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Session GM4.5 – Geodiversity and Geosystem Services of Drainage Basins: from Assessment to Enhancement

Geodiversity assessment with global and local S-MCA in different landscapes based on expert and crowdsourcing data

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Main problem:

Evaluating the efficacy of Weighted Linear Combination (WLC) and Local Weighted Linear Combination (L-WLC) techniques across different landscape types to assess geodiversity

The specific aims of the talk are:

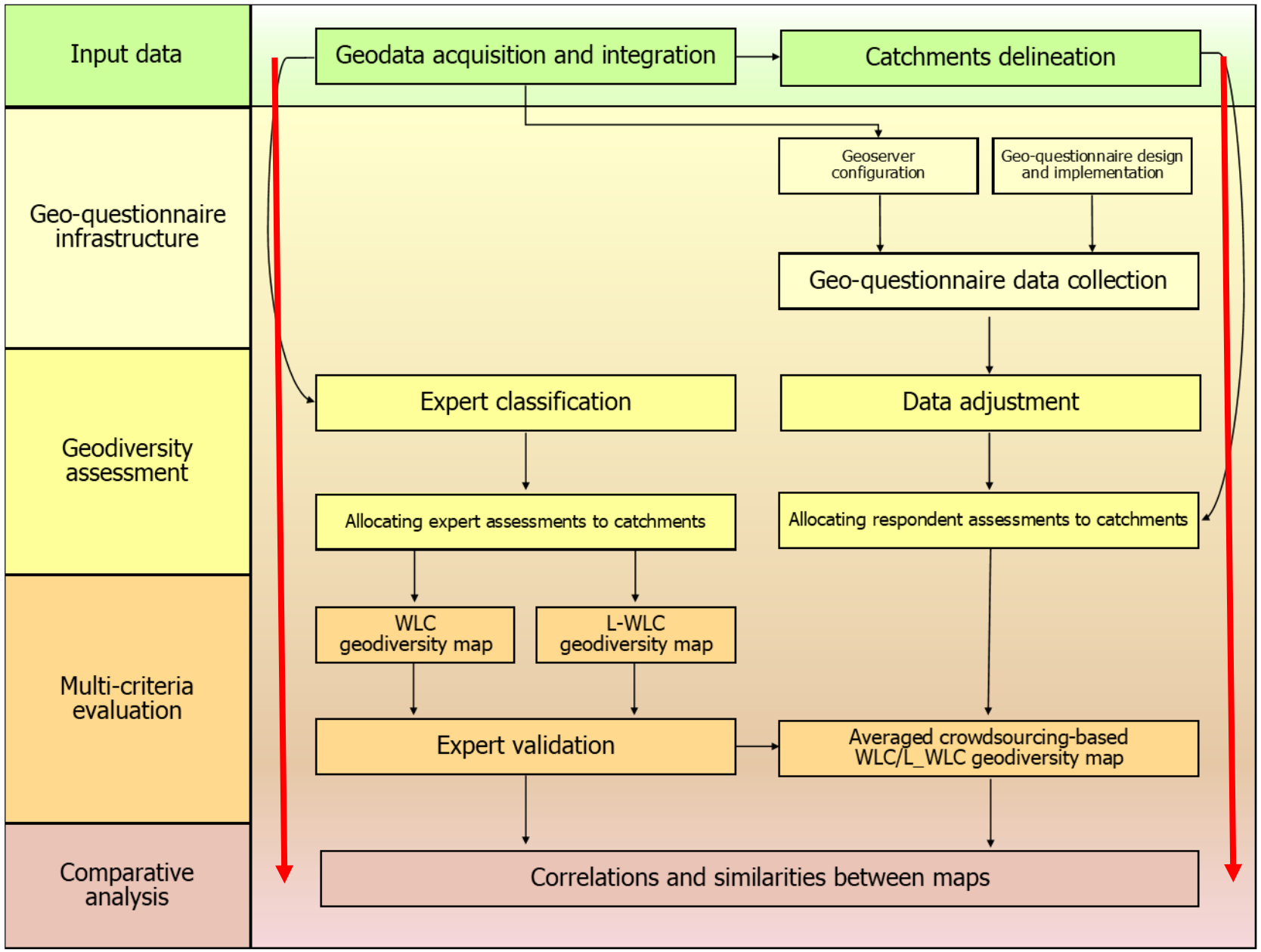
1. carry out the geodiversity assessment for morphogenetically diverse types of landscapes including mountains, upland and lowland areas,
2. compare the results of WLC- and L-WLC-based geodiversity maps compiled using crowdsourcing data with maps compiled by experts, and
3. evaluate the efficacy of the two spatial multi-criteria analysis (S-MCA) techniques for each of three landscape categories.

Flowchart

The tasks include:

