FragCube - Using Ecologically Scaled Landscape Indices for Monitoring Landscape Pattern in Canada's National Parks

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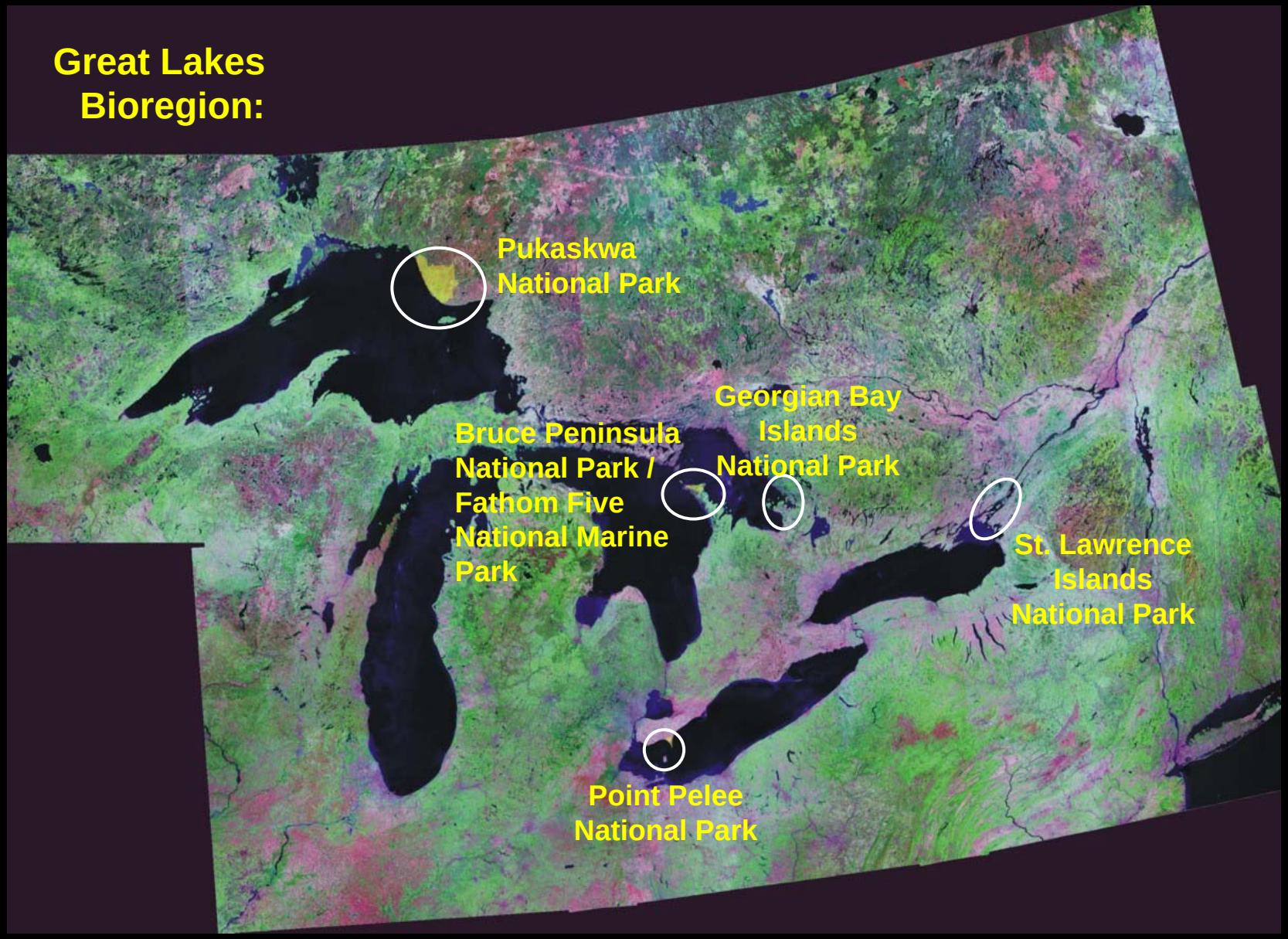
Outline

1. Project history
2. Proposed method
3. Application of the method to the Great Lakes Bioregion.
4. Conclusion

Canada

Great Lakes Bioregion:

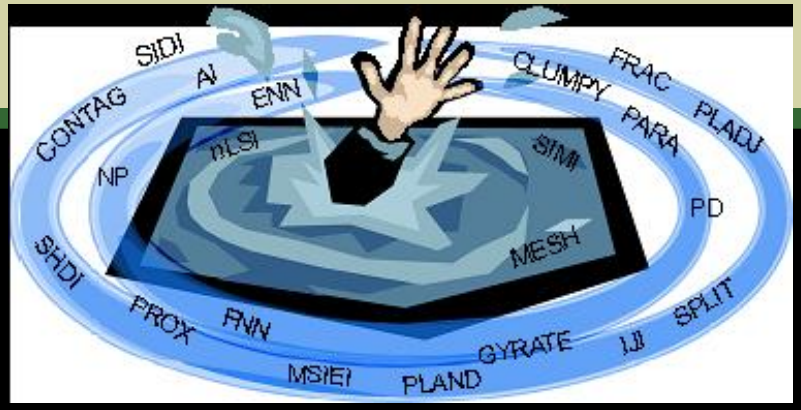


Measure Selection

Frag factor

- **Purpose: Develop standardized monitoring protocol for measuring changes in landscape pattern.**
- **Many fragmentation metrics *(110 at last count)* can be calculated from available software (eg, Fragstats 3.3) at the patch, class and landscape level.**
- **Metrics are based on the following groups (McGarigal et al., 2002) :**
  - **Area / Density / Edge, Shape, Core Area, Isolation / Proximity, Contrast, Contagion / Interspersion, Connectivity.**
- **Published studies on metric selection focus on multi-variate analyses to reduce collinearity and identify a concise subset of metrics that explains the majority of landscape pattern (Ritters et al., 1995).**

Multi-Variate Muddle?

