Keeping NATURE in Our Future

Designing and Implementing Ecosystem Connectivity in the Okanagan

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Okanagan Collaborative Conservation Program

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Introduction

Designing and Implementing Ecosystem Connectivity in the Okanagan was developed as part of the Biodiversity Conservation Strategy work undertaken by the Okanagan Collaborative Conservation Program. As part of the ***Keeping Nature in Our Future Series***, this document is one of the Supporting Regional Documents. This guide strives to outline the considerations necessary to identify and undertake land use planning for wildlife corridors and ecosystem connectivity. *Designing and Implementing Ecosystem Connectivity in the Okanagan* is not a checklist or a definitive outline of what to do for any specific species or ecosystem. It offers a general discussion of the types of regulatory tools and opportunities to permit inclusion of connectivity areas in land use plans, land management plans and other resource management planning initiatives.

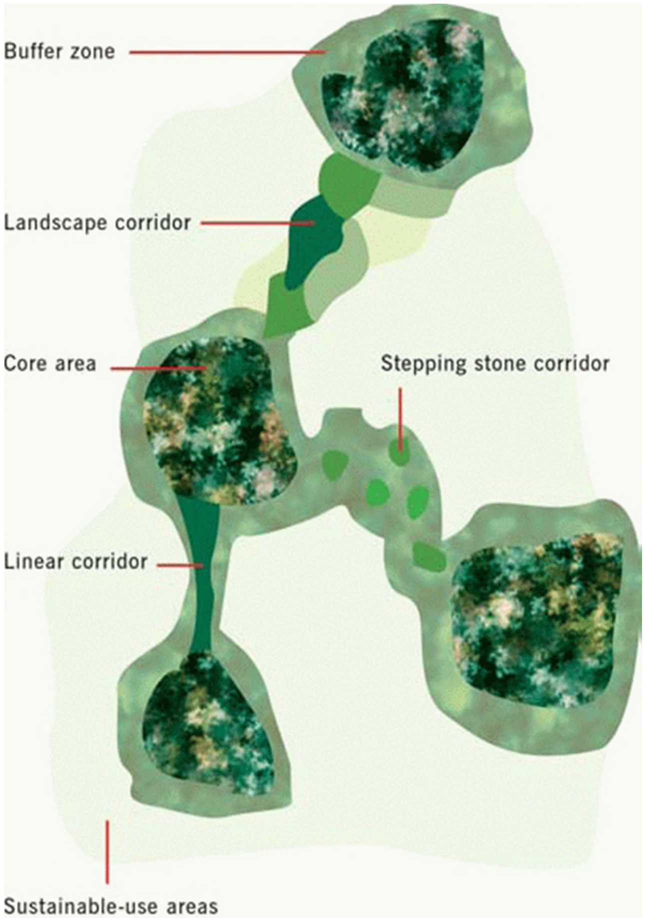
Section 1 begins with a definition of ecosystem connectivity and its necessity, including a general discussion of what connectivity areas provide both to the landscape and to human settlement areas. Section 2 outlines the necessary components of functional connectivity corridors and patches, including a discussion of the ecological services these areas provide. Section 3 focuses on the practical requirements for developing connectivity areas and emphasizes the need for early corridor identification and inclusion in land use planning. The appendix provides further details and references for the discussion and tools outlined in the main text.

Land use planners are considered to be the primary audience for this guide, but it also provides useful information for all stakeholders and levels of government involved in land management and planning, whether they are working at a regional, sub-regional or local level. This guide may also be of use to community members and private land owners who are interested in contributing to and participating in the identification, creation and management of connectivity areas. For those not familiar with connectivity planning, this guide can assist with the biophysical analysis used to identify functional connectivity options and help highlight tools available to create plans to maintain connected landscapes. This guide is not intended to be the definitive document on connectivity, but is a starting point to bring the many stakeholders and participants together to encourage discussion, partnership and participation in land use planning initiatives that support connectivity.

While local government is a key agency responsible for undertaking and planning land use, effective corridor and connectivity planning requires consideration of and partnerships between many jurisdictions and land ownership types. Whether planning overlaps private, crown, or public land, each land ownership type carries specific regulatory guidelines, requirements and limitations. These must be integrated and considered fully to develop a successful connectivity plan. Federal, provincial and local governments, First Nations, private landowners and various stakeholders have a role to play in ensuring sufficient area is retained. Planning and implementing ecosystem connectivity will safeguard functioning of ecosystem services, retain thriving natural areas, sustain wildlife movement without conflict, and secure community enjoyment of recreation and beautiful natural areas throughout the province.

1.0 WHAT IS ECOSYSTEM CONNECTIVITY AND WHY IS IT REQUIRED?

1.1 Purpose and summary of the components in this guide



This guide is designed as a tool for local and senior government planners and land managers interested in supporting biodiversity conservation by retaining and restoring ecosystem connectivity. The guide explains what connectivity is and why it is important to support biodiversity. The guide also explains the fundamentals of designing and implementing an ecosystem connectivity plan. Whether you are planning to hire consultants to assist in the development of a plan, or intend to work with local partners to build a strategy yourself, this guide can help direct the planning process and produce results that benefit ecosystems and the species (including people) that live in them.

At regional, sub-regional and local scales, ecosystem connectivity planning can be integrated into a wide array of land use decision making, management and planning efforts. These activities may include: regional growth strategies, official community plans, area plans, parks and recreational plans, water management plans, transportation and utility plans, agricultural development, forestry plans, crown land management as well as land acquisition, management or restoration plans by conservancies, land trusts, and other nongovernmental organizations.

Figure 1: Connectivity Elements

Physical and functional links between ecosystems (called connectivity) are necessary to support biodiversity. A connected network of ecosystems supports ecosystem services, provides opportunities for animal movement across the landscape and sustains natural areas close to populated areas. As shown, connectivity plans define core areas (also called ecosystem patches) connected by connectivity elements like landscape corridors, stepping stone corridors, linear corridors, and buffer zones.[1]

[1] Diagram adapted from IUCN Countdown 2010. International Union for Conservation of Nature website. Used with permission. http://countdwon2010.net/archivee/paneuropean.html

Private landowners have a role to play, whether contributing to local stewardship or conservation efforts, managing habitat on their own land or creating a conservation trust as a legacy. This guide will provide information to understand how they can be a part of developing a regional conservation goal or be engaged in the discussion on protecting local natural areas and species sensitive to human disturbances. The tools for implementing ecosystem connectivity plans on private land, provincial crown land and other areas are different than those used by local governments, but information on these tools are available elsewhere and are discussed in Appendix 1-F.

This guide presents key ideas and messages in bold text, with glossary words marked in yellow—mouse over to see the definitions. Section 1 introduces the concept of ecosystem connectivity and explains why it requires consideration for planning and regulation. Section 2 explains connectivity components (i.e. ecosystem patches and connective elements), describes a systematic approach for constructing connectivity plans and presents some of the key factors that must be considered to create robust connectivity. Section 2 concludes with a discussion of management considerations to support connectivity in the future. Section 3 provides a summary of planning and regulatory tools available to local governments to implement connectivity plans. Following section 3 is a glossary of terms and list of references used to support development of this guide. A summary of key ideas is presented at the end of each of the four sections.

Ecosystem connectivity tends to be reduced where people work and live. Urban development, linear developments like roads and other land uses tend to overlap and occur in low-elevation valley bottoms and areas near water. The result is alteration of habitat patches and natural processes like water movement, purification, fire and soil erosion.

1.2 What is ecosystem connectivity?

Ecosystem Connectivity is achieved by conserving and maintaining a connected network of natural areas. Connections support ecosystem functions and the movement of species. A connected landscape consists of linked natural areas. Ecosystem connectivity tends to be reduced where people work and live. Communities, linear developments (roads, utility corridors) and other land uses tend to overlap and occur in valley bottoms and in areas near water. Lower elevation areas and sites near water are also vitally important to support ecosystem connectivity. In the absence of planning for connectivity, intensive human use in these areas tends to alter natural processes like water movement and purification, fire and erosion. Connectivity is also affected by the natural features of a landscape including: topography, vegetation, wetlands, lakes and streams. These natural features have varying implications for ecosystem services and species movements [1]. Communities can plan to maintain connectivity rather than assuming that ecosystems will function regardless of development activities such as roads, buildings, vegetation modification, changes to water courses and lakeshores. Building a connected network of natural areas is an excellent strategy to support a variety of values and needs, including those of ecosystems and the species they support, including people.

The building blocks of a connectivity strategy include ecosystem patches linked by connective elements such as landscape corridors or linear corridors. Buffer zones associated with corridors and patches are also sometimes added to limit impacts of adjacent land use on these areas. For some species, or where continuous connectivity cannot be achieved, a series of small ecosystem patches, called stepping stone corridors, can be substituted for continuous corridors. Well-designed connectivity strategies consider both species and ecosystems present, together with their expected use and locations in the area [2].

1.3 Why is ecosystem connectivity required?

Like well-designed transportation networks that provide efficient travel options for people, natural ecosystems are designed to provide for efficient movement of species and effective delivery of ecosystem services. Imagine the impacts to people where water, electrical and sewer systems have insufficient connections and undersized infrastructure. In areas modified by human use, ecosystem connectivity can be similarly insufficient or interrupted. Like planning for transportation or infrastructure for people, planning for ecosystem connections is required in landscapes with extensive human modification. When human populations were smaller, planning tended to focus on protection of natural areas away from human development. As development proceeds and options for retention become more limited, there is an increasing lack of connectivity between natural areas and associated impacts to ecosystem services. To avoid these problems, planning for ecosystem connectivity must occur both in places where natural areas are common, and in places used intensively by people.

Planning for connectivity in one community gains momentum and supports better local results as well as interest and benefits from surrounding neighbors. Below are some key reasons for maintaining and supporting ecosystem connectivity.

Ecosystem connectivity supports delivery of ecosystem services. Communities across BC recognize the value of retaining natural areas including the ecosystems they contain and the services they provide. Science is showing that the extent, quality and arrangement of retained natural areas affect the health of individual ecosystems, and the extent of available ecosystem services. Historically, natural areas were plentiful and supported surrounding ecosystems and species in the areas surrounding communities. Connected ecosystems support ecosystem functions such as water cycles, soil production, and plant and animal species that make important contributions to human survival. For example, connected ecosystems enable pollination by providing habitat for insects and birds. Without these pollinators, the survival and reproduction of many plants including agricultural crops would be threatened. Without connections, pollinators could not move efficiently between backyard gardens, natural areas, farms, and ranches.

Keeping native vegetation will help provide habitat for native pollinators, support their movement between habitats and thereby support the viability of our agricultural crops [3]. Successful pollination depends on maintaining a variety of pollinators, including native pollinators. For example, the Mason Bee is 5 to 10 times more efficient at pollination than are domestic honey bees. Unfortunately both species are declining. Scientists believe that habitat loss and alteration must be addressed to reverse these declines. Maintaining ecosystem connections helps ensure that pollination and other ecosystem services will continue to occur by supporting bee movement between patches of suitable habitat.

Ecological Connectivity provides vital benefits particularly related to water. Connectivity supports improved water quality (purification) and protects aquifers. Corridors near streams and wetlands help absorb, filter and release water to benefit people, wildlife and agriculture. Rainfall patterns and climate are important in determining the quantity and timing of stream flows, but the streamside vegetation modifies stream flow significantly. Soil and litter (dead vegetation/organic material on the ground) associated with riparian areas acts as a sponge to hold water, which is later slowly released, stabilizing the water supply for the stream. Floodplain forests and riparian wetlands store water to moderate floods, provide safe areas and vegetation to hold excess water, slow its movement and provide larger areas for infiltration. Also, vegetation in the riparian zone absorbs water and eventually releases it to the atmosphere. In arid environments, vegetation substantially influences the quantity, temperature and duration of stream flow moderating local air temperatures as well.

Ecosystem connectivity also moderates the impacts of climate change on temperature, carbon dioxide levels and overall biodiversity. Natural areas support plants which provide shade, reduce water loss in creeks and rivers, as well as moderate local temperatures and associated energy costs to cool homes in summer and warm them in winter. Plants moderate the potential impacts of climate change by absorbing excess carbon produced by cars, industry and other human activities. In a recent review of biodiversity management [4], the primary recommendation to address climate warming was to increase connectivity. Similarly, various studies highlight the importance of maintaining or restoring connectivity to support ecosystem resilience, or the capacity of ecosystems to resist damage and recover quickly from disturbances like fire, windstorms, or forest insect outbreaks. Addressing these disturbances may be a rising priority as they appear to have become more frequent in recent years [5].

Ecological connectivity supports genetic diversity and the movement wildlife and plants require for their reproduction and survival. Movement of species within and between ecosystems is essential to their long term survival. Movement is essential for species to find food, shelter, water and mates. Movement is also essential for species to maintain genetic diversity and to adapt to shifts in ecosystems resulting from climate warming. Tools like corridors and buffer zones are used to create ecological connectivity and have been shown to help support species diversity [6].They may substantially increase the total amount of suitable habitat and, in some areas, provide the majority of remaining habitat for wildlife [7]. Connectivity corridors provide important refuges for rare and threatened species including plants, especially in landscapes where natural vegetation is limited [8,9].

Planning for connectivity helps limit the impact of roads on species at risk. Significant numbers of amphibians and reptiles are killed by vehicles every year when they cross roads to move between areas of suitable habitat. It is difficult to build effective crossing structures or barriers to prevent road use by species like the Tiger Salamander shown here. Continuous connectivity corridors help provide connections between habitats for vulnerable species groups like amphibians and also avoids losses resulting from roads and vehicles.

Ecological connectivity supports a cost effective way to protect species at risk, reduce human-wildlife conflicts and address challenges created by barriers. Development and transportation networks are designed to facilitate movement of people but may also affect the quality of places where wildlife species live. Roads, fences, and ditches can create barriers to movement by species isolating them and increasing the chance they will either die or move to populated areas where they are unwelcome. Larger animals sometimes blunder into or are attracted into communities by food supplies like commercial fruit and berries [10]. Planning to maintain or restore connected ecosystems will permit species to move safely through natural areas and across or around communities. Connectivity corridors help prevent vehicle collisions caused by wildlife and reduce overall human-wildlife conflicts by providing a safer route for wildlife to travel back to native habitat. When vulnerable species like snakes, frogs and herons decline because of habitat loss, movement barriers or human persecution, providing ecological connectivity can help restore their populations, prevent isolation of smaller pockets of habitat and sustain a greater diversity of sensitive species in remaining natural areas.

