes of this discussion, how these documents are framed is of lesser importance.*)

Transportation Policies

Two municipal systems that must be aware of and respect each other are the transportation system and the ecological connectivity system. Human safety and ecological function depend on this.

Because a transportation plan sits very high in the municipal planning hierarchy, it is critically important that 1) the policies mentioned above take full advantage of their ability to facilitate planning for connectivity, and 2) the transportation plan incorporates direct references to these policies. If a transportation policy is not considering connectivity at the outset, it is very difficult to incorporate connectivity considerations into site-specific plans.

Open Space Policy

Municipal open space policies have evolved considerably over the last couple of decades. Previously, open space was simply 'nothing built there'. The ineffectiveness of this from a policy perspective led municipalities to define 'types' of open space.

Examples now include Recreational Open Space (ball diamonds, parks, soccer fields, campgrounds), Institutional Open Space (schools, stormwater ponds, cemeteries, boulevards), Agricultural/Forest Open Space (farms, woodlots), Downton Open Space (plazas, squares), Hazard Lands (flood areas, escarpments, contaminated sites), Trails and Pathways, and Natural Open Space.

Policies, bylaws and master plans for open space usually include at least Recreational and Natural open spaces. The Natural Open Space category can be defined in such a way that it encompasses unbuilt areas that currently provide a connectivity function. Permissible types of activities and developments can be articulated that support the goals of maintaining ecological connectivity. As well, at a municipal-wide level, these policies can articulate a goal for a continuous open space corridor system.

Urban Wildland Interface Policy

Urban-Wildland Interface policies are generally put in place to manage the fire risk to buildings in close proximity to forests. The policy and the guidelines focus on the location and details of buildings, giving direction to modify this in such a way as to minimize the risk.

Such policies could be ideal for managing development adjacent to connectivity zones, providing guidelines for placement of buildings (setbacks), building of fences (wildlife friendly), and practices within the yard (attractants like fruit trees and dog food).

Parks Plan

For those involve in ecological conservation, 'park' generally means ecological protection, but the array of park types in a municipality tend more towards recreation and managed landscapes. However, most municipalities have a sub-set of parks that is dedicated to ecological conservation (natural areas, natural area parks, conservation areas, etc.).

The ecological viability of these areas is very often dependent on connectivity of some sort. Identifying the explicit relationship between natural area parks and their related corridors and linkage zones bolsters both the natural areas and connectivity as a whole.

Water Management Policies

Municipalities have a host of policies that relate to water: treatment, wastewater transport, potable water transport, groundwater use, stormwater management. Increasingly, a natural infrastructure perspective has led to these strategies considering — and incorporating — natural systems.

Hydrological connectivity is a critical part of ecological connectivity, as wetland systems, drainage systems, storm and flood management, etc. rely so heavily on this type of 'corridor.' In the same way wildlife movement can be modelled and mapped such that we can plan and mitigate for its effectiveness, so too can hydrological pathways be recognized, mapped, and planned for in various water management policies.

Green Infrastructure Plans

Green infrastructure goes by many names, including 'natural infrastructure' and 'ecological networks.' And there are almost as many definitions of Green Infrastructure as there are people using the term. Regardless, many municipalities are now moving to create comprehensive, municipality-wide green infrastructure plans.

Whether these plans have a specific hydrological focus, or a more expansive green space focus, they represent a significant opportunity to incorporate policies for the maintenance of interconnected landscapes (and waterscapes), and the critical linkage zones that these natural processes rely on. This can include identification of these assets, policies for the maintenance of their functions, and direction for how ASPs and outline plans must accommodate them.

Connected Communities Policies

As noted before, the term 'connectivity' is generally used in municipalities to mean facilitating the movement of *people* from one part of the municipality to another. This potentially source of confusion and concern, can also be an opportunity. 'Connected Communities' policies are very common, and very people-oriented. They can be an ideal place to broaden the concept of connectivity to include 'nature', and talk about the

integration of human systems and ecological systems (see *Development and Ecological Connectivity*, above).

