Developing an index of vulnerability to climate change for Arctic fox dens

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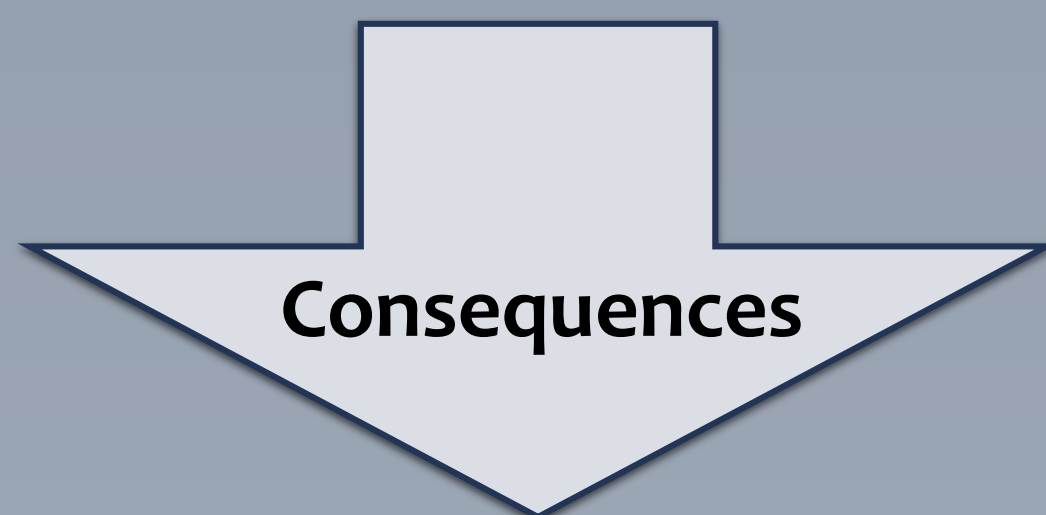
1. Context

Climate change in the Arctic is projected to :

Increase **air temperature**

Increase **precipitation**

Increase **storm magnitude and frequency**

Consequences

Thawing permafrost

Slope instability

High water levels (rapid spring melting)

More hazard-triggering events (extreme weather events)

Arctic foxes use the same den year after year and highly depend on a good denning site for reproductive and protection purposes.

The **increasing frequency of geohazards** may be a serious threat for the stability of arctic fox dens.

2. Objective

To develop a simple vulnerability index to climate change-related hazards for arctic fox dens

How can we assess vulnerability?

(See definition above)

- Exposure : **All dens are exposed** to the projected changes in the arctic ✅

- Sensitivity : The sensitivity **depends on den characteristics** together with its surroundings. ☐

- Adaptive capacity : Foxes can easily adapt to slow alterations by compensatory digging, hence we must **select only moderately-fast to fast-acting geohazards.** ☐

Vulnerability definition

« Vulnerability is a function of […] climate variation to which a system is **exposed**, its **sensitivity**, and its **adaptive capacity**. »

- IPCC (2001)

3. Method

Step 1 Identification of relevant hazards

Thaw settlement   **Mass movements**   **Thermo-erosion**

Step 2 Choice of vulnerability indicators

	Thaw settlement	Mass movements	Thermo-erosion
Ground ice content	X	X	X
Slope gradient	X	X	
Erosion		X	X

Step 3 Normalization and weighting of indicators for each hazard

Mass movements
Relative Vulnerability Index

0.3 — Ground ice content
Excess ice close to the surface
- No — 0
- Yes — 1

0.10 — Ground ice content
Surficial deposit
- Coarse sand and gravel — 0.2
- Sand and till — 0.4
- Fine sand and silt — 0.6