Ecological Connectivity combines benefits for ecosystems and species with benefits for people. Connectivity within communities provides our children with opportunities to see natural areas and understand the value of habitat and connectivity. Connectivity also meets needs associated with agriculture, forestry, recreation, aesthetics, community and culture. Connectivity contributes to the economic and social fabric of the community by providing recreation opportunities and business opportunities associated with tourism. Recent studies also show that contact with natural areas provides health benefits to people including reduced stress and improved memory [11].The best connectivity strategies consider both the needs of nature and people [12].

Riparian corridors provide ecological connectivity, outdoor education opportunities and reduce flood risk to adjacent neighbourhoods. The interpretive trail in North Vernon Park provides an opportunity for residents and school children to understand the importance of riparian and wetland habitats. In times of high water, this area also provides capacity to absorb flood waters and storage to sustain flows from BX Creek.

1.4 Key Messages about Ecosystem Connectivity

- Connectivity, comprised of physical and functional links between ecosystems, is necessary to support biodiversity.
- A connected network of ecosystems supports ecosystem services, provides opportunities for animal and plant movement across the landscape and sustains natural areas close to populated areas.
- Ecosystem connectivity tends to be reduced where people work and live (e.g. low elevations; flat terrain; areas near water).
- The building blocks of a connectivity strategy include ecosystem patches linked by connective elements such as landscape and linear corridors. Buffer zones to limit impacts of adjacent land use may also be added. Where corridors are not possible, effective connectivity for some species can sometimes be achieved by small ecosystem patches (stepping stones corridors).
- Ecosystem connectivity supports the delivery of ecosystem services and particularly helps conserve riparian areas, water purification and flood control areas.
- Ecosystem connectivity also moderates impacts of climate change on temperature, carbon dioxide storage and overall biodiversity.
- Ecological connectivity supports genetic diversity; connectivity also supports movement opportunities that wildlife and plants require for their reproduction and survival.
- Ecological connectivity supports a cost effective way to protect species at risk, reduce wildlife conflicts and address challenges created by man-made barriers.
- Ecological Connectivity combines benefits for ecosystems and species with benefits for people.

2.0 WHAT ARE THE BUILDING BLOCKS FOR ECOSYSTEM CONNECTIVITY?

Together with corridors, ecosystem patches are the components or building blocks of connectivity. This section is designed to help explain how ecosystem patches and connective elements are identified. It presents the qualities of patches and connective elements that best support connectivity, functional ecosystems, biodiversity and ecosystem services.

2.1 Understanding Ecosystem Patches and Fragmentation

Ecosystem patches are undisturbed natural areas. They are generally described and defined by the common plant species they contain. In undisturbed landscapes, patches are connected across a landscape and distributed in patterns defined by natural processes like fire, wind and other natural disturbances. These processes influence size, shape and location of patches. Patches are also affected by people through influences like roads, utility corridors, and industrial or residential development. Managing for connectivity involves planning in space and time to retain landscape connections between patches. Connectivity management also requires land use planners to mitigate the impact of human influences, based on an understanding of how natural processes affect connections between habitats.

Fragmentation results when larger ecosystem patches are split into smaller fragments isolated from one another by barriers that prevent or restrict movement between patches of some or all plant and animal species. Fragmentation acts in opposition to connectivity, breaking the connections between patches, and impeding ecosystem services.

Some fragmentation occurs naturally when disturbances like fire move across a landscape burning some areas completely, partly disturbing others, while leaving the remainder untouched. Human use tends to magnify existing fragmentation concentrating in developed areas through activities like construction of linear infrastructure including roads, powerlines, and railroads between and within communities [13]. Once roads are constructed, other services such as power, sewer, and water are added. This encourages other more intensive development, reinforcing and increasing fragmentation.

Ecological processes are affected by fragmentation, **but retaining connectivity helps counteract these impacts:** As the footprint of human land use increases, natural areas are increasingly isolated. As the total area of natural vegetation declines, natural processes like fire and wind are increasingly negatively affected by fragmentation [9]. Retaining patches of natural habitat and corridors between patches helps support natural processes that in turn support healthy, functioning ecosystems.

Because human use enhances fragmentation, it tends to increase the length of the boundaries between ecosystems (i.e. edge habitat), reduce the amount of interior habitat (core area habitat which is located at a distance from the edge of a patch). Fragmentation also reduces connectivity and alters a variety of ecological processes including predator-prey relationships, competition between species, seed dispersal, pollination, nutrient cycling, ecological succession in vegetation communities, uptake of carbon, micro climate and filtering of water. Impacts of fragmentation are complex and difficult to predict and are dependent on the species present [15].

Roads, intensive agriculture, and increased urbanization may have cumulative effects. Our understanding of cumulative impacts is limited because it requires long term, expensive research to isolate complex, interacting factors. In the absence of certainty about impacts, changes to landscape continue, despite the precautionary principle, with development advocates arguing the need for more research and more certainty before impacts are mitigated. This situation constitutes a 'fragmentation spiral' [14], because research to assess ecological effects cannot keep pace with the rapid changes that are occurring.

2.2 Criteria for Patch Selection

A variety of factors influence the value of ecosystem patches and their use by species. Factors of primary importance include the overall amount of habitat available on the landscape as well as the size, shape, and quality of the habitat in each of the patches. Other factors to consider are location/configuration, condition, core area, edge habitat, as well as the role of small habitat patches [16].

Choose patches with native vegetation and structural diversity. Structural diversity in moist forest patches (left) and dry grassland ecosystems (right).

Large ecosystem patches benefit many of the Okanagan region's sensitive species, but small patches increase the accessibility of a landscape to wildlife. In combination with larger adjacent natural areas connected by corridors, biodiversity is enhanced and connectivity is made more effective by urban areas with scattered trees, shrubs, vegetated yards, greenways, and green roofs [17].

Like any other land use planning process, patch selection involves tradeoffs. Each patch has certain values and lacks others. Patch selection is the top priority in designing connectivity because selecting the highest quality patches is critical to the support of ecosystem services and species. It is sometimes possible to revise or rebuild connective elements, but restoration of high quality intact ecosystems is difficult or impossible to achieve.

Below is a list of principles used to compare and select the best ecosystem patches. These provide priorities that planners, biologists and other landscape managers can consider in designing strategies to conserve connectivity on the landscape [2].

Select the best patches:

- Conserve larger ecosystem patches; they generally have higher biodiversity, and are rarer than small patches.
- Conserve natural areas containing native ecosystems and species, as well as structural diversity.
- Conserve natural areas containing distinctive features that are rare on the landscape like wetlands, streams, wildlife trees, large woody debris, talus slopes, caves, and cliffs.
- Focus on retaining natural areas in low elevation, flatter valley bottoms as these generally are capable of supporting higher biodiversity. Natural areas like these are less common than those on steeper slopes or higher elevations.
- Conserve aggregated or adjacent patches. If this is not possible, conserve patches separated by agricultural areas, backyards, recreation areas and other areas that retain some important features of natural areas.

Meet the needs of species:

- Work with scientists, and federal and provincial government staff to manage for a variety of species with similar needs.
- Consider the patch size, edge and core area needs of target species.
- Consider the capacity of species to move between patches (some can fly, some can move easily across long distances along the ground, while some move slowly).

Enhance, maintain or restore the quality of existing patches:

- Select patches in locations that will support and maintain ecological processes like pollination, predation, and seed dispersal.
- Manage natural areas to reduce the amount of edge. This helps to limit opportunities for invasion of exotic plants and animals into natural areas.

Plan Strategically:

- Conserve natural areas that can help serve multiple functions such as recreation, hiking, flood and erosion protection, water quality and connectivity.
- While mapping for connectivity in the community is the best way to plan strategically, do not be afraid to start small and move toward conserving connectivity.

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[2] Further information is provided in Appendix 1-A.

2.3 Understanding Connective Elements

Connective elements like corridors, play an extremely important role in the maintenance of biodiversity: Corridors help protect biodiversity but they can only partly compensate for the overall habitat loss when landscapes are fragmented by human use. Therefore, it is important that natural areas and vegetated corridors are maintained and enhanced in communities and beyond. [3]

The other building blocks of a connectivity strategy are to use a variety of specialized types of connective elements, such as corridors and buffer zones, to join ecosystem patches together. Some characteristics of connective elements influence their effectiveness, for example wider corridors are better than narrow ones. Other characteristics, like direction and habitat type, are useful in different circumstances.

This section describes and defines connective elements and discusses the qualities by which they are distinguished and the values associated with the various types.

A corridor is a land area that links habitat patches together. Generally composed of native vegetation, corridors join two or more larger areas of similar habitat. Corridors are critical for the maintenance of ecological processes and facilitate the movement of species between patches. By providing connections between larger natural areas, corridors enable activities critical to the survival of species including migration, moving to a new habitat and breeding. Effective corridors provide a continuous or near continuous link of suitable habitat through altered land areas like cities, towns, and industrial areas.

Corridors include three distinct types: landscape corridors, linear corridors and stepping stone corridors. Landscape Corridors are corridors identified or embedded within larger diverse, uninterrupted habitat areas (i.e. a mosaic). Landscape corridors are often identified because of their importance for specific species such as bighorn sheep, grizzly bear, and elk. These areas offer enough cover to encourage species to move from one ecosystem patch to another. They connect rare elements, such as wetlands, riparian areas, grasslands and old forests [18]. Linear Corridors are long, continuous strips of vegetation such as the riparian vegetation growing alongside rivers and streams.

[3] Illustration from Bentrup, G. 2008 [59].

Connectivity can also be facilitated by stepping stone corridors, made up of a series of small, unconnected habitats used by various species to find shelter, food, or resting areas. Stepping stones may take the form of natural patches such as a series of wetlands embedded in a grassland habitat. Or they may be composed of remnants of larger habitats patches within human altered landscapes. In urban areas, they may include artificial ponds or urban parks. They can enhance connectivity in the absence of corridors, particularly in developed landscapes where options are limited. Stepping stones facilitate short movements through disturbed habitats for a variety of species, helping them to cross areas that otherwise do not contain suitable habitat.

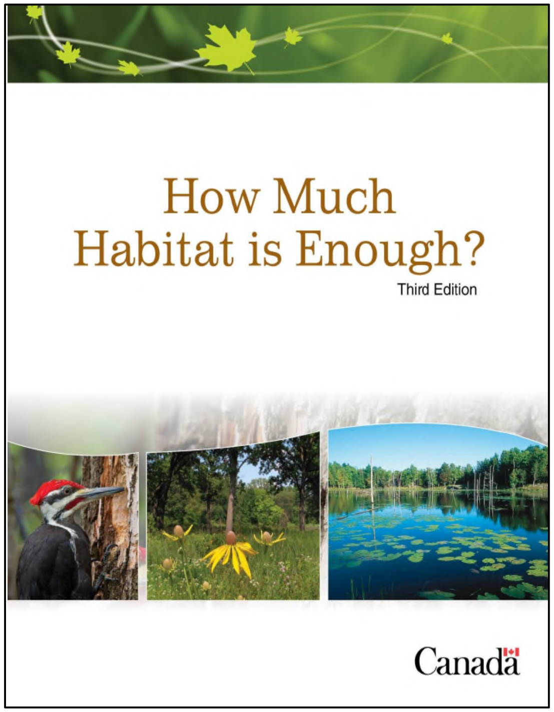
Stepping stones work particularly well for mobile species like birds and butterflies that can fly from one suitable patch to another.

Buffer zones are zones that minimize the impact of an adjacent land use. Buffers can provide a transition from a central protected habitat area to a more intensive human use area. Thus, a multi-use area like a golf course can buffer an area of wildlife habitat. The buffer area provides a zone of less intense land use to moderate the impact of more intensively used areas like roads, residential, commercial or industrial development. Sometimes, specific land uses are restricted within buffers to sustain and protect sensitive features and species. For example, recreation use or construction activities might be restricted for a short time during spring breeding to reduce disturbance to Great Blue Heron.

The Lumby Salmon Trail provides connectivity, recreational opportunities and preserves valuable riparian floodplain areas for Duteau Creek. When water levels rise, this provides a place for water which helps prevent flooding of surrounding homes and buildings.

2.4 Criteria for Selecting Connective Elements

The effectiveness of corridors is influenced by the amount of natural habitat available, the surrounding land use and the capacity of species in the region to use corridors and the lands adjacent to them. At the site level, factors to consider in connectivity design include width (wider is better) and habitat type (a mixture of both riparian and upland corridors[4] should be included). Habitat quality is important; higher quality habitat includes natural vegetation and structural diversity (i.e. multiple layers of vegetation including: grasses and other low level plants, shrubs, deciduous and coniferous trees). The ecosystem processes occurring in the area and the needs of species are also important. Species of particular significance in designing corridors include those that migrate, live in corridors and/or travel slowly taking multiple generations to move through corridors from one habitat patch to the next.



At the broader level of watershed or region, the design of corridors is hierarchical, with three types of corridors described including: regional corridors up to 2 kilometers, sub-regional corridors up to 300 meters and local corridors up to 50 meters in width. Regional corridors are reserved for major migration routes and large river systems. The provincial government has an important role in identifying regional connectivity. Identifying, creating and managing the other two types of corridors are more likely to involve local and regional governments.

Environment Canada's *How Much Habitat is Enough*? (3rd edition, 2013) describes the minimum amounts of habitats needed to help support populations of wildlife. The report recommends watershed targets including: retaining a minimum of 30 to 50% forest cover, the greater of 10% current or 40% historic wetland cover per watershed, 75% of streams with natural riparian vegetation, minimum 50 ha grassland patch sizes and less than 10% impervious cover (paved road) in a watershed[5]. While the size and extent of retained natural areas may seem very high, research increasingly supports the need for retaining extensive natural areas in all regions (25-75%) [18].

[4] Riparian corridors are vegetated areas reserved from development along a stream, creek, river, wetland or lake. Upland corridors are mapped linear corridors identifying habitat areas away from water influence like forests or grasslands.

[5] For further information, see "How Much Habitat is Enough?" [62].