Dedicated Plans or Policies for Conservation

Similar to 'municipality-wide policies', these are non-site-specific policies created to address specific concerns that might occur anywhere in the municipality. However, these are targeted specifically to the conservation of environmental features (biodiversity, connectivity, habitat, riparian, wetland, etc.).

These plans and policies tend to inform the more spatially-explicit plans, and provide a background to *how* development or conservation of the landscape should take place.

Plans and policies dedicated to conservation offer at least the following opportunities for maintaining ecological connectivity.

Conservation or Biodiversity Policy/Strategy

More and more municipalities are creating dedicated biodiversity or ecological conservation strategies. Often, these have emerged as 'coordinating' strategies, gathering numerous disparate polices that each speak to some aspect of biodiversity or conservation. The policies generally reference goals and strategies for ecological networks, biodiversity conservation, specific species of concern, natural areas, important habitats, and/or human-wildlife coexistence.

Because connectivity is one of the most central pillars of biodiversity conservation, these policies can identify the ecologically-valuable corridors, and outline the supporting management actions that must be taken (and when) across multiple planning contexts for the municipality. This type of policy could include summarizing the scientific bases, outlining development standards and guidelines, flagging knowledge gaps (and procedures to fill them), spatially specify their location, and detailing how new data and knowledge will be incorporated.

Environmentally Significant Areas (ESA) Policy

Virtually all municipalities have some sort of Environmentally Significant Areas policy, listing the specific areas across the municipality that are considered ecologically significant, and usually some detailing of how their importance was determined.

Municipal ESA policies can be amended to explicitly reference connectivity. There are two basic approaches. First, the actual connectivity areas or linkage zones could be spatially laid

out. Alternately, the criteria for what makes connectivity 'significant' could be identified, with a requirement that subsequent plans detail specific areas, based on the policy guidance in the ESA document.

Wildlife Corridor / Ecological Network Policies

Wildlife Corridor Policies would play a very similar role to the Conservation or Biodiversity Policies described above, but would drop down one level to focus only on connectivity of wildlife or other ecological connectivity priorities (vegetation, pollinators, water).

Wildlife corridor policies could also provide the opportunity to stratify known corridors, identifying and naming (for ease of reference) major or primary corridors, as well the smaller connecting corridors that may have slightly different guidelines.

Such corridor or network policies an identify at a high level where the corridors are, how habitat patches and linking corridors are to be considered in planning, relevant definitions, specific global policies, supporting committees and external partners, and cross-municipality principles. They can also enable setback requirements, including specific numerical guidance, or referencing a more comprehensive setback measurement resource.

Riparian Management Policy

Riparian Management Policies focus on the maintenance of the especially-biodiverse strips of land between waterbodies and their associated uplands. These policies offer a tremendous opportunity for addressing connectivity since there can be significant overlap between a municipality's riparian areas and its wildlife movement corridors.

Riparian setbacks and management principles can be written such that they incorporate the movement and connectivity aspects of riparian areas, or reference these if they are articulated in other policies.

Habitat/Species Protection Policies

Municipalities can create habitat or species-specific protection policies (or management policies) that lay our goals and associated actions the municipality will take to maintain a subset of a bigger ecosystem. This can be for a vegetation type (grasslands, forests), groupings or 'guilds' (songbirds, aquatic species, pollinators), or even one issue/species (BearSmart). Such policies lay out how development will or will not happen in these areas, and the proactive conservation steps the municipality might take

Some of these have very direct connections to ecological connectivity as part of what supports they viability. Including reference to connectivity (identified corridors, principles, corridor setbacks, etc.) can bolster both the specific policy and connectivity as a whole.

Guidelines and Practices

Ecological connectivity policy is only good if it enables and catalyzes specific planning and development practices. This guide cannot encompass the full range of potential site-specific practices, but can offer these areas of focus:

Development Guidelines

Create development guidelines that require consideration of connectivity, and embed those in the requirements for both internal municipal developments and those proposed by community members.

Framing 'avoidance' as the first step in planning and development with regard to corridors can set the tone that the municipality's preference is for proactive, contributory activity, rather than expensive recreation or restoration.