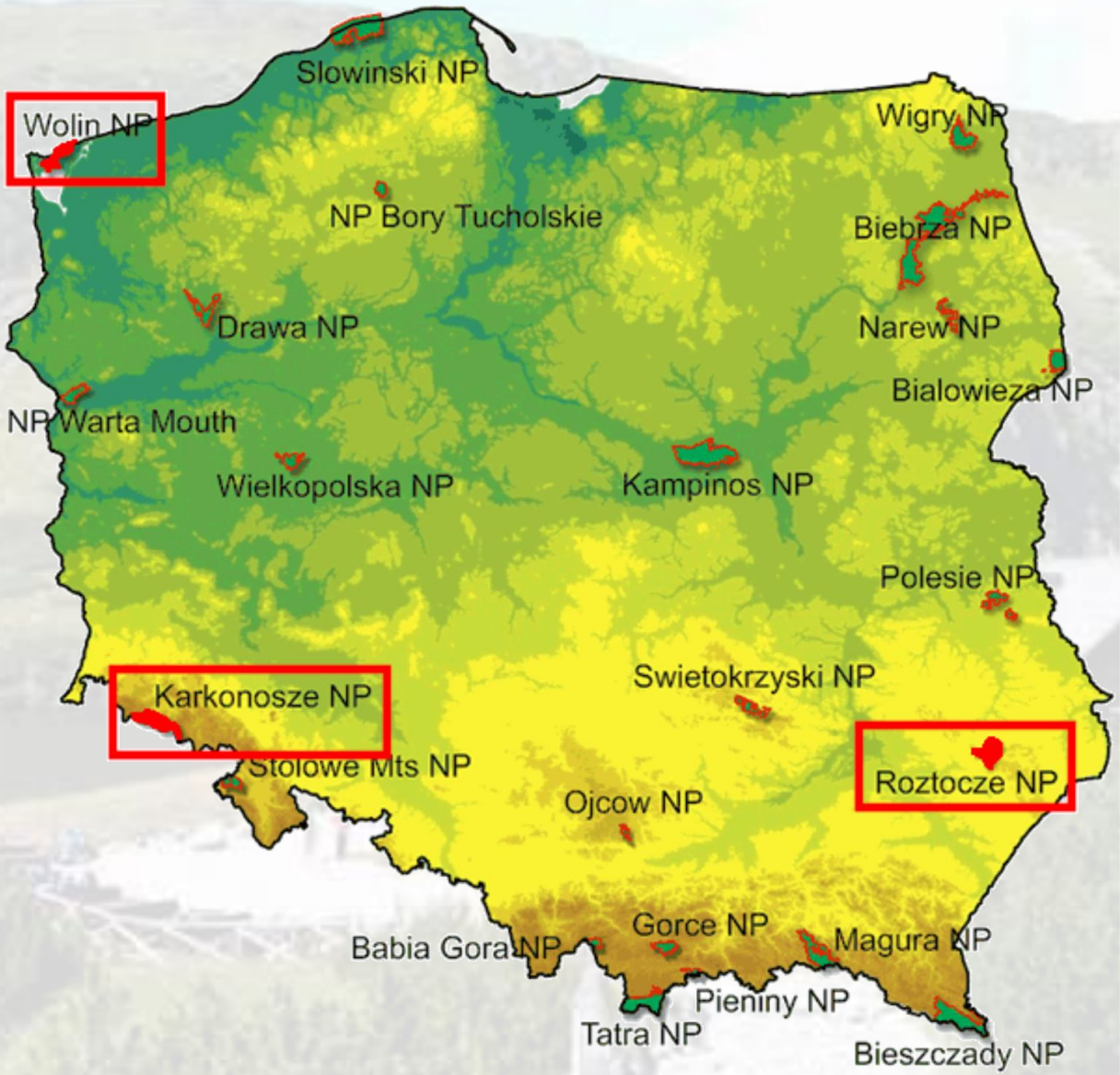
1. compilation of a geodatabase with input datasets,
2. geodiversity factor ratings and weights obtained through crowdsourcing with a geo-questionnaire tool,
3. geodiversity assessment,
4. compilation of geodiversity maps with results of multi-criteria analysis, and
5. comparative analysis of expert-based and crowdsourcing-based geodiversity maps.

Two routines



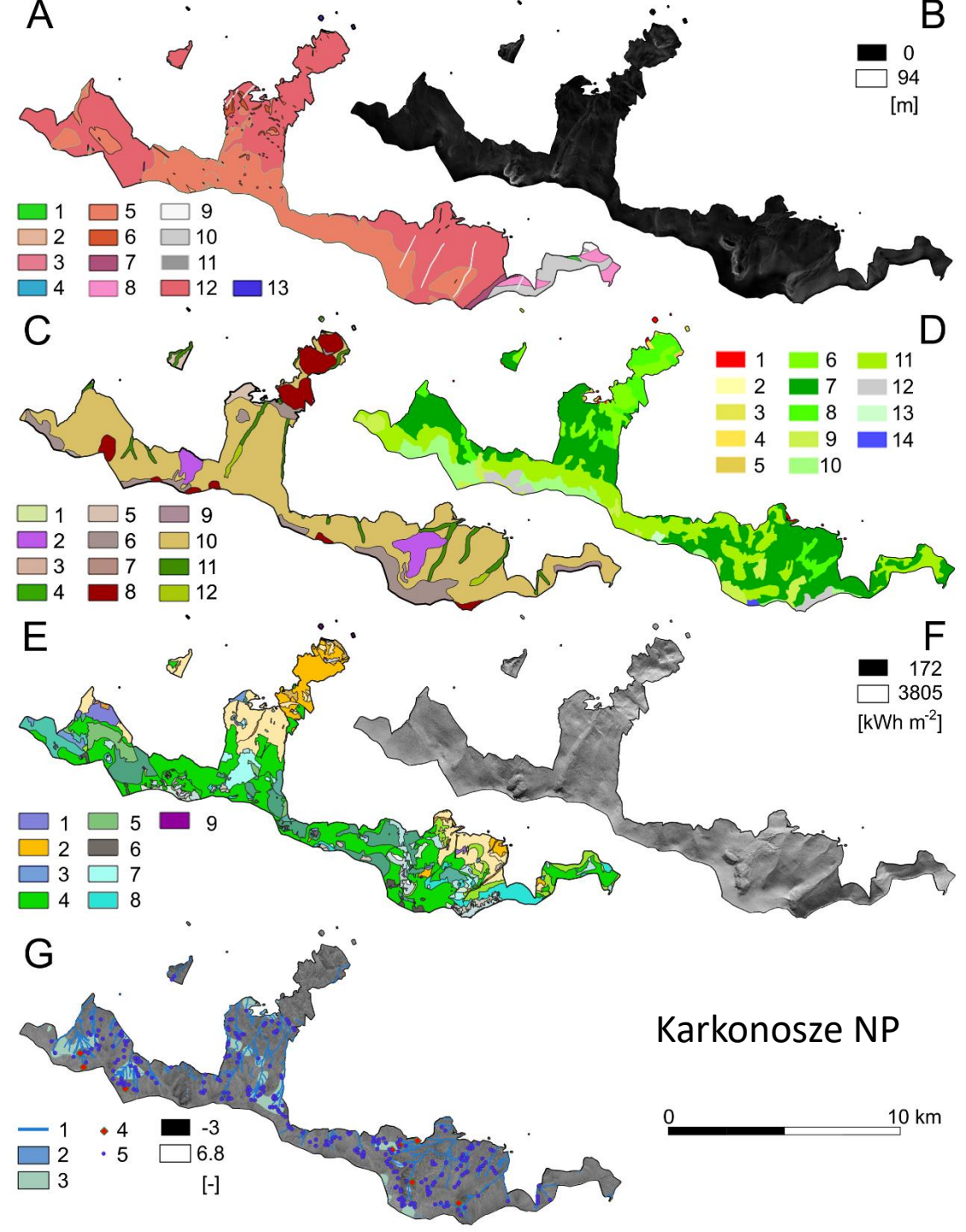
Study area

- The study area encompasses three national parks in Poland, where from the hypsometric perspective, one can distinguish three types of landscape:
  - lowlands (Wolin National Park),
  - uplands (Roztocze National Park) and
  - mountains (Karkonosze National Park).
- The parks are diversified in terms of environmental components, especially lithology and morphogenesis, and the variability of the land cover and land use.