For riparian corridors, the vegetation provides a significant clue about the width required since the area influenced by flooding and water is defined by the types of plants growing near the water feature[6]. One further important consideration for corridor design is their orientation (north-south, east-west, low elevation to high elevation). Connectivity plans should include both altitudinal pathways-- corridors that cross elevations, and latitudinal pathways--corridors that cross altitudes. The Okanagan Valley is part of a regional, low elevation valley corridor linking the arid basins in the United States to the central interior grasslands of British Columbia. This latitudinal pathway between the US and Canada links species populations that occur in both places. Occasionally, certain sites are vital to maintaining connectivity in the wider landscape, either because other options have been lost, or because loss of habitat or geographic features in the area, have created a bottleneck or pinch point to movement. Large lakes and steep terrain often create barriers in the Okanagan. Most of these pinch points can be identified through regional scale planning processes so that options for protection are considered before site development occurs. However, if these processes have not been completed, biology professionals and technical experts from government or non-government agencies can provide advice.

The criteria for selection of connective elements are listed below. These principles set out priorities that land use planners and other landscape managers can consider in designing strategies to conserve connectivity on the landscape. These principles also help direct decision-making to protect remaining corridors along with the ecosystem functions and the biodiversity they support[7].

Select the best corridors:

- Where possible, choose wider corridors, especially in valley bottoms; at low elevation, where development tends to limit options for connectivity and species diversity is high.
- Conserve corridors containing native ecosystems and species as well as structural diversity. If this is not possible, conserve corridors including modified habitats such as old fields, agriculture areas, recreation areas, and other modified landscapes that contain structural diversity.
- Select corridors that facilitate movement between elevations and latitudes.
- Plan connectivity strategies with an awareness of major landscape barriers and pinch points where limited opportunities for connectivity remain.

Meet the needs of wildlife and plants:

- Consider the needs of target species. Corridors should be at least twice the width of a species' home range (the area the species lives in and requires for survival). Wider corridors will also help species adapt to climate change and limit effects of edge habitat.

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[6] Defining the appropriate width of a riparian corridor should also include consideration of the species expected to use it. For example, Tiger Salamanders use an area beyond where riparian vegetation occurs and thus corridors for their use would be wider than the area defined by riparian vegetation. https://groups.nceas.ucsb.edu/trn/background-reading/Semlitsch%20and%20Bodie%202003.pdf/view

[7] Further information is provided in Appendix 1-B.

- Consider the capacity of species to move through corridors, including the variety of requirements at different life stages. Conserve corridors in both riparian and upland habitats to provide habitat for the largest variety of species.
- Provide corridors oriented in different directions at all planning scales (local, sub-regional and regional) to provide for species movement in all directions.

Enhance, maintain or restore the quality of existing habitats:

- Select corridors in locations and widths sufficient to protect sensitive soils and support ecological processes like pollination and seed dispersal.
- Where natural areas have been lost, enhance connectivity by planting native species in hedgerows, parks, backyards and other urban areas. Where necessary, construct underpasses or bridges to facilitate species movement past barriers like wide roads.

Plan Strategically:

- Include sufficient area within the connectivity strategy. Conservation of biodiversity requires sufficient habitat conservation; a few patches, corridors and buffer zones will not fix a shortfall [19].
- Conserve corridors that can help serve multiple functions (recreation, water quality, supply management, temperature moderation, carbon storage, erosion reduction, and other ecosystem services).
- When designing connectivity at the regional/sub-regional scale, encourage participation by First Nations, affected governments and stakeholders, including U.S. representatives where plans are adjacent to the border.
- Plan for connectivity in your community even if partners in surrounding areas are not available to collaborate.

Consider limiting factors:

- Not all species use corridors. Narrower connective elements are usually associated with large amounts of edge habitat, so edge sensitive species may not use corridors.
- Many landscapes are already extensively modified with opportunities for corridors limited or absent. Restoring habitat after development is difficult, so keep options available if you have them.
- Research indicates that habitat requirements tend to be under estimated. Connectivity strategies cannot replace natural environments, so plan for generous targets.

2.5 Key messages about Ecosystem Patches and Connective Elements

- Together with connective elements, ecosystem patches are the components or building blocks of connectivity. Ecosystem patches are undisturbed natural areas. Connective elements include: landscape, linear and stepping stone corridors. Buffer zones are sometimes also used to minimize the impact of adjacent land use.
- Patch selection is the top priority in designing connectivity because selection of the highest quality patches is critical to the support of ecosystem services and species. Connective elements also play an extremely important role in the maintenance of biodiversity and can significantly increase species movement between patches. There may be options to revise or rebuild corridors, but restoration of high quality intact ecosystem patches is difficult or impossible to achieve.
- Support connectivity planning by conserving the best patches. Examples of high-quality patches are: larger; more natural areas with structural diversity; rare features like wetlands, streams, wildlife trees, large woody debris, talus, caves and cliffs; lower elevation sites on flat terrain; aggregated patches or areas of native vegetation surrounded by modified habitat with some habitat characteristics (recreation trails with some native vegetation and agricultural fields).
- Support connectivity planning by conserving corridors with attributes such as adequate width, valley bottoms, areas with native vegetation and structural diversity, areas that cross elevations and latitudes, and areas that address barriers and pinch points for connectivity.
- Where required, support restoration of lost habitat elements by planting native species in hedgerows, backyards, and urban parks, and restoring connectivity across road barriers with underpasses or wildlife-friendly bridges.
- Plan strategically to conserve natural areas (patches and connective elements) that support multiple functions such as hiking, flood and erosion protection, protecting viewscapes, water quality as well as connectivity. Include experts and interested parties from all jurisdictions, but move forward with partners even if everyone cannot participate.
- If connectivity planning at every scale is not possible, focus on the broadest scale (i.e. regional). If broader scales are not possible immediately, there is value in working to retain connectivity locally in subdivisions and neighbourhoods.
- Recognize the limitations of connectivity planning. Planning with insufficient habitat targets is counter-productive. Retain natural areas to the fullest extent possible, remembering that research indicates that habitat requirements tend to be under estimated.

3.0 HOW ARE CONNECTIVITY PLANS CONSTRUCTED AND IMPLEMENTED?

3.1 Overview of Connectivity Planning

Ideally, connectivity is built on a land area with a large, existing framework of natural ecosystems capable of supporting biodiversity and maintaining ecosystem services, although sometimes planning for connectivity happens when almost all the land has been fragmented or developed. It is far simpler, more cost-efficient and more ecologically effective to protect habitats *before* they are lost, than to attempt to restore landscape connectivity afterwards [6]. Regardless of the circumstance, connectivity planning can mitigate loss of connectivity between natural areas, but will not replace undisturbed ecosystems.

A connectivity strategy is particularly desirable to promote landscape connectivity in the following circumstances:

- in modified landscapes or those that have become inhospitable to native species;
- when managing for species sensitive to disturbance, habitat loss, or barriers; and
- to support continuity and sustained delivery of ecosystem services [9].

The intent of developing a connectivity strategy is to provide input at an appropriate scale, and to direct developers, planners and other land managers to high-priority areas where connectivity management is important to consider. Without a connectivity strategy, connectivity is mainly considered at the site level during the approval process for development; an approach that lacks a coordinated approached to maintaining important connections between sites.

Both within and outside B.C., various authors have described approaches used to develop connectivity strategies [20, 21]. Some communities have already initiated or completed a biodiversity strategy, including mapping that identifies opportunities for connectivity. If available, this type of mapping uses an ecosystem based approach, evaluating patches in the landscape as well as highlighting the quality and locations of existing connectivity. Completing a connectivity strategy requires the development of options based on strategy mapping, with final selections of connectivity elements and patches to build a network.

Connectivity planning can be led by consultants or a community-based team and typically requires consideration of multiple mapping layers. Participants look beyond patch and connectivity opportunities, to explore existing land use designations, zoning, transportation corridors, utility corridors and constraints to development[8]. Selections often begin with the areas already set aside for complementary purposes such as parks, trails, riparian corridors, greenways and other reserves. Sometimes a series of draft options are developed, with selection of the

[8] Examples of constraints to development include: steep slopes, sensitive aquifers, flood plains, etc.

preferred option resulting from public and/or expert consultation. Support from geographic information specialists (GIS) is particularly helpful in identifying and mapping values, as well as testing various options [22]. Connectivity strategies also provide strategic direction to facilitate land use decisions and must proceed with an awareness of the planning and regulatory tools available to implement the connectivity plan.

The following is a brief list of the steps in a connectivity planning process. These are the basic steps to plan connectivity for a region or sub-regional area. Some steps are not required for smaller scale planning, but many of these still apply even for local connectivity planning. The order in the steps can also vary depending on the legal mechanisms used to implement the plan. For example, planning for connectivity by local governments can be implemented using land use bylaws and development permit areas

More detail on the considerations for designing corridors and connectivity are provided in Appendix 1-C.

1. Define the process, build partnerships and educate the community. If possible, involve the public and stakeholders in the earliest stages. Encourage all parties to define their roles in planning, implementation and management.
2. Determine the connectivity planning area (scale). Large areas will require a mixture of ecosystem patches connected by regional, sub-regional and local corridors.
3. Set targets for patch and corridor areas using science-based approaches.[9]
4. Identify the opportunities for ecosystem patches/natural areas/connectivity elements, using criteria introduced in Section 2 and more fully described in Appendix 1-A & B. Build on existing suitable natural areas already reserved for conservation, or designated for land uses consistent with connectivity. Look for ways to serve multiple purposes and facilitate human use consistent with the goal of maintaining connectivity. Select some extra corridors and patches beyond the natural area targets, to provide flexibility and provide options to move corridors or select alternate patches to adapt to future changes and priorities.
5. If possible, conduct a field review of a subset of areas to help confirm accuracy of information being considered and to provide a practical view of available options. Alternately, include in decision-making several partners who are familiar with the area and have direct, detailed local knowledge.
6. Consider land tenure and use for potential patches and connectivity elements; this action helps identify the legal and regulatory options to maintain connectivity.[10] Also, consider the pace and patterns of conversion, and the effect of increasing scarcity on the value of undeveloped land [23, 24]. This action helps factor in costs of different options and priorities for including different parcels in the plan.

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[9] Experts can help with target setting. Documents including: *How much habitat is enough?* [62] and references available for specific regions are also useful (Okanagan specific references including [60,61].

[10] The *Keeping Nature in Our Future Series* presents Biodiversity Conservation Analyses for the South Okanagan-Similkameen; and North and Central Okanagan. The two reports provide tools and support to establish baseline information for planning. Available at http://a100.gov.bc.ca/pub/acat/public/viewReport.do?reportId=42389

7. Consider and, if appropriate, select specific groups or species in connectivity planning (called focal species). Some plans avoid focal species altogether. Others use them to help develop targets and approaches to designing corridors. Research indicates home range and requirements of a specific species can help direct selection of corridor locations, habitat types, width, and management approaches. Other plans take an ecosystem approach to design and then look at specific species when they conduct monitoring. This helps managers understand if planned connectivity is achieving the intended results.
8. Look for linkages to connectivity in adjacent jurisdictions. Avoid selecting corridors that are blocked by barriers just outside the planning area.
9. Identify key natural and man-made barriers to connectivity. Consider and address the implications of barriers on connective elements and ecosystem patches. Roads have significant impacts on connectivity (see Appendix 1-D). Consider implications of land management and use on effectiveness of connectivity. For example, areas visited by domestic pets, with invasive species, or where artificial light is used, may discourage wildlife.
10. Consider possible shifts in location and elevation ranges for ecosystems such as grasslands that are expected to migrate with climate change. Creating connections in transition zones (above the current extent of an ecosystem, but within the area projected to be transformed) may help address connectivity in lower elevation areas where options for connectivity are currently limited by development[11] (see Appendix 1-E for more information).
11. Refine options into a selection map showing a network of linked habitat patches and connectivity corridors. Rank corridors by priority or value, but recognize that priority for inclusion in the strategy may be based on practical opportunities, feasibility, and other business considerations. Cost, risk of loss or damage will also affect strategic planning [23]. Also, include land-tenure patterns, the pace and patterns of conversion, and the effect of increasing scarcity on the value of undeveloped land [23, 24]. Alternately, some planning processes present several connectivity network options and identify pros and cons for each, to facilitate public and local government involvement.
12. Finalize connectivity plan and monitor for species movement and indications of ecosystem health.

[11] The BC Ministry of Forests, Lands and Resource Operations has modeled expected shifts. More information is available at http://www.genetics.forestry.ubc.ca/cfcg/climate-models.html

3.2 Local Government Tools to Implement Connectivity Planning

Beyond the biology of connectivity and the details of patch and connectivity selection, there are the tasks associated with implementing the plan. Corridor design must be completed with an awareness of opportunities and tools for implementation. The goal is to retain connectivity values on lands identified as a priority for connectivity. This means that implementation involves identifying lands for connectivity management and then working with landowners, land users and other partners to conserve connectivity values. Implementation tools are linked to land ownership and the partners who participate in the planning exercise. While tools like parks and protected areas are one possibility, there are many other options. In connectivity planning, the focus is on retaining habitat connections and associated ecosystem services. Various human activities may occur and be consistent with retaining connectivity.

Local governments can use land use regulations, bylaws and other regulatory tools to control where ecosystems are disturbed by development and how that disturbance occurs. Indeed, two aspects of the land use planning and regulatory approaches available to local governments fit well with connectivity. First, local government planning tends to be organized into a hierarchy of plans (i.e. regional growth strategies, sub-regional official community plans, and local area plans), and connectivity can be implemented along similar lines (i.e. as a series of regional, sub-regional and local corridors). Second, both local government planning and connectivity can set priorities relative to habitat quality, with a focus on the protection and preservation of higher-quality habitat.

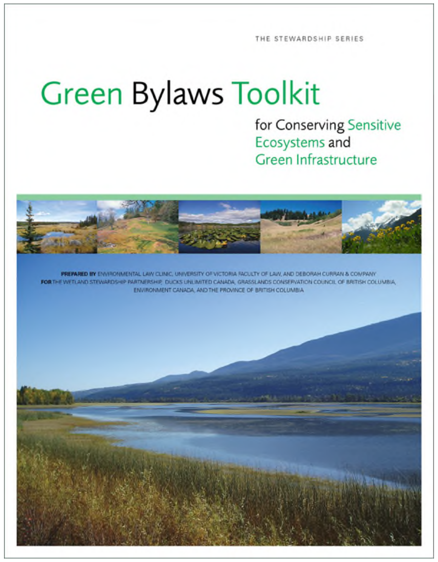
Some provincial legislation already requires connectivity elements as part of the protection of certain ecosystem elements. For example, the Riparian Areas Regulation under the *Fish Protection Act* mandates assessment by a qualified professional and designation of a streamside protection and enhancement area when new development is proposed on all fish-bearing watercourses, in certain regional districts. [12] Local governments and landowners are directed by this provincial regulation which provides an opportunity for significant connectivity benefits by requiring similar landscape level outcomes in all regions. Thus, a community engaged in ecosystem connectivity planning could identify riparian corridors as part of its plan and place specific requirements on the management of those areas (e.g. minimum widths for retention from development or other management criteria designed to protect connectivity).