At a larger scale, development guidance can include infrastructure adaptation, including appropriate siting and wildlife-movement friendly design (built form that promotes low-friction movement of wildlife through an area).

At a more site-specific scale, development guidance can include practices such as minimizing attractants (fruit trees, pet food), wildlife-friendly lighting (not shining into the corridor), tree protection (where they provide cover or habitat), and vegetation management guidelines (restrictions on mowing, spraying).

Hazard lands (steep slopes, flood-prone areas, etc.) are often critical movement and habitat areas. Preventing hazard lands that are important for ecological connectivity from being developed can be vital, even if mitigations are suggested which could address the development potential.

Ensuring Policies are Evidence-based

A first step will need to be the identification of the ecological connectivity zones for the municipality, including the corridors and the associated patches. Those then need to be mapped, including the barriers associated with them.

A key development parameter will be the 'setback' of development from corridors that will be effective in various circumstances. Empirical guidance or methods for determining functional setbacks for connectivity should be created and provided to the building community.

A municipality will rarely have expertise needed to identify or assess corridors, or comment the impact of potential threats. A conservation committee or corridor committee, populated by experts in the field, can provide that capacity.

Securement Tools

In some cases, a municipality may want to actively 'secure' the connectivity areas that are deemed most important. Several tools are available to municipalities to do this, including:

Environmental reserve — while focused on hazard lands rather than environmental criteria, there is often overlap between these, allowing environmental reserves to be used to protect wildlife movement.

Conservation reserve — a new, and as-yet unused, tool for municipalities enabled in the 2017 revision of the Municipal Government Act.

Conservation easement — municipalities in Alberta have already used the conservation easement tool to protect wildlife habitat.

Land swaps — some municipalities have used this technique where areas of low connectivity importance (but potentially high economic development importance) is swapped for parcels with the opposite characteristics.

Transfer of Development Credits — a tool enabled under the Alberta Land Stewardship Act which allows municipalities to allocate credits to ecologically-important parcels which can be bought and used for bonus development in areas more appropriate for development.

Supporting Your Decisions

Connectivity Mapping and Modelling

Municipal planning activity is highly dependent on maps, so having a good sense of what areas on the landscapes are important for connectivity – i.e., maps – is vital. Creating those maps is generally based on modelling; taking the available data and processing it in a way that gives a plausible picture of which areas might be important for ecological connectivity.

Planners do not need to be experts on wildlife modelling, connectivity algorithms, and GIS processing, but it is valuable to have a basic understanding of what is involved in this process, to better understand what the final products are telling you.

Three concepts are important: resistance, one/many species, and patches.

Resistance

Nature is extremely adaptable. Redundant pathways in an ecological system create choices, and animals, plants, and water are very good at executing their Plan B ... to a point. Not all paths are the same, and some of those alternate choices take much more energy, limiting how much and how long a given species can keep finding workable Plan Bs.

The degree to which human development makes it harder for those species to connect with the resources they need is called 'friction' or 'resistance.' Think of it as the difference between running, running in water, and running in molasses – same task, just harder to do in different environments.

In ecological connectivity terms, 'resistance' is increased by having to cross roads, climb fences, take circuitous routes, avoid humans, etc. Natural features can create resistance, too – rivers, cliffs, and dense vegetation can require energy to get around, too.

Connectivity modelling assesses and illustrates this landscape dynamic – less resistance is assumed to equal better connectivity

Connectivity for One Species or Many Species

The study of ecological connectivity is broad and can quickly get complex, especially when asking the question, "Connectivity for what?" Sometimes there is a clear answer, sometimes there is not. A basic separation used in answering this question is to consider whether you are modelling and mapping 'structural' or 'functional' connectivity.

This dichotomy splits based on whether you are looking at maintaining connectivity for a specific species (functional connectivity), or whether you are trying maintain connectivity for as many species as possible (structural connectivity).

The assumption behind *functional* connectivity modelling is you know what species or group of species you are concerned about. The assumption behind *structural* connectivity modelling is that a more intact landscape (less human disturbance) is better for animal movement, and that most species are more likely to move through areas with less human disturbance.

