

LANDSCAPE RESILIENCE

CONCEPTS & SCORE

THIS IS NOT AN OVERVIEW OF THE LANDSCAPE RESILIENCE TOOL

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What is Landscape Resilience?

- NCC infers the term **Landscape Resilience** as the capacity for biodiversity to recover from local losses and persist at the landscape scale.
- For a **landscape** to be **resilient**, it must be able to **adapt** to pressures over time in a way that supports the **long-term survival** of biodiversity and ecosystems.
- Landscape Resilience within this context considers **ecological variables** and aligns more closely with **Ecological Resilience** defined in the academic literature.
- NCC's Landscape scale is **1km x 1km** square pixel



How can NCC Contribute to Landscape Resilience?

- Addressing the existing protected area **gaps** to better **represent** ecosystems, increase **connectivity** and promote species **persistence** within intact landscapes.
- By building a system of protected areas with a **diverse** ecological portfolio to help **mitigate** the risk of biodiversity loss.
- Adding redundancy of species and their habitat through protection ensures persistence of biodiversity at the **landscape level** (Peterson, Allen & Holling, 1998).



Why is a Score Needed?

- To **operationalize** the concept of Landscape Resilience.
- To consolidate conservation variables that support the definition of Landscape Resilience into a **single composite metric**.
- To **assess** a project's contribution to Landscape Resilience and **validate** securement.
- Provide basis for directing **limited resources** to those areas on the landscape where they are likely to have the **greatest benefit**.



How will the Score be used?

1. Enhance **Where To Work** site selection outputs
 - Extracting the Landscape Resilience Score to Where To Work outputs provides a continuous variable to assess Landscape Resilience between planning units.
2. Guide Project Management Plans and validate **Securement**
 - Extracting the Landscape Resilience Score to parcel boundaries provides a means to assess a projects contribution to Landscape Resilience.

Landscape Resilience Tool is the interface to extract the **score**



What makes up the Score?

NCC valued conservation themes that capture concepts of Landscape Resilience impacts and risks:

1. **Protection:** existing conservation
2. **Biodiversity:** richness, adequacy, key biodiversity areas, critical habitat
3. **Connectivity:** current density
4. **Climate:** centrality, refugia
5. **Habitat:** forest, wetland, grassland, rivers, shoreline
6. **Threats:** human disturbance, climate extremes



Landscape Resilience Score Inputs

Protection

- Protected areas contribute to Landscape Resilience by safeguarding species from threats of biodiversity loss.
- Protected areas that intersect other themes of **Biodiversity**, **Connectivity** and **Climate** with less influence of **Threats** are more resilient.

Variable(s) that capture **Protection**:

- Existing conservation from [Canadian Protected and Conserved Areas Database](#)
- NCC fee simple and conservation agreement achievements
- All classes of protections is considered equal



Landscape Resilience Score Inputs

Biodiversity

- Biodiversity theme is captured by mapping species data and calculating cumulative adequacy goals for each individual species.
- The adequacy goal explains the required protection needed to ensure species persistence throughout time; where some species need more conservation than others.

Variable(s) that capture Biodiversity:

- Species at risk: richness & cumulative adequacy goal ([ECCC](#))
- Endemic species: richness & cumulative adequacy goal (NSC)
- Common species: richness & cumulative adequacy goal (IUCN & NSC)
- Key biodiversity areas ([IBA Canada](#))
- Critical habitat for species at risk ([ECCC](#))



Landscape Resilience Score Inputs

Connectivity

- Landscapes that are connected promote the movement of species among habitat patches
- High connectivity values favor biological flows and represent movement and dispersal patterns of species.

Variable(s) that capture Connectivity:

- Current density ([Pither et al, 2023](#))
 - Considered anthropogenic and natural features and their known effects on the movement of terrestrial non-volant fauna to predict connectivity.



Landscape Resilience Score Inputs

Climate

- Related to connectivity, it is important to adjust for the effects of climate change and give species the opportunity to move as climate conditions change.
- Areas that provide climate resiliency increase the Landscape Resilience Score

Variable(s) that capture Climate:

- Climate refugia (Stralberg et al. 2021; [AdaptWest](#))
 - Locations with rare climatic conditions that are likely to facilitate species persistence under climate change
- Climate centrality (Carroll et al. 2018; [AdaptWest](#))
 - Represents connectivity between current and future climate analogs



Landscape Resilience Score Inputs

Habitat

- By securing a diverse portfolio of habitat types ensures redundancy is built into the protected area network.
- Habitat types reflect NCC impact metrics.