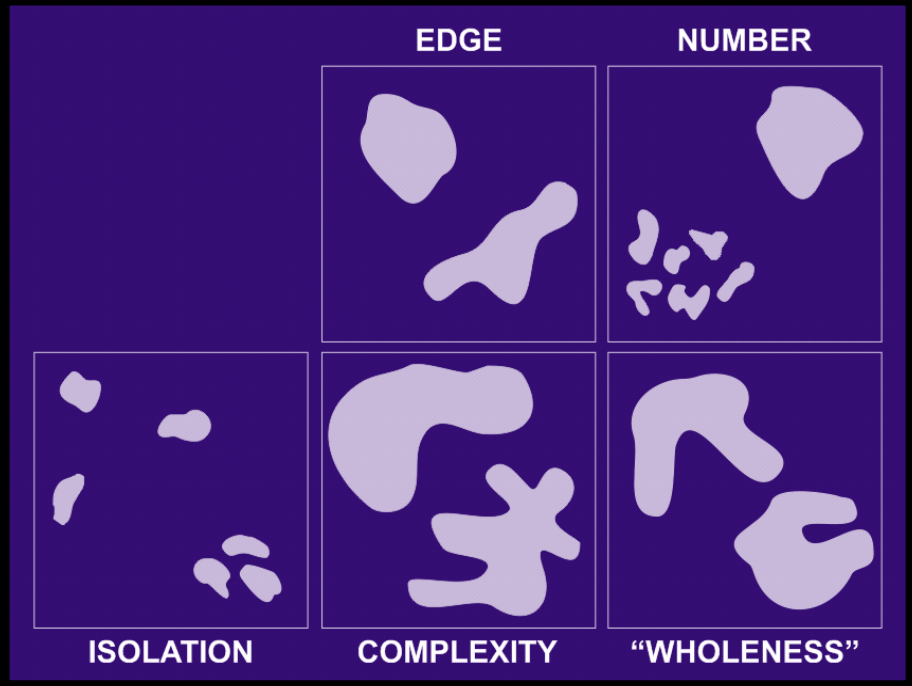


- Different published studies vary in their metric selection based on PCA. However, the basic groups of metrics are consistent (eg, area, shape, isolation).
- We conducted PCA on Fragstat metrics for all NP's in Ontario and their GPE's. Consistency among park's in their factor loadings.
- **Perimeter / Edge (PERIM), Contiguity Index (CONTIG), Fractal Dimension (FRAC), Nearest Neighbor (ENN), # of Patches (NP)**
- As the data changes (same landscape different time, same time different landscape) so will the pattern. Factor loadings will then likely change. Is this the right way to go?
- What is the ecological significance of changes in these metrics (eg, FRAC from 1.49 to 1.53)?

Ecological Theory and Thinking

- **Pattern recognition methods are only part of the solution. Ecological theory can support metric selection as well.**
  - **Island Biogeography, Metapopulation Theory, Landscape Ecology.**

- **Various metapopulation studies have demonstrated effects of *habitat amount and isolation (connectivity)* on viability by influencing extinction and colonization rates (eg, Levins 1969, Lande 1987, Gilpin and Hanski 1991).**



Proposed Measures

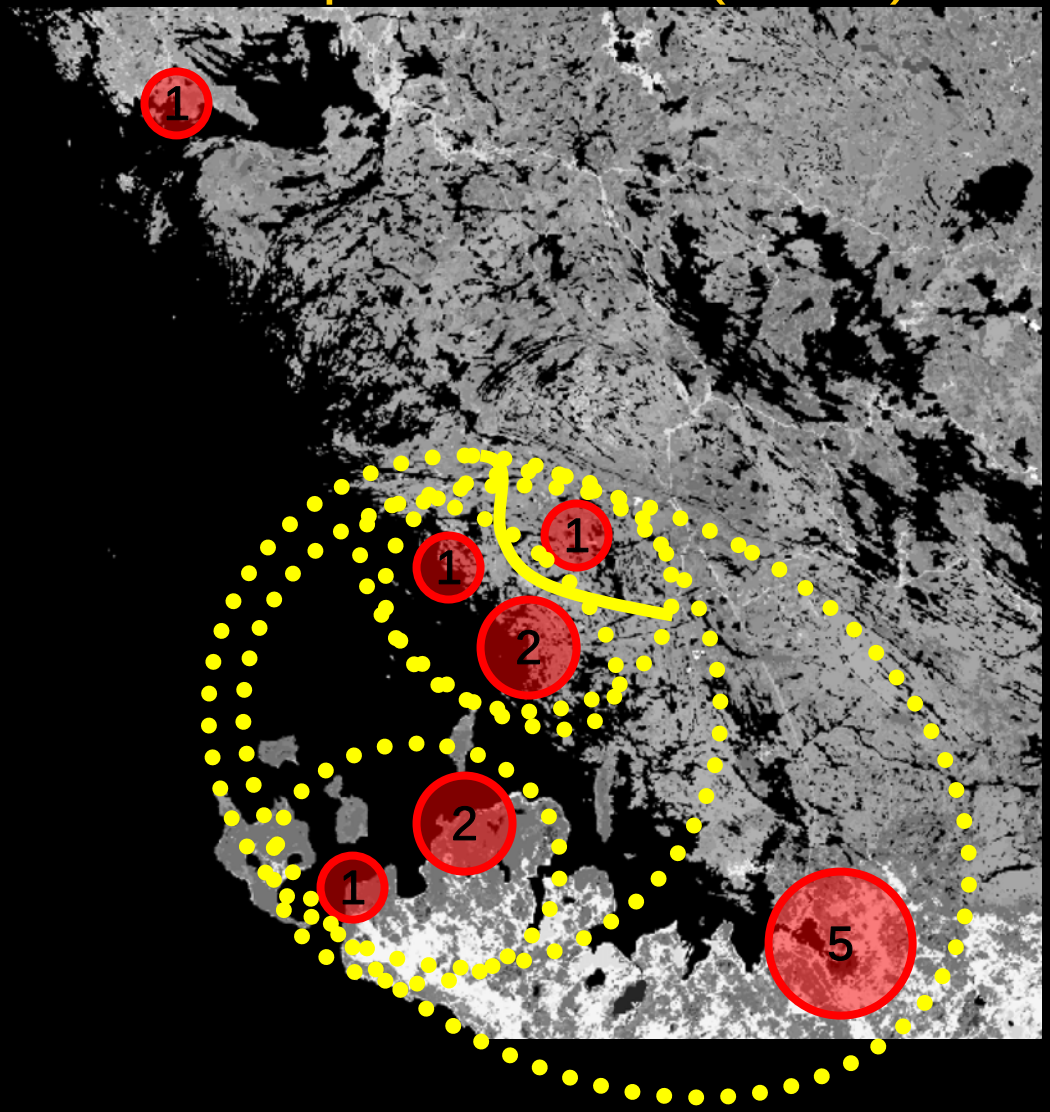
"Effective Patch Amount"