Local governments have the opportunity to facilitate the designation, planning, creation and management of connectivity corridors. Their authority comes through provisions in the *Local Government Act* and through administration of provincial and federal laws on environmental and species protection. At specific points in the development process, local governments can regulate land use type, density, timing and activity. This regulation can contribute to retaining connectivity on private land. Local governments can also work cooperatively with the province and First Nations through joint planning exercises and the pursuit of agreements related to conservation and connectivity. Purchase or donation of land to protect it for connectivity purposes can be very expensive, so the capacity of local governments to designate and

[12] *Fish Protection Act*, S.B.C. 1997 c. 21 at section 12; Riparian Areas Regulation B.C. Reg. 376/2004.

acquire land for connectivity corridors can be limited. Other tools are also available. Density, land use types and development permit requirements can contribute to the implementation of connectivity plans.

Also, local governments can use ecological quality and sensitivity of habitats to inform development permit area requirements, and enable consideration of the condition of the land as part of the development of neighbourhood or area plans. Similarly, local government can identify potential park acquisition areas during the analysis of rezoning and subdivision applications. When development permit areas and associated requirements are developed as part of an Official Community Plan, ecosystem, habitat quality and habitat sensitivity may be used as part of the necessary written justification for designating development permit areas intended to assist in the protection of ecosystems, biodiversity and the natural environment.[13] These provisions allow local governments to implement connectivity strategies based on both location of desired landscape features and integrity of ecosystem qualities.



Thus, the regulatory context for environmental protection provided to local government enables decision makers to protect landscape patches and connectivity. Development and the fragmentation it may cause can be influenced by land use planning documents including: Regional Growth Strategies (RGS), Official Community Plans (OCP), Zoning Bylaws and Development Permits. They may direct site selection, density of use, design, and construction of a subdivision or development, and influence decisions by elected officials and the approving officers.

Further details about various planning tools available to local government are provided in Appendix 1-F. The appendix includes a general discussion of regional to site-specific scale tools, with regional and sub-regional plans discussed first (regional conservation strategies, RGS, and OCPs). The appendix also considers the role of regulatory bylaws and plans with development permit requirements that have implications for specific parcels of land (zoning, subdivision, development permit areas for the protection of the natural environment), and potential use of development cost charges to fund park acquisition. Finally, the appendix addresses the role of conservation covenants in maintaining connectivity. Where available, the appendix includes examples where these tools have been applied to address connectivity.

For sample bylaw wording and more detail on the use of these regulatory tools see the Green Bylaws Toolkit www.greenbylaws.ca.[14]

[13] *Local Government Act*, at section 919.1(1)(a).
[14] Deborah Curran, 2007. **Green Bylaws Toolkit.** Ducks Unlimited Canada [63].

3.3 Connectivity Planning Examples in the Okanagan Region

Regional Plan:

At a regional scale, an example of working and defining corridors was undertaken in association with Dr. Lael Parrott (UBC, Okanagan Campus), Dr. Jeffrey Cardille (McGill University), graduate research assistant Katey Kyle (UBC) and undergraduate students Maryssa Soroke (UBC) and Charles Bouchard (McGill). The objective of this study was to build on the GIS mapping developed for *A Biodiversity Conservation Strategy for the Okanagan Region* and to further define regional and sub-regional corridors for the North and Central Okanagan Regional Districts (RDNO and RDCO). The Circuitscape program (http://www.circuitscape.org) was applied to the unclassified data from the BCS Habitat Connectivity map to identify "least cost" movement paths for wildlife through the landscape. This resulted in a "skeleton" or network of lines on the map representing the most likely routes for species movement, based on the assumptions and criteria inherent in the connectivity map. The skeleton created by Circuitscape was then used to identify priority areas for habitat corridors that link large (>100 Ha) contiguous patches of natural vegetation on the landscape. Since existing parks and conservation lands had existing legal protection and natural linkage features like riparian areas, these areas were also added to produce a final map showing both key regional and sub- regional corridors and important areas for conservation.

Sub-regional Plan/Community:

The City of Vernon, BC developed their Environmental Management Areas Strategy (EMA) in 2008 as a way to provide an effective, transparent and biophysically appropriate strategy to provide guidance in land use decision within the city. The EMA Strategy identifies key critical ecosystems, corridors and natural features essential to the quality of life and attractiveness of Vernon. It provides guidelines aimed at the protection, maintenance and enhancement of the beauty of the area that supports the natural physical foundation for Vernon while acknowledging the need to accommodate growth.

As part of the Official Community Plan review process, the Environmental Management Areas were chosen to act as an overlay to work in coordination with other zoning and development guidelines and procedures. The EMA strategy has been developed to provide clear direction for the treatment of existing natural area features, significant habitats, corridors and protected areas on an environmental management area (district) basis. These EMA areas align with existing development districts (#1: City Centre, #2 Neighbourhood District, and #3 Hillside Residential and Agricultural District). This management area approach is intended to simplify the process of identifying the areas which contain sensitive ecosystems, important corridor connections and natural features. The approach will also clarify expectations for environmental surveys, habitat assessments and land use requirements to be conducted as part of the development permit process for each management area. For further information see http://www.vernon.ca/services/pde/documents/ema_strategy_final.pdf.

Local Plan:

At the local level, the District of Lake Country applied some of the connectivity planning principles to a rezoning that fell within a previously identified corridor for connectivity. This area was also mapped as a high conservation value area identified in Sensitive Ecosystem Inventory. Mapping layers representing hazard lands were added to those showing sensitive ecosystems and identified developable land areas. From this comparison, planners delineated potential covenants to protect the majority of the sensitive habitats and retain a corridor for connectivity. For more information on this case study, see *Case Studies from North and Central Okanagan that support the Biodiversity Conservation Strategy for the Okanagan Region.*[15]

[15] Available at http://a100.gov.bc.ca/pub/acat/public/viewReport.do?reportId=42389

3.4 Key Messages about Connectivity Planning and Implementation

- Connectivity planning is challenging because it can be applied to a broad scale and include a wide variety of stakeholders, land use categories and land owners. Without planning, natural areas and species are increasingly at risk of loss while ecosystem processes are at risk of failure.

- Land use and development are most intensive in communities, so connectivity planning must be a priority in these areas. It is important that local governments use their land regulating capacity to manage and maintain connectivity.

- The connectivity planning process includes a number of steps including:
  - define the planning process and partners to be involved;
  - determine connectivity planning area;
  - set targets and identify candidate ecosystem patches and corridors on a map;
  - conduct a field review of some sites and/or involve partners that have direct, detailed local knowledge of the planning area;
  - establish land tenure, use, and ownership of candidate areas;
  - consider needs of target focal species;
  - identify barriers and linkages to connectivity in adjacent jurisdictions;
  - select best candidates including some extra areas beyond the targets, to allow for future loss and planning flexibility;
  - consider and address roads and natural barriers, adjacent communities, and ecosystem shifts due to climate change;
  - identify a draft connectivity plan and priorities for incorporating the patches/elements identified, or develop several options for public/local government consideration; finalize the connectivity plan; and monitor for use by species as well as indications that ecosystem processes are functioning.

- Local Government tools which assist in the opportunity to develop and implement connectivity plans include: Official Community Plans, Development Permit Areas, Zoning Bylaws and local implementation of Riparian Areas Regulation (*Fish Protection Act*).

Glossary of Terms

Altitudinal Pathways are major routes that species use to move between higher and lower elevations.

Biodiversity is the variety of life including genetic variation within and between species and ecosystems as well as the ecological processes that support them.

Buffer Zones are land areas that minimize the impact of an adjacent land use.

Core Area is the part of a larger patch that is located in the interior, away from the influence of the edge or boundary of the patch.

Connectivity is the linked quality of land areas or regions that allows them to support ecosystem processes and movement of species between ecosystems and between habitat patches.

Corridor is a land area that joins two or more larger areas of similar habitat.

Diurnal refers to activity patterns of wildlife species. Diurnal means mainly active in the day-time and contrasts with nocturnal (mainly active at night) and crepuscular (mainly active at dawn and dusk).

Ecological Succession is one of the first ecological theories to be developed. It describes the slow and ordered process that progressively changes ecosystems over time, developing and substituting plant associations through a series of seral stages, until a stable climax condition is established. The climax state is sustained until a future natural or human-caused disturbance (e.g. wind, fire, landslide, forest harvesting) restarts the success process again.

Ecosystem Patch is an undisturbed natural area or area of green space, ecosystem patches provide the resources and conditions required for an ecosystem and associated natural processes like fire, erosion, pollination, soil development/decomposition, and water cycling to persist. Ecosystems are often described by the common vegetation species that are found within them.

Ecosystem Functions are the activities that are performed by natural areas (and the species that live there) as they interact with non-living (abiotic) features in the environment (e.g. climate, terrain, wind, fire, etc.). Ecosystem functions include water cycles, soil production, pollination, photosynthesis, nitrogen fixing, soil production, decomposition etc.

Ecosystem Services are amenities or benefits people derive from ecosystem functions. These services are performed naturally and efficiently by ecosystems and save people from requiring expensive technology. Examples of ecosystem services include: growth and reproduction of a variety of plant species based on processes like pollination, photosynthesis, and carbon storage; water cycling including water quality and quantity; nutrient cycling; climate regulation; natural waste treatment by wetlands etc.

Edge is the boundary between two ecosystems or landscape features (e.g. the area along the boundary of a field where it meets a road, a forest or a housing development would be considered edge).

Focal Species are species selected to define spatial, structural and functional attributes required in the landscape for the species that live there to survive. Generally focal species are particularly sensitive to a particular threat (e.g. road mortality, fragmentation, loss of connectivity, pesticides etc.). By meeting the needs of a group of focal species, planners can evaluate the success and increase the effectiveness of connectivity strategies.

Fragmentation is the process of splitting ecosystem patches into smaller fragments isolated from one another by barriers that prevent or restrict movement of some or all species between patches.

Green Space is one type of ***natural area***, green spaces are areas that have been altered by land use practices but are recovering from these changes. Green spaces still contain components and species that are typical of the ecosystems that were present in their place, prior to land use. Examples of green space areas include old fields. These areas often show some common species found in undisturbed areas, but also support domestic or introduced species. Often these areas lack the complex ***structural diversity*** found in undisturbed ecosystems, but science also shows that such patches have significant value as habitat for a variety of native species, including species at risk. Green space also makes an excellent ***buffer zone*** for ***ecosystem patches*** and provides a suitable location for recreation trails.

Greenway is a linear strip of vegetated land located near or within a community and reserved for recreation or environmental reasons. Greenways are one type of ***Green Space***.

Habitat is the resources and conditions required by a species to live in an area. Some species can survive in a variety of conditions and use widely differing areas of habitat successfully, while others have very narrow requirements for very specific ecosystems or vegetation conditions. For others, habitat requirements vary with their stage of life. For example, frogs typically require wetlands or riparian areas for breeding and growth of young, but adults may use forest, grassland or other types of ecosystems for feeding, and cover from weather or predators.

Home Range is the area an animal moves through to complete normal activities like feeding, mating and rearing young. Home range sizes vary between locations, species and individuals of the same species, based on a variety of factors like availability of food, mates and cover from predators.

Landscape Corridors are defined within larger diverse, uninterrupted habitat areas (i.e. a ***mosaic*** *of* different ecosystems). Landscape corridors are frequently established to retain connectivity for large mammals like bighorn sheep, grizzly bear, and elk. These specific areas are managed to provide the characteristics required for species to move from one ***ecosystem patch*** to another, and may be part of a large, relatively natural landscape, where activities like forestry, mining and other resource use are common.

Landscape Permeability is the extent or freedom with which animals can move through a region or land area. Depending on natural characteristics and changes to land resulting from human use, movement by wildlife and plants may be easy or difficult. Permeability is influenced both by the physical structure of elements across a site (e.g. terrain and vegetation) and the ability of an organism to move among patches on that landscape. Consideration of permeability helps identify bottlenecks or barriers to movement.

Latitudinal Pathways are major north-south routes that species used to move between latitudes.

Linear Corridors are long, continuous strips of vegetation (e.g. riparian vegetation growing on banks of rivers and streams).

Local Corridors are narrower linkages that provide local connections between patches of vegetation and landscape features like creeks, gullies, wetlands and ridgelines.

Mosaic is a landscape area including multiple interconnected patches with different characteristics resulting from different ecosystems, and different land use impacts

Natural areas are relatively undisturbed areas that contain a high percentage of native species, and provide habitats for a diversity of native wildlife. They are natural or near natural in character, or are in the process of recovery from human disturbance. These areas may represent or contain regionally typical ecosystems and they may contain habitat for endangered plant and animal species (definition derived from Saanich Natural Areas Action Plan [25]).

Pinch points are also called bottlenecks. These are places where animal movement is funneled or restricted due to limited connectivity. Pinch points result from either geographic features (lakes, rivers, cliffs) or land use (wide highways; tall fences, extensive cleared and developed areas).

Precautionary Principle is an evolving concept used throughout the world. The precautionary principle was most famously defined by the United Nations Convention on Biological Diversity which said, "*Where there is a threat of significant reduction or loss of biological diversity, lack of full scientific certainty should not be used as a reason for postponing measures to avoid or minimize such a threat" [26].* For a review of policy documents that use this principle and other definitions used to explain this principle, see [27].

Riparian Corridors are linear vegetated areas reserved from development along a stream, creek, river, wetland or lake.

Regional corridors are primary landscape connections between larger natural areas considered of primary importance. They are generally substantial in width (300-2000m) and provide not only for dispersal of a variety of species, but also provide habitat for some. They may be associated with large rivers or may represent the only suitable connection between a group of species and ecosystems found in one area and a similar group found a significant distance away.

Stepping Stone Corridors are a series of small, unconnected patches used by various species to find shelter, food, or to rest (see also diagram on page 1).

Structural diversity is a naturally occurring characteristic of ecosystems. It is the three dimensional variety created by multiple horizontal or vertical layers of vegetation (e.g. grasses; shrubs, and different tree species of varying heights). A photo showing structural diversity is found on page 10.