0.25 — Slope gradient
Presence of cracks or landslide scars
- No — 0
- Yes — 0.8

0.35 — Erosion
Den located along a shoreline or river bank
- No — 0
- Yes — 0.8

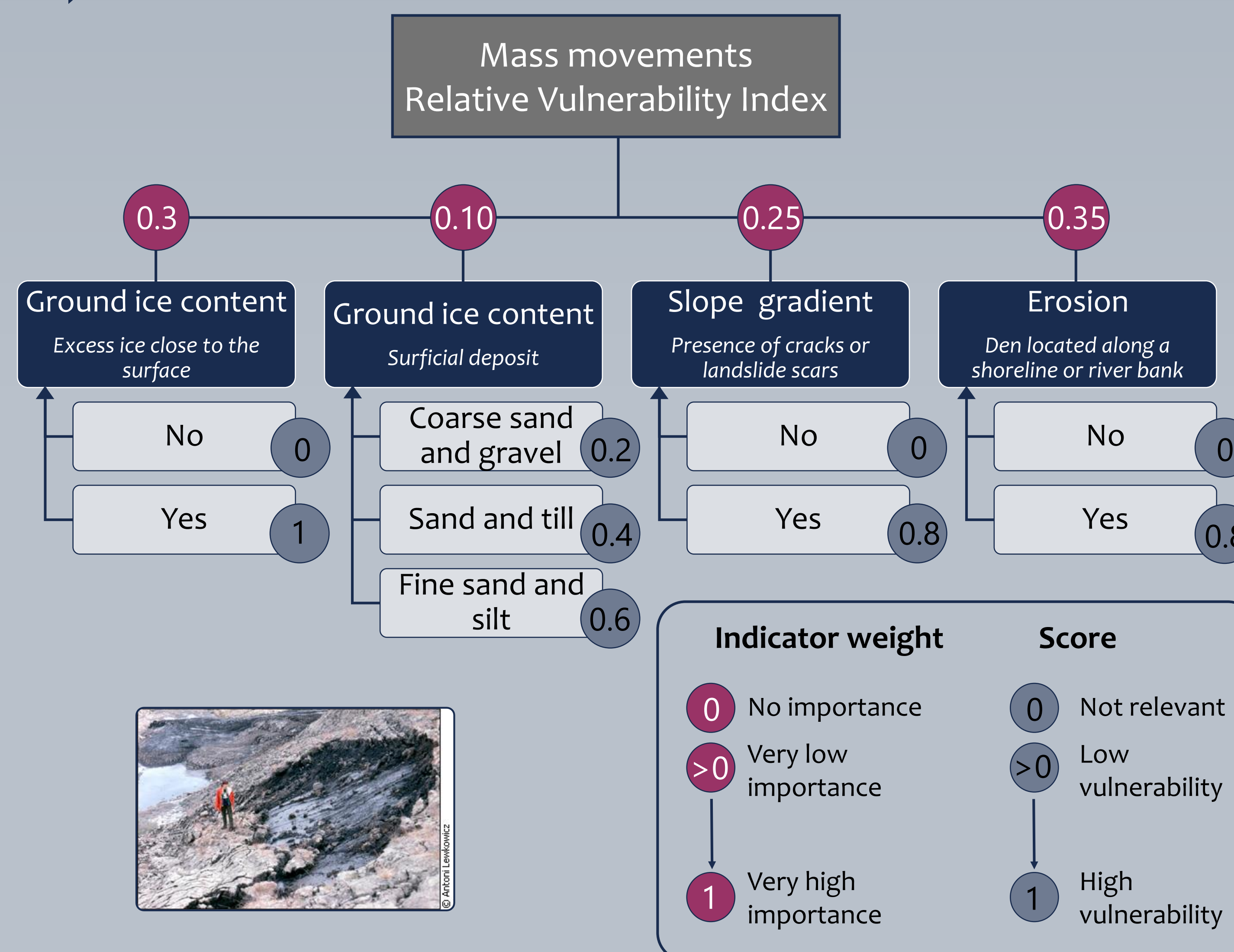| Indicator weight		Score	
0	No importance	0	Not relevant
>0	Very low importance	>0	Low vulnerability
1	Very high importance	1	High vulnerability

Fig. 1. Vulnerability computation framework for one hazard (here mass movements). *Adapted from Kappes et al. (2012)*