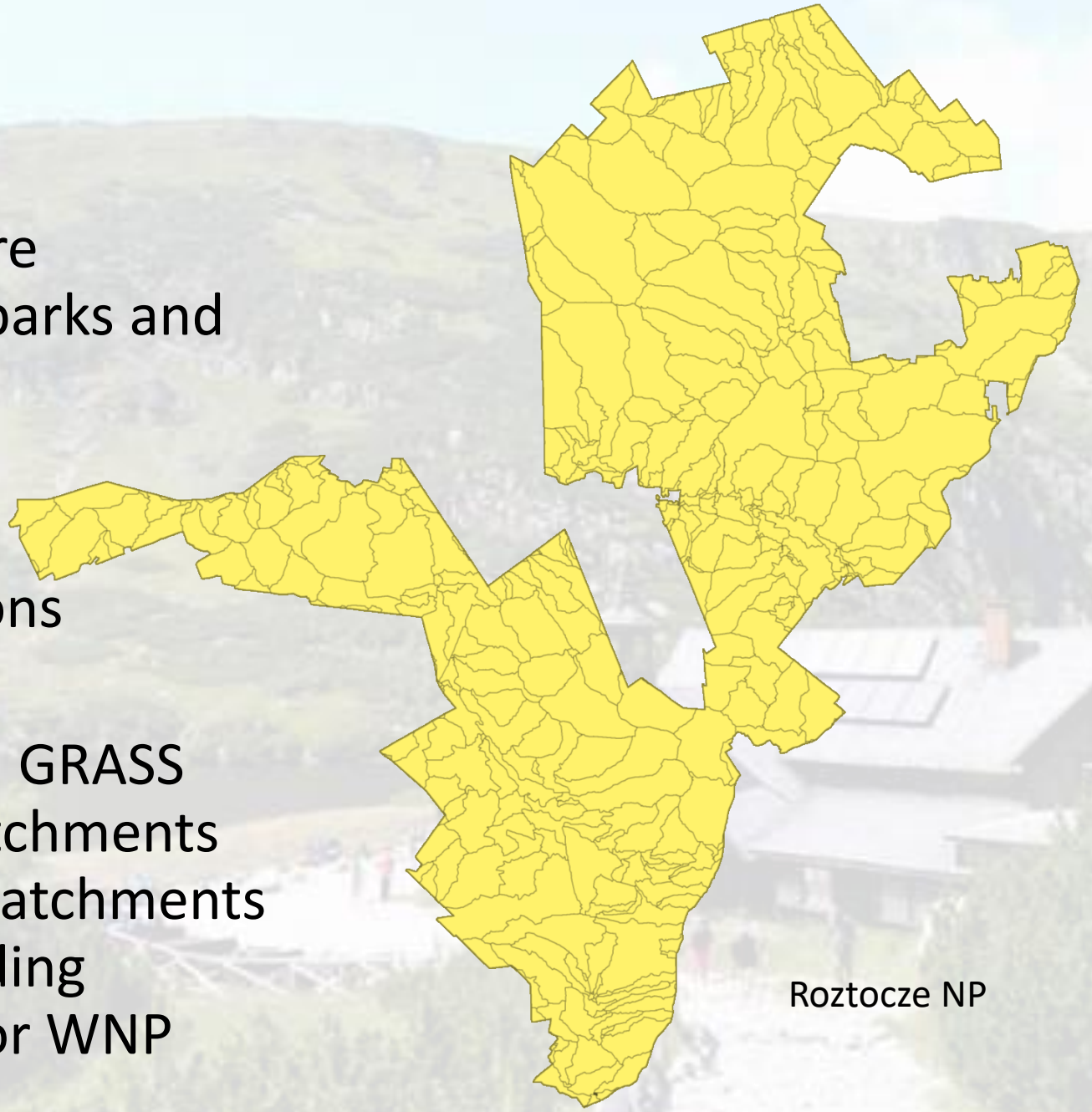
Data

- 1 m DEM and thematic map layers: lithological, geomorphological, hydrographical and soils features as well as CORINE Land Cover.
- The geodatabase data were used to compile 7 factor maps for geodiversity assessment:
  - A. lithology,
  - B. relief energy (represented by relative height),
  - C. geomorphology,
  - D. land use/land cover (as an anthropopression indicator on the Earth's surface),
  - E. soils,
  - F. mesoclimate (Total Insolation), and
  - G. hydrography (Topographic Wetness Index).



