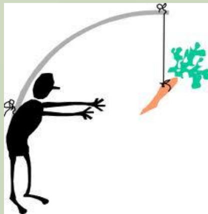
Inclusion of geodiversity information improves biodiversity models across boreal vegetation zone

Jan Hjort[*], Risto K. Heikkinen & Miska Luoto
[*]Department of Geography
University of Oulu
jan.hjort@oulu.fi

Background and motivation

- The preservation of biodiversity is of paramount importance under current global change
- Effective conservation planning is often difficult because of data constrains (biodiversity data are sparse or expensive to acquire)
- A long-term challenge in biodiversity research has been the development of methods for cost-effective targeting of conservation actions (→ indirect surrogates of biodiversity)
- Recently, the concept of geodiversity (i.e. the variability of earth surface materials, forms and processes) has been put forward as a novel complementary and potentially useful means to explore biodiversity



Study objectives

- The objective was to <u>compare the performance</u> of measures of geodiversity and commonly used abiotic surrogates of biodiversity in modelling plant species richness

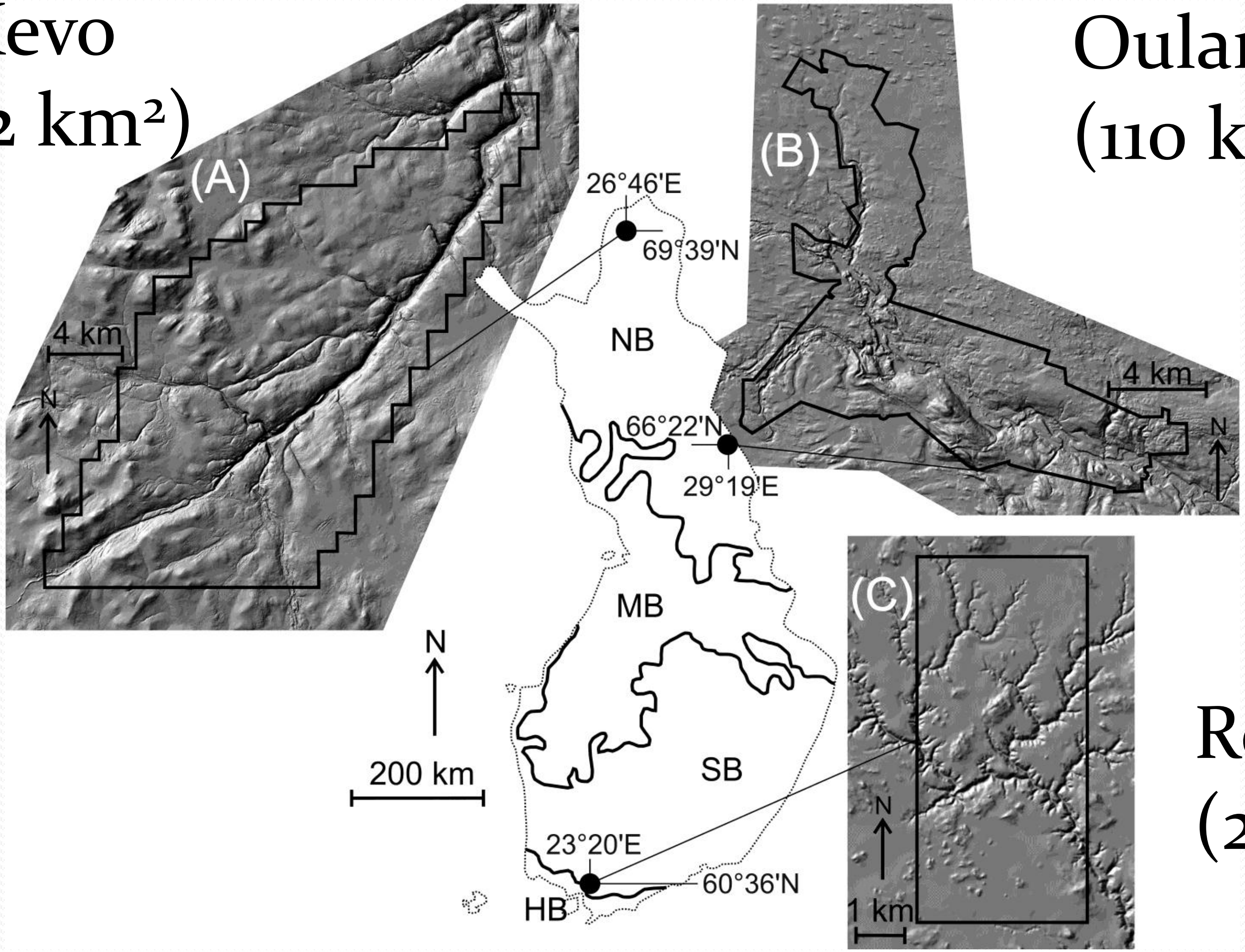
- The aim was to explore can the (i) <u>explanatory power</u> and (ii) <u>predictive ability</u> of the plant species richness models be improved by considering explicit measures of geodiversity?