Resource 'Patches'

A key feature of connectivity modelling is the identification of resource *patches*. These are the habitat areas or water bodies or other elements in the ecosystem that need to be connected to each other so that species can access the diversity of *resources* they need to thrive (seasonal habitat, space for offspring, genetic diversity, etc.).

Identifying habitat *patches* can be highly subjective and species specific, and challenging if the supporting data is hard to come by. For that reason some connectivity modeling at regional scales uses a sort of 'patch-free' approach to modeling. In this case *patches* are replaced with a series of points around the study area, and the model assesses the quality of all the points in between in terms of their *resistance* – areas with low resistance are considered higher quality habitat.

Another variation in connectivity modelling is to designate resource *patches* based on those areas managed for conservation, such as protected areas, natural areas, or open space. In this case, connectivity modeling determines how species move between those protected areas.

Understanding the role these patches have played in the modelling is critical for planning, because if they disappear or are locally obstructed, efforts to connect them may become irrelevant.

Setbacks and Buffers

A standard practice for ensuring the corridors and connectivity zones remain unimpaired is to establish setbacks and buffers. These provide a cushion to ensure the effective function of these corridors and safety for humans.

In the sharp-line world of municipal planning, it is tempting to reduce these to hard boundaries and tightly-engineered channels. The reality however, is that they are fluid and

malleable, changing with seasons, climate, and regional influences, and therefore require looser demarcation than most planners and developers are comfortable with.

While the bad news is that 100% certainty will never be available and the precautionary principle will have to be pre-eminent, the good news is that much has been done to understand the rough parameters of these buffers for specific places, species and circumstances.

In the resources section below, under *Sample Setback Guidelines*, Miistakis has gathered several examples of setback and buffer calculations for corridors, core areas, and the isolated but important stepping stone habitat. These include science-based calculations, determinations by fellow municipalities.

Finding the Data and Information

Finding data and information to indicate where ecological connectivity zones exist in the municipality can be challenging. Additionally, it can be challenging to identify the best response once that information is known. The following guidelines can help municipalities address this dilemma.

Work with local biologists — Much of the connectivity data, and the information about effective approaches, will be local, and hard to derive from large-scale or regional work. Local biologists who have studied, or can study, connectivity at the scale of the municipal decisions are vital.

Consult the provincial agency — Provincial agencies (environmental and transportation) may have data, modelling, and other information the municipality can use to better understand whee wildlife are, and where conflicts are likely to occur.

Consult regional strategies — Municipal decisions are often required to be nested in a regional context. In Alberta, this includes regional plans, biodiversity management frameworks, transportation plans, and public lands plans or designations.

Use local modelling or species-specific data — While not always available, the ideal is when modelling or research specific to the species or issue of concern (e.g., hydrological connectivity) has been done for the area. Again, local biologists and regional agencies can direct municipalities to the most comprehensive information available.

Consider human safety — In many cases, ecological connectivity relates to human safety. Initiatives and research such as BearSmart, WildSmart, and cost-to-society calculations can help municipalities better understand the human dynamic to ecological connectivity.

Highway 3 Resources

The following resources can provide Highway 3 municipalities with information and data specific to wildlife movement in the area:

Miistakis Institute. (2016) Linking Landscapes and Wildlife along the Highway 3 Transportation Corridor: Workshop Summary.

Clevenger et al. (2010) Highway 3: Transportation Mitigation for Wildlife and Connectivity Report.URL:
https://www.rockies.ca/files/reports/H3%20Final%20Report%200607_June8.pdf

Resources

Resource Library

The following list of resources is comprised of policies and plans from local governments in different areas who have faced the same challenge - trying to integrate ecological corridors and wildlife movement into municipal planning.

Some resources are very specific to connectivity, while others are included because they are good examples of MDP-level documents that incorporate planning for connectivity at that level.

All resources listed are available as a package from the Miistakis Institute.