Variable(s) that capture Habitat:

- Forest landcover hectares ([VLCE2](#) and [AFFC LUTS](#))
- Wetland hectares ([CanVec](#))
- Grassland hectares ([AAFC LU](#))
- River kilometers ([NRCan](#))
- Shoreline kilometers ([CanVec](#))



Landscape Resilience Score Inputs

Threats

- Habitat pressures pose a negative impact on Landscape Resilience.
- Protected areas decreases the threat of biodiversity loss from anthropogenic pressures.

Variable(s) that capture Threats:

- Human footprint index ([UNBC](#))
 - considers built environments, population density, nighttime lights, crop lands, pasture lands, forestry, railways, roads dams, reservoirs, navigable waterways, mining and oil and gas disturbances.
- Climate extremes ([La Sorte et al. 2021](#))
 - Useful way to capture extreme stressors on biodiversity



Landscape Resilience Score Details

Each variable is **scaled** between **0** and **1** before the score is executed. This step is required to combine features that have different units of measurement.

For variables that have **extreme** concentration of high or low values, a **log** transformation is applied before scaling.

Scaling equation:

Normalized feature = (feature – min value) / (max value – min value)



Landscape Resilience Score Details

Landscape Resilience Score =

$$\begin{aligned} & (\text{protection} * \text{value}) + \\ & (\text{key biodiversity area} * \text{value}) + (\text{critical habitat} * \text{value}) + (\text{SAR richness} * \text{value}) + (\text{END richness} * \text{value}) + \\ & (\text{common richness} * \text{value}) + (\text{SAR goal} * \text{value}) + (\text{END goal} * \text{value}) + (\text{common goal} * \text{value}) + \\ & (\text{connectivity} * \text{value}) + \\ & (\text{climate centrality} * \text{value}) + (\text{climate refugia} * \text{value}) + \\ & (\text{forest landcover} * \text{value}) + (\text{wetland} * \text{value}) + (\text{grassland} * \text{value}) + (\text{rivers} * \text{value}) + (\text{shoreline} * \text{value}) \\ & - (\text{human footprint index} * \text{value}) - (\text{climate extremes} * \text{value}) \end{aligned}$$

Where **value** represents the relative importance in rank with other variables in the equation.

Each unique 1km x 1km pixel has a score



Landscape Resilience Score Details

- For now, each variable gets an equal weight of **1**.
- Eventually, we will need to decide **IF** variables **should** or **should not** be influenced by a “**relative importance value**”.
- This decision should align with what NCC infers as **Landscape Resilience**.
- There is no **right** or **wrong** approach, as argument could be made for many different combinations.

Example of importance broken down by **Impact** and **Risk**:

Impacts = Protection > Biodiversity > Connectivity > Climate > Habitat

Risks = Threats





LANDSCAPE RESILIENCE BUILDER

THIS IS NOT THE LANDSCAPE RESILIENCE TOOL

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Landscape Resilience Builder

- Designed as an **engagement** tool that shows transparency in the make-up of the Landscape Resilience (LR) Score.
- Provides a **proto-type** of Landscape Resilience, where each **pixel** has a score
- Users can **change** values and update the **LR score** in real time. This provides a means to reason with the relative importance of layers that comprise the score.



Landscape Resilience Builder

LANDSCAPE RESILIENCE BUILDER

Biodiversity

Key Biodiversity Areas

1

Species at Risk, Critical Habitat

1

Species at Risk, Richness

1

Endemic Species, Richness

1

Common Species, Richness

1

Species at Risk, Goal

1

Endemic Species, Goal

1

Common Species, Goal

1

Connectivity

Connectivity

1

Climate

Refugia

1

Centrality

1

Habitat

Forest

1

Grassland

1

Wetland

1

Rivers

1

Shoreline

1

Protection

Existing Conservation

1

Threats

Human Footprint Index

1

Climate Extremes

1

RESET VALUES

UPDATE SCORE

Download score (.tif) and values (.xlsx)