Data

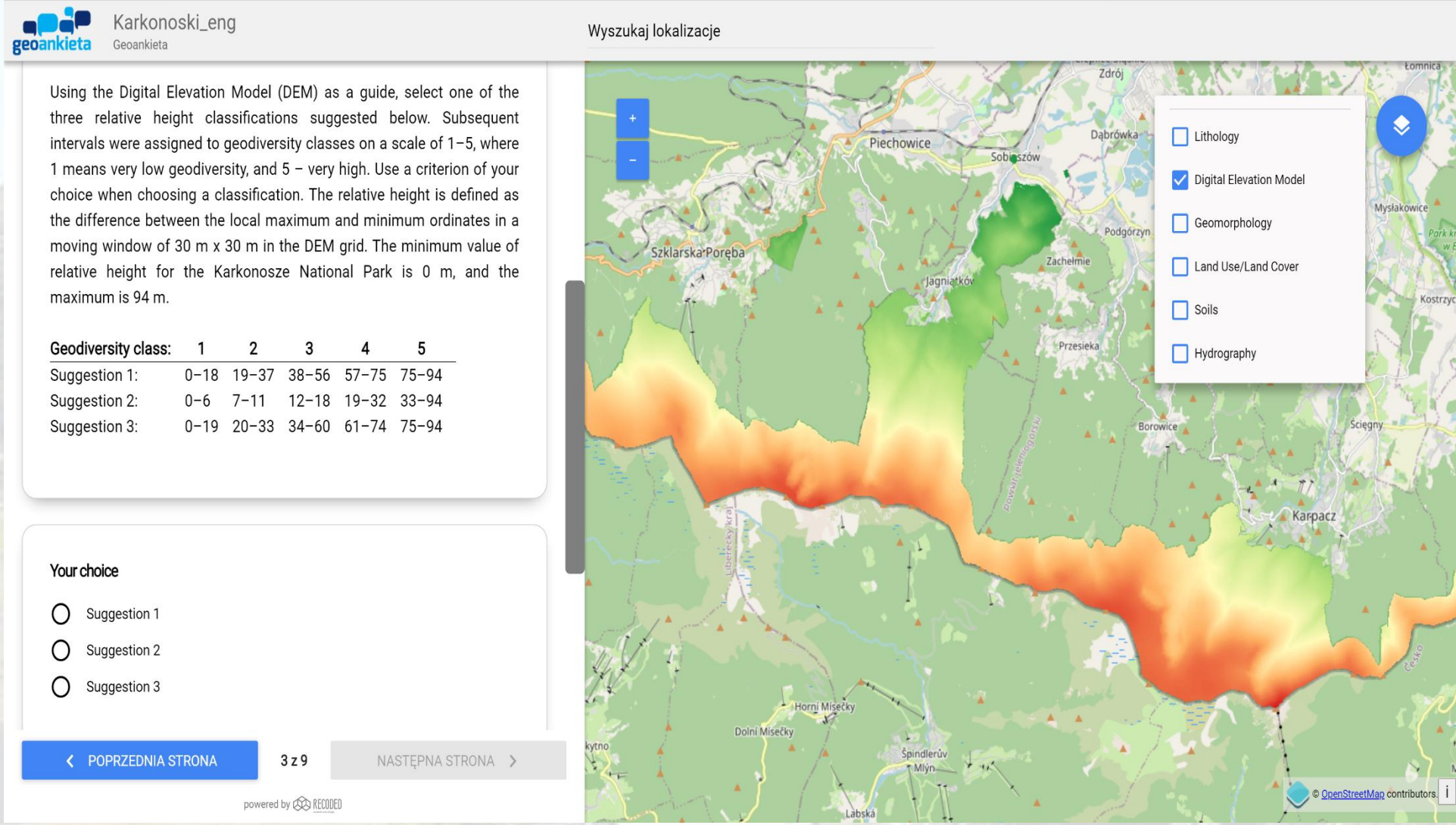
- Using the DEM data, catchments were delineated for the areas of national parks and used as spatial units for geodiversity assessment.
- The use of catchments instead of squares, grid cells or arbitrary polygons is new in geodiversity assessments.
- The r.watershed tool implemented in GRASS was used to define the first order catchments areas. Within the KNP, **212** polygon catchments were delineated with the corresponding numbers for RNP equal to **403** and for WNP equal to **289** catchments.



Roztocze NP

Methods

Geo-questionnaire was the crowd-sourcing tool employed in the study to obtain information about the ratings and weights of geodiversity components for three national parks.



Geo-questionnaire is a web online application for gathering public opinion by obtaining answers to a prepared set of questions related to a map. The questions directly or indirectly concern geographical space; hence a geo-questionnaire usually contains an interactive map where it is possible to mark geographical features and/or examine their attributes. The geo-questionnaire collecting data from volunteer responders. A separate geo-questionnaire was prepared for each park due to the differences in classes within the abiotic components.

Methods

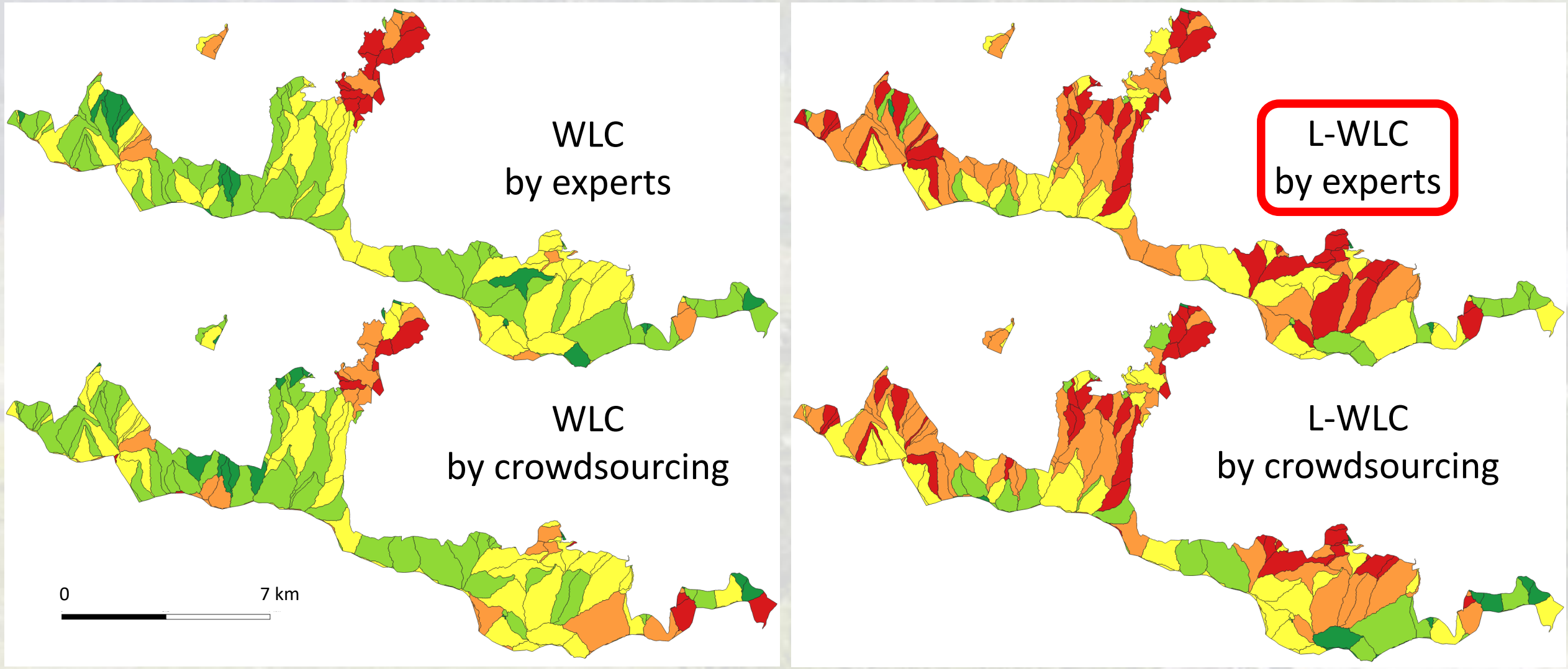
Both the expert geodiversity map and the crowdsourced geodiversity map were computed with two MCE techniques each: weighted linear combination (WLC) and local weighted linear combination (L-WLC).