Sub-regional Corridors are linkages wide enough to provide landscape connections for species movement and dispersal (generally 50-300m), but generally too narrow to provide substantial habitat values for most species.

Upland corridors are linear corridors described or mapped for connectivity planning in drier land areas, away from the influence of water.

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Other references that were consulted are listed in Appendix 1-G.

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Appendix 1-A. Ecosystem Patches

Site Level Characteristics

Patch Size:

If all other variables such as the shape, configuration and condition are the same, larger patches are better at sustaining ecosystem functions and biodiversity. Smaller patches do not support complex natural disturbances like fire. While avoiding fire may seem desirable near cities and towns, normal nutrient cycling, renewal of vegetation and soil development does not occur consistently without fire. Without these ecosystem processes, ecosystems do not remain healthy. Small patches can provide habitat for some species, but protecting larger habitat patches is important, because they support more species and are difficult to restore once they are lost. Large patches help limit the impact of climate change, and make patches more robust against disturbances like fire, weeds and wind-throw [17].

Protect remaining large habitat patches: Large patches are a rare, precious resource and are difficult to replace. As patch size increases, other ecological qualities also tend to increase including the diversity of vegetation types, the likelihood of occurrence of rare ecosystems, the size of populations and the sustainability of natural disturbance regimes. In particular, the maintenance of natural processes in fragmented landscapes is critically dependent on there being areas of sufficient size to support a mosaic of ecosystems in different states (e.g. early seral or young vegetation, mid seral/age vegetation, and old growth). The presence of a natural diversity of vegetation in different classes is dependent on a patch being sufficiently large that a single fire does not reduce all of its vegetation to the same stage. [9]

Patch Shape:

Patches with less edge and more core area are generally less common and are a higher conservation priority than those with more edge and less core area. The shape of a patch affects its ecology and influences the species that occur within its boundaries. Edge and core area are two characteristics used to describe patches; these are both influenced by patch shape. An edge is the boundary between two ecosystems or landscape features (e.g. edge habitat is the area along the boundary of a field where it meets a road, a forest or a housing development). Core area is the part of the patch that is located in the interior, outside the influence of forest edge. In intensively developed landscapes, patches tend to be smaller, often linear (e.g. road sides) with more edge and less core area. These characteristics have a negative impact on ecosystem processes, species diversity and composition [9; 17; 28; 29; 30; 31; 32; 33; 34; 35]. Species especially vulnerable to edge effects include:

- large-bodied animals that use large areas: (e.g. Grizzly Bears; Mountain Caribou)
- top of the food chain predators: (e.g. owls, diurnal raptors, badgers, snakes, wolverine and large carnivorous mammals); and
- species with specialized food or habitat needs: species with seasonally variable or spatially irregular food/habitat/breeding distribution (e.g. hummingbirds, Great Basin Spadefoot).

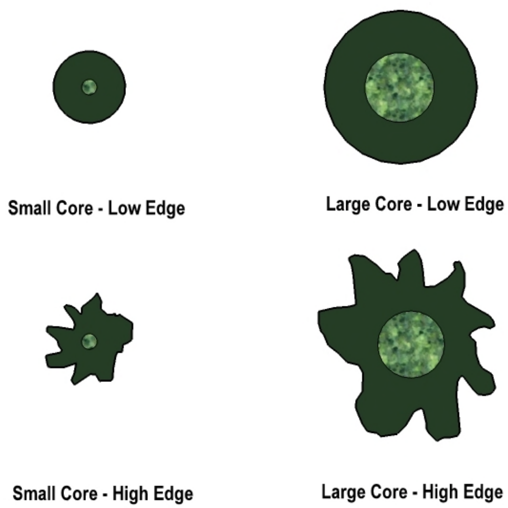


Figure 2: Edge and core area variations

Larger more circular patches contain less edge and more core area than smaller more convoluted shapes. Even circular patches have limited or no core area when they are small.[16]

Grizzly bears are one of many species that are vulnerable to edge effects.

[16] Figure 2 by Susan Latimer.

Patch Quality:

Higher quality patches are dominated by native vegetation. Larger patches with less edge are likely to support higher species diversity and rarer species, but other characteristics of habitat patches also enhance their value. Patches with healthy native vegetation, natural drainage patterns and fewer non-native species tend to have higher conservation value than patches with introduced or invasive species and modified drainage [15]. Patches also have higher value if they contain distinctive features that are rare on the landscape such as wetlands, streams, wildlife trees, large woody debris, talus slopes, caves, and cliffs; or support rare or threatened ecosystems such as black cottonwood riparian areas, old growth forest, antelope brush and Idaho fescue-blue bunch wheatgrass grasslands in the Okanagan.

Structural diversity is another factor that enhances habitat quality. Where it occurs, patches are more likely to support more species in the long term. Structural diversity means there is a variety of horizontal or vertical layers of vegetation (e.g. grasses; shrubs, and different tree species of varying heights).

Landscape Level Characteristics

Much of the study of patches and fragmentation effects is focused on the evaluation and comparison of patches; however patches also need to be evaluated by their arrangements across land areas (e.g. a watershed or a region). Large areas are complex and have properties that are more than the sum of their components (i.e. ecosystem patches, the services they provide and the species that use them). To make the best patch selections, we need to consider interactions between ecosystem patches and the species within them.

An urban housing development is likely to have a more severe isolating effect for woodland butterflies than a lightly-wooded golf course.

Patch Location:

The land area in which patches reside may have an even greater effect on the function and sustainability of natural areas than the characteristics of the patch itself [8]. Together with the species and ecosystem processes they support, patches are strongly influenced by physical and biological processes in the region. The function of patches depends not only on their distance from a similar ecosystem patch, but also on their position in the landscape, the types of surrounding land uses, as well as how land uses influence species movement patterns and habitat use [8,9,13]. For example, a patch that is effectively isolated for a small woodland rodent may easily be reached by migratory birds or forest bats [9].

For landscapes altered by development, conserving ecosystem patches on low elevation sites is one of the highest priorities. Landscape change is not random; rather, disproportionate change occurs in certain areas such as places where people live and work. Fragmentation in valley bottoms tends to reduce species diversity. Today's biodiversity is significantly reduced from what occurred historically [13]. Scientists studying habitats in the Okanagan have found few if any remaining unfragmented patches are left for some habitats, especially those that are found in valley bottoms. In contrast, larger areas of other habitats are relatively common. Conservation priorities often focus on retaining patches in low elevation, flatter valley bottom areas as these generally are capable of supporting a high diversity of species and natural low elevation sites are in short supply.

The extent to which a landscape is modified by human use is affected by factors like slope, elevation and soil. Vegetation is more likely to be cleared or modified in valley bottoms, areas near water, on flat areas and where richer soils and floodplains occur. These patterns of alteration generally affect ecosystems in areas preferred or frequented by people. **A disproportionate number of our ecosystems at risk are in the valley bottom.**

Patch Aggregation/Distance between patches:

Even without human influences, ecosystems naturally occur in patches surrounded by other ecosystems. Most species are adapted to moving between patches to allow them to occupy new habitat and breed with individuals in other areas. Small groups are less genetically diverse and less able to adapt to changes in their environment, so when individuals from different groups breed, they help avoid isolation and increase genetic diversity. Maintaining connectivity and ensuring that patches are not too far apart helps ensure that populations of species continue to survive.

The arrangement of patches in a fragmented landscape is important. Movement between isolated patches may be severely restricted by the surrounding land use and risk of mortality may increase when wildlife leave one suitable patch searching for another. Patches closer together or connected by corridors are better than isolated patches, but small distances between patches may be difficult to traverse for some species, while much larger distances may be tolerated by others. Beyond distance, various characteristics influence whether or not wildlife species can travel between patches. These characteristics include: the species capacity for movement, timing of movement (in the day or at night), season of use, as well as the availability of shelter, cover, and food in the areas between patches.

Ecosystems support various relationships and activities that occur within their boundaries. Many are linked to the survival of species within the ecosystem.

These processes include: seed dispersal, pollination, predation, and disease. When patches are isolated, these processes are disrupted, particularly if specific species that participate in these processes cannot move between patches [9]. Since different species have different limitations, there is no set minimum distance between patches that supports their function. To some extent, distances are defined by natural processes and terrain, but concern for connectivity between ecosystems increases as human influences and fragmentation become more common and extensive.

Since it is impractical to try to manage all species and all relationships, planners can select focal species to consider when designing connectivity. By ensuring the needs of these species are met, planners help protect other species with similar or less stringent requirements [36].

Arrangement of patches on the landscape:

Selecting the best arrangement of patches across a watershed or region is a balancing act. Seldom is there just one possible option. The largest patches may be dispersed; adjacent patches may contain more edge habitat than is desired. The best planning approach selects adjacent patches where opportunities are available, while also distributing patches across the landscape to capture a variety of habitats and ecosystems. Ideally, some patches will contain more uniform habitat and others a variety of habitats.

Biodiversity is influenced by the total habitat available in natural areas and the variety of these habitats in a native or natural state. Habitats are likely to vary significantly between parts of the landscape, and some ecosystems will be missed if all patches are selected only in one area. Although some specific species require uniform conditions without much variety, other species need variety. For example, amphibians at different life stages need both aquatic and terrestrial habitat. As a result they are more likely to be found in landscapes having both aquatic and terrestrial habitats.

There are computer programs, such as Circuitscape and Marxan, which have been used in the Okanagan Region. The selection process can also be supported by aerial photo mosaics together with biodiversity strategy mapping (e.g. *A Biodiversity Conservation Strategy for the Okanagan Region* includes connectivity, conservation ranking and relative biodiversity maps). Some planners use a matrix [17] to facilitate decision making or hire consultants to make systematic recommendations. The best strategies identify more area (i.e. more patches) than will ultimately become a permanent part of the connectivity plan. This approach helps retain choices for the future, and options to replace areas that are lost to fire, land use or other impacts.

[17] A matrix is an organized table that allows planners and biologists to take a systematic approach to comparing patches of habitat. Measurements like size, edge, focal species use, distance to nearest patch etc. can be made and a scoring system developed to compare different patch options. Social factors can also be included. For example, cost of land could be compared, if purchase is required. Existing land uses and required roads are other useful considerations.

It is evident that even if planners set detailed ratings and refine conservation priorities across the region, natural areas retained are often significantly influenced by social and economic opportunities. Connectivity planning decisions may be affected when a supportive developer retains sensitive ecosystems in a conservation covenant or a landowner chooses to donate to a local regional district. Considering social and economic opportunities together with environmental priorities can benefit connectivity in the long run. Social and economic factors also affect which properties are most at risk of alienation. By taking a coordinated approach, planning teams can do a better job of acquiring patches of key importance to maintaining connectivity [37].

Appendix 1-B. Connective Elements

Species Considerations in the Use of Connective Elements

Summary of the Potential Effectiveness of Different Types of Connective Elements Influenced by Various Levels of Environmental Disturbance

Symbols indicate the connective elements are likely to be effective***; somewhat effective * or unlikely to be effective -

Type of Use	Type of Connective Element: Landscape (Regional, Subregional)	Local: Stepping Stones	Local: Linear
Less Disturbed Landscapes			
Species tolerant of habitat disturbance	***	***	-
Species intolerant of habitat disturbance	*	*	***
Wide ranging and mobile species	***	***	*
Ecosystems and ecological processes	***	*	***
Greatly Disturbed Landscapes			
Species tolerant of habitat disturbance	*	***	*
Species intolerant of habitat disturbance	-	*	***
Wide ranging and mobile species	*	***	*
Ecosystems and ecological processes	-	-	***

Adapted from Bennett 2003-Table 4-1 [9].

The effectiveness of corridors is influenced by the surrounding land area and the capacity of species in the region to use corridors and the lands adjacent to them. The area between patches may include natural areas through which an animal can move easily, areas that are not easily used and places where barriers prevent or redirect movement. It is the composition and configuration of these characteristics that support movement for some species and make it difficult or impossible for others [38, 39, 40]. For example, wolves will move freely over long distances and through marginal habitats while grizzly bears tend to avoid them. Grizzly bears are restricted to high quality habitat as they move across the landscape and are affected by roads and human development. These features reduce survival and grizzly bear movement between patches [40].

When planning for connectivity, consider the variety of requirements of species and their various life stages. For example, amphibians need access to both water and upland habitats and they may need to disperse long distances overland, depending on the distance between suitable habitat areas. Alternatively, hummingbirds may only need breeding habitats since additional requirements are met outside of British Columbia.

Site Level Characteristics

Width:

Wider corridors provide better connectivity than narrow corridors. The recommended width of connectivity corridors varies according to spatial scale (i.e. local, sub-regional and regional). The smallest corridors are reserved for the local level and the largest for the regional level.

In riparian corridors, riparian vegetation tends to occur naturally in wider corridors as stream width increases, although land use can impact natural vegetation. Thus, the natural condition helps signal what width of corridor is required to sustain streams. The impacts of making stream corridors too narrow in urban areas include increased stream temperature, a tendency for streams to become unnaturally straight rather than meandering, and increased erosion pressures. While engineering can provide temporary solutions, streams with too narrow riparian corridors tend to require ongoing expensive maintenance. Damage to adjacent properties is also more likely. Better than intensive engineered solutions, wide vegetated strips are best in stabilizing and protecting stream banks, regulating flows, and maintaining integrity of the system [41].

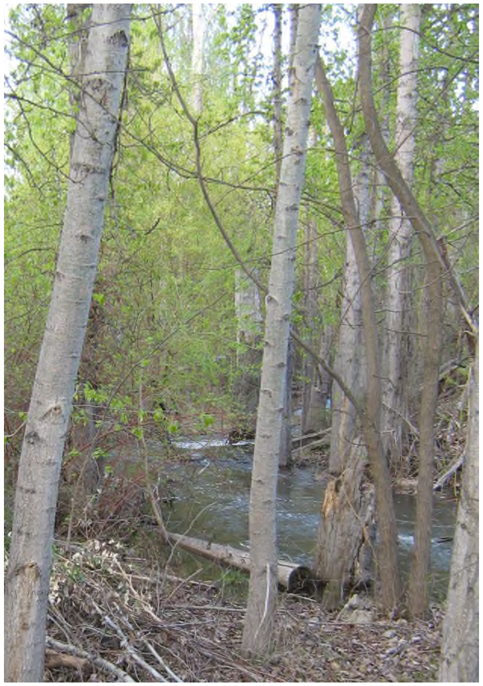
Appropriate corridor width can also be inferred from home range sizes for a particular species or group of species that inhabit corridors. Research suggests corridor width should be a minimum of twice the width of the average home range to address needs of target species. Home range sizes vary between species and between individuals of the same species depending on habitat quality (e.g. availability of food, mates and cover from predators). Home range data is not always available, but, where available, this type of information helps to guide corridor width for species that inhabit corridors. Also, for short corridors, the dimensions of home range are less important, because the adjacent ecosystem patches can be included as part of the available habitat [42].