A Forest Habitat Network for Edinburgh and the Lothians_2015
Forest Research

Biodiversity and Planning in Buckinghamshire_2014
Buckinghamshire County

Community Strategies for Vermont's Forests and Wildlife_Sec 14 Overlay Districts_2013
Vermont Natural Resources Council

Connecting the Dots_Planning Guide_Nov_2016
Miistakis Institute

Designing and Implementing Ecosystem Connectivity in the Okanagan_2014
Okanagan Collaborative Conservation Program

Ecological Network Management Strategy_2015
City of Richmond

Ecology in Neighbourhood Planning
Bath and NE Somerset Council

Environmental Guide for Mitigating Road Impacts to Wildlife_2017
ON Ministry of Transportation

Environmental Management Areas Strategy_2013
City of Vernon

Green Infrastructure Strategy_2015
Borough of North Tyneside

Guidance for the Integration of Biodiversity Conservation into Local Planning Strategies and Schemes_ 2012
City of Perth

Habitat Corridors Strategy_2015
City of Maroondah

Homes for people and wildlife_2016
The Wildlife Trusts

Land Use Tools to Protect Groundwater-Overlay District_2011
Environmental Law and Policy Center

Leduc Wildlife Corridor Study_Final Report_2018
City of Leduc, Leduc County

Local Biodiversity Strategy_2013
Geraldton and Chapman Valley

Local Development Framework Background Paper 5 – Biodiversity_2011
Wealden District

Municipal Development Plan_2007
Strathcona County

Natural Connections - Strategic Plan_2007
City of Edmonton

Natural Environment Policy-Local Plan Part 7_2005
Town of Milton Keynes

Natural Environment-Local Plan Sec 4.0_2005
City of Oxford

Nature Conservation Strategy
City of Westminster

Newcastle's Wildlife Enhancement Corridors_2013
City of Newcastle

Official Community Plan_2018
District of Ucluelet

Policy on the Protection and Enhancement of Natural Habitats_2004
City of Montreal

Wildlife Connections Plan_2018
City of Redland

Wildlife Corridor And Habitat Patch Guidelines For The Bow Valley_Updated 2012
Bow Corridor Ecosystem Advisory Group (BCEAG)

Wildlife Corridor Protection Enhancement Plan_2015
Central Lake Ontario Conservation

Wildlife Corridors Initiative_2008
Western Governors Association.pdf

Wildlife Habitat Conservation Strategy_2008
Township of Langley

Wildlife Links & Corridors_ 2001
Metropolitan Borough of Bury

Wildlife Links & Corridors_ Development Control Policy Guidance Note 2
Metropolitan Borough of Bury

Policy Clause Catalogue

There is little need to reinvent the wheel. Most policy wording that a municipal government might seek out related to connectivity and wildlife movement has probably already been written. To that end, Miistakis has created a 'Policy Catalogue' based on the resources in the library above. This catalogue has been compiled in a separate Excel workbook. The intent was that any user can then search, sort and adjust the catalogue to suit their own needs.

The catalogue was compiled using a keyword search on the following terms:
- connectivity
- corridor
- ecological network
- natural area
- wildlife

- wildlife movement

The catalogue is organized under three tabs:
- Policy and Guidelines
- Definitions
- Context

Each entry gives the user the verbatim text, the document from which it came, and the location within that document. Entries in the catalogue are not cleaned and formed into perfect policy templates. Rather, the intent of the catalogue is to create a first step in helping municipal planners distill the wealth of policy and planning knowledge contained in the Resource Library.

Sample Setback Guidelines

Corridor	Pathways that offer species and ecological processes connection between core areas.

Recommended requirement	References	Notes
Min length of 15m, max length of 60m	Indiana Division of Fish & Wildlife. 2004. "Wildlife Corridors Habitat Management Fact Sheet."	To provide habitat for species using corridors as a travel lane or for food, nesting or escape cover.
50m width	Susan Latimer and Alison Peatt. 2014. Designing and Implementing Ecosystem Connectivity in the Okanagan. Prepared for the Okanagan Collaborative Conservation Program.	Local corridors, likely to be influenced by edge effects.
100m width	HB Lanarc, and Raincoast. 2011. "City of Surrey Ecosystem Management Study," no. April. Office of Environmental and Heritage, Department of Premier and Cabinet NSW Conservation Management Notes	Identified corridors using a least-cost path analysis. Potential corridors were created by buffering 50 m on each side. These are potential alignments for connection and can be adjusted and changed in terms of width and location to best suit the local area and opportunities. Notes that the maximum separation distance for patches to provide connectivity and act as a corridor is generally accepted to be 100m. Includes a "useful references" section.