Step 4 Effect of hazard interaction on the overall vulnerability

4. Results

= 65.7%

= 17.6%

= 16.7%

NUNAVUT

CANADA

Bylot Island

Nanisivik   Pond Inlet
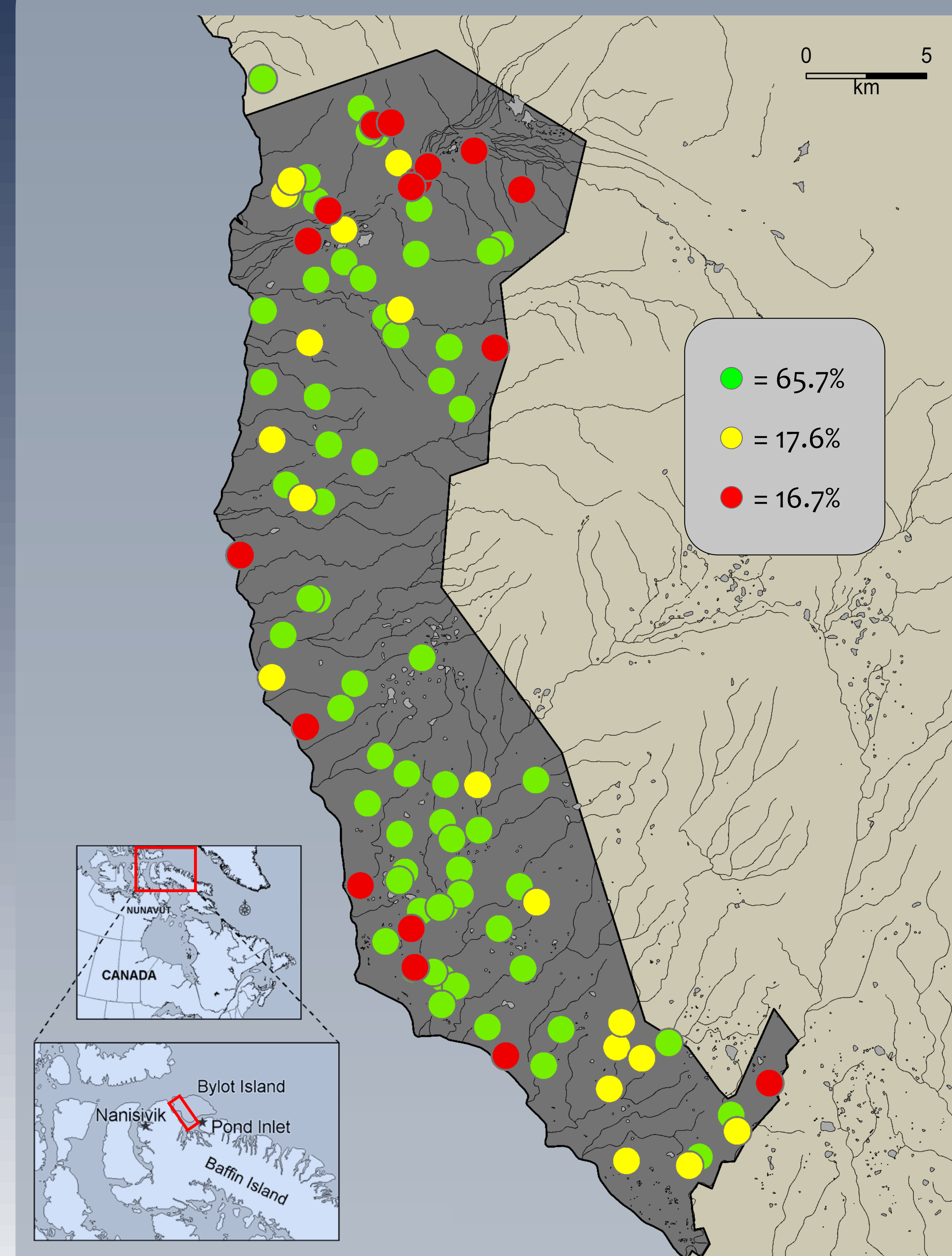
Baffin Island

Fig. 2. Percentage (%) of dens (*n* = 110) classified in each vulnerability class (*green* = low vulnerability, *yellow* = moderate vulnerability, *red* = high vulnerability) with their distribution in the study area.

5. Conclusion

We assessed vulnerability of arctic fox dens to climate change using an indicator-based approach. This very flexible method is often employed in infrastructure/building management or in social vulnerability assessments. Here we show that it is also suitable for evaluating physical structures used by animal species.

Main references

IPCC, McCarthy JJ, Canziani OF, Leary NA, Dokken DJ, White KS, eds. Climate change 2001: impacts, adaptation and vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, 2001.
Kappes M.S., M. Papathoma-Köhle and M. Keiler, 2012. Assessing physical vulnerability for multi-hazards using an indicator-based methodology. *Applied Geography* 32: 577-590.