Wider corridors also influence edge and interior habitat availability in corridors. Because of their linear design, corridors tend to have more edge, but this is mitigated by corridor width, with wider corridors providing increasing amounts of interior habitat.

Riparian and Upland Areas:

Scientists often distinguish between riparian (influenced by water) and upland (grassland, forest, alpine) types of natural areas. Riparian areas have natural linear strips of vegetation that are different from surrounding upland areas, whereas upland vegetation tends to support habitat in patches. Corridors defined in connectivity strategies should consist of both riparian and upland areas. Some species use both habitats but some use only one or the other. Ecosystem processes and services operate differently in each type of area and thus, to achieve the full range of services, both habitat types are necessary.

Riparian corridors are vegetated areas reserved from development along a stream, creek, river, wetland or lake. These areas help protect water quality, bank stability, and fish and wildlife habitat. Riparian corridors filter sediment and nutrients (including pollutants), stabilize streams banks and bottoms, increase the productivity of aquatic habitats, and regulate water and air temperatures at the stream and within the adjacent riparian area. Riparian corridors are zones of high biodiversity that contain aquatic and terrestrial species.



Riparian corridors provide an important contribution in connectivity, particularly in the Okanagan where such habitats are rare and heavily used by a variety of species.

The effectiveness of riparian corridors is determined by a variety of physical and biological factors, but wider buffer zones help ensure that corridors capture the necessary attributes. Riparian corridors can also be enhanced by additional buffers that increase their width and restrict specific land uses, like development and construction, while permitting others such as recreation trails. Examples of Okanagan riparian corridors include the regional Shuswap River and Kelowna’s sub-regional Mission Creek corridors. In the Okanagan particularly, riparian habitats are distinct from their surroundings both in natural semi-arid/arid environments and also in cleared or developed landscapes.

Upland areas vary across the landscape according to complex physical and climatic factors. Rather than being defined by vegetation community changes, they are usually mapped with linear boundaries to define where connectivity management will be a priority. They may connect habitat patches. For example, an upland corridor may be identified to protect a linkage between a series of wetlands within a dry ecosystem like a grassland.

Habitat Quality:

Similar to ecosystem patches, the quality of habitat in corridors is important. Corridors dominated by native vegetation and containing structural diversity are preferred, although greenways and modified areas recovering from disturbance are often more common in developed areas. Modified corridors can be used where other options are not available or to buffer areas of natural vegetation.

Landscape Level Characteristics

Managing Connective Elements at Different Scales:

Corridors can be applied at the regional, sub-regional and local scales. Designing and sustaining connectivity requires us to consider how ecological processes and species operate in space and time. Birds and bats have greater mobility than snakes and frogs. Birds, bats and some insects fly; snakes, small mammals and many invertebrates do not. Some species like chipmunks and squirrels use a relatively small area while others such as badgers and bears range over large areas. Individuals from different species have different requirements for movement at different times of life. For example, frogs generally spend the first part of life as a tadpole in water, then disperse to terrestrial habitats and later may migrate between terrestrial and aquatic environments for breeding. Migratory species such as hummingbirds undertake long distance migrations twice yearly in spring and fall. Most species of birds and mammals also disperse from where they were born often over much greater distances than are typical for day-to-day movements [9].

Regional corridors are primary landscape connections between larger important areas of habitat. They are generally substantial in width and range from the optimal 2 km to a narrower width of 500 meters. Regional corridors provide not only for dispersal of a variety of species, but also habitat for various species. As mentioned above, ecological principles indicate that regional corridors should be designed at a minimum of twice the width of the average home range area for species likely to use the corridor.

Many species benefit from wide (regional) corridors. These linkages help ensure a supply of host plants, connectivity and habitat for pollinators such as butterflies, while also providing areas with lower predation risk for many species. In addition, many natural processes like fires and floods continue to operate in wide linkages, with minimal constraints to adjacent urban areas. These disturbances help maintain undisturbed habitats that are otherwise unlikely to persist and also facilitate reproduction in various species. Wide regional corridors also provide enhanced capacity of species to adapt to climate change and ensure that some core areas buffered from edge effects remains available to species that require such habitat.

While not as substantial in width as regional corridors, sub-regional corridors are wide enough to provide landscape connections for species movement and dispersal. They are generally less than 300 meters in width. Sub-regional corridors may not be large enough to provide substantial species habitat. Sub-regional corridors typically connect larger vegetated landscape features such as riparian areas, ridgelines and valley floors. Connectivity at this scale can be addressed in regional growth strategies, official community plans, crown land management plans and other related sub-regional plans.

Vegetation in gullies helps provide connectivity across elevations (e.g. from the valley floor to the ridge top).

Local corridors are smaller, less defined linkages that provide local connections between patches of vegetation and landscape features like creeks, gullies, wetlands and ridgelines.

Local corridors widths are usually less than 50 meters and thus are likely to be influenced by edge effects. Local riparian corridors are an important component of an overall regional landscape conservation framework and a very important feature of the urban landscape. In arid climates such as the Okanagan, these wetter landscape features provide habitat for species that do not exist elsewhere as well as pathways for dispersal and other types of movement. Local corridors are managed within the jurisdiction of local governments and are found within most towns, cities and regional districts.

Sub-regional and local corridors typically provide both movement and habitat values for smaller species. Some species breed and live several generations within these smaller corridors before reaching the habitat patch. Dispersing rodents have been shown to have a strong tendency to remain in suitable habitat while dispersing [42]. It is likely that these subregional and local corridors will be addressed within local and regional government jurisdictions, whereas regional corridors will typically be part of senior government planning.

Connectivity strategies are strongest when regional corridors are defined and then linked to sub-regional and local corridors. Designing connectivity at the regional and sub-regional scale requires multi-jurisdictional planning between local, federal, provincial and First Nations governments as well as affected stakeholders, since corridors will extend beyond community boundaries. Cooperative planning involves affected parties including: local government representatives, regional district staff, Crown land managers, First Nations, federal land managers, other stakeholders and even US representatives where plans are adjacent to the border. When priorities of adjacent communities and land managers are different, integrated planning approaches become more challenging. Where necessary, local communities can draft their own strategies and engage at different scales with parties to secure implementation and facilitate connections to areas outside their planning boundary.

The figure on the following page provides details about how different corridor types can be adapted to address connectivity requirements at local, sub-regional and regional scales.

Landscape configurations to enhance connectivity for animal populations at different spatial scales			
Landscape Configuration	Local scale (1 km)	Landscape scale (1-10 km.)	Regional or biogeographic scale (100-1000 km.)
Habitat Corridor	hedgerows, fencerows; streams; roadsides; forest corridors; underpasses	rivers and associated riparian vegetation; broad links between reserves	major river systems; mountain ranges; isthmus between land masses
Stepping stones	patches of native plants; small patches of woods; chains of wetlands	series of small reserves; woodland patches in farmland; urban parks	chains of islands in an archipelago; wetlands along a waterfowl flight path; alpine habitats along a mountain chain
Habitat mosaics	patchy native vegetation in farmland; mosaic of gardens and parks in cities	mosaics of regenerating and old growth forests in forest blocks	regional soil mosaics supporting different vegetation communities

Table 4-2 adapted from Bennett 2003 [9].

The Okanagan corridor is a regional corridor that connects the Columbia Basin region in the United States to similar grassland habitat in the Okanagan, Thompson-Nicola and Cariboo-Chilcotin regions in B.C.

Regional corridors typically connect along major movement pathways that are used consistently by many species. These include altitudinal and/or latitudinal migratory pathways. Altitudinal pathways are major routes that species use to migrate between higher and lower elevations. Seasonal migration by mule deer is an example of an altitudinal pathway. Latitudinal pathways are major routes that species use to migrate between northern and southern latitudes. The Okanagan Valley is an example of a regional, low elevation valley corridor linking the arid basins in the U.S. to the central interior grasslands of B.C.

Although these types of corridors are planned at the regional scale, similar principles apply for smaller scale sub-regional and local corridors. Ideally, corridors moving in different directions are required at all scales so species can move at moderate elevations along valley bottoms or along moderate slopes, and also across elevations from valley to valley or sub-basin to sub-basin within a watershed.

Appendix 1-C. Corridor Planning & Design

Science and Planning Considerations for Building a Corridor

Step 1: Define the Connectivity Planning Process

Science/Connectivity Design Considerations	Is environmental protection a priority in the area in question? What information already exists to help inform the planning process? Is there a need for inventory, data collection or other science studies before planning begins? Biodiversity strategies and other approaches can provide direction on the best opportunities available on the landscape to provide connectivity [29; 31]. Sensitive Ecosystem Mapping (SEI) available in many parts of the province (including the Okanagan) is one product that helps planners consider the needs of species in building a connectivity strategy. Look at ecosystem network/park and green space/ connectivity plans from elsewhere. How did they approach the effort; what process did they use? (See *Case Studies from North and Central Okanagan that support the Biodiversity Conservation Strategy for the Okanagan Region*). Establish a technical support team, technical information, funding resources and political support sufficient to support both the project design and implementation.
Planning/Local Government Considerations	Has the area under consideration been identified as an area of interest for environmental protection, park space, sensitive ecosystem or other open space designations or development permit requirements? If not, is the application or plan in question providing the opportunity to consider creating an open space requirement? Is there bylaw language, requirements, or general commitments to the identification and creation of wildlife corridors within the lands in question? Are there other regional/local plans that might direct or define the planning process, e.g. Bylaws, existing plans, environmental protection priorities etc. Early in the process of building a strategy, public education and outreach is useful to build understanding of the purpose and significance of connectivity. Consider integrating this into other regional land use discussions (e.g. regional growth strategies, official community plans, neighbourhood plans, etc.). Who are the stakeholders, experts, funders and agencies that need to be involved to make this planning process a success? How can effective communication be established between the parties to sustain the planning process? Consider the anticipated opportunities and challenges presented by the proposal relative to residents, developers, recreation users and other key groups affected by the strategy [9].

Step 2: Define Plan Area/Scale

Science/Connectivity Design Considerations	Determine the land use scale at which a property, group of properties, or land use designation are being considered. Match scale of data to scale of planning.
Planning/Local Government Considerations	Is there bylaw language, requirements, or general commitments to the identification and creation of wildlife corridors within the lands in question?

Step 3: Set Goals/Targets

Science/Connectivity Design Considerations	In the Okanagan valley, conservation targets could be applied. Alternately, the approach could focus on a goal like addressing N-S and E-W barriers to connectivity for specific focal species.
Planning/Local Government Considerations	Goals and targets are linked to scale of planning; budget and tools being used to maintain connectivity; needs of species; planning direction; and priorities from local, provincial, federal jurisdictions.

Step 4: Identify Opportunities for Patches and Connectivity Elements

Science/Connectivity Design Considerations	Based on existing ecological information (e.g. information in Biodiversity Conservation Strategies written for the South Okanagan-Similkameen, and also the Okanagan Region: conservation rank, relative biodiversity and connectivity maps, sensitive ecosystem maps, foreshore/wetland mapping, old growth management areas, etc.), identify important patches or habitats.
Planning/Local Government Considerations	See Appendix 1-F to review tools available to execute the plan. When patches and connectivity elements are identified, the mechanisms available for protection require consideration. Is there a mechanism in place to establish the parameters for acquisition of the land, through purchase, park land dedication, sensitive ecosystem covenant; conservation or gifting? Review and assess land use opportunities and constraints identified in Official Community Plans, Development Permit Areas and Neighbourhood Plans. Consider specific information available for applicable properties and adjacent areas. Select the best, available, options for corridor placement(s). This may include accommodating corridors as a shared land use with adjoining properties (e.g. trail and other access corridors, as part of subdivision).

Step 5: Field Review

Science/Connectivity Design Considerations	Conduct field review of ecosystem patches/connectivity elements. If budgets prevent full review, sample a subset of sites to confirm if mapping matches field conditions; look for barriers that may have been missed and opportunities to mitigate these. Consider working with local colleges and universities to collect this information or seek local experts who have extensive local knowledge of field sites. Confirm land use in the field and seek opportunities to enhance corridor function and minimize mortality of vulnerable species. Complete a field survey to ground-truth habitat conditions and identify unexpected barriers. Look for ways that barriers can be mitigated (see Appendix 1-D). Consider other opportunities to improve corridor function, and minimize potential mortality of vulnerable species.
Planning/Local Government Considerations	Seek support from bylaw officers, Conservation Officers, operations, maintenance and other field staff to understand land uses and issues that may be associated with patches and connectivity elements under review.

Step 6: Identify Land Tenure/Consider Opportunities and Costs of Acquisition of Ownership or Opportunities to Influence/Regulate Management of Lands for Connectivity

Science/Connectivity Design Considerations	Exploit opportunities to utilize lands with high connectivity values and existing protections or land use constraints consistent with maintaining connectivity (e.g. aquifers, slopes, flood plains, and geotechnical hazard areas), accommodating more species, and supporting more ecosystem services (e.g. infiltration of water into aquifer and water purification.).
Planning/Local Government Considerations	Determine land ownership to assess regulatory tool available to protect connectivity and regulate land use. Does the land fall within a development permit area? Does local government have jurisdiction to influence or regulate land or do other partners/ governments have that responsibility?

Step 7: Determine Focal Species, if appropriate

Science/Connectivity Design Considerations	Determine appropriate focal species. Linkages that encompass the requirements of the most sensitive species will, in most cases, also be effective for the majority of more common species. An ideal group of target species would also include species in each category below. Species may fit several categories: -*Area-sensitive species:* species with large home ranges or requiring long-distance movement to interact with other individuals in other patches to maintain genetic diversity (e.g., cougar, grizzly bear, badger, bighorn sheep). -*Barrier-sensitive species:* species most reluctant to traverse roads, fences, canals, urban areas, and other barriers in the planning area (e.g. amphibians). -*Less mobile species:* species whose mobility or home range is limited (e.g. plants, amphibians, insects, small mammals). These species will often be corridor-dwellers and will require multiple generations to move between landscapes [43]. -*Habitat specialists:* species strongly associated with a major vegetation type or topographic element in the planning area (e.g. Mormon Metalmark associated with Snow Buckwheat in British Columbia). -*Ecological indicators:* species tied to an important ecological process, such as predation, pollination, or fire regime, e.g. Mason Bees. -*Non-flying migratory populations:* Seasonal migration is crucial for some species (e.g. Mule Deer).
Planning/Local Government Considerations	Iconic *species:* species managed by local governments with special planning measures. For example, Campbell River protects Bald Eagle nests through environmental development permit areas, and the Okanagan-Similkameen is managing for Bighorn Sheep connectivity.