WLC is one of the most widely used decision rules in spatial multi-criteria analysis. WLC can be operationalized in any GIS software with overlay capabilities. In WLC technique, the global weights are constant for the entire investigated area, i.e. national park.

L-WLC extends WLC technique by taking into account spatial variability of input data locally within a defined neighbourhood and relating the local variability to global variability within the study area. L-WLC relies on two types of weights to calculate an evaluation score for each spatial unit: spatially variable local weights and spatially invariant global weights (the same type of weight as used in WLC).

Results

Geodiversity for Karkonosze NP



Results

Geodiversity for Roztocze NP

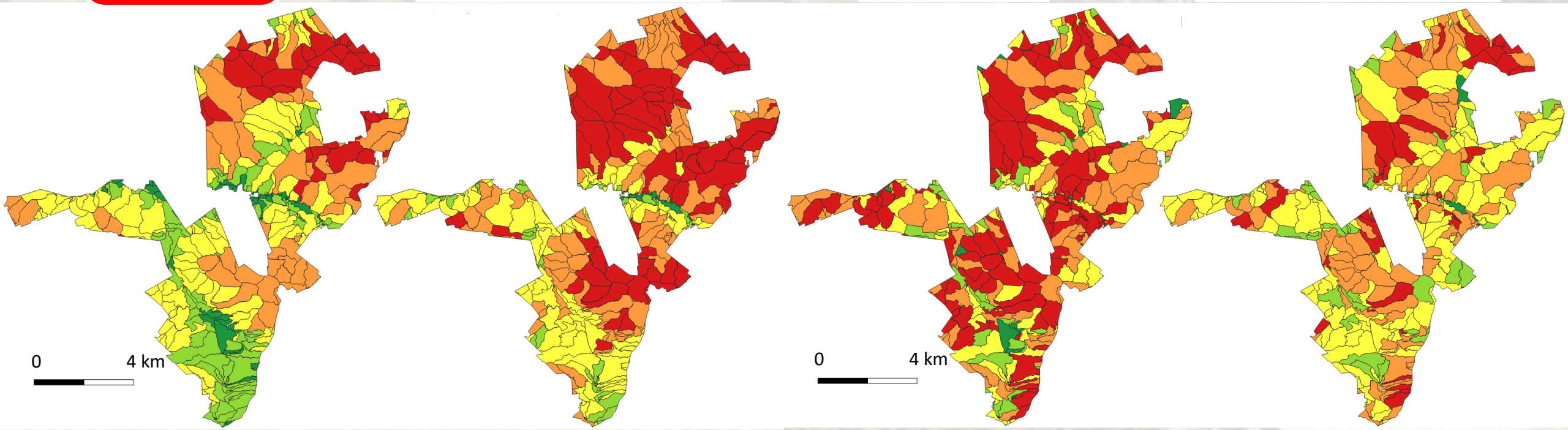
Very low
Low
Medium
High
Very high

WLC
by experts

WLC
by crowdsourcing

L-WLC
by experts

L-WLC
by crowdsourcing



Results

Geodiversity for Wolin NP

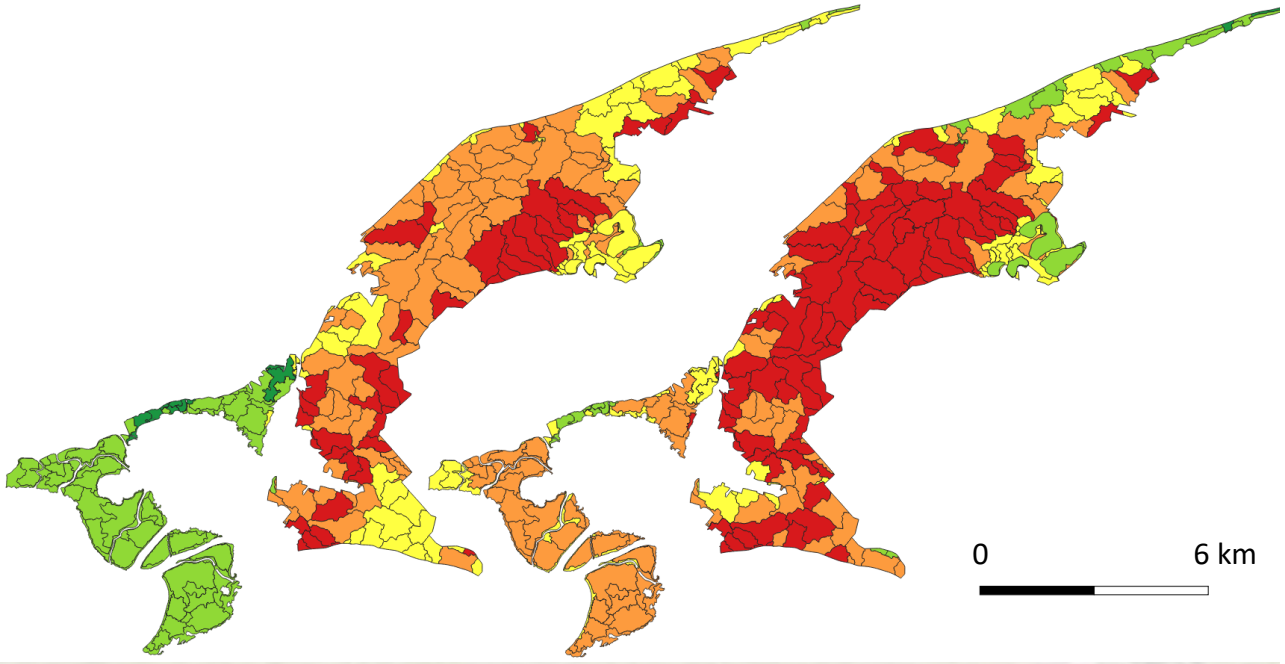
Very low
Low
Medium
High
Very high

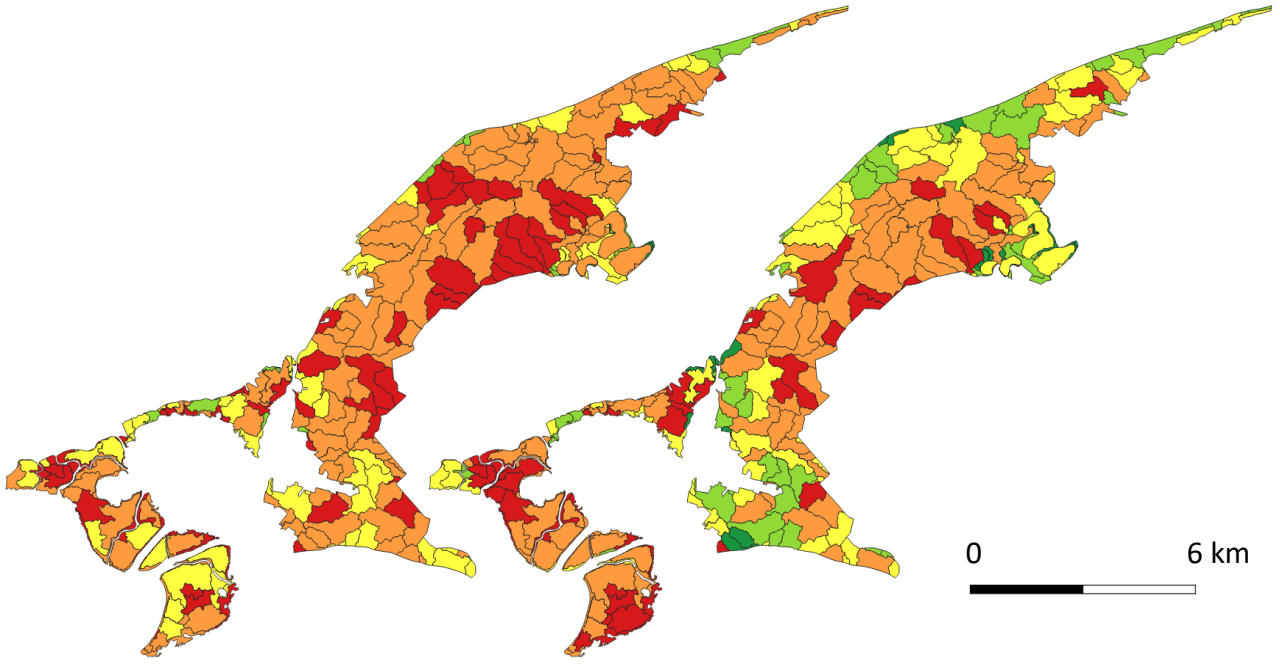
WLC
by experts

WLC
by crowdsourcing

L-WLC
by experts

L-WLC
by crowdsourcing





Methods

Comparative analysis – two steps

In the first step the suitability of two MCE techniques (WLC and L-WLC) was assessed by geodiversity experts for each particular landscape type. The assessment involved determining, across each national park, a number of prominent landmarks that are characterized by either high/very high or low/very low level of geodiversity. The determination was based on the experts' intimate knowledge of local park landscapes.

The second task involved the comparison of an expert map, selected in the previous task as representative for the given landscape, with two crowdsourcing data-based maps (WLC and L-WLC) and the evaluation of their fit with the corresponding expert-based map. This was done by a numerical comparison, and backed up with visual assessment.

Methods

Comparative analysis – two steps

In order to assure the reliability of numerical comparison, three different similarity measures were used:

1) the Spearman's correlation coefficient,
2) the Jaccard similarity index, also known as Tanimoto index, and
3) the relative Manhattan similarity, which is defined in this research as one minus the ratio of the well-known Manhattan distance between two maps to the maximum possible Manhattan distance between them.

The Spearman's correlation coefficient gives a number from -1 to 1, where -1 and 1 mean maximum positive and negative correlation, respectively, whereas 0 denotes no correlation.

The Jaccard and Manhattan similarities take values between 0 and 1, where 0 represents no similarity, and 1 means that compared maps are identical.

