

Landscape Connectivity: A Provincial Biodiversity Indicator

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ABMI

ALBERTA BIODIVERSITY
MONITORING INSTITUTE

Alberta 

Environment and
Protected Areas





Outline

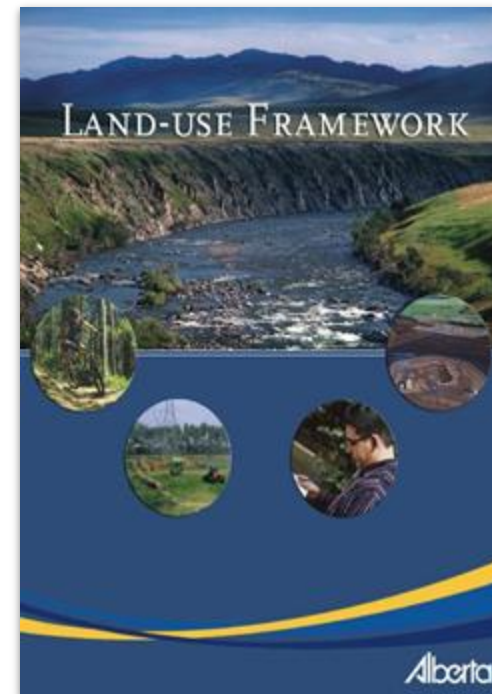
1. Provincial biodiversity indicators for land-use applications
2. Provincial landscape connectivity indicator
3. A (not-so) technical explanation of the indicator
4. Example: Landscape connectivity assessment and reporting



Cumulative Effects Management

Land Use Framework (LUF)

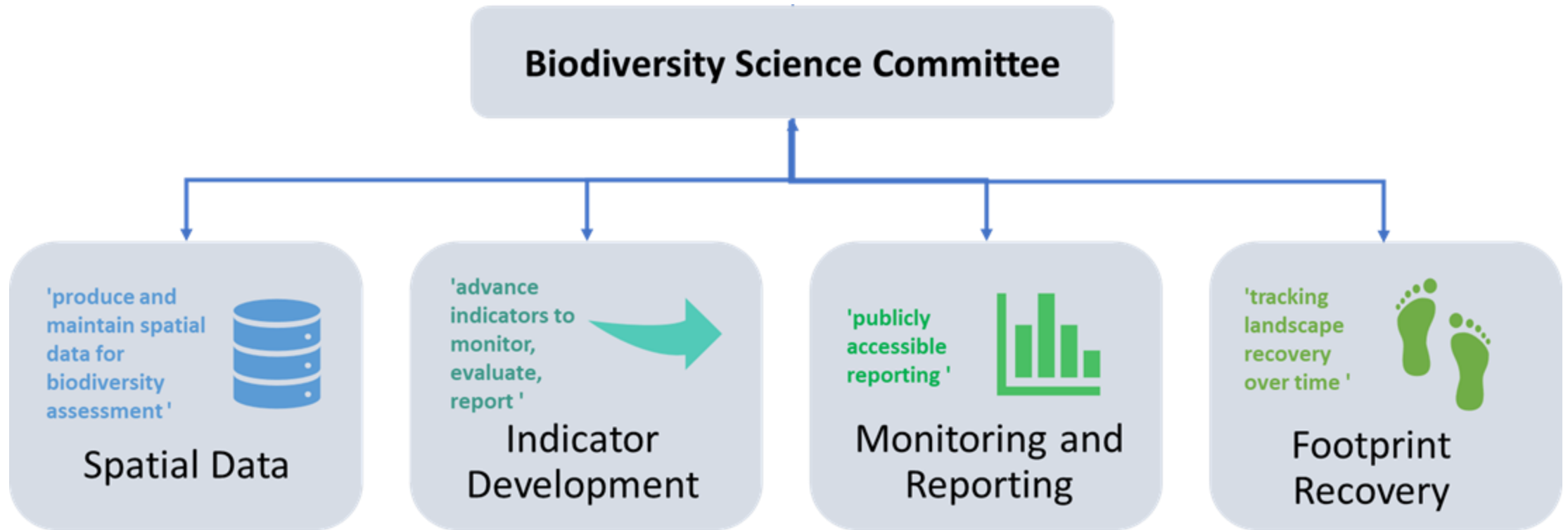
- LUF (2008) sets out an approach to manage public and private lands and natural resources in Alberta.
- Strategy 6: “Good land-use decisions require accurate, timely and accessible information.”
- EPA began chairing a cross-ministry scientific committee* to develop a monitoring, reporting, and management approach for biodiversity in Alberta.
 - Forestry & Parks, ABMI and AER are also members.



*Formerly the BMF Science Technical Committee, now the Biodiversity Science Committee



Biodiversity Science Committee Workgroups



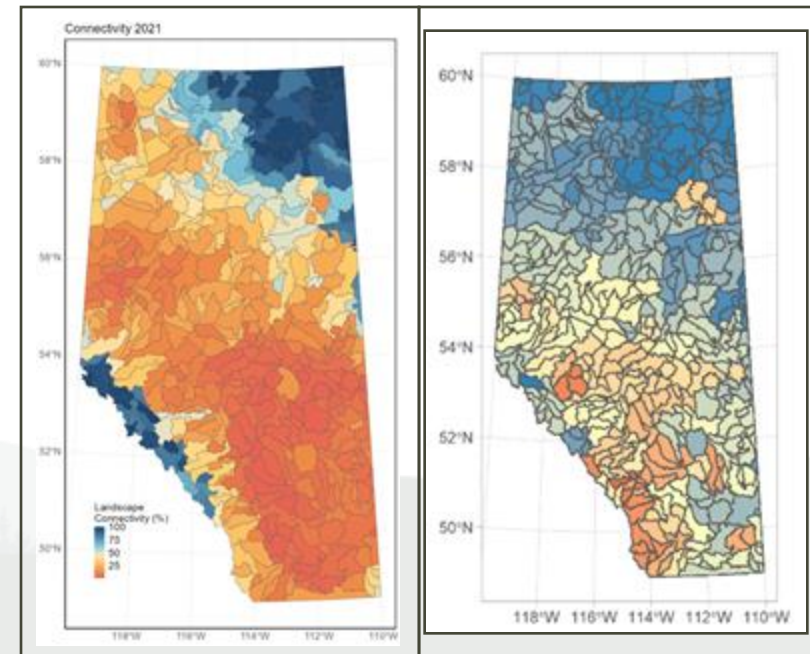
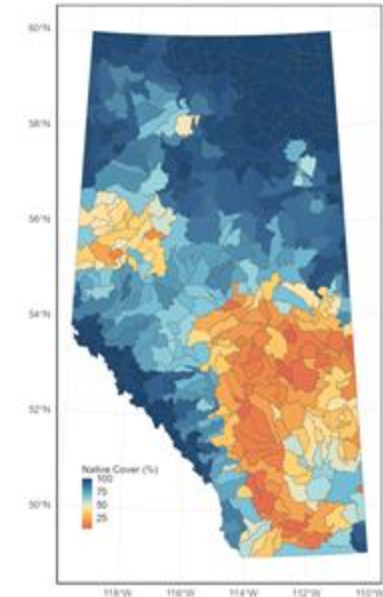
Biodiversity Indicators

Publicly Available Indicators:

Through the joint EPA-ABMI partnership, four coarse filter biodiversity indicators have been developed and released publicly:

- Native Cover
- Interior Habitat
- Landscape Connectivity
- Stream Connectivity

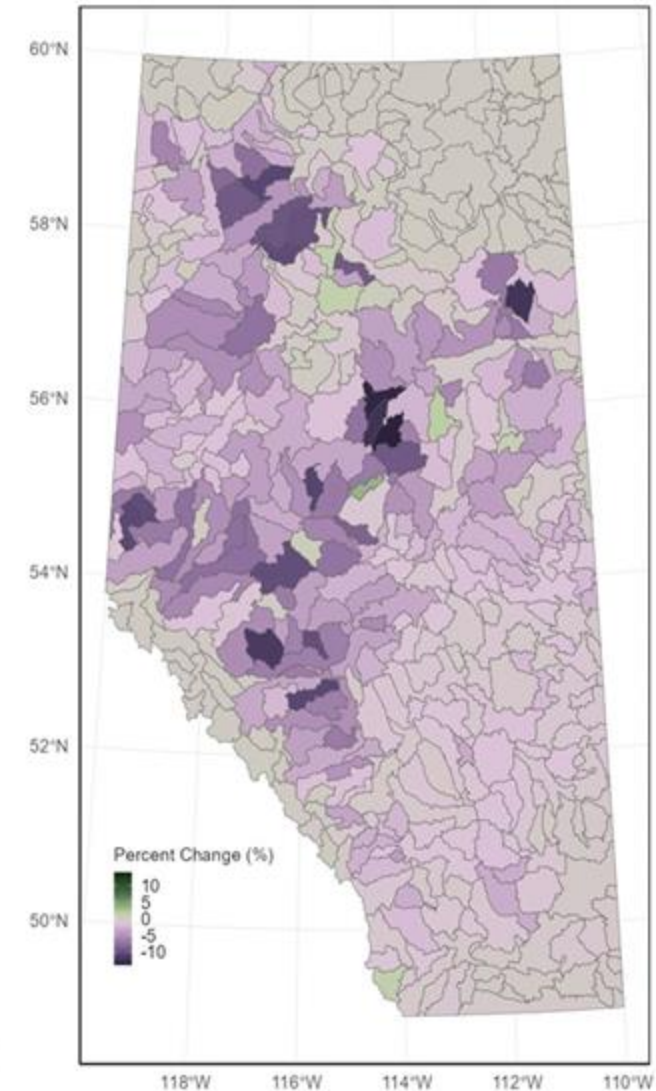
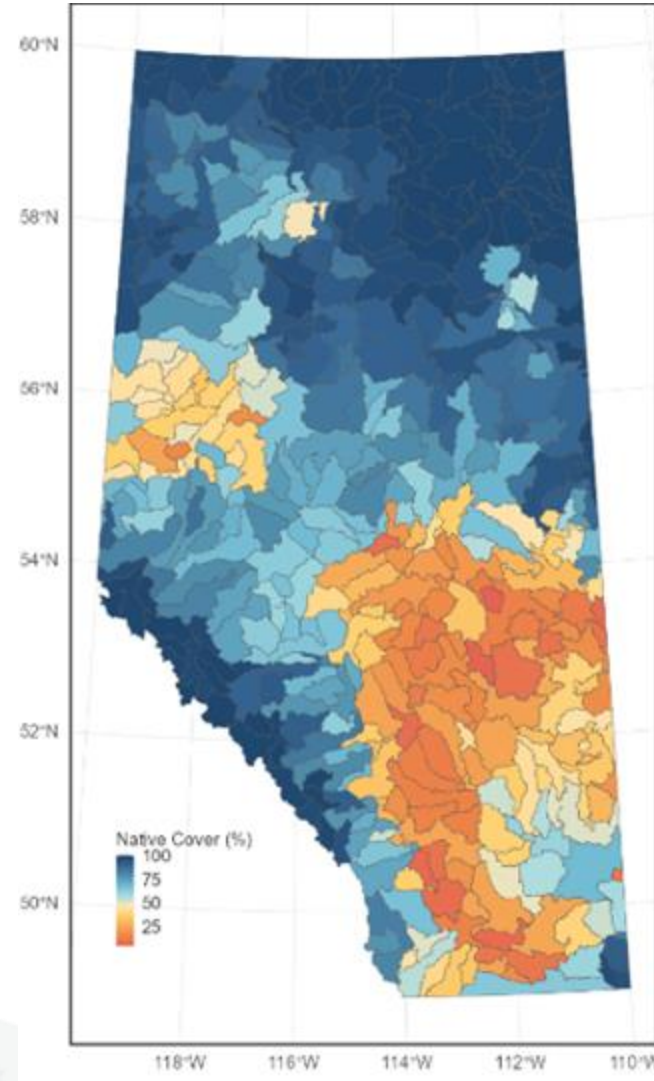
All indicators are summarized at the scale of HUC-8 watersheds.



Native Cover

Indicator Goal

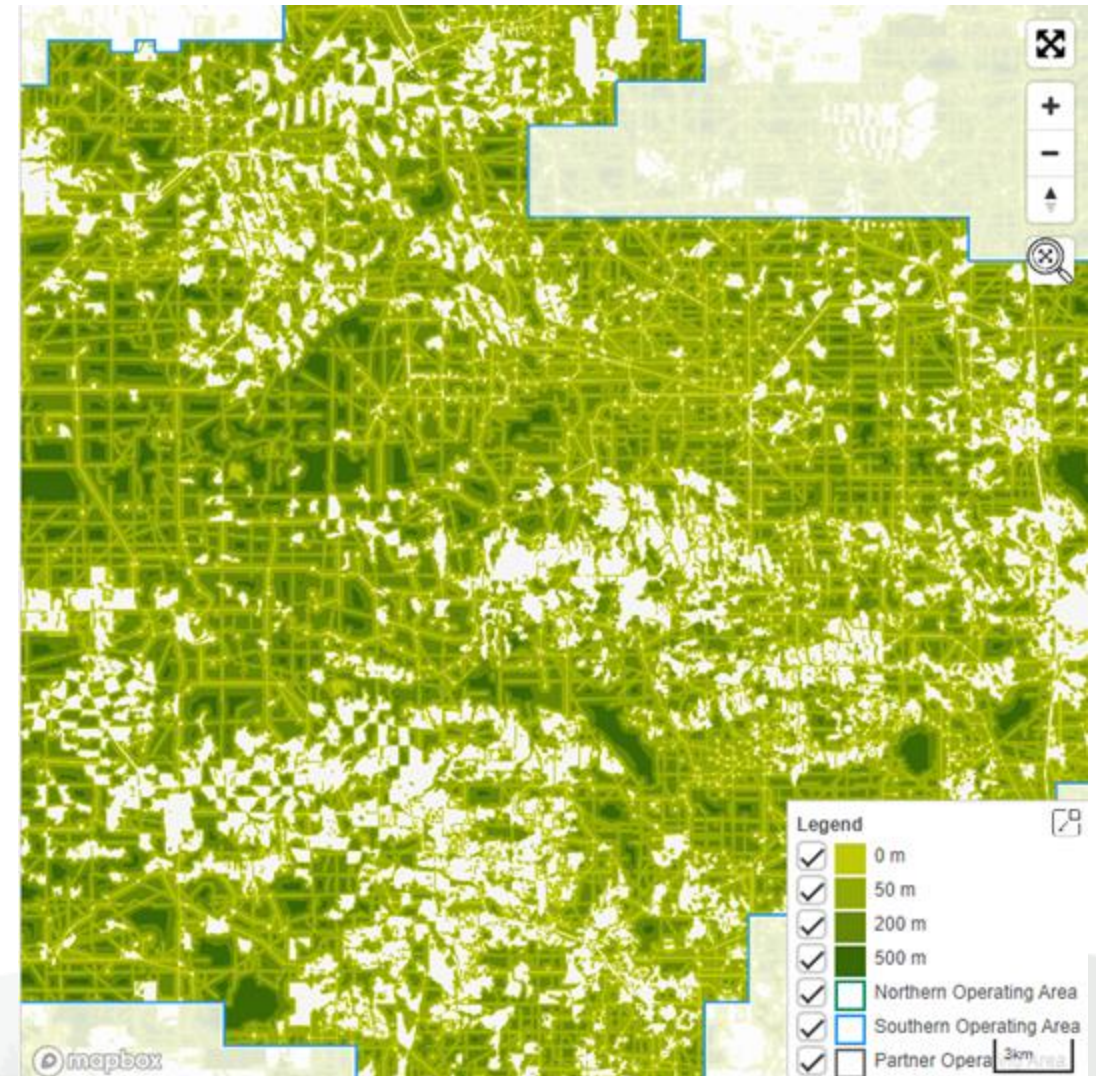
- **Habitat loss** is widely understood as the main contributor to biodiversity loss (Brooks et al., 2022).
- Measures the amount of aquatic and terrestrial native cover undisturbed by human footprint within watersheds.
- Provides valuable information on how the extent of habitats is changing over time.