Step 8: Check for Important Linkages/Connections Outside the Planning Area

Science/Connectivity Design Considerations	Linkages may cross outside community or district boundaries.
Planning/Local Government Considerations	Share mapping with surrounding jurisdictions; promote discussion about implications of conn ectivity to adjacent communities, provincial crown land, First Nations territories etc.

Step 9: Identify Potential and Existing Barriers and other Management Challenges

Science/Connectivity Design Considerations	Using air photos and mapping, identify potential barriers within corridors such as road barriers or pinch points where current development or topographic barriers restrict movement. Where mitigation is possible, barriers can be included within corridors or patches. Otherwise, consider alternate routes. Mitigation may include installation of crossing structures, and wider corridors to allow movement around barriers. Consider other land use challenges that may affect connectivity management and effectiveness (access/impact of cats and dogs; human use, light influence on wildlife use and behavior, proximity to intensive agriculture, industrial and recreation activities; invasive species, hunting and trapping).
Planning/Local Government Considerations	Is there an opportunity for the corridor under consideration to continue beyond the property boundary? Several conditions may restrict the identification of a contiguous corridor (e.g. existing development patterns, roadways, changing jurisdictional lines, competing or incompatible neighbouring land uses). If there is a significant limitation to corridors being established across property lines, there can be opportunities to provide a (discontinuous) stepping stone corridor or a narrowed corridor area to link wildlife movement areas.

Step 10: Consider Revisions Required to Address Climate Change

Science/Connectivity Design Considerations	Consider placement of corridors relative to predicted changes due to climate; Consider wider corridors to take in a wider range of elevations or increasing the number of cross-elevation corridors.
Planning/Local Government Considerations	Consider impact of future land use changes and predicted growth. Will corridors still function as communities grow and land uses intensify?

Step 11: Define Best Options for Connectivity to Create a Network Map

Science/Connectivity Design Considerations	At this stage options are defined and choices between different options are finalized balancing patch and connective element qualities, with costs, community concerns, planning and land use constraints. The result would be a connected network of ecosystems patches joined by connective elements. Consider using a matrix table to compare different areas.
Planning/Local Government Considerations	Map corridors and note any special considerations for corridor management and long term maintenance, including monitoring needs.

Step 12: Finalize Connectivity Plan and Implement Plan including Protection, Management, Enforcement and Monitoring.

Science/Connectivity Design Considerations	Finalize map; add to plan any special considerations for corridor management and long term maintenance, including monitoring for corridor integrity, species movement and indications of ecosystem health
Planning/Local Government Considerations	The effective identification, delineation, development and ongoing management of corridors, requires resources such as staff time, consulting contract funding or partnerships with third party organizations to ensure that corridors are maintained.

Appendix 1-D. Roads and Other Land Use Barriers

The impact of a road reaches far beyond the road surface itself. Roads contribute to a number of the fragmentation issues already discussed in this document. Roads impose complex hazards to species trying to cross them. Roads become barriers to the movement of wildlife, increase wildlife mortality, result in the loss of habitat, increase edge and cause habitat changes associated with edge including: wildlife avoidance or behavioral changes due to noise, air quality, light, traffic sounds, highway lane dividers, chemical emissions and intensity of road use [9,44]. Wildlife-vehicle collisions result in human injury and related economic damages [45]. A simple paved highway (one lane in each direction) can block movement and breeding between populations of a variety of vertebrate species, unless mitigation techniques like fencing and crossing structures are used [46]. Roads become a route for invasive species spread and establishment. Roads also cause reduced water quality which affects both aquatic and terrestrial ecosystems.

Roads negatively impact some groups of species more than others. Species more affected by roads include those attracted to roads (e.g. Badgers; various insects), and those that are vulnerable to wildlife-human conflicts (e.g. bears). Reptiles (e.g. turtles; snakes) and amphibians (e.g. frogs; salamanders) are particularly vulnerable to road effects, both because they move slowly in cold temperatures (i.e. more likely to be hit when crossing a road) and because when roads pass between habitats they require, it is difficult to design effective crossing structures.

The best option for both wildlife and people is to plan for roads so they do not present a barrier to movement by wildlife. Where wide highways cannot be avoided, crossing structures such as overpasses or underpasses are necessary. The barrier effect and the risks associated with crossing wildlife can be mitigated for narrower roads and trails by facilitating crossings at safe locations. This can include providing vegetation screening closer to the road edge, signs to warn travelers to slow down at sites where wildlife tend to cross, and culverts under the road to encourage crossing by species that will use them.

Designing Culverts and Crossings:

The best option for both wildlife and people is to plan for roads so they do not present a barrier to movement by wildlife. Crossing structures tend to be expensive, challenging to design and some species avoid using them, even when the crossing is well designed. For example, it is difficult to mitigate impacts on a population of turtles when a road crosses between wetland habitat and upland areas traditionally used for nesting. A small change in road alignment can address the problem so that the road moves around the wetland and upland habitat leaving them together.

Transportation corridors are a primary source of mortality for badgers in the Thompson-Okanagan region. Research shows that badgers have large home ranges that overlap highways and railways. This increases their risk of mortality, particularly during times of peak summer traffic, when badgers travel large distances for breeding, juvenile dispersal or foraging. Road side barriers appear to increase the mortality risk. Areas with continuous barriers on only one side of the highway showed a higher mortality as badgers accessing the road cannot exit safely. To reduce badger deaths, barriers should be continuous on both sides of the road and include ground level exits. Research also recommends installing drift fencing together with safe crossing structures to guide animals to crossing locations along new or upgraded roads and railways [47].

Planning for roads and wildlife:

The best option for both wildlife and people is to plan for roads so they do not present a barrier to movement by wildlife and that they maintain existing connections between ecosystems. Connectivity benefits are significant when planning for roads and infrastructure includes tools and approaches that minimize fragmentation and road impacts [48].

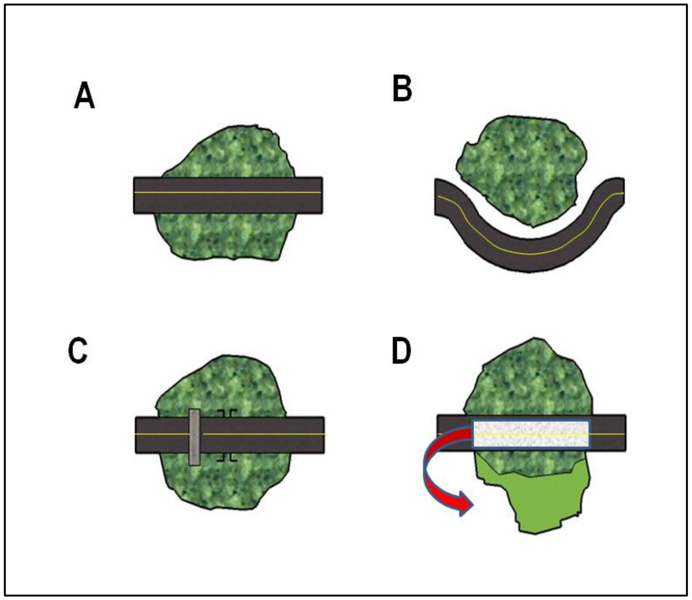


Figure 3: Options to reduce road impact

Fragmentation of a green patch (A) can be avoided or mitigated by moving the road (B), constructing crossing structures that connect the two patches (C), or creating adjacent similar habitat nearby to replace what was lost to road impacts (D).[18]

Measures to protect ecosystems and wildlife along transportation corridors can be divided into three categories:

- Measures that directly reduce fragmentation by providing links over or under the road:
    - wildlife overpasses,
    - underpasses for small mammals,
    - amphibian tunnels,
    - structures that support fish passage
- Measures that reduce losses of habitat associated with roads:
    - adjusting roads to the landform (see figure above),
    - reducing the width of roads and road right of ways (areas on either side of a road)
    - locating roads in disturbed areas or avoiding location of roads in high value habitats
    - limiting road footprints in high value habitats by removing excess soil rather than side casting it,
    - avoiding soil compaction, or
    - retaining top soil for restoration and planting

[18] Adapted by Susan Latimer from Clevenger et al., page 22. See reference [48].

- Measures that aim to improve road safety and reduce impacts of traffic on animal populations:
  - fences,
  - warning signs,
  - adapting habitat adjacent to roads by clearing or planting vegetation to encourage crossings and use by wildlife at the safest locations,
  - adapting infrastructure to make them more wildlife friendly, such as curbs with openings to allow wildlife movement, road drains with escape ramps to avoid trapping animals, designing placement of roads and lights to minimize noise and light impacts on habitat and wildlife, adjusting roads to landform as in figure above [57].

Crossing structures help restore connectivity: Where large freeways provide major barriers for wildlife species like Wolverine, connectivity can sometimes be restored using overpasses, underpasses, and tunnels.

Overpasses and underpasses:

Where barriers cannot be avoided, existing roads and railways can be made more permeable for wildlife by building crossing structures like tunnels, wildlife overpasses, viaducts and underpasses with drift fences to guide them to the safe crossing. Alternately, roads may be engineered on pillars so that traffic passes above the habitat. In general, the larger the habitat patches linked by crossing structures, the more effective the measures will be. Planting native vegetation on and adjacent to the structure helps encourage wildlife to use the structure by screening or hiding the road and making the structure blend into surrounding natural areas.

Overpasses have been shown to act as flight path guides for birds, bats and butterflies. Overpasses act both to enhance the movement of flying species reluctant to cross open areas and to reduce mortality of terrestrial wildlife like bears and badgers.

The choice of crossing structure type will depend upon various factors including: the terrain, groundwater levels, wildlife or plants to be accommodated and cost considerations. Vegetation generally encourages wildlife use and is easier to establish in overpasses, but when animals such as amphibians require moist and humid conditions, tunnels may be better [49].

The number of crossings required will depend on landscape permeability, the species using the crossings and the habitats that need to be connected. In some cases, multiple smaller underpasses may be more useful to construct than one large overpass. Other factors influencing design include the required width of crossing structures, and the desire to combine wildlife and human crossing opportunities (where appropriate, making structures for joint use of bicyclists, pedestrians and wildlife).

A recent study of road impacts found three Okanagan amphibian species (Great Basin Spadefoot, Pacific Tree Frog and Tiger Salamander) were particularly vulnerable to road mortality. These losses were concentrated on wet, rainy spring and summer nights. Mitigation options include installing corrugated steel pipe culverts (900-1200mm width) placed in areas where amphibians commonly cross. A soil floor and refuge materials are added to culverts to encourage use [51].

Adaptation of existing infrastructure:

Historically, most highway crossing structures, like overpasses, have been designed with a focus on human needs. Many of these can be modified to increase landscape permeability for wildlife without compromising human safety. Much of this involves modification of drainage structures with the help of a design team that includes biologists as well as engineers. Larger structures may provide more opportunities for modification, since they can accommodate a wider range of species. When road design and planning teams include collaboration between engineers and biologists, many potential impacts to wildlife can be avoided.

Structures like barriers, drains, and curbs can all affect wildlife safety. Noise barriers block movement by wildlife and transparent screens can be a hazard to birds. Drains can trap small mammals, reptiles and amphibians, while curbs and other road barriers can trap animals in high hazard areas adjacent to vehicle traffic. Often minor changes to the design of road structures can significantly reduce wildlife mortality.

This structure is a specialized climate tunnel to help amphibians like this Western Toad safely cross roads [50]. Research shows that amphibians and reptiles are particularly vulnerable to road mortality. Designing effective crossing structures for these species is difficult and requires annual maintenance to support ongoing effectiveness and use of the structure.

Vegetated underpass with fencing to prevent access to the roadway, from Banff National Park.

Managing vegetation make road crossing safer:

Managing vegetation adjacent to roads and crossing structures can help reduce wildlife mortality. For example, creating V-shaped hedgerows (crossing structure at the point of the V) will help funnel species to safe crossing locations. For large animals like moose which prefer to be hidden by vegetation, mowing can reduce their attraction to the edge of a road and increase their visibility when they cross. This also reduces the chance of vehicle collisions, although in absence of crossing structures, this strategy increases the barrier effect of roads. For species like bears, highways surrounded by mowed right of ways tend to isolate one part of a population from breeding with individuals on the other side of the road. The type of vegetation planted can also influence wildlife behavior next to roads. Planting less palatable vegetation can reduce use by those species that eat plants. Planting tall trees can make birds fly higher over the road thus reducing collisions.

Appendix 1-E. Climate change implications

Landscape connectivity is dynamic and changes with time and land use. Ecological succession, human population density, settlement patterns, transportation systems, climate change, land use change and other factors can influence connectivity over time. Effectively managing and maintaining it requires periodic assessment and review, as well as the application of adaptive management to ensure it continues to function [52].

As climate shifts, conditions in ecosystem patches also change. Important factors like temperature and precipitation affect habitat conditions. Species can adapt if they are able to move to new locations that more closely match their requirements, but connectivity is important to facilitate movement.

Based on climate models, scientists are able to project changes in climate over time and develop ideas about how climate conditions in one place might occur elsewhere at some future time. This modeling suggests that climatic conditions found in B.C. today may expand, shrink, move northward or shift to higher elevation areas. With these changing climate conditions, ecosystems will shift and change as well. Some ecosystems, will disappear, some will shift location, while others will be transformed into new ecosystems not currently found in today's climates. For example, grassland ecosystems are expected to expand providing new opportunities for connecting grassland ecosystems in areas where connectivity is currently limited. Strategic planning will be required to consider connectivity requirements in a shifting climate.