Results

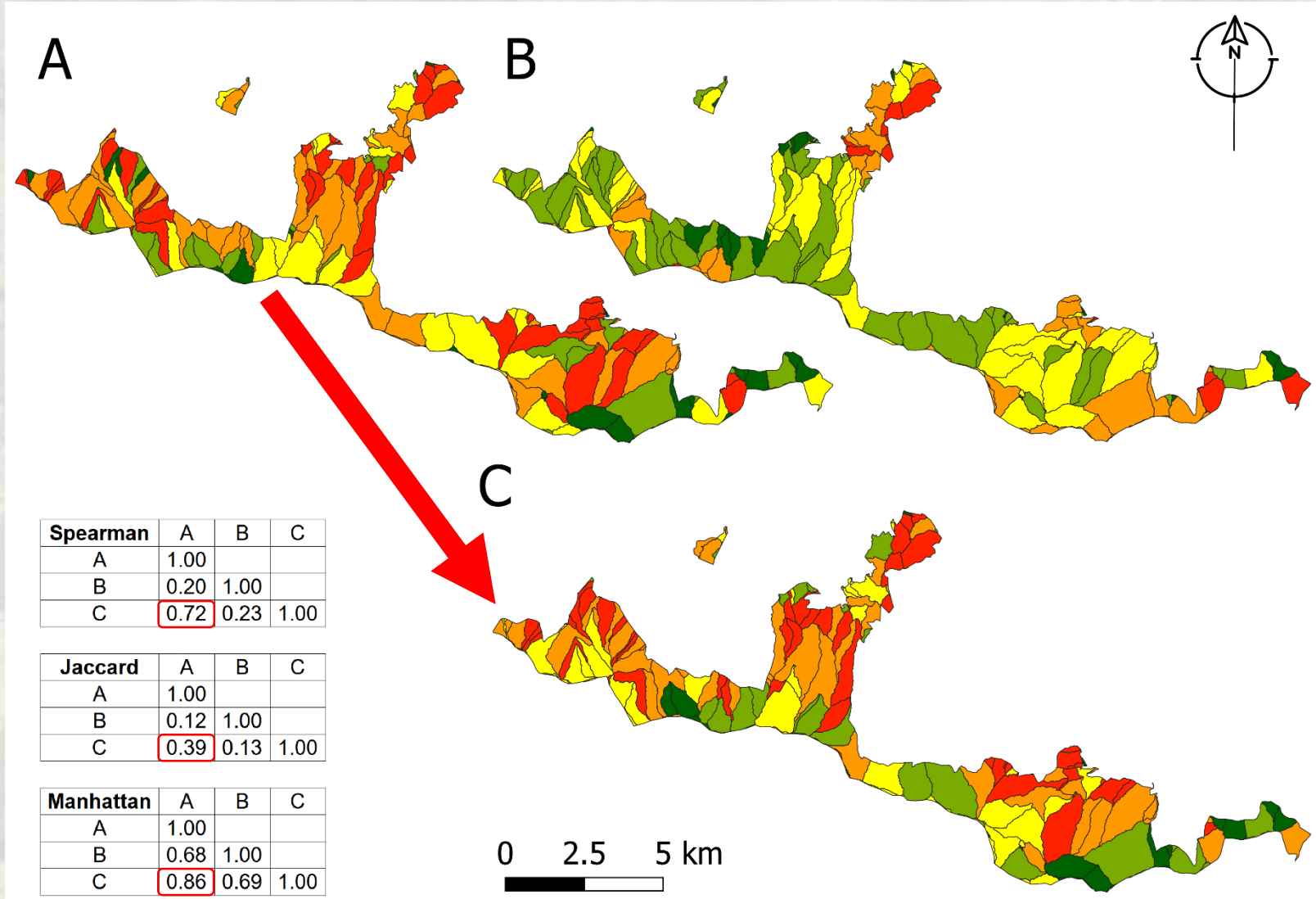
Geodiversity for Karkonosze NP

A ≈ C

A – L-WLC by experts
B – WLC by crowdsourcing
C – L-WLC by crowdsourcing

The Spearman's correlation coefficient values indicate high correlation (Spearman's Rho = 0.72) between the L-WLC expert (A) and L-WLC crowdsourced map (C), and low correlation (Spearman's Rho = 0.20) between the L-WLC expert and the WLC crowdsourced map (B).

The percentage of exact matches between these two maps is 39 catchments (out of 212 in total).