Interior Habitat

Indicator Goal

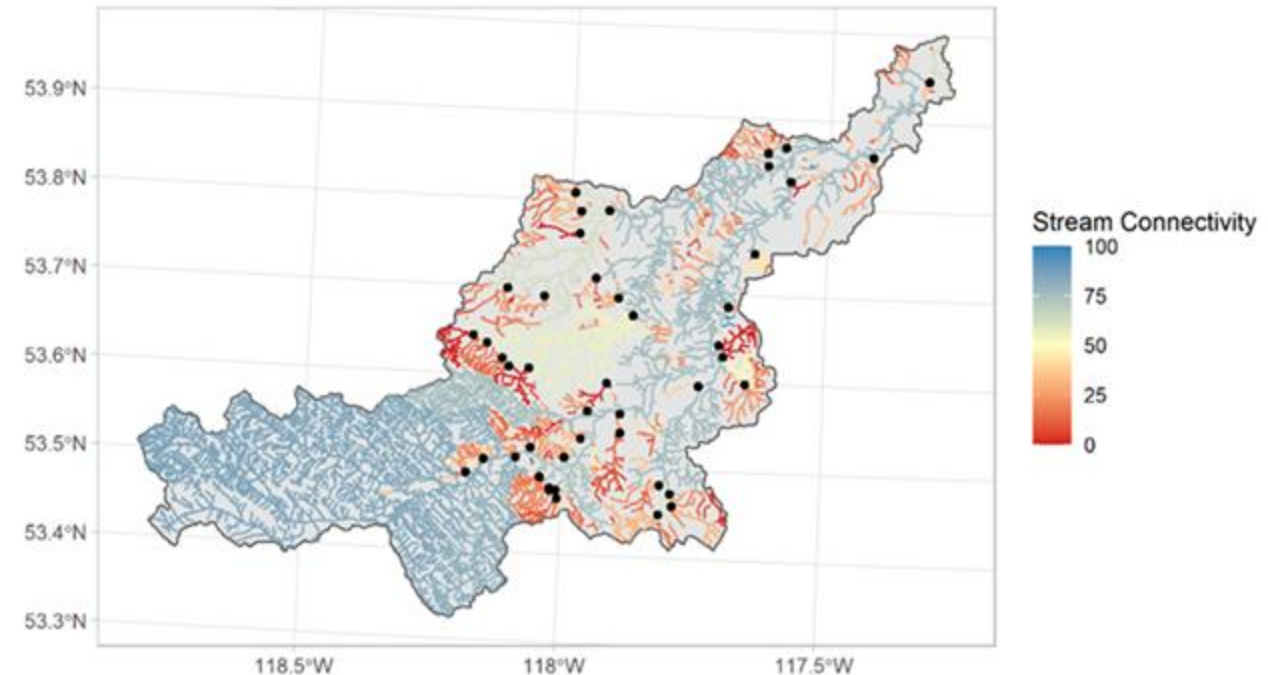
- The impacts of **human footprint** can extend beyond the footprint boundaries (i.e., edge effects; Franklin et al., 2002).
- Measures the amount of habitat that lies outside the range of influence of human footprint.
- Provides valuable information for identify large patches of habitat that are remaining outside the influence of human footprint.



Stream Connectivity

Indicator Goal

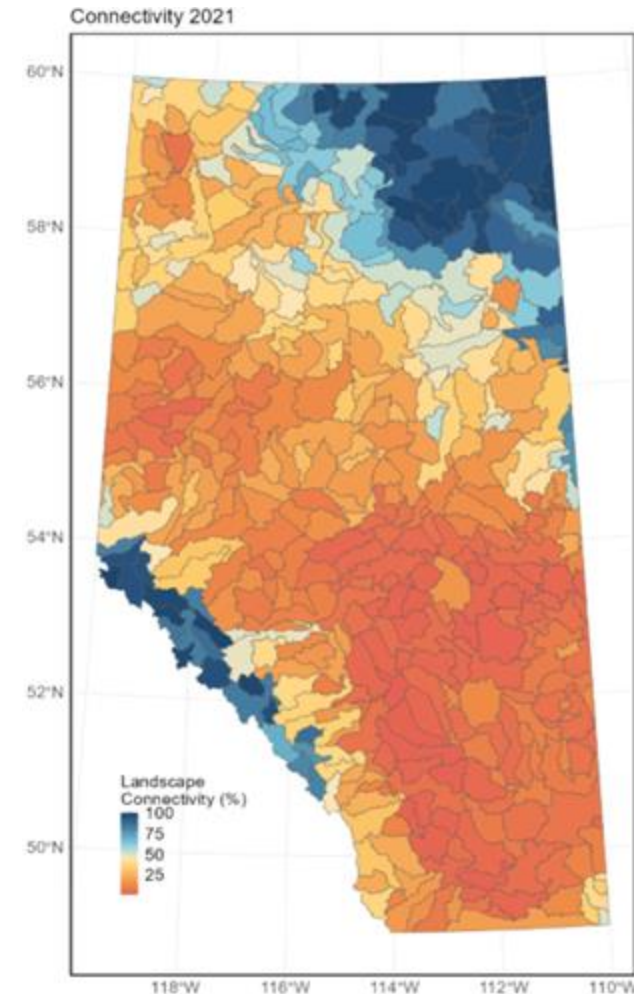
- **Freshwater ecosystems** experience fragmentation driven by culverts, dams, and other road-stream crossing infrastructure (Branco et al., 2014).
- Measures how connected streams segments are to one another.
- Provides valuable information about how expanding road networks impact the connectivity of streams.



Landscape Connectivity

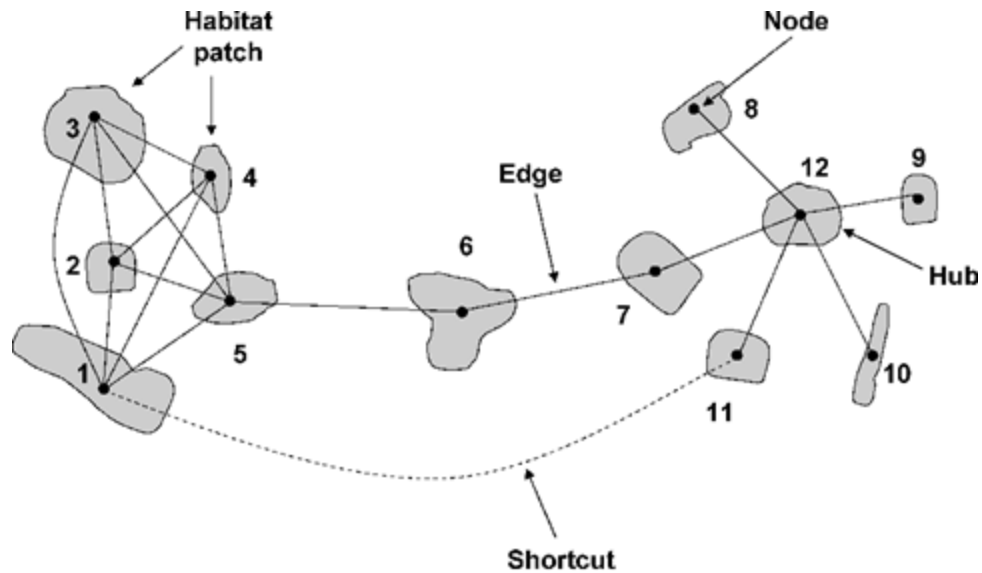
Indicator Goal

- The **fragmentation of habitats** into many small patches decreases landscape connectivity (Forman, 1995).
- Measures how connected the remaining habitat patches are across the landscape.
- Classifies habitat into 3 major types: Upland Forests, Lowland Forests, and Grass-Shrub
- Provides valuable information about how the amount and placement of human footprint on the landscape impacts connectivity between habitats.

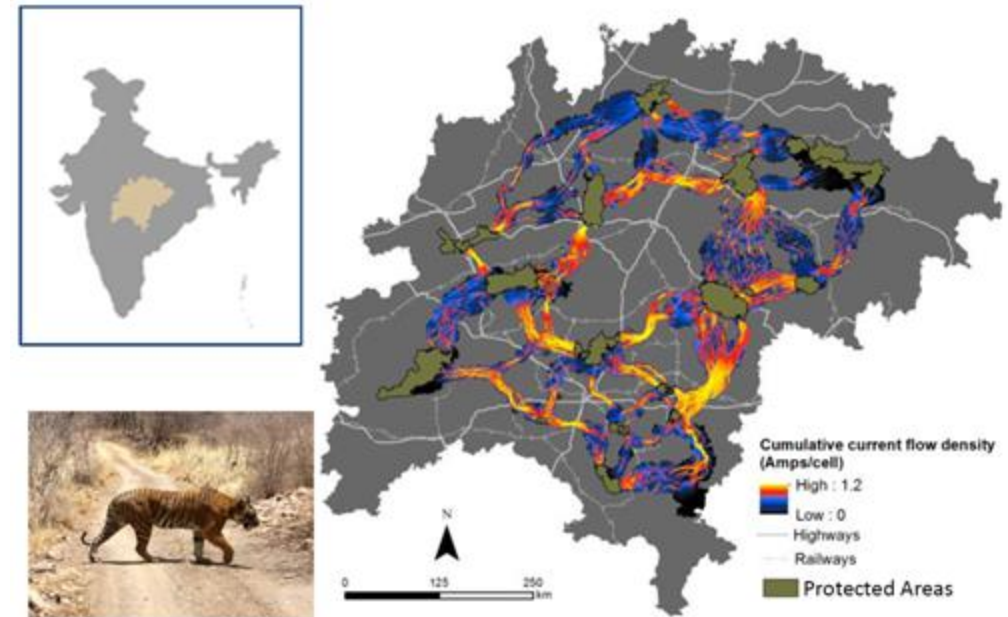


Methodological Approaches

Graph & Network Theory



Circuit Theory



The provincial indicator uses a graph & network theory approach.



3. A (not-so) technical explanation of the indicator

Data

Landcover, footprint, and connecting features

1. ABMI's Human Footprint Inventory

- Provincial scale GIS layer that consolidates 115 types of anthropogenic disturbance into 20 subcategories (~7 million features in 2023).