200m width total - 100m width with a 50m buffer of native vegetation on each side	Redland City Council. n.d. "Wildlife Connections Plan 2018-2028."	For established corridors (highest priority) to retain a variety of bird species and complete suite of arboreal mammals. Widths determined through literature review.
350m width	The Bow Corridor Ecosystem Advisory Group. 2012. "Wildlife Corridor and Habitat Patch Guidelines for the Bow Valley." Golder Associates. 2017. "Wildlife Corridors for Smith Creek: An Evaluation," no. March.	Primary corridors 350m. Determined through literature review. The 1992 NRCB decision requires that primary wildlife corridors should not be narrower than 350m, except under unusual circumstances (NRCB 1992 pp. 10-38).
3000-6000m width for corridors adjacent to residential development; **400-1000m width for corridors adjacent to recreational trails**	Ford, Adam. 2018. "Human Impacts on the Spatial Ecology of Large Carnivores: Implications for the Design of Effective Wildlife Corridors." *In press.*	Synthesized information from studies on large carnivore (black bear, cougar, wolf, and grizzly bear) avoidance of infrastructure or people.
1km length	The Bow Corridor Ecosystem Advisory Group. 2012. "Wildlife Corridor and Habitat Patch Guidelines for the Bow Valley."	For primary and secondary corridors.
3.2km length	University of Wisconsin Extension. n.d. "Environmental Corridors Lifelines of the Natural Resource Base: A Series of Fact Sheets on Regional Planning Issues in Southeastern Wisconsin."	Primary environmental corridors contain concentrations of our most significant natural resources. They are at least 400 acres in size, at least two miles long, and at least 200 feet wide. Secondary environmental corridors contain significant but smaller concentrations of natural resources. They are at least 100 acres in size and at least one mile long, unless serving to link primary corridors.

Straight edge	The Bow Corridor Ecosystem Advisory Group. 2012. "Wildlife Corridor and Habitat Patch Guidelines for the Bow Valley."	Development around corridor should be as straight as possible. Peninsulas, doglegs and cul-de-sacs have the potential to trap animals or direct them out of the corridor network and into development areas where conflict with humans may result.
Feathered edge	Redland City Council. n.d. "Wildlife Connections Plan 2018-2028."	To minimize edge effects and keep species movements within the corridor, wildlife habitat corridors should have an edge with a feathered shape. Determined through literature review.
20 – 40m setback from development	The Bow Corridor Ecosystem Advisory Group. 2012. "Wildlife Corridor and Habitat Patch Guidelines for the Bow Valley."	20m setback from single family residential to four unit residential, 40m setback from local commercial. Determined through literature review.

Core areas
Habitat patches of suitable size and quality so as to provide environmental conditions that support entire populations of animals and plants as associated ecological functions.

Recommended requirement	References	Notes
Min 10ha in size	HB Lanarc, and Raincoast. 2011. "City of Surrey Ecosystem Management Study," no. April. City of Richmond. 2015. "Richmond's Ecological Network Management Strategy," no. August: 51. http://www.richmond.ca/__shared/assets/Ecological_Network_Management_Strategy42545.	Selected to encompass moderately large natural areas that can support populations of many native wildlife species, particularly if there other natural areas nearby. 15ha and 20ha were considered, but they excluded areas considered to be important ecological features in Surrey. Selected as the size threshold for hubs (core