PowerPoint

Web link

Update values

Legend

Landscape Resilience Equation

View layers one at a time

Toggle overlays

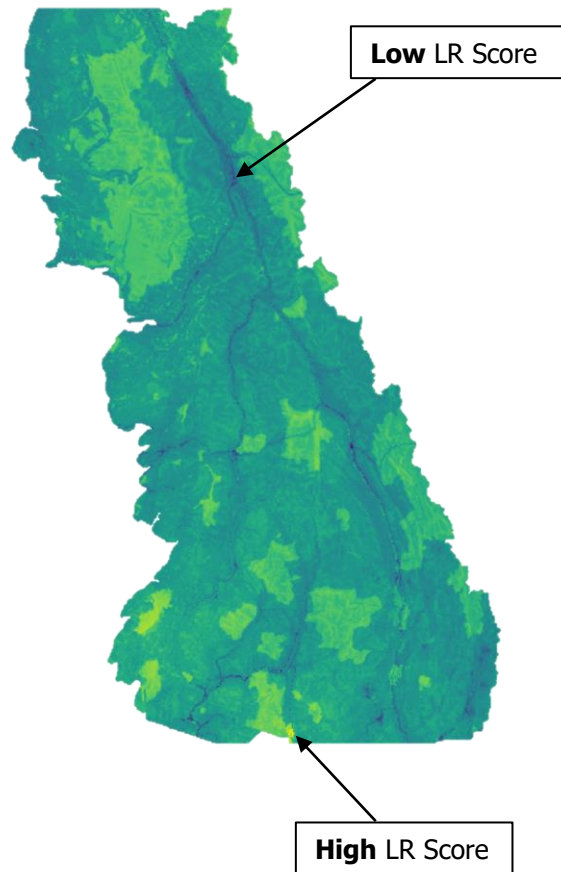
Click points to view LR Score

Landscape Resilience Score:

$$(KBA * 1) + (critical\ habitat * 1) + (SAR\ richness * 1) + (END\ richness * 1) + (common\ richness * 1) + (SAR\ goal * 1) + (END\ goal * 1) + (common\ goal * 1) + (climate\ refugia * 1) + (climate\ centrality * 1) + (connectivity * 1) + (forest * 1) + (grassland * 1) + (wetland * 1) + (rivers * 1) + (shoreline * 1) + (existing\ conservation * 1) - (human\ footprint * 1) - (climate\ extremes * 1)$$

NEXT STEPS

- Finding agreement on Landscape Resilience **definition**
- Finding agreement on Landscape Resilience **inputs**
- Finding agreement on Landscape Resilience **values**
- Communicating the difference between Landscape Resilience **concept, score** and **tool**



References

Ecological Resilience, Biodiversity and Scale

<https://link.springer.com/article/10.1007/s100219900002>

Resilience and stability of ecological systems:

<https://www.annualreviews.org/doi/abs/10.1146/annurev.es.04.110173.000245>

Metrics and Models for Quantifying Ecological Resilience at Landscape Scales:

<https://www.frontiersin.org/articles/10.3389/fevo.2019.00440/full>

Wild, connected, and diverse: building a more resilient system of protected areas:

<https://esajournals.onlinelibrary.wiley.com/doi/full/10.1002/eap.1527>

Understanding protected area resilience: a multi-scale, social-ecological approach:

https://esajournals.onlinelibrary.wiley.com/doi/abs/10.1890/13-2113.1?casa_token=a5GUcC01mnsAAAAA:dsV4tSiXnHfhPwnCutvAEmA-FGFrXO40JND730ft-ni6Oq_Eqe6GlarmszasTqznSmhyP1B2BW-0UNNg5

Landscape ecological concepts in planning: review of recent developments:

<https://link.springer.com/article/10.1007/s10980-021-01193-y>

Managing Rather Than Avoiding “Difficulties” in Building Landscape Resilience:

<https://www.mdpi.com/2071-1050/13/5/2629>

Quantifying spatial resilience:

<https://besjournals.onlinelibrary.wiley.com/doi/full/10.1111/1365-2664.12634>

Resilience in the Studies of Biodiversity-Ecosystem Functioning:

[https://www.cell.com/trends/ecology-evolution/fulltext/S0169-5347\(15\)00321-3](https://www.cell.com/trends/ecology-evolution/fulltext/S0169-5347(15)00321-3)

Perspectives for ecosystem management based on ecosystem resilience and ecological thresholds against multiple and stochastic disturbances:

<https://www.sciencedirect.com/science/article/pii/S1470160X15002411>

A riparian conservation network for ecological resilience:

<https://www.sciencedirect.com/science/article/pii/S0006320715002529#bb0155>

A resilient and connected network of sites to sustain biodiversity under a changing climate

<https://www.pnas.org/doi/10.1073/pnas.2204434119>

Biodiversity, ecosystem function, and resilience: ten guiding principles for commodity production landscapes

https://esajournals.onlinelibrary.wiley.com/doi/full/10.1890/1540-9295%282006%29004%5B0080%3ABEFART%5D2.0.CO%3B2?casa_token=ISM4aLrMYhcAAAA%3A7vbR7SrZmxu_f3k5FDiNeRWU9icdsIW24OMs6uA9QyAp6uCxU-JlKypg2ox7W9UpNIh2NCDROQtKxkV4l