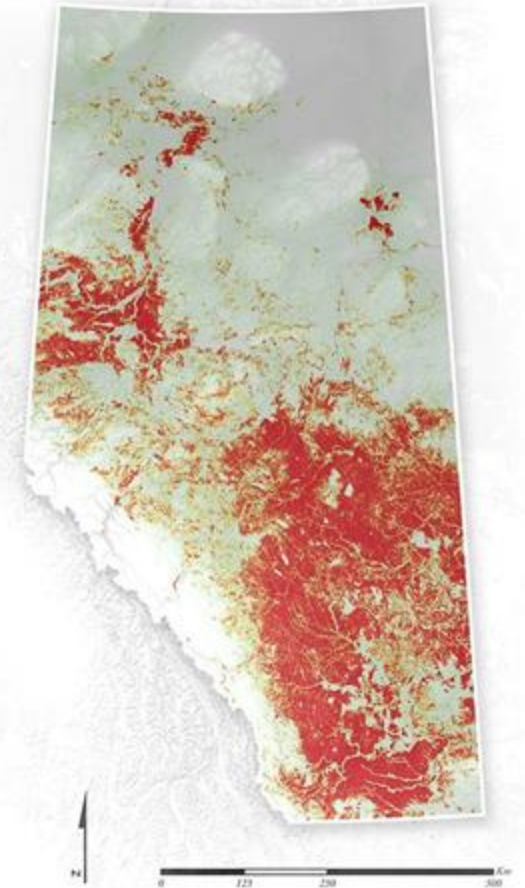
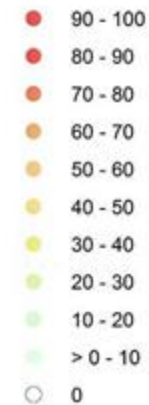
2. ABMI's Wall-to-Wall Vegetation Layer Including "Backfilled" Vegetation

- Provincial scale GIS layer that tracks the current vegetation, habitat, soil, and anthropogenic disturbances.
- Allows assignment of habitat types and stand types for harvest areas.
- Provides information on the landcover type prior to disturbance.

3. Wildlife crossing locations in National Parks

- Facilitates movement between patches, reducing impacts of roads.

Human Footprint
Percentage

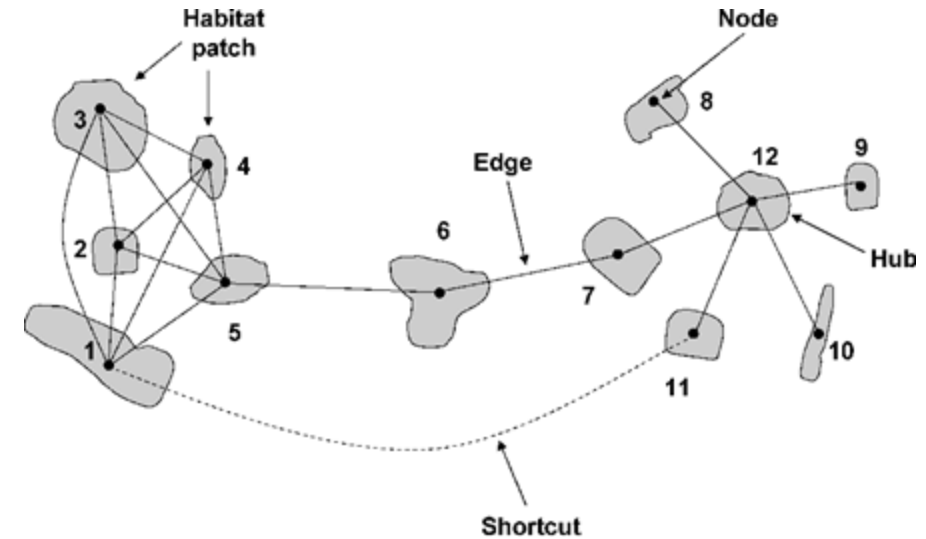


Network Approach

Equivalent Connected Area (ECA)

Represents the area of a perfectly connected habitat that would provide the same connectivity value as the actual, fragmented landscape.

- **Includes:**
 - (1) patch size
 - (2) distance between patches
 - (3) dispersal abilities of organisms, and
 - (4) resistance to movement (based on human footprint).
- Expressed as a percentage of the **Reference Condition** (i.e., pre-disturbance connectivity)



$$ECA = \sqrt{\sum_{i=1}^n \sum_{j=1}^n a_i a_j p_{ij}^*}$$

a_i = Area of patch 1 a_j = Area of patch 2

p_{ij} = Maximum probability of connection between i and j (a function of distance and cost)



Reference Condition

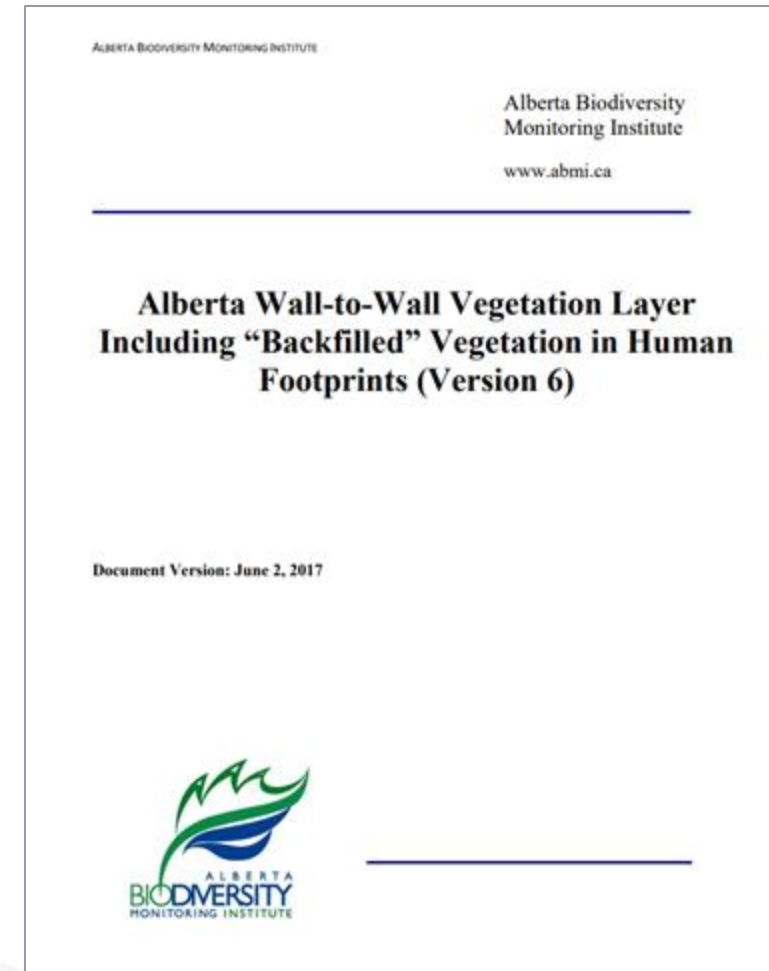
Importance:

- ECA requires an “equivalent” (footprint-free) reference condition for comparison.
- Reference should be as analogous to the modern landscape as possible, without human footprint.

Decision:

- The ABMI backfill layer represents a de-footprinted landscape which isolates the impacts of disturbance on connectivity.

More info at abmi.ca.



Network Approach

Advantages of the ECA approach

ECA is particularly useful for land-use applications because:

- Translates complex spatial patterns into a single, interpretable value.
- Allows comparison across regions and time periods.
- Helps identify critical areas for maintaining or restoring connectivity.
- Supports decisions via scenarios by showing how development affects ecological networks.



$$ECA = \sqrt{\sum_{i=1}^n \sum_{j=1}^n a_i a_j p_{ij}^*}$$

a_i = Area of patch 1 a_j = Area of patch 2
 p_{ij} = Maximum probability of connection between i and j (a function of distance and cost)

ECA ~

Size of patches (+)

Proximity of patches (+)

Dispersal limitation (-)

Cost to move
between patches (-)



Sensitivity of Indicator

Human Footprint

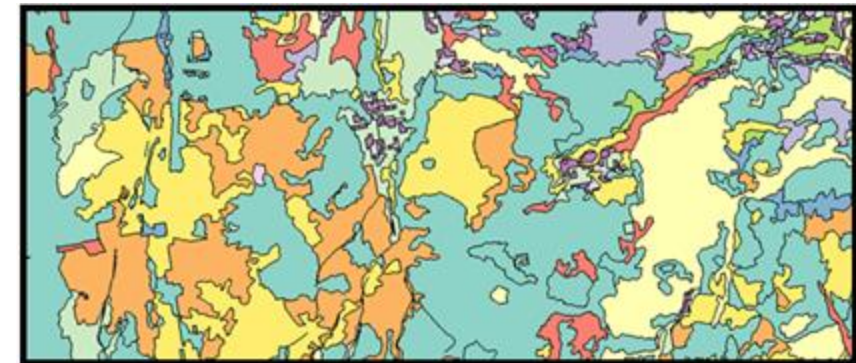
- Human footprint features impede movement of organisms.
- Different feature types have different impacts on movement of different organisms.
- **The indicator uses ABMI's Provincial Human Footprint Inventory (HFI) to capture anthropogenic barriers.**
- HFI contains >7 million individual features of >100 feature types (e.g., roads, harvest areas, pipelines, urban).