Study areas

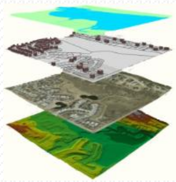
Kevo
(362 km²)

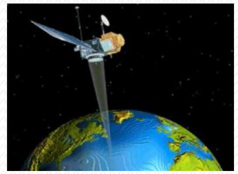
Oulanka
(110 km²)

Rekijoki
(26 km²)

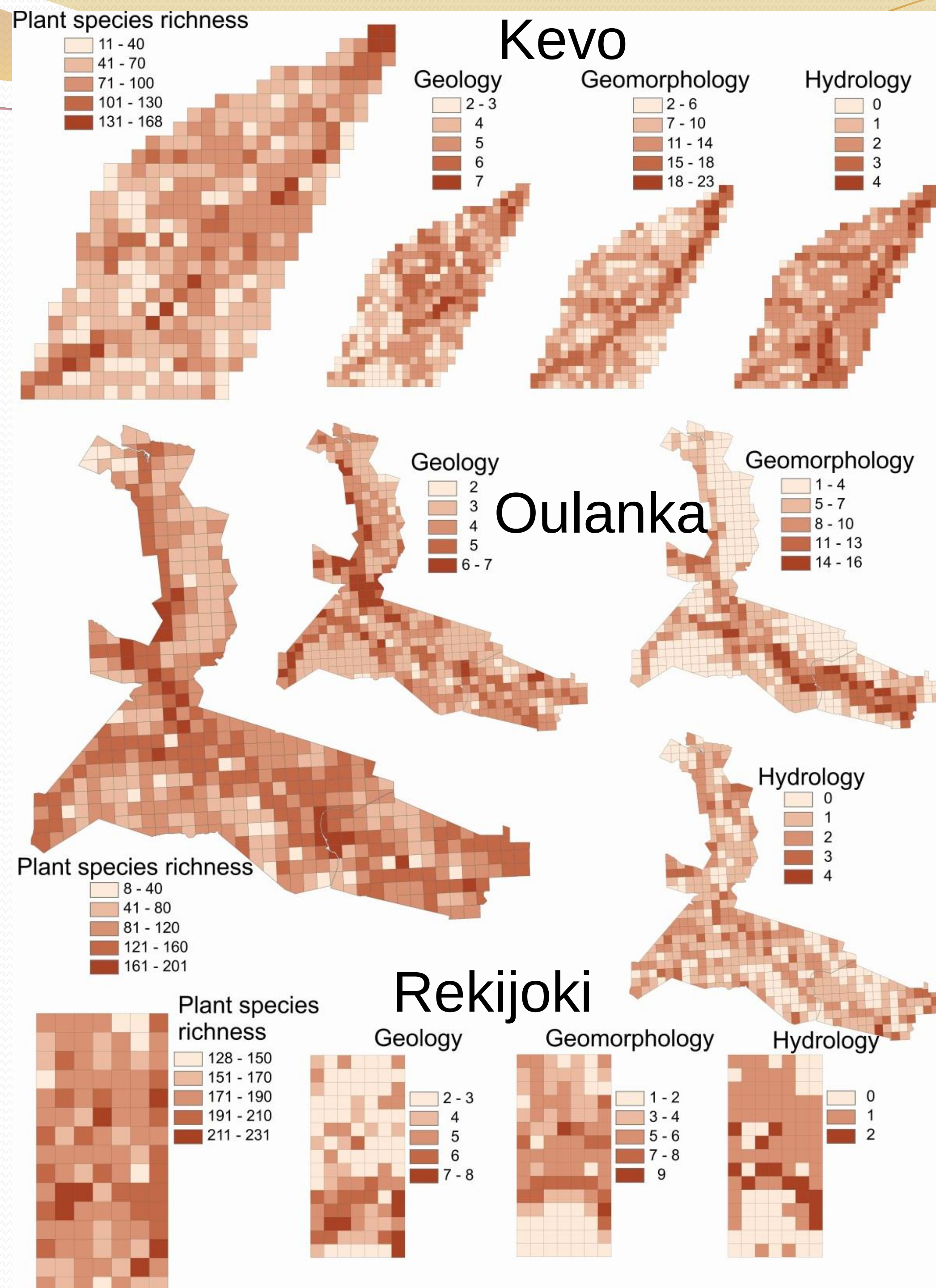


Data

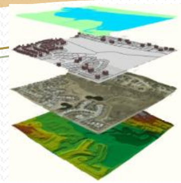


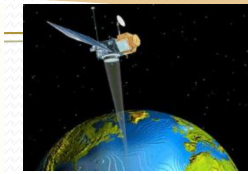


- A grid system at a mesoscale resolution (500 m and 1000 m)
- Plant data from digital data bases and literature
- Measures of geodiversity (i.e. geological, geomorphological and hydrological variability) were compiled using aerial photos, GIS data and published literature



