NATURE CONSERVANCY CANADA

LANDSCAPE RESILIENCE
CONCEPTS & SCORE

THIS IS NOT AN OVERVIEW OF THE LANSCAPE RESILIENCE TOOL

Dan Wismer
Conservation Data Specialist

Last major edit: Sep 14th, 2023

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?

- To strategically protect lands that **capture** species redundancy and **promote** connectivity.

- 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 know 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:

$$\text{Normalized feature} = (\text{feature} - \text{min value}) / (\text{max value} - \text{min value})$$

Landscape Resilience Score Details

Landscape Resilience Score =

(protection * value) +

(key biodiversity area * value) + (critical habitat * value) + (SAR richness * value) + (END richness * value) +

(common richness * value) + (SAR goal * value) + (END goal * value) + (common goal * value) +

(connectivity * value) +

(climate centrality * value) + (climate refugia * value) +

(forest landcover * value) + (wetland * value) + (grassland * value) + (rivers * value) + (shoreline * value)

- (human footprint index * value) - (climate extremes * value)

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

NATURE CONSERVANCY CANADA

LANDSCAPE RESILIENCE
BUILDER

THIS IS NOT THE LANSCAPE RESILIENCE TOOL

Dan Wismer

Conservation Data Specialist

Last major edit: Sep 14th, 2023

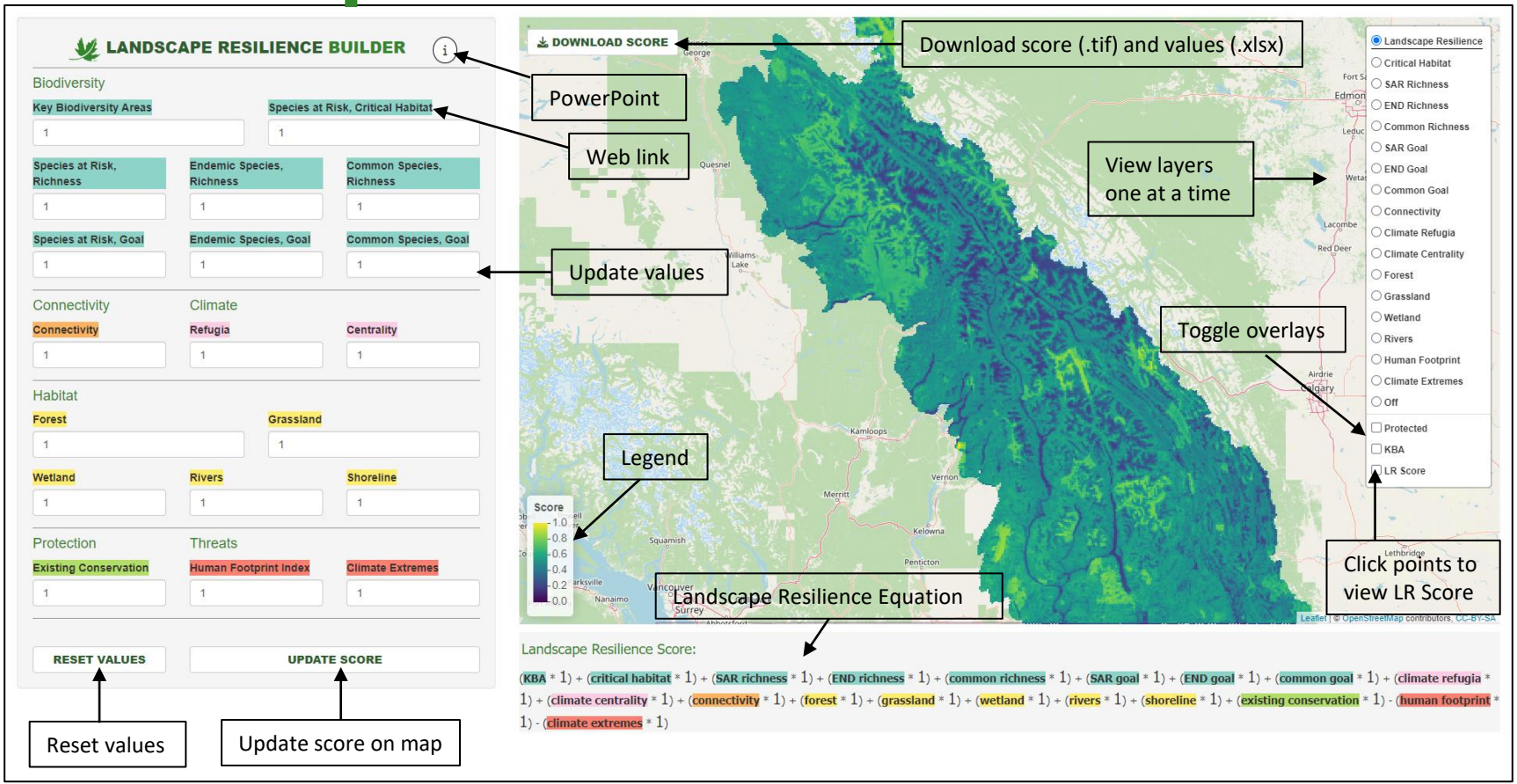
Landscape Resilience Builder

- 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

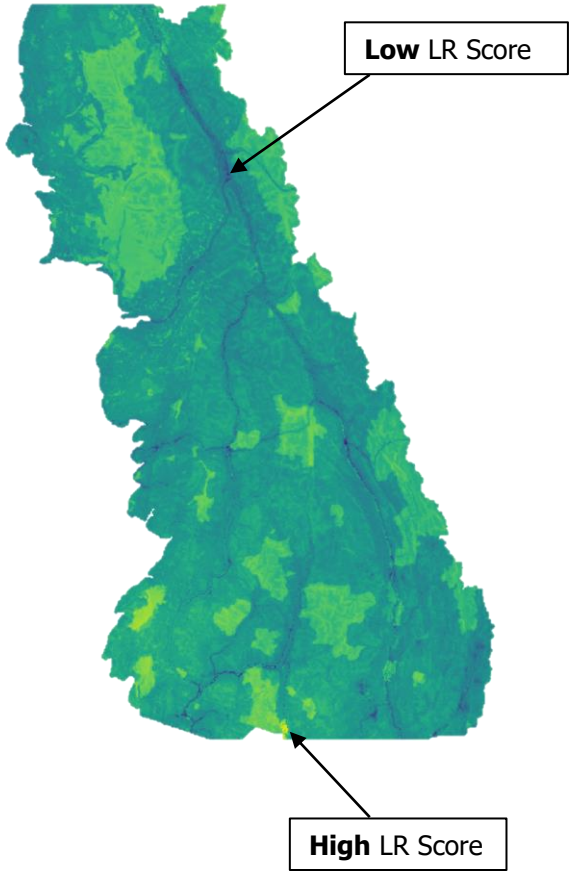
- Users can **change** values and update the **LR score** in real time. This provides a means to reason with the relative importance of layers that comprise the score.

Landscape Resilience Builder



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_Eqe6GlarmzasTqznSmhyP1B2BW-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

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=iSM4aLrMYhcAAAAA%3A7vbR7SrZmxu_f3k5FDiNeRWU9icdsIW24OMs6uA9QyAp6uCxU-JiKypg2ox7W9UpNIh2NCDROQtxkV4I