LEVEL_1	LEVEL_2	FEATURE_TY	Marrec et al 2020
Agriculture and aquaculture	Annual and perennial non-timber crops	CROP	0.75
Agriculture and aquaculture	Livestock farming and ranching	CFO	1
Agriculture and aquaculture	Livestock farming and ranching	ROUGH_PASTURE	0.25
Agriculture and aquaculture	Livestock farming and ranching	TAME_PASTURE	0.6
Energy production and mining	Mining and quarrying	WELL-ABAND	0.1
Energy production and mining	Mining and quarrying	WELL-BIT	0.4
Transportation and service corridors	Logging and wood harvesting	HARVEST-AREA-	0
		15	



Landcover / Habitat

- Species often use a subset of habitat types that are available to them.
- From this perspective, many natural landscapes never had “100%” connectivity.
- **The indicator aggregates the landscape into three classes: Upland Forest, Lowland Forest, Grass-Shrub.**



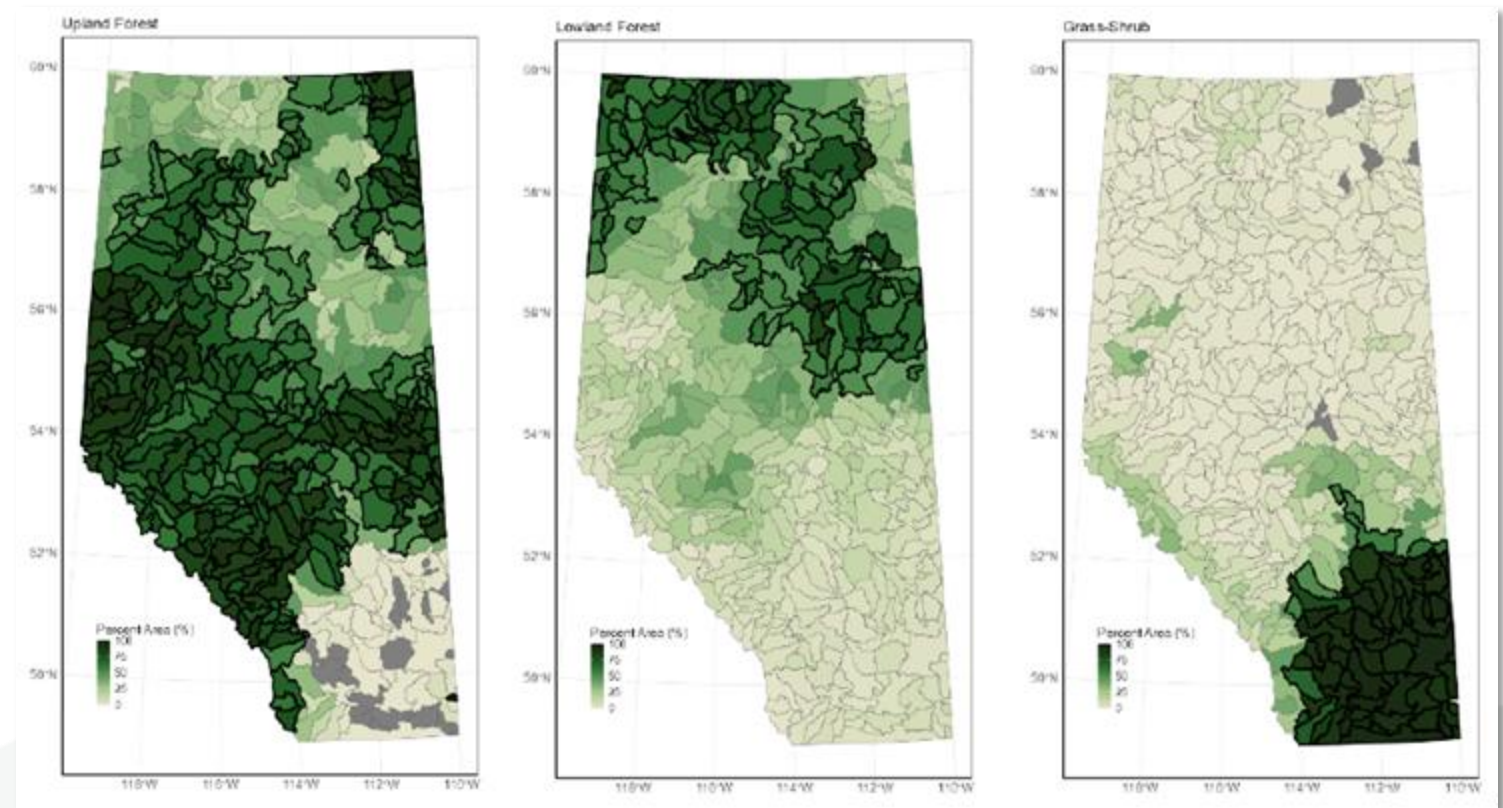
Habitat classification

3 habitat types: Upland Forest, Lowland Forest, Grass-Shrub

Province is divided into three dominant habitat types that broadly represent different Natural Regions:

1. Upland Forest (left)
2. Lowland Forest (centre)
3. Grass-Shrub (right)

Note: Streams and rivers were not considered as habitat types for this indicator.

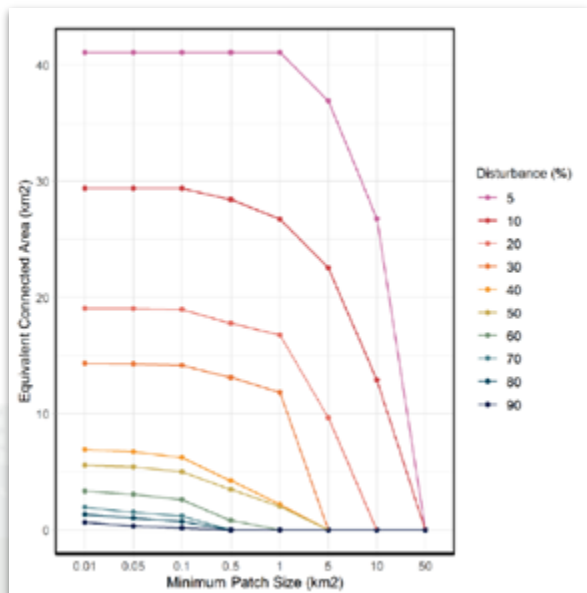


3. A (not-so) technical explanation of the indicator

Sensitivity of the Indicator

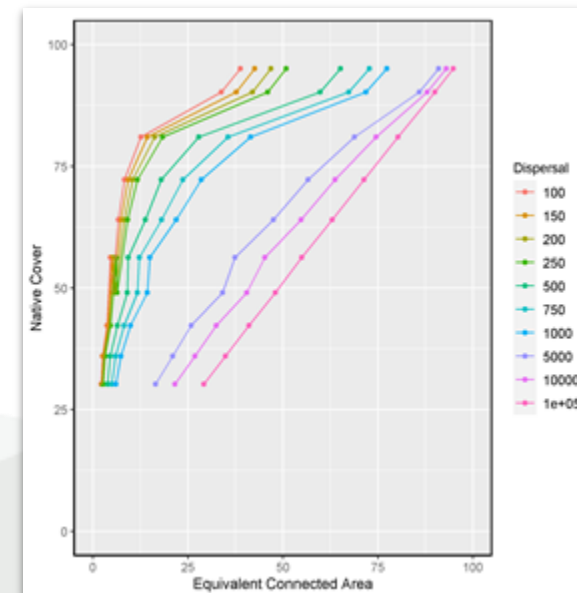
Minimum Patch Size

- Influences how quickly the indicator declines in response to new disturbance.
- **Minimum patch size is set to 1 ha (100 m x 100 m):**
 - Allows indicator to be responsive to new disturbance in small native habitat patches
 - Prevents the indicator from converging rapidly to zero under varying amounts of human disturbance
 - Reduces the computational resources



