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Title	Inclusion of geodiversity information improves biodiversity models across boreal vegetation zone
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Citation	フィンランド-日本 共同シンポジウムシリーズ : 北方圏の環境研究に関するシンポジウム2012(Joint Finnish- Japanese Symposium Series Northern Environmental Research Symposium 2012). 2012年9月10日-14日. オウル大学 、オウランカ研究所, フィンランド.
Issue Date	2012-09-10
Doc URL	http://hdl.handle.net/2115/51371
Туре	conference presentation
File Information	08_JanHjort.pdf



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Inclusion of geodiversity information improves biodiversity models across boreal vegetation zone

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Background and motivation

- The <u>preservation of biodiversity</u> is of paramount importance under current global change
- Effective conservation planning is often difficult because of <u>data constrains</u> (biodiversity data are sparse or expensive to acquire)
- A long-term challenge in biodiversity research has been the development of methods for <u>cost-effective</u> targeting of conservation actions (→ indirect <u>surrogates</u> of biodiversity)
- Recently, the concept of <u>geodiversity</u> (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



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





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 (-3.61.3)	-0.3 (-1.0-0.2)	4.7 (4.6-4.8)
Mean temperature of coldest month	°C	-15.1 (-16.313.9)	-13.2 (-13.912.6)	-5.1 (-5.25.0)
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.1.	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)	0	4.7 (0.7-17.8)	4.2 (0.3-15.0)	2.4 (0.4-8.2)
Slope angle (std)	0	3.4 (0.6-14.8)	3.0 (0.4-11.8)	2.1 (0.4-5.8)
Slope angle (range)	0	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



- 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.

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	Mean of R _s	Mean of R _s	Change in R _s	Mean of R _s	
	in calibration	in intra-area	(calibration \rightarrow	in inter-area	
		evaluation ¹	evaluation ¹)	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-	Better model in inter-	
	area evaluation data	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 <u>increased</u> 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 <u>insufficient climate and topography</u> 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!