"Effective Patch Connectivity"

- **A parsimonious standardized set. Can add other metrics if desired *(eg, Perimeter / Edge (PERIM), Contiguity Index (CONTIG), Fractal Dimension (FRAC), Nearest Neighbor (ENN), # of Patches (NP).)***
- **Consistent with metapopulation theory and models.**
- **Consistent with landscape ecology and fragmentation multi-variate analyses.**
- **Appropriate for any landscape.**
- **Can be "ecologically scaled".**

Ecologically Scaled Landscape Indices (ESLI)

- **ESLI = Measures of landscape pattern interpreted from a species' perception.**
- ***"How big is big enough?" "How connected is connected enough?"* …depends on the species.**
- **Species' characteristics are used to "scale" the interpretation of landscape indices.**
- **ESLI's are new concepts first introduced in 2001 (Vos et al., 2001) but more prominent since 2004.**



Species Profiles

- Many characteristics can be used to create ESLI's.
- Niche breadth, movement behaviour, and spatial scale were selected to create ESLI's (Gehring and Swihart, 2003).

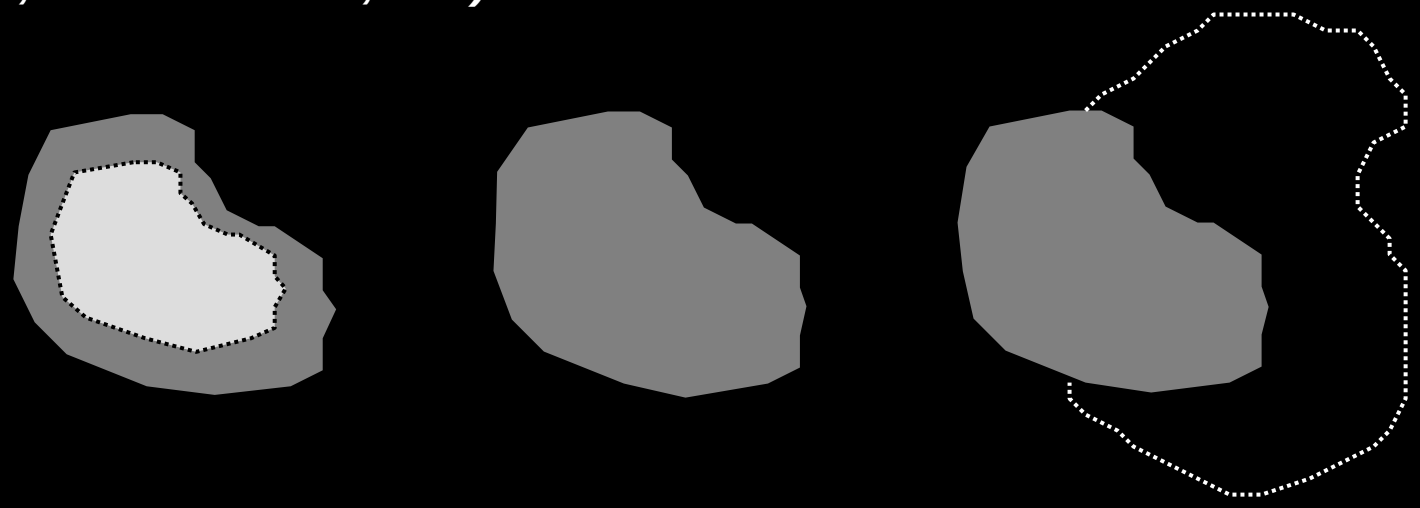
Niche Breadth

<u>Core Area</u>: Interior patch specialist.

<u>Patch</u>: Moderate.

<u>Aggregate</u>: Generalist able to use complementary patches of a different type. *(Decide for each ESLI what patch types are to be considered complementary.)*

- A range of definitions can be used to determine "patch" (eg, cover type, minimum size, etc.).

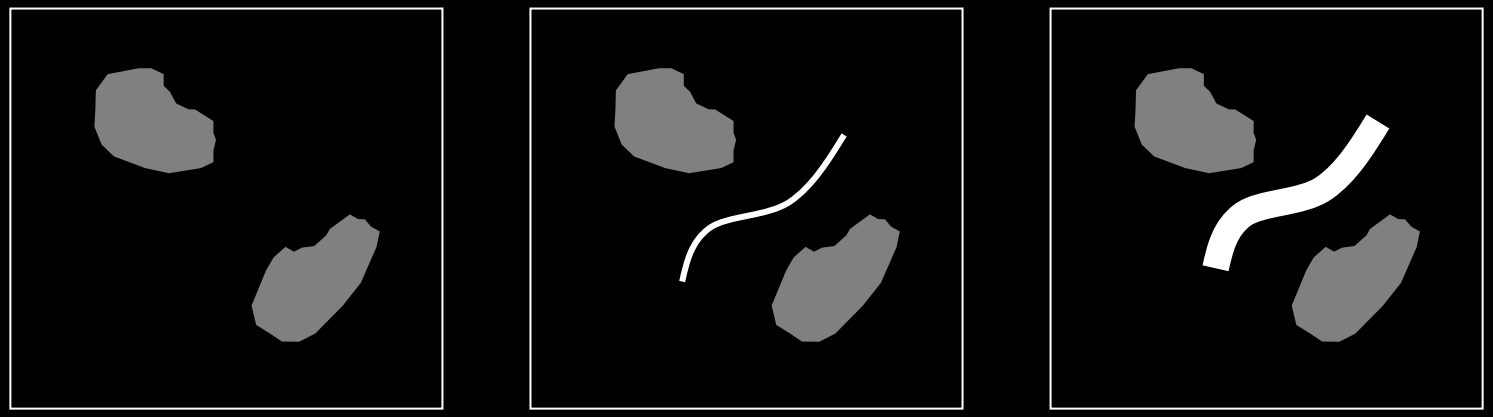


Movement Behaviour

<u>Euclidean Nearest Neighbour</u> (ENN): Movement between patches is unencumbered by the non-patch matrix. Connectivity is determined by proximity of patches.

<u>Weighted Nearest Neighbour</u> (w-ENN): Proximity is weighted by a cost surface created by the non-patch matrix (*<u>road density</u>*) .