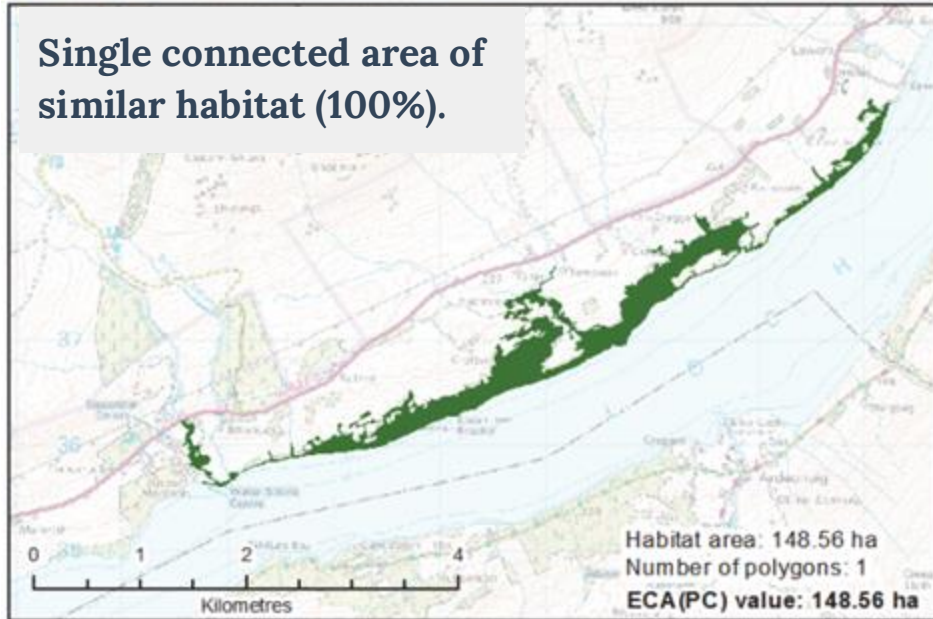
Dispersal Distance

- Determines how far hypothetical “species” can travel between patches of native habitat.
- **Indicator uses a single 250m dispersal distance:**
 - A single species-agnostic distance that captures a gradient of connectivity values across the province.
 - Simplifies indicator application in land-use planning.
 - Reduces computational resources.

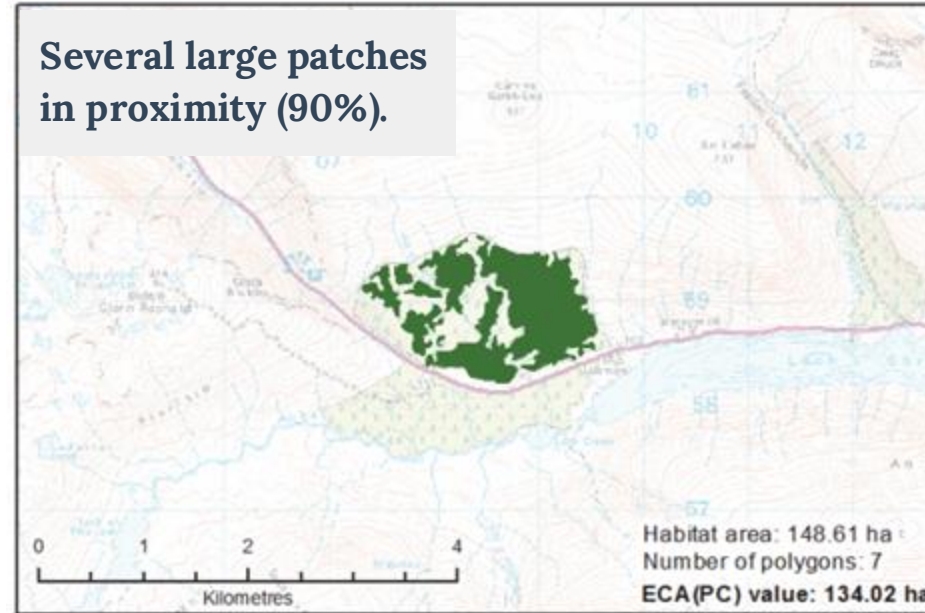


3. A (not-so) technical explanation of the indicator

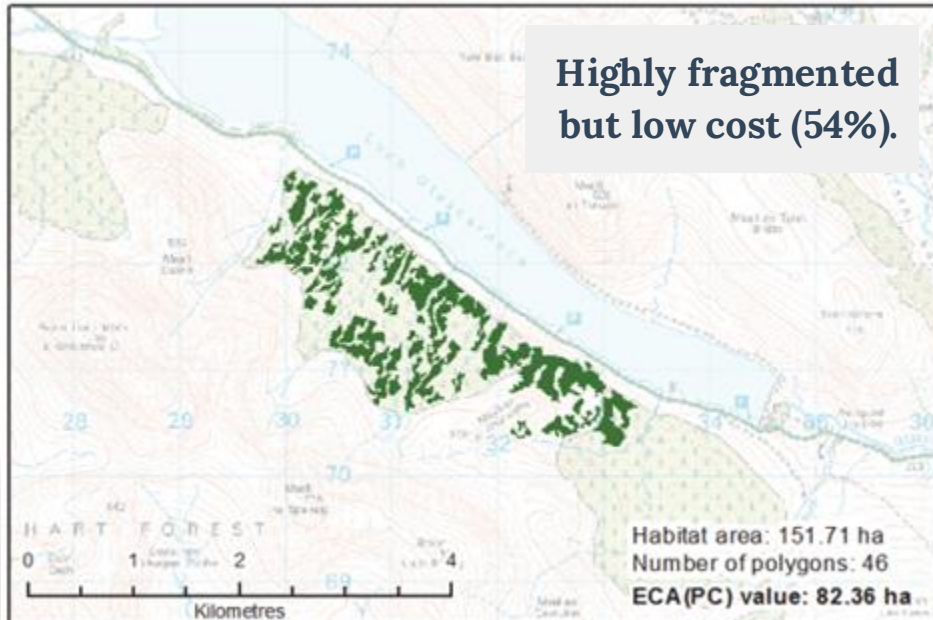
Single connected area of similar habitat (100%).



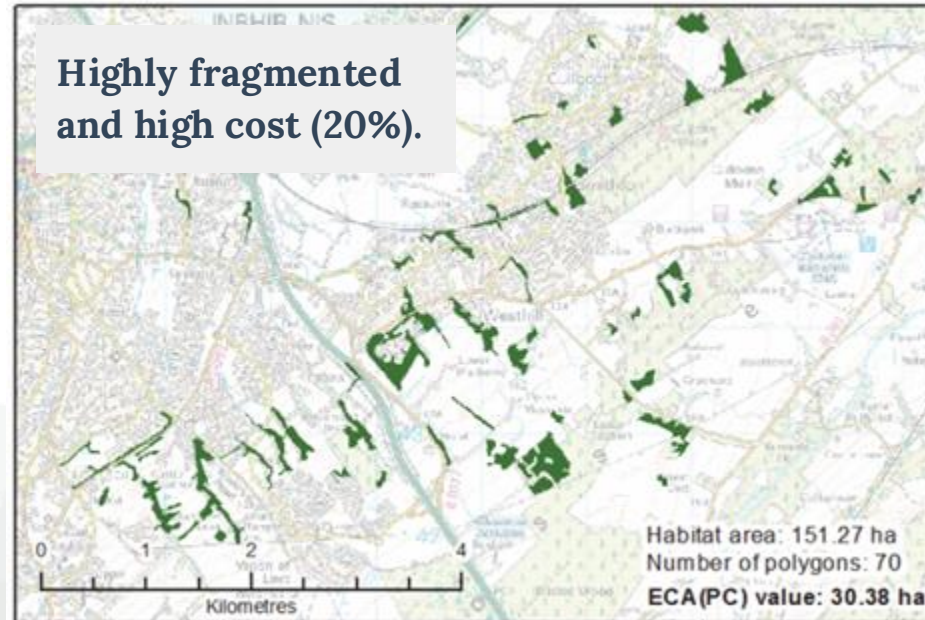
Several large patches in proximity (90%).



Highly fragmented but low cost (54%).



Highly fragmented and high cost (20%).



Blake, D., and P. Baarda.
(2018) *Developing a Habitat Connectivity Indicator for Scotland*. Scottish Natural Heritage Research Report, No. 887.