Data



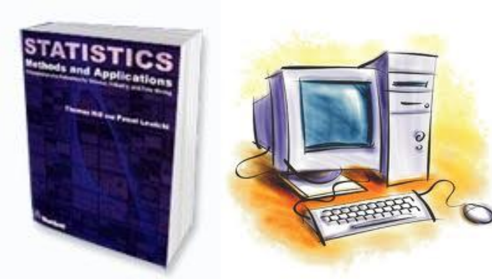


Explanatory variable	Unit	Kevo (NB–HA)	Oulanka (NB)	Rekijoki (HB–SB)
Geodiversity		*Md (min–max)*	*Md (min–max)*	*Md (min–max)*
Geological diversity	–	5 (2–7)	4 (2–7)	4 (2–8)
Geomorphological diversity	–	10 (2–23)	5 (1–16)	4 (1–9)
Hydrological diversity	–	2 (0–4)	1 (0–4)	1 (0–2)
Climate		*Mean (min–max)*	*Mean (min–max)*	*Mean (min–max)*
Mean annual air temperature	°C	−2.5 (−3.6– −1.3)	−0.3 (−1.0–0.2)	4.7 (4.6–4.8)
Mean temperature of coldest month	°C	−15.1 (−16.3– −13.9)	−13.2 (−13.9– −12.6)	−5.1 (−5.2– −5.0)
Mean annual precipitation	mm	466 (462–470)	598 (592–604)	638 (637–639)
Potential evapotranspiration	mm $year^{-1}$	182 (153–210)	236 (218–248)	358 (356–360)
Water balance	mm $year^{-1}$	293 (203–371)	358 (324–409)	281 (275–286)
Potential solar radiation (mean)	Mj cm^{-2} $year^{-1}$	0.41 (0.34–0.48)	0.50 (0.36–0.59)	0.57 (0.53–0.59)
Potential solar radiation (std)	Mj cm^{-2} $year^{-1}$	0.04 (<0.01–0.16)	0.03 (<0.01–0.11)	0.02 (<0.01–0.77)
Potential solar radiation (range)	Mj cm^{-2} $year^{-1}$	0.24 (0.03–0.74)	0.19 (0.02–0.56)	0.15 (0.01–0.42)
Topography		*Mean (min–max)*	*Mean (min–max)*	*Mean (min–max)*
Elevation (mean)	m a.s.l.	335 (144–509)	226 (145–338)	83 (70–96)
Elevation (std)	m	17.9 (2.7–72.4)	8.5 (<0.1–44.2)	3.5 (0.4–12.1)
Elevation (range)	m	75 (13–206)	34 (1–173)	16 (1–49)
Slope angle (mean)	°	4.7 (0.7–17.8)	4.2 (0.3–15.0)	2.4 (0.4–8.2)
Slope angle (std)	°	3.4 (0.6–14.8)	3.0 (0.4–11.8)	2.1 (0.4–5.8)
Slope angle (range)	°	18.3 (2.6–62.3)	14.2 (1.3–37.2)	9.1 (1.3–24.1)
Topographical wetness index (mean)	–	9.5 (8.1 – 13.0)	9.7 (7.0–18.5)	10.2 (7.6–15.5)
Topographical wetness index (std)	–	4.3 (3.2–5.5)	2.4 (0.9–4.5)	4.5 (3.3–5.6)
Topographical wetness index (range)	–	20.6 (12.9–28.4)	19.1 (9.7–29.1)	18.5 (12.4–25.8)