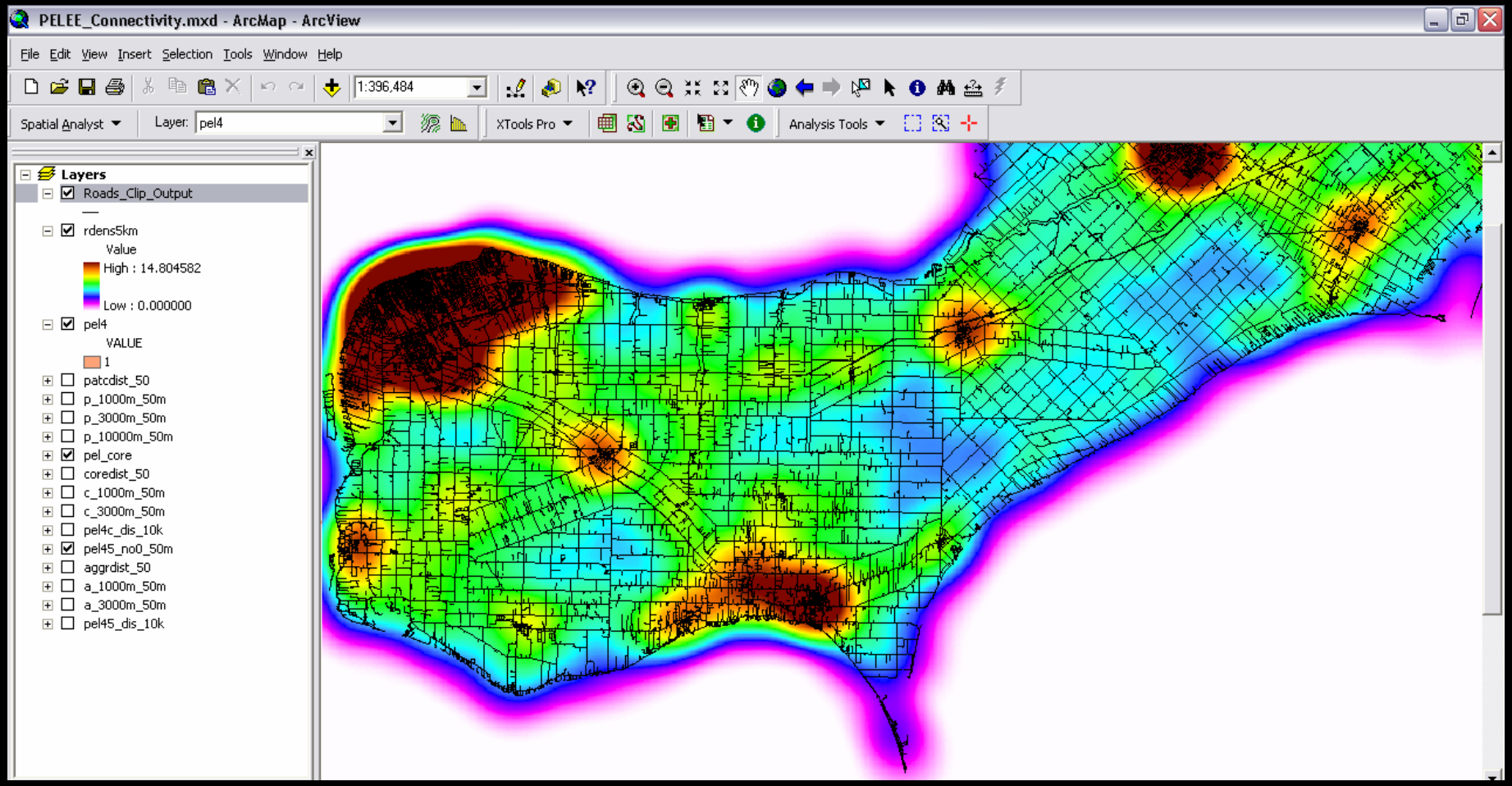
<u>Large Weighted Nearest Neighbour</u> (W-ENN): Cost surface is exaggerated to represent species especially sensitive to the matrix.



ENN **w-ENN** **W-ENN**

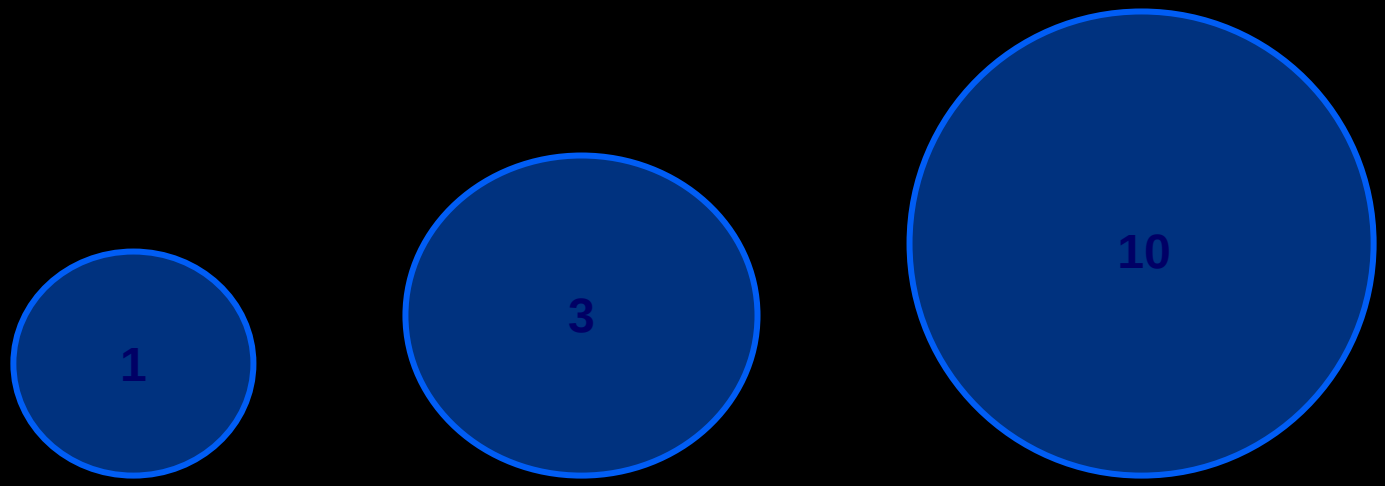
Cost Surface

- **Cost surfaces of road density incorporates the non-patch matrix and trends in human footprint.**