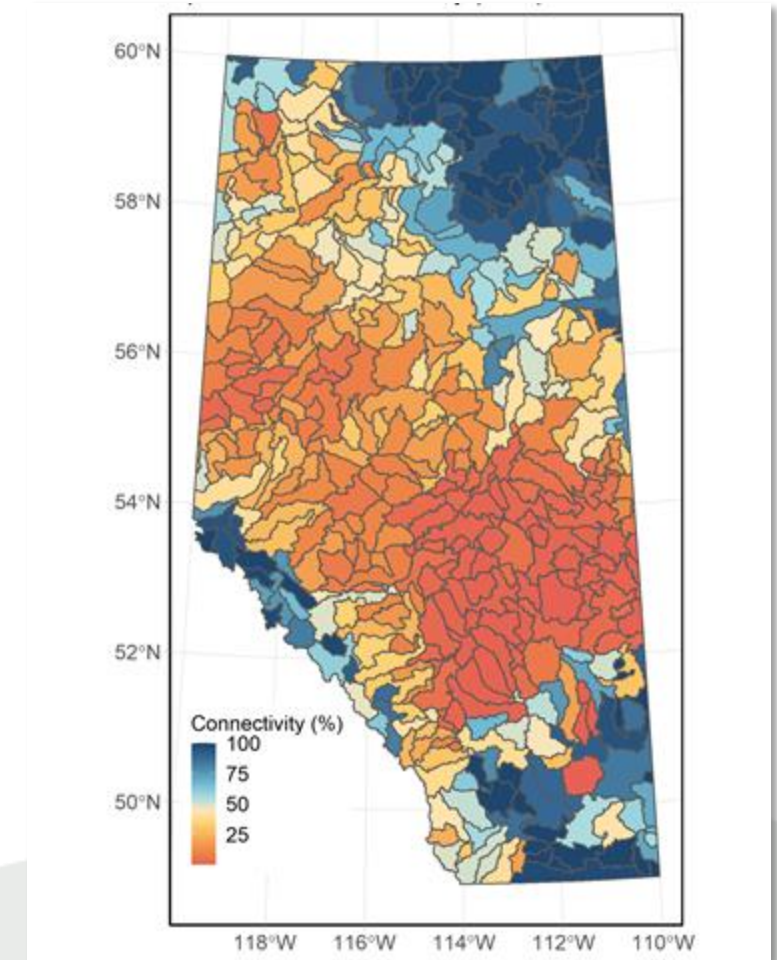
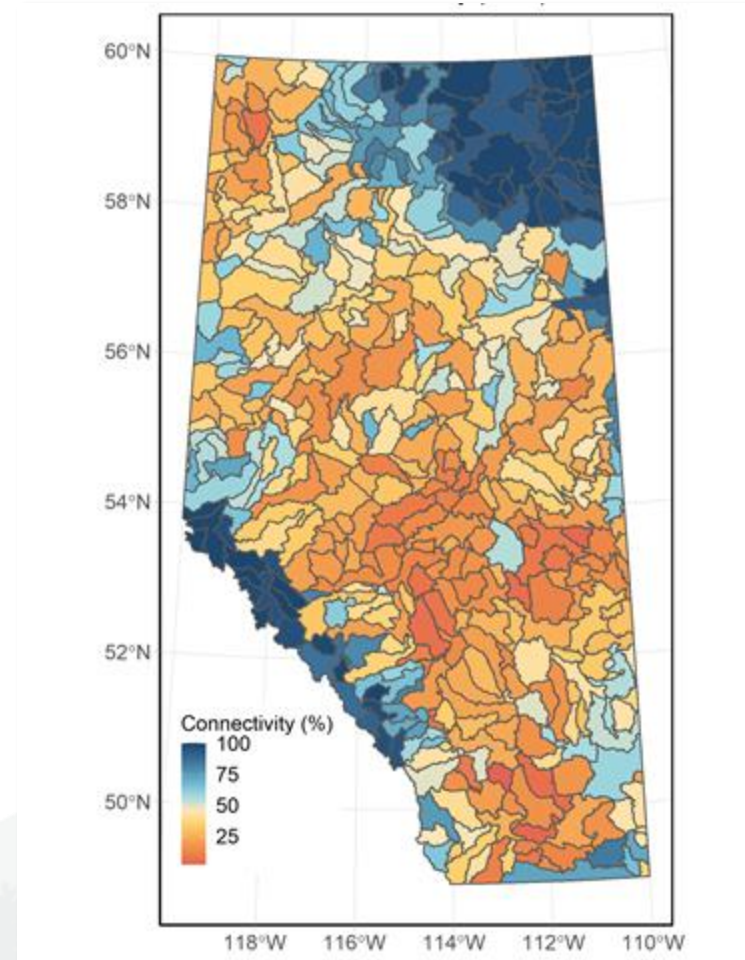
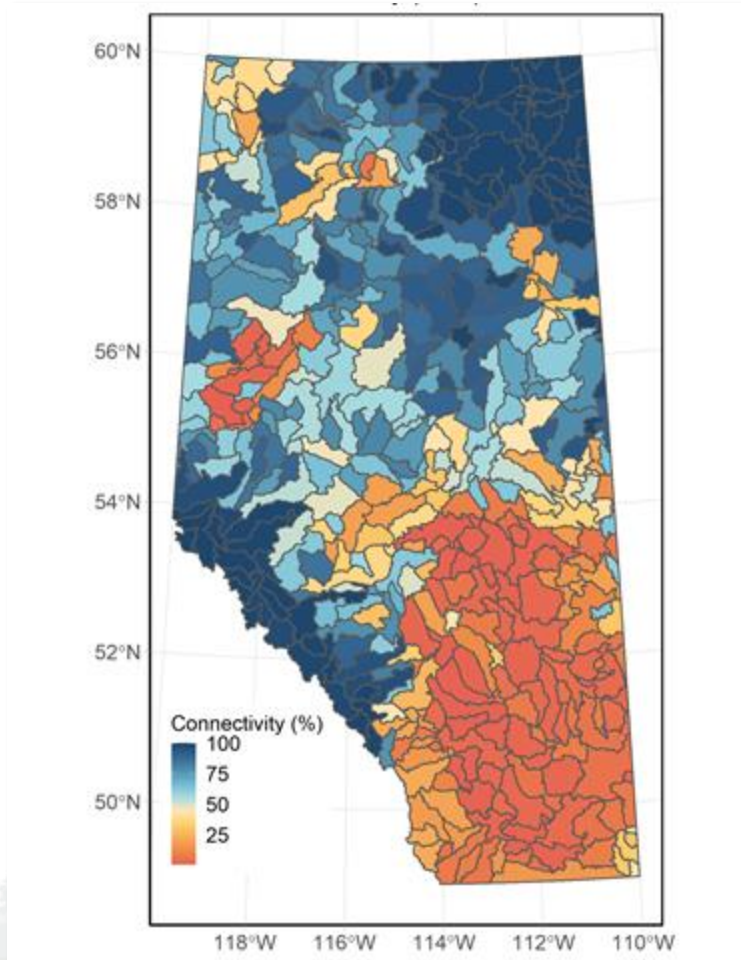
4. Example: Landscape Connectivity Assessment and Reporting

Results at the HUC-8 Watershed Scale (Habitat type)

Grassland

Lowland forest

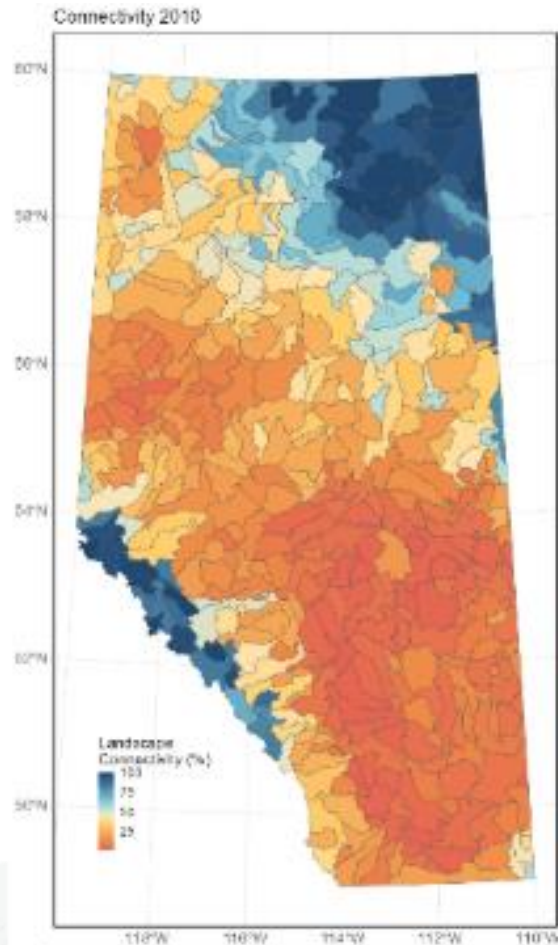
Upland forest



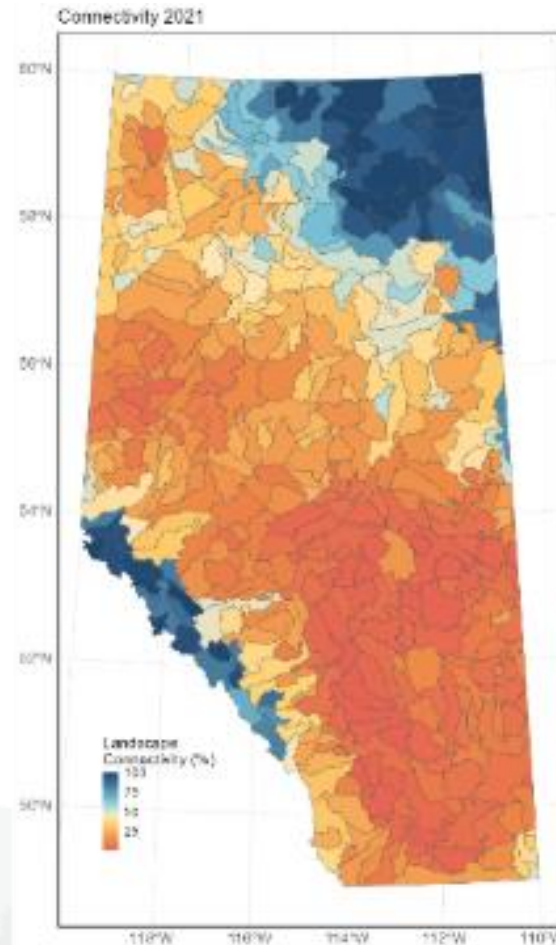
4. Example: Landscape Connectivity Assessment and Reporting