	pdf.	areas) because they can support populations of many native wildlife species, particularly if there are other natural areas nearby.
Greater than 55ha in size, goal of parcels greater than 2,500ha	Environmental Law Institute. 2003. Conservation thresholds for landuse planners. Environmental Law Institute, Washington, D.C. Avail-able from www.elistore.org	Literature review of 160 papers.
As large as possible	Redland City Council. n.d. "Wildlife Connections Plan 2018-2028."	To provide necessary resources and environmental conditions required for survivorship, reproduction and movement of a species core habitat. Determined through literature review.
Max 1100m gaps	Redland City Council. n.d. "Wildlife Connections Plan 2018-2028."	Core areas should be no more than 1100m apart even where structurally intact corridors are linking. Determined through literature review.
20 – 40m setback from development	The Bow Corridor Ecosystem Advisory Group. 2012. "Wildlife Corridor and Habitat Patch Guidelines for the Bow Valley."	20m setback from single family residential to four unit residential, 40m setback from local commercial. Determined through literature review.
230-300m buffer zone	Environmental Law Institute. 2003. Conservation thresholds for landuse planners. Environmental Law Institute, Washington, D.C. Avail-able from www.elistore.org	Literature review of 160 papers. Buffer zone up to at least 230-300m from periphery of edges.

Stepping stones	Links between habitat patches, natural or semi-natural non-linear vegetated patches that provide resources for species but may not be of sufficient size of quality to provide for all habitat requirements or ecological functions.	
Recommended requirement	**References**	**Notes**
0.25 – 10ha in size	HB Lanarc, and Raincoast. 2011. "City of Surrey Ecosystem Management Study," no. April. City of Richmond. 2015. "Richmond's Ecological Network Management Strategy," no. August: 51. http://www.richmond.ca/__shared/assets/Ecological_Network_Management_Strategy42545.pdf.	Selected areas of this size are important to the functioning of Surrey's Green Infrastructure Network, but too small to be considered hubs (core areas). Many neighborhood parks have areas of forest or shrub vegetation in this size range. Identified as a component of Richmond's Ecological Network using science-based approach to mapping, assessment and examining potential connections between natural and semi-natural vegetation.

Glossary

The following terms and definitions are drawn from the City of Edmonton's <u>Natural Connections Strategic Plan</u>, 2007

Barriers: Elements that wildlife would consider a deterrent to movement and would avoid crossing such as roads. In other words, barriers significantly reduce connectivity.

Buffers: Protect core areas and linkages from negative impacts from the matrix and associated human activities. In other words, a buffer allows conflicting land uses to coexist and mitigates edge effects.

Connectivity: The degree to which a landscape facilitates or impedes movement among resource patches. It may be provided by stepping stones, corridors and/or compatible land uses.

Core areas: habitat patches of suitable size and quality so as to provide environmental conditions that support entire populations of animals and plants and associated ecological functions.

Corridor: Natural or semi-natural linear vegetated patches that enhance movement among other habitat patches such as core areas or natural stepping stones.

Ecological network: A coherent system of natural and/or semi-natural landscape elements that is configured and managed with the objective of maintain or restoring ecological functions as a means to conserve biodiversity.

The basic structure of an ecological network has three main landscape elements: core areas, linkages (stepping stones and/ or corridors) and matrix.

Linkages: arrangements of natural or semi-natural vegetation that enhance either structural and/or functional connectivity (for species, communities or ecological processes) between core areas. There are 2 main types of linkages: stepping stones and corridors.
- Stepping stones: natural or semi-natural non-linear vegetated patches that provide many resources for species but may not be of sufficient size or quality to provide for all habitat requirements or ecological functions. They are usually separated by a less hospitable matrix or linked by corridors.
- Corridors: natural or semi-natural linear vegetated patches that enhance movement among other habitat patches such as core areas or natural stepping stones.

Matrix: all of the land not considered to be part of core areas or linkages i.e. background ecosystems or land uses within which habitat patches (core areas and linkages) lie on a landscape. In an urban landscape the matrix generally represents development.

Stepping Stone: Natural or semi-natural non-linear vegetated patches that provide many resources for species but may not be of sufficient size or quality to provide for all habitat requirements or ecological functions. They are usually separated by a less hospitable matrix or linked by corridors.