Spatial Scale

- **We selected home range sizes to represent small, medium and large dispersers (1km, 3km, and 10km radius) (Vos et al., 2001).**



ESLI: Profiles

Effective Patch Amount

Effective Patch Connectivity

Movement Behaviour

Niche Breadth

Spatial Scale

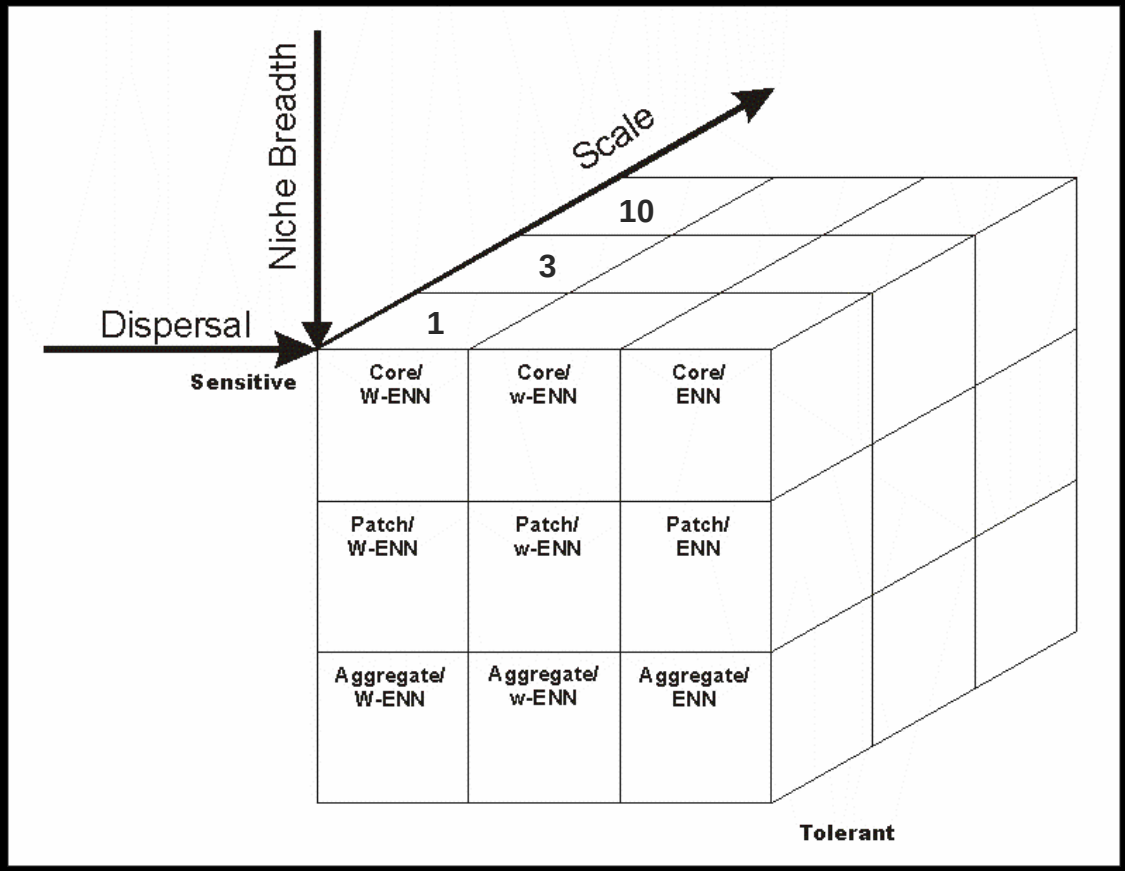
	sensitive	*moderate*	*tolerant*
narrow (specialist)	**sensitive**		
moderate			
wide (generalist)			**tolerant**

small
high

- **A specific interpretation of fragmentation is created for each cell in the "profile cube" *(does not have to be a cube). 3x3x3 cube contains 27 specific ESLI maps.***

ESLI: Profile Cube

- Maps are created for each cell in the Cube to represent a range of effects from landscape fragmentation.