Differences in temperature, precipitation, terrain, soils and the species found on a site will all influence vegetation and drive shifts in ecosystems. If suitable climate conditions disappear, species that depend on these will become extinct, unless they can adapt to new conditions. Species that colonize new natural areas more slowly and those more sensitive to changing climate such as water dependent species like amphibians, may be blocked from reaching areas where suitable climate remains [53]. Also, some species including an estimated 9% of mammals in the western hemisphere, may not be capable of dispersing swiftly enough as habitat conditions change, to reach new suitable climate areas [54].

It has been suggested that connectivity between patches may have an important conservation role in response to climate change [55, 56, 57]. In some situations connectivity in the landscape may assist plant and animal species to extend their geographic range and track suitable climatic conditions.

Maintaining connectivity has a potentially important role in countering climate change by:

- facilitating effective range shifts as some existing ecosystems move upwards in elevation (e.g. B.C. grasslands);

- maintaining the continuity of species' populations throughout their current geographic range, thus maximizing a species' ability to persist within those parts of its range where climatic conditions may remain suitable; and;

- interconnecting existing patches (natural area reserves, core area habitats and protected areas) to help maximize the resilience of the present conservation network.

Linkages of particular value are those that maintain large contiguous natural areas, or continuity with a corridor along a gradient of gradually changing physical factors like altitude, temperature and slope. Large populations and those that span environmentally diverse areas are likely to have greater capacity to respond to changing conditions.

Given present uncertainty about the nature and magnitude of future climate change and its potential impacts, it appears prudent to maintain and restore connectivity regardless of the exact nature of impending climate change [9]. To facilitate species' range shifts and therefore the maintenance and establishment of functioning ecosystems, policies are required to create and promote connected landscapes. It will likely also be necessary to regulate and facilitate assisted colonization (i.e. movement of species between patches) when other options are unavailable. Critically important to successful climate adaptation is the development and implementation of policies to integrate approaches for both people and biodiversity. If policies do not simultaneously address the needs of both human and natural systems, these policies are likely to protect neither [58].

Appendix 1-F. Local government tools

Regional Conservation Strategies:

Regional conservation strategies (RCS), also known as regional biodiversity strategies, are a comprehensive long term plan for ecological protection and restoration in a region. A regional connectivity strategy is an important component of a RCS and the RCS as a whole would be based on the mapping and understanding of ecosystem function that is recommended in *A Biodiversity Conservation Strategy for the Okanagan Region*. In addition to the baseline of connectivity planning, the RCS establishes parkland acquisition priorities, biodiversity goals, and management objectives for all parties – landowners, regional districts, municipalities, senior government and First Nations. While the RCS is not binding, a Regional Growth Strategy (RGS) can incorporate directive goals and mapping from the RCS. In this way a RCS and component regional connectivity strategy can act as the baseline for growth management in a region. As with all good planning, ecosystem integrity comes first and land development is subsequently layered onto it.

Regional Conservation Strategy Examples

Local governments in the Capital Regional District adopted their Regional Conservation Strategy, called the *Regional Green/Blue Spaces Strategy*, as the foundation for the Regional Growth Strategy.
http://www.crd.bc.ca/reports/regionalplanning_/generalreports_/regionalgrowthstrate_/regionalgrowthstrate/regionalgrowthstrate.pdf
(page 23)

Keeping Nature in our Future Series, is another example of a regional conservation strategy.

Regional Growth/Sustainability Strategies:

A RGS is a long term plan of twenty years that sets out social, economic and environmental objectives and priority actions for a region. As an agreement between member municipalities and a regional district, it is intended to guide decisions on growth and development. In addition to establishing goals for the projected need for housing, transportation, regional district services, and economic development, it also addresses parks and natural areas. Specifically, one of the goals of a RGS is to protect environmentally sensitive areas. [19]

The foundation for a RGS should be regional conservation and regional connectivity strategies, as supported by ecosystem mapping, and

[19] *Local Government Act,* at section s.849(1)(d).

include regional and local policies for implementing the regional scale connectivity. It is the ideal venue in which to identify and establish regional agreement on the protection of regional corridors of 500 meters to 2 kilometers in width and sub-regional corridors of less than 300 meters width, as well as important patches.

Regional district services and bylaws must be consistent with the RGS.[20] Municipalities address compliance with the RGS by including a regional context statement in their OCP detailing how their OCP will become consistent with the RGS over time.[21]

Connectivity Addressed in Regional Growth Strategies

Connectivity in the Capital Regional District (CRD) – Action 2.1.1 of the Capital Regional District RGS addresses regional connectivity: "The CRD and member municipalities agree to work as partners and individually to establish the *Regional Green/Blue Spaces System* identified on Map 4. In doing this priority will be given to community and regional park land acquisition, public and private land stewardship programs and regional trail network construction that contributes to completion of the Sea to Sea Green/Blue Belt."

All three regional growth strategies in the Okanagan contain references to connectivity and corridors.

- See Regional District of the North Okanagan's regional growth strategy at http://www.rdno.ca/bylaws/Bylaw_2500.pdf
- See Regional District of the Central Okanagan's regional growth strategy at http://www.regionaldistrict.com/services/planning-section/growth-strategy/regional-growth-strategy.aspx
- See Regional District of the South Okanagan-Similkameen regional growth strategy at http://www.rdos.bc.ca/departments/development-services/regional-growth-strategy/what-we-do/

Official Community Plans:

Official community plans (OCP) and the sub-plans of which they are composed, such as neighbourhood plans, local area plans, and/or watershed plans, set out a local government's specific objectives and policies for land regulation and future development. Although OCPs are not directly binding on local government decisions, all bylaws must be consistent with the OCP,[22] and OCPs give direction to the regional

[20] *Local Government Act*, at section 865(1).
[21] *Local Government Act,* at section 866.
[22] *Local Government Act*, at section 884.

district board, municipal councillors, subdivision approving officers, and staff when they are making decisions about land development applications.

Connectivity Addressed in Community and Neighbourhood Plans

The Town of Gibson's Gospel Rock Neighbourhood Plan - Part F of OCP
http://www.gibsons.ca/images/stories/officialcommunityplan/OCP_PartF.pdf (page 281) is an example of a neighbourhood plan that addresses connectivity.

The City of Vernon has corridors identified in their Environmental Management Areas Strategy.
http://www.vernon.ca/services/pde/documents/ema_strategy_final.pdf.

An OCP must include statements and map designations for the approximate location, and phasing of any major road, sewer and water systems, as well as restrictions on land that is subject to hazardous conditions or that is environmentally sensitive to development. [23] It is through this anticipated planning, as identified in future land use maps, that regional and sub-regional corridors and patches from the RGS can be designated as environmentally sensitive. At the same time, local corridors can be identified through additional mapping, and infrastructure planning can avoid those areas that are a priority for connectivity. Given this baseline of connectivity, local governments can then develop policies for clustering new development away from connectivity corridors and in locations suitable for more intensive residential, commercial and industrial development, as well as policies for protecting connectivity. Policies for protecting connectivity can include objectives for acquisition of patches as parkland, creation of development permit areas for the protection of the natural environment, and amendments to the zoning bylaw to create or maintain low intensity uses in corridors and patches.

Connectivity Addressed in Mapping

District of Highlands has developed a general land use map that clearly shows north-south connectivity. For more information see http://www.highlands.bc.ca/bylaws/276-300/277%20-%20Schedule%20A%20-%20Official%20Community%20Plan%20-%20Consolidated.pdf (page 7).

[23] *Local Government Act,* at section 877(1).

Zoning:

Zoning for Ecosystem Protection

The Comox Valley Regional District's Zoning Bylaw contains a Water Supply and Resource Area Zone designed to protect ground water. Its purpose and effect also serve connectivity objectives by establishing a minimum lot size for subdivision of 400 hectares and living density to one single family dwelling per lot.

The Regional District of Central Okanagan has zoning to protect a 30 m setback which provides a corridor around lakeshores. This setback is designed to support water quality--an ecosystem service. For more information, see consolidated bylaw 871 Section 5.3 Conservation Lands page 5-3 http://www.regionaldistrict.com/media/27155/consolidated_zoning_bylaw_no._871.pdf.

Zoning bylaws, sometimes called land use bylaws, dictate what uses or activities may occur on a parcel of land, and how much of those uses are allowed.[24] In simple terms, zoning should prohibit intensive or potentially harmful uses in ecologically sensitive areas and direct those uses to urbanized areas. Zoning can be very specific, for example, allow only one single detached dwelling per lot on any parcel in areas identified as patches or connectivity corridors, or it can more generally direct development into urbanized areas and protect the rural nature of the rest of the landscape. The key for connectivity through zoning is that ecologically sensitive areas are not identified for intensive development. If they are, there should be very specific policies in the OCP and guidelines in development permit areas for protection of the natural environment. These should identify corridors and patches that will provide the connectivity through the new development.

Some local governments use amenity bonuses to secure corridors and patches as parkland. Amenity bonuses allow landowners to build to a higher density or number of units in return for providing amenities to the local government. Although amenities can be many things, in the context of connectivity they can mean the donation of upwards of 40 percent of the parcel for parkland, and protecting the remaining private land on the site with conservation covenants. This allows local governments to cluster new developments, even in rural areas, away from ecologically sensitive areas in corridors, and still maintain the rural nature of the area. Amenity bonuses are easier in highly urbanized areas because one or two additional floors on a highrise are less noticeable than ten new homes in a rural area. However, they can be successful where the proposed increase in density meets criteria set out in the OCP, such as maximum increase in density, the desired amenities, and the ability for design of the new development to maintain rural character.

[24] *Local Government Act*, at section 903.

Connectivity through Scafe Hill

The District of Highlands allowed additional rural density of 11 units in the Scafe Hill area in return for conservation of almost 90 percent of the 190 hectare property as parkland and through conservation covenants on private land. The patch from this development proposal achieved significant regional connectivity by linking three regional parks. For more information see pages 68-70 of the Green Bylaws Toolkit www.greenbylaws.ca [63].

Development Permit Areas:

Development permit areas for protection of the natural environment (called environmental DPAs) are the strongest regulatory tool for ecological protection that local governments possess. In most cases, land within environmental DPAs must not be subdivided or construction of a building started unless the owner obtains a development permit from the local government.[25] As a fine-grained land regulation that supplements zoning, guidelines in the OCP may direct staff to impose development permit conditions to tailor land development to the specific ecological quality and features of each site. From a connectivity perspective, environmental DPAs allow local governments to tailor the development design to the ecosystem conditions on the site. Conditions imposed through the development permit approval process can prohibit development on portions of the site, require that natural features like stepping stone corridors be protected and require the dedication of water courses. All corridors, patches and stepping stones should be designated as environmental DPAs. This designation prohibits the alteration of land before a permit is obtained, and can shape development to preserve the features that make the site valuable as a corridor or patch.

Subdivision:

Subdivision bylaws typically specify what infrastructure must be provided in support of new development; for example, such bylaws can specify the width of roads and approaches to drainage. An approving officer can refuse to approve a subdivision that does not conform to all local government bylaws regulating subdivision and zoning.[26] Courts have interpreted this to mean that an approving officer has no jurisdiction to approve a subdivision that does not meet the requirements of a local government's bylaws. In addition, the approving officer may refuse to approve the subdivision plan if the approving officer considers the plan to be against the public interest.[27]

[25] Note that local governments may also specify conditions or circumstances in which a development permit will not be required, by noting these exemptions in an OCP or zoning bylaw. Common exemptions include minor landscaping and renovations (where it is not worth staff time and landowner expense to go through the full permitting process), and actions taken to remedy hazardous conditions. *Local Government Act,* at Section 920(1).
[26] *Land Title Act*, R.S.B.C. 1996 c. 250 at section 87(b).
[27] *Land Title Act*, at section 85(3).

This public interest discretion gives the approving officer extensive discretion to require an applicant to address connectivity when supported by bylaw provisions and policies that are located outside of the subdivision bylaw. If a subdivision does not conform to connectivity goals as expressed through mapping in the OCP, the approving officer can refuse to approve an application for subdivision. Although sufficient, ideally an approving officer will have more than a single source of policy or bylaw to rely on for this decision. For example, connectivity goals should be included not only in an OCP but in development permit areas for protection of the natural environment and the zoning bylaw.

Development Cost Charges:

A local government may levy development cost charges (DCCs) for subdivision and building permit approvals and use those DCC funds to pay for the capital costs of providing sewage, water, drainage, and road facilities, as well as providing and improving parkland that services the new development.[28] Most importantly, DCCs can be used to purchase land identified as patches or corridors.

Local governments also can impose variable DCCs that are tailored to different types of development and in different areas to reflect the actual cost of providing services and to create incentives for certain types of development. Specifically, local governments may waive or reduce DCCs for development of small lots that have low greenhouse gas emissions or are designed to result in low environmental impact.[29] Variable DCCs based on environmental impact, type of design and location can send a price signal to landowners about the benefits of achieving connectivity goals.

DCCs for Green Infrastructure and Parkland

In the Grandview Heights Neighbourhood Concept Plan, the City of Surrey used Development Cost Charges to purchase parkland along Highway 99 that serves the multiple purposes of stormwater management and ecosystem connectivity. For more information see http://www.surrey.ca/city-services/1327.aspx

[28] *Local Government Act*, at section 933(1).
[29] *Local Government Act*, at section 933.1(1).

Conservation Covenants:

A conservation covenant is a voluntary agreement between a landowner and a covenant holder (a municipality, regional district, or an approved non-governmental organization) that can prohibit activities on parcels of land in furtherance of maintaining ecosystem integrity and connectivity.[30] As part of negotiating for new development or voluntarily, a landowner agrees to protect private land according to the wording of the covenant, and the covenant holder has the right to monitor and enforce the covenant. When registered on the title to the land, covenants "run with the land," meaning they apply to whoever owns the land, thus creating obligations on future landowners that endure over the long term.

In addition to protection through bylaws, local governments and conservation organizations secure additional protection of ecologically sensitive areas through conservation covenants, in particular to protect specific characteristics such as wetlands, grasslands, and forested areas that could be considered stepping stones.

In accordance with its written content, conservation covenants enable the protection, preservation, conservation, maintenance, enhancement, restoration or retention of land areas in its natural or existing state. Conservation covenants may limit or prevent:

- use of the land or the construction and use of a building;
- subdivision except as directed by the covenant; and
- sale or separate transfer of designated parcels of land.

Conservation Covenants

For more information about conservation covenants see Greening Your Title: A Guide to Best Practices for Conservation Covenants (2nd Edition) by West Coast Environmental Law Association
http://wcel.org/sites/default/files/publications/Greening%20Your%20Title.pdf

[30] *Land Title Act,* at section 219.

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