NB = northern boreal, HA = hemiarctic, SB = southern boreal, HB = hemiboreal

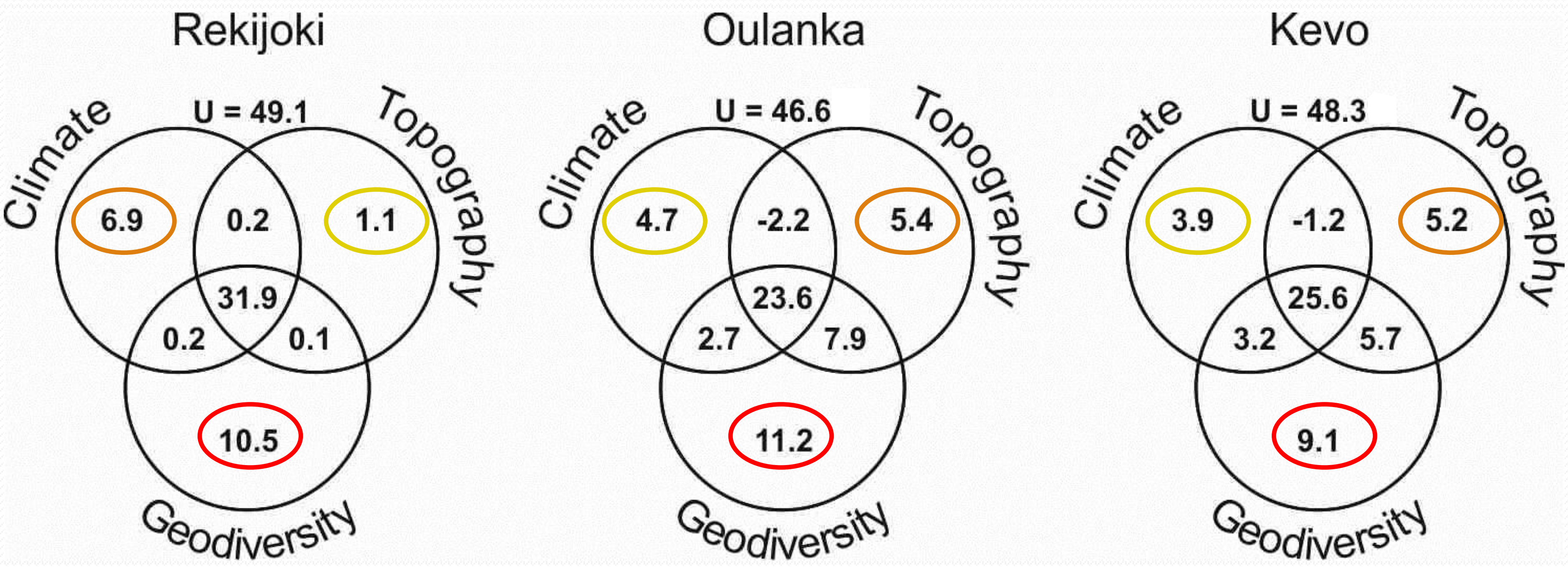
a.s.l. = above sea level

Methods



- Explanatory power :
  - Partial generalized linear model (GLM) analyses (i.e. variation partitioning, VP)
  - Groups: geodiversity (GD) vs. climate (CLIM) vs. topography (TOPO)
- Predictive ability:
  - Calibration using generalized additive model (GAM)
  - Groups: GD vs. CLIM+TOPO vs. GD+CLIM+TOPO
  - Evaluation of the models within (e.g. Kevo) and between areas (e.g. Kevo → Oulanka)

Results: Variation Partitioning (VP)



Results: prediction (GAM)

The mean of Spearman's rank correlation coefficients (R_s) between observed and fitted/predicted plant species richness values in model calibration and evaluation data sets.

	Mean of R_s in calibration	Mean of R_s in intra-area evaluation[1]	Change in R_s (calibration → evaluation[1])	Mean of R_s in inter-area evaluation[2]
GD	0.65	**0.59**	**−0.06**	**0.51**
CLIMTOPO	0.62	0.38	−0.24	0.24
ALL	**0.73**	0.54	−0.19	0.37

Results of the Student's paired t-test for the comparison of the generalized additive model (GAM) performances in model evaluation.

Compared models	Better model in intra-area evaluation data	Better model in inter-area evaluation data[2]
GD vs. CLIMTOPO	GD***	GD***
CLIMTOPO vs. ALL	ALL***	ALL*
GD vs. ALL	GD**	GD**

*** $p < 0.001$ ** $p < 0.01$ * $p < 0.05$

Conclusions

- Inclusion of variables describing geodiversity increased the (i) explanatory power, (ii) prediction ability and (iii) robustness of plant species richness models at the mesoscale resolution.
- The measures of geodiversity appeared to be promising surrogates of biodiversity which both directly and indirectly reflected important abiotic resource factors.
- In areas with insufficient climate and topography data, simple measures of geodiversity may provide the best surrogates for biodiversity patterns.

The next steps…

- Application of the measures of geodiversity in other environments and at different scales
- Computation of new GIS-based indices
- Development of ecologically focused measures of geodiversity

Thank you for your attention!