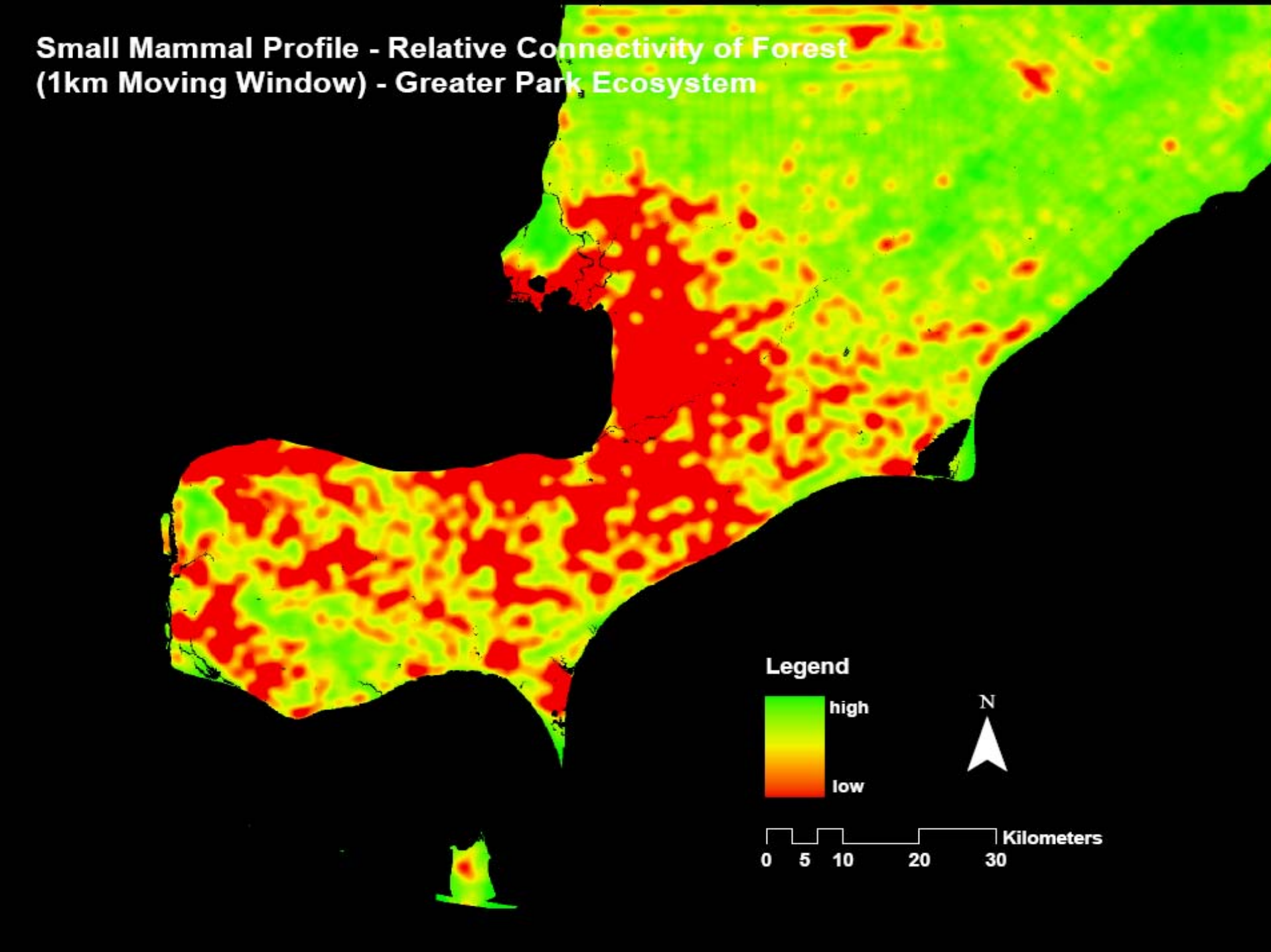


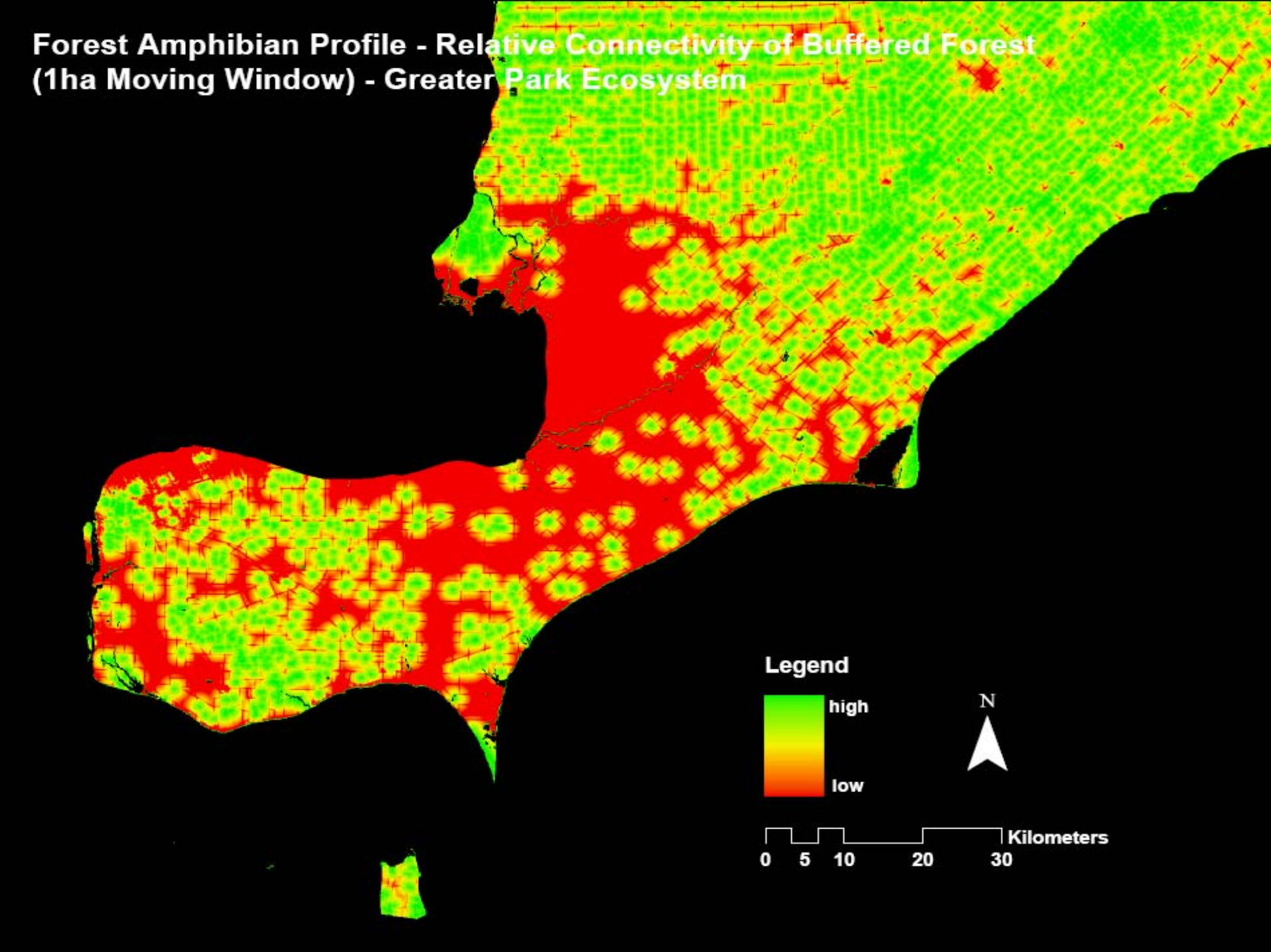
Gradient Maps

- **Landscape characteristics of discreet patches are analyzed using a <u>moving window gradient analysis method</u> (McGarigal et al., 2002).**
- **Size of window determined by ESLI.**
- **Patch definition determined by ESLI.**
- **Cost surface and weighting determined by ESLI.**
- **The amount of effective patch and effective patch isolation (weighted by cost surface) is analyzed within the window as it moves about the landscape.**
- **See *McGarigal and Cushman (2005)* for more info.**

Species Profiles

- In-park meetings at Bruce Peninsula, Point Pelee and St. Lawrence Islands (so far) to develop species profiles.
- Contract tendered to undertake comprehensive literature review to develop species profiles & ESLI's for all Ontario NP's.
- Examples to date...
  - Intolerant Hardwood Forest Birds (eg, least flycatcher, eastern wood pee-wee, scarlet tanager): Patch = dense deciduous buffered 50m adjacent to roads, water, agriculture, non-forest. Cost Surface = none. Scale = 10km.
  - Forest Amphibians (eg, woodfrog, spring peeper, eastern redbacked salamander): Patch = forest buffered 10m from any non-forest edge. Cost Surface = heavily weighted on road density, light weighted on trail density. Scale = 1ha.
  - Small Mammals (eg, meadow vole, white-footed mouse): Patch = forest, no edge effect. Cost Surface = heavily weighted on road density, light weighted on trail density. Scale = 1km.
  - Large Mammals (eg, coyote, black bear): Patch = non-converted of any type, no edge effect. Cost Surface = light weight on highways only. Scale = 10km.