Results at the HUC-8 Watershed Scale (Aggregate)

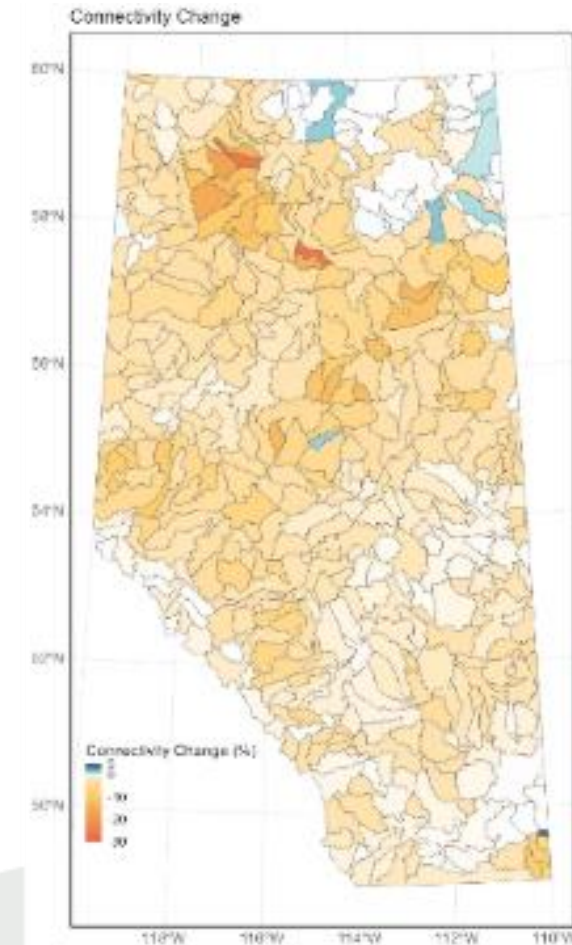
2010



2021

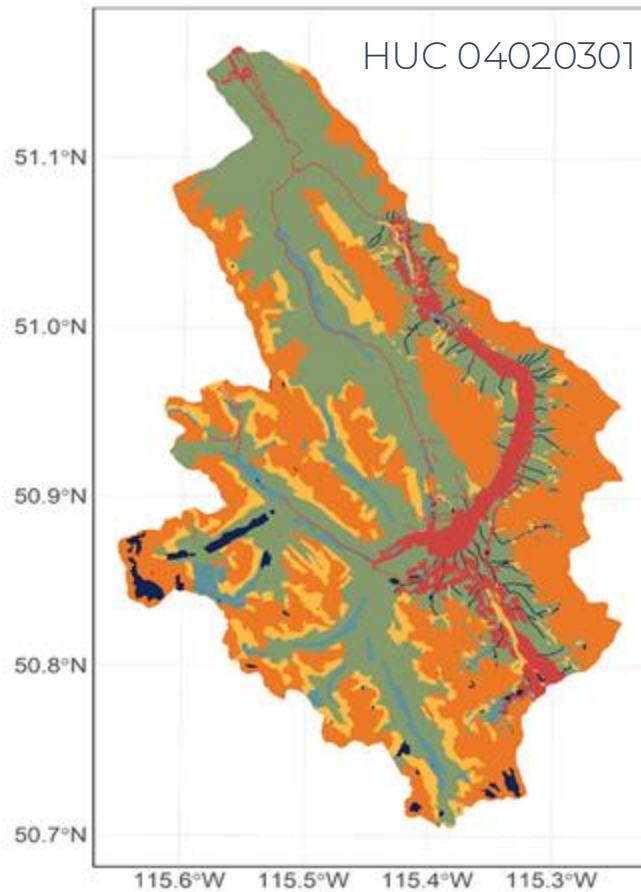


% Change

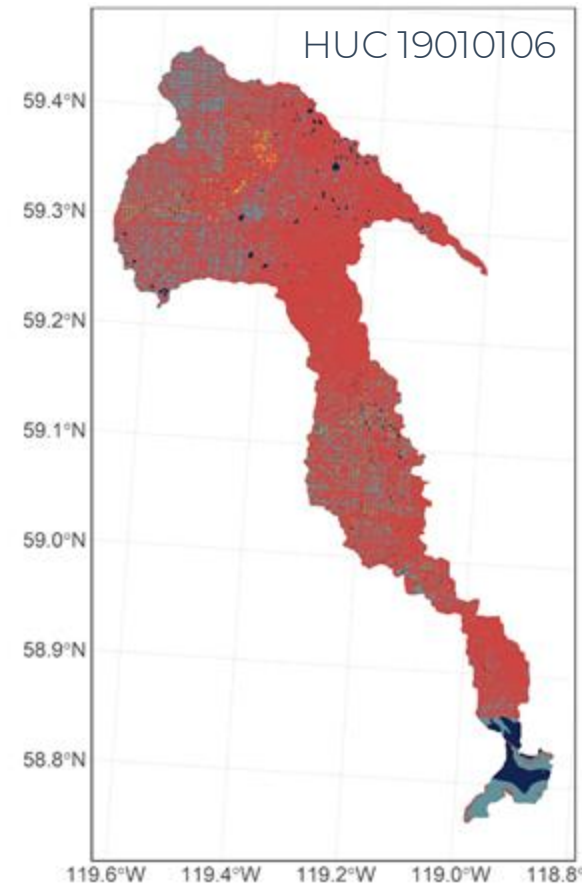


4. Example: Landscape Connectivity Assessment and Reporting

Better than most



Worse than most



Predominant in:	Rocky Mountain and Foothills natural regions	Boreal natural region (Northwest Alberta).
% Human Footprint	Low (4.8%)	Low (9.7%)
% Connectivity	High (81.8%)	Low (17.2%)
Driven by	Concentrated HF & Large native patches	Sprawling linear features & bifurcation of connected habitat



Intent of the indicator:

To serve as a general indicator of habitat connectivity at the regional and sub-regional levels for land-use applications.

Data and report are available on

<https://open.alberta.ca/publications/landscape-connectivity-indicator-for-alberta>

Limitations:

- It's a species agnostic approach. While it is intended to represent landscape connectivity for a large suite of species, it may not capture all species.
- It doesn't not capture the connectivity of migratory species or identify specific connectivity corridors.
- Recovery of human footprint is only incorporated for forest harvest areas through recovery curves and for those features that have been reclaimed and are no longer present in the Human Footprint Inventory.

The screenshot displays the Alberta Government website's 'Publications' section for the 'Landscape connectivity indicator for Alberta'. The page features a search bar at the top right and navigation tabs for 'Resources' and 'Interact'. Below the navigation, there are links for 'Open Data', 'Publications', and 'Documentation'. The main content area shows the publication title, a 'Summary' tab, and a 'Description' section. The description states that the indicator quantifies the amount of undisturbed landcover and its configuration in the province of Alberta, intended to measure and track connectivity of three broad forest types (Forest and Grass-Shrub) compared to the state of the landscape in the absence of human footprint. The 'Updated' date is August 12, 2024. The 'Tags' section includes 'Equivalent Connected Area', 'Grass-Shrub', 'Lowland Forest', 'Upland Forest', and 'biodiversity indicators'. The 'Resources' section lists the publication title with 'More Information' and 'Download' buttons. The 'Downloads' count is 243. On the right side, there is a map of Alberta titled 'Connectivity 2021' showing landscape connectivity percentages. The map uses a color scale from blue (low connectivity) to red (high connectivity). The legend indicates 'Landscape Connectivity (%)' with values 21, 52, 83, and 123.





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Alberta Environment and Protected Areas. "Landscape Connectivity Indicator for Alberta." Spatial Data Layer. Government of Alberta, August 12, 2024.
<https://open.alberta.ca/publications/landscape-connectivity-indicator-for-alberta>.