Small Mammal Profile - Relative Connectivity of Forest
(1km Moving Window) - Greater Park Ecosystem
Legend
high
low
N
Kilometers
0
5
10
20
30


Forest Amphibian Profile - Relative Connectivity of Buffered Forest
(1ha Moving Window) - Greater Park Ecosystem
Legend
high
low
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Kilometers
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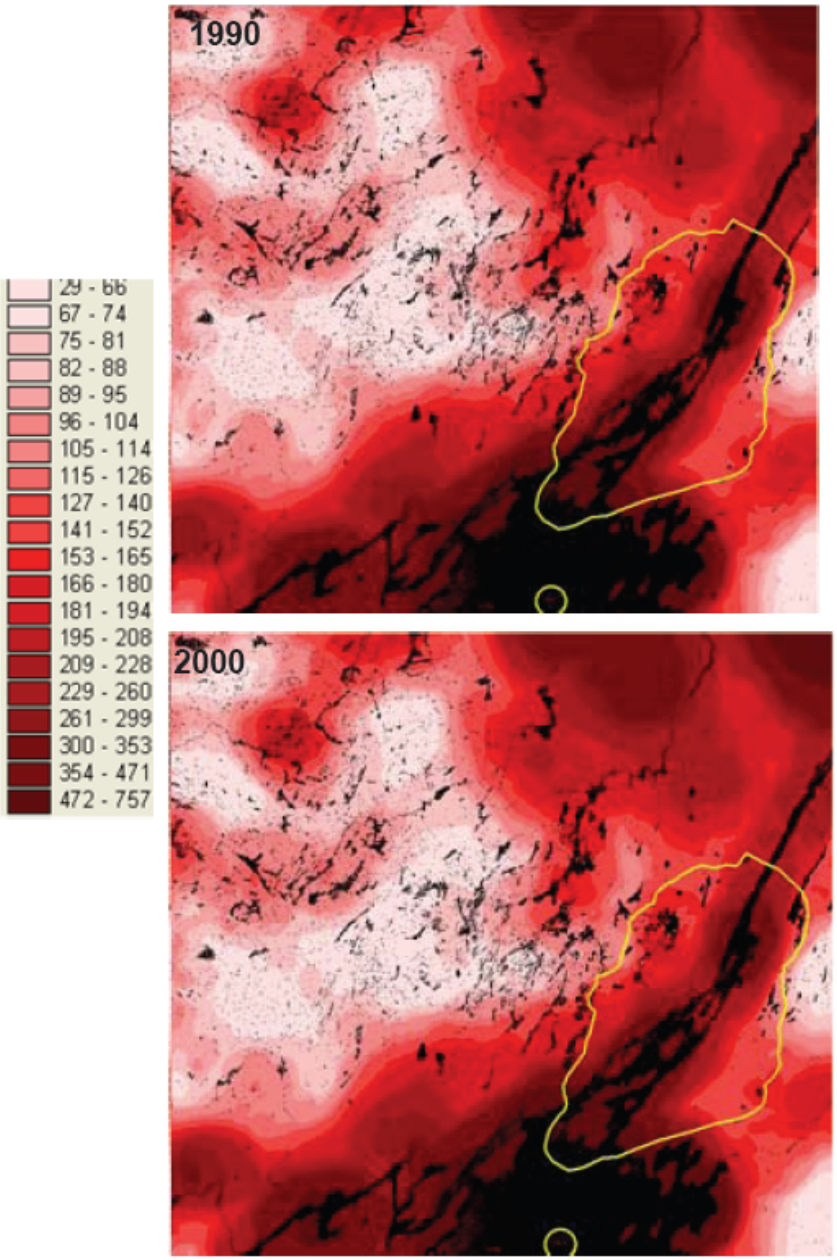
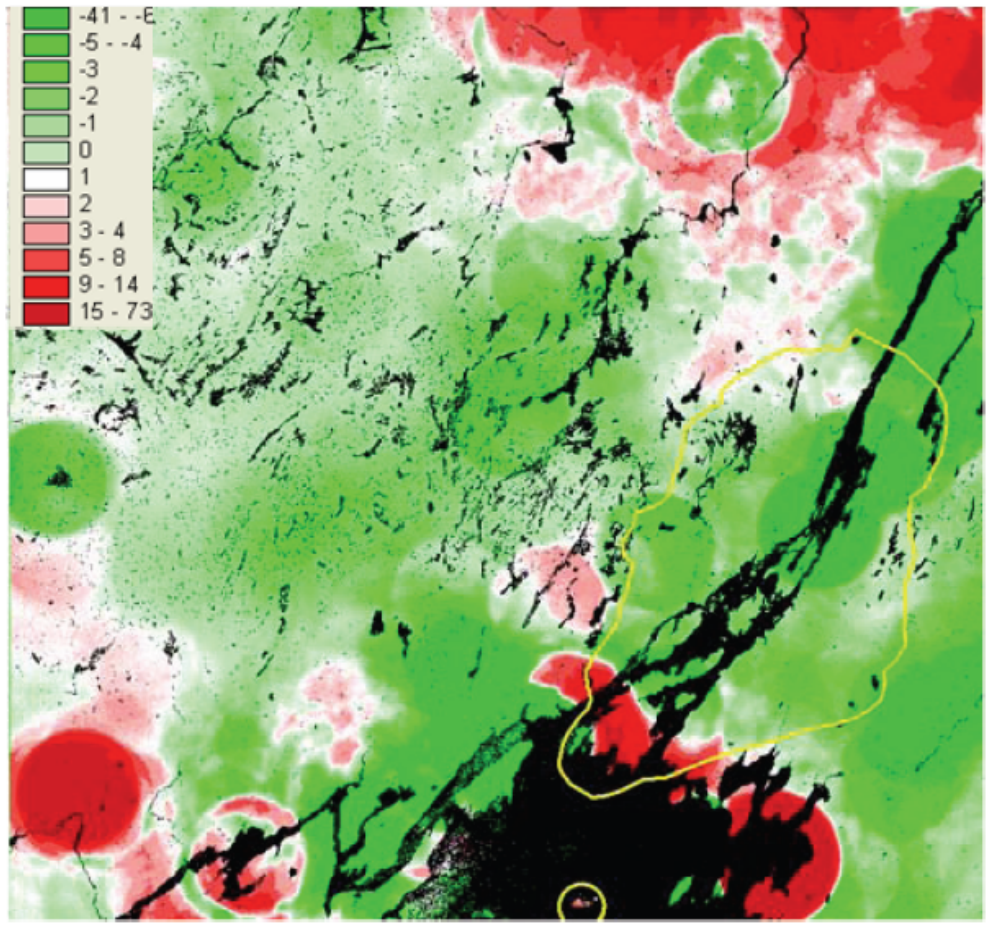
SLI NP Hardwood Forest Birds Profile
Habitat Connectivity MWA for 1990 and 2000

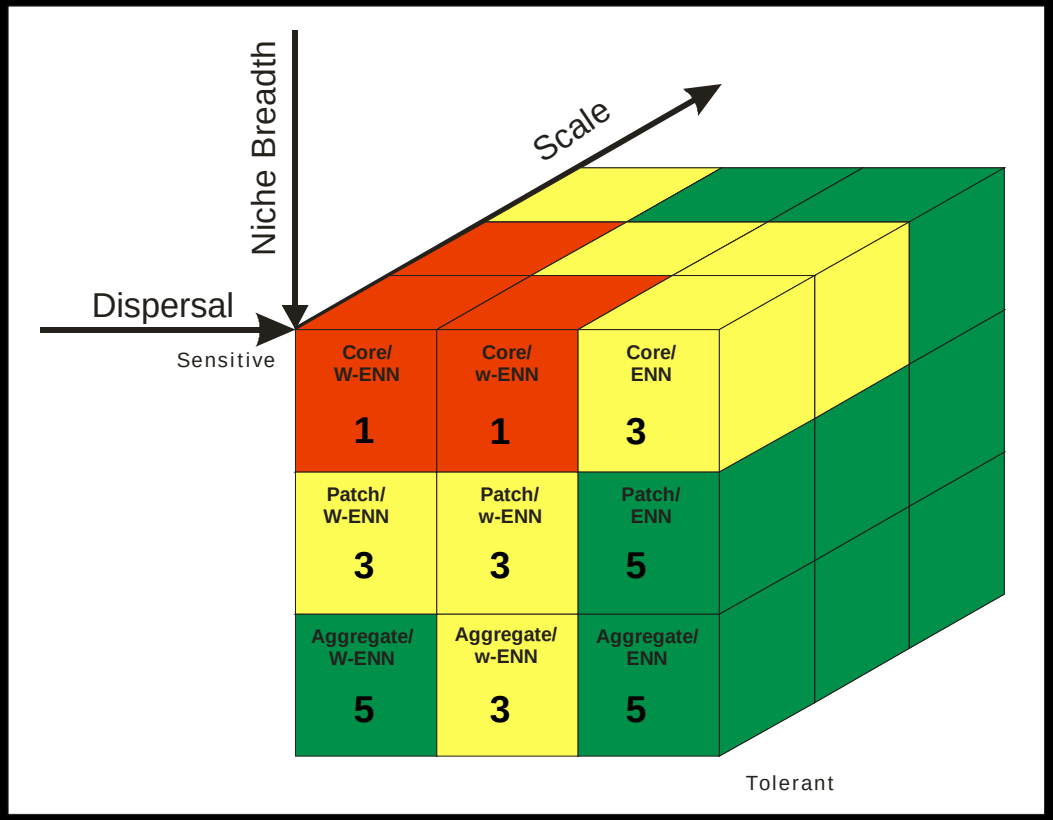


2000 MWV – 1990 MWA
(Red areas indicate where deciduous habitat connectivity is decreasing)



Reporting on Fragmentation

- The fragmentation "Rubics Cube".
- Different gradient map for each cell in the "Cube".
- Output is spatially explicit.
- Can report in a variety of ways (eg, park of GPE mean values, values associated with park zones or sensitive areas).
- These measures are monitored in association with other field survey measures.



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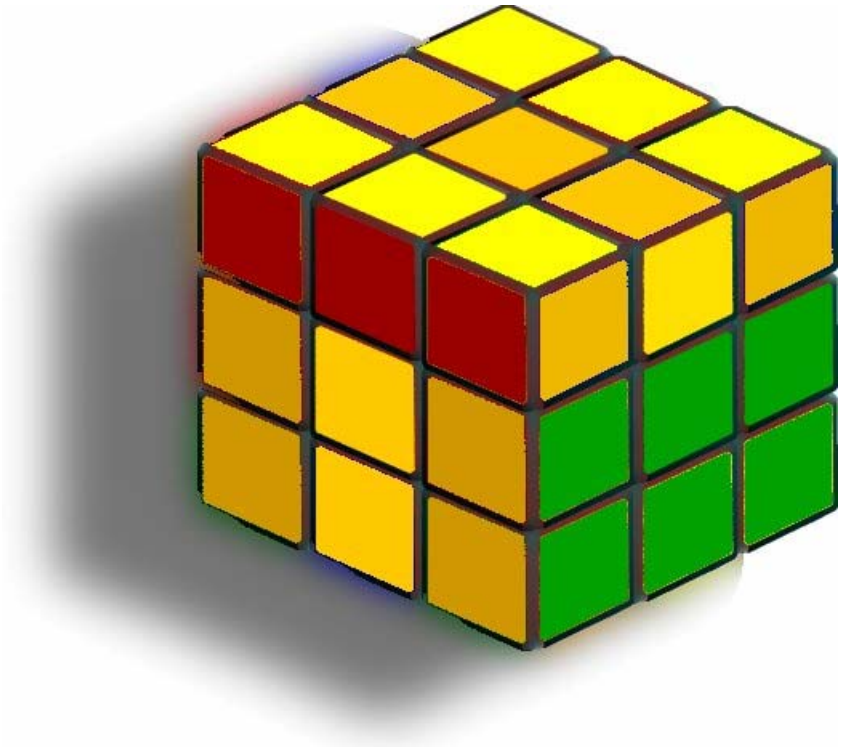
Ecologically Scaled Landscape Indices
- The Fragmentation Rubic's Cube -