Spearman	A	B	C
A	1.00		
B	0.20	1.00	
C	0.72	0.23	1.00

Jaccard	A	B	C
A	1.00		
B	0.12	1.00	
C	0.39	0.13	1.00

Manhattan	A	B	C
A	1.00		
B	0.68	1.00	
C	0.86	0.69	1.00

Results

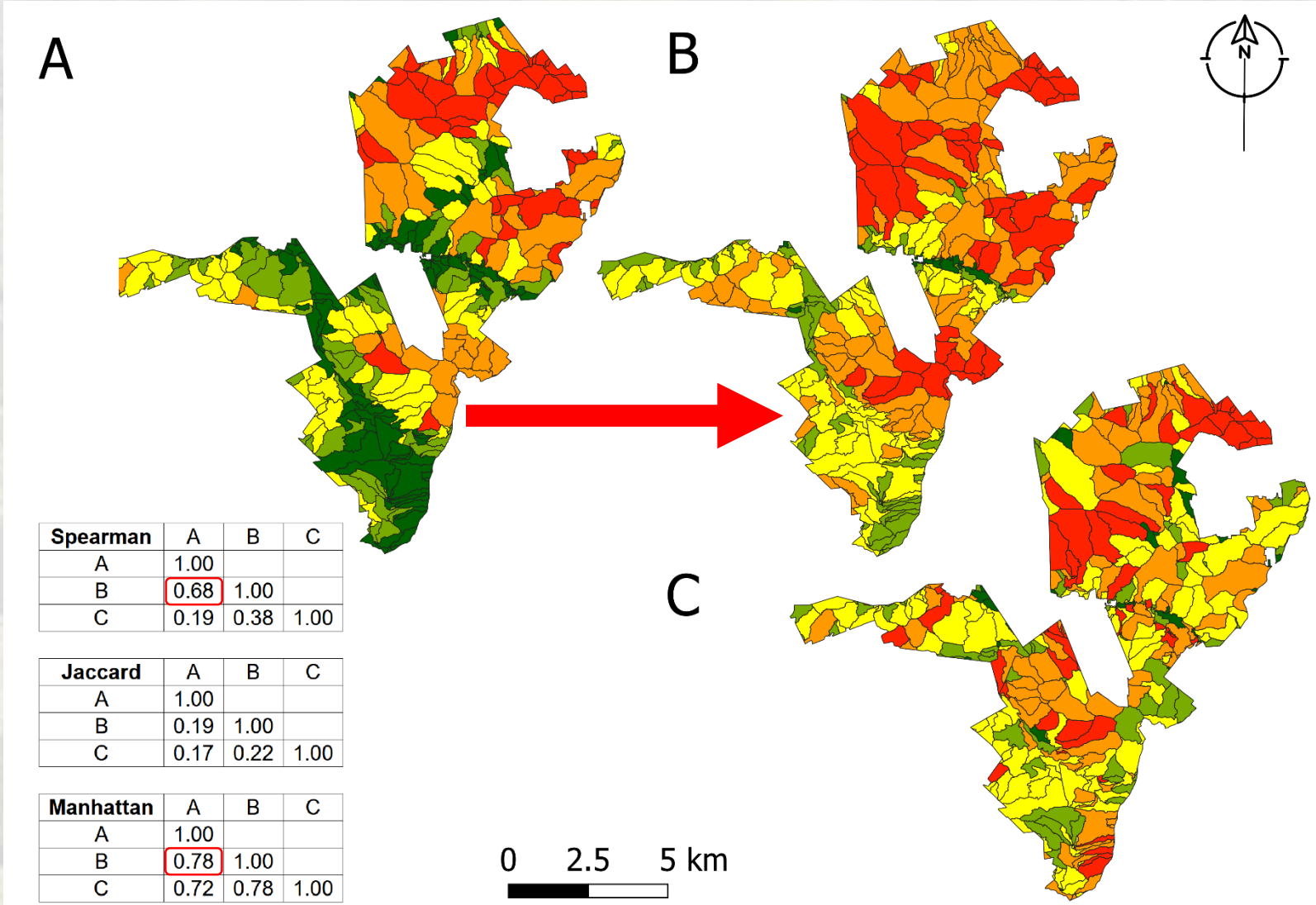
Geodiversity for Roztocze NP

A ≈ B

A – WLC by experts
B – WLC by crowdsourcing
C – L-WLC by crowdsourcing

Despite a low value of the coefficient of determination, the Spearman's correlation coefficient value (Rho = 0.68) indicates medium-high correlation between the expert (A) and crowdsourced (B) WLC-based maps, compared to 0.19 between the WLC-based and L-WLC-based maps.

The percentage of exact matches between these two maps is 52 catchments (out of 403 in total).



Spearman	A	B	C
A	1.00		
B	0.68	1.00	
C	0.19	0.38	1.00

Jaccard	A	B	C
A	1.00		
B	0.19	1.00	
C	0.17	0.22	1.00

Manhattan	A	B	C
A	1.00		
B	0.78	1.00	
C	0.72	0.78	1.00

Very low
Low
Medium
High
Very high

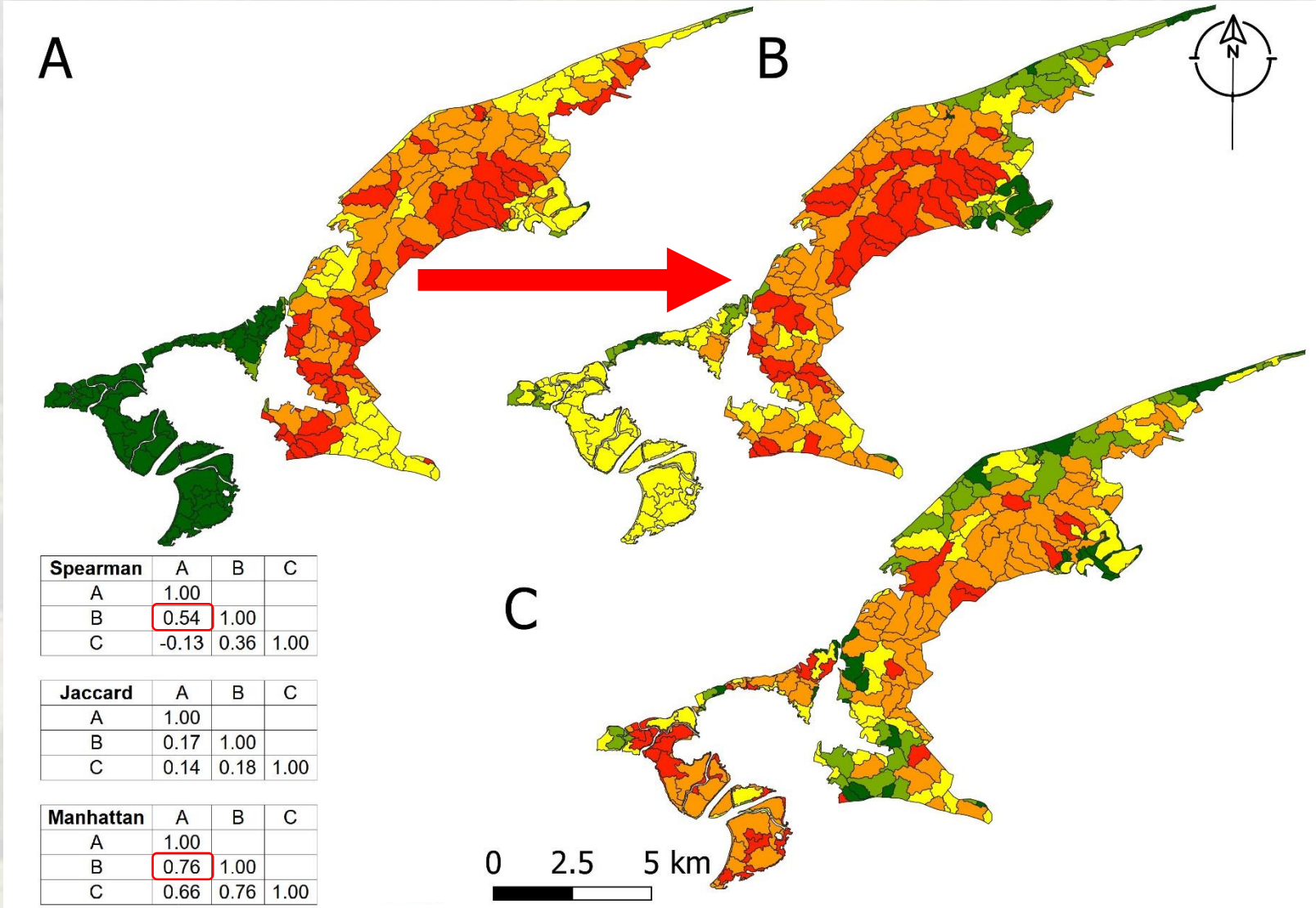
Results

Geodiversity for Wolin NP

A ≈ B

A – WLC by experts
B – WLC by crowdsourcing
C – L-WLC by crowdsourcing

The Spearman's correlation coefficient shows the average correlation (Rho = 0.54) between the expert WLC-based (A) and the crowdsourced WLC-based (B) geodiversity maps.



Spearman	A	B	C
A	1.00		
B	0.54	1.00	
C	-0.13	0.36	1.00

Jaccard	A	B	C
A	1.00		
B	0.17	1.00	
C	0.14	0.18	1.00

Manhattan	A	B	C
A	1.00		
B	0.76	1.00	
C	0.66	0.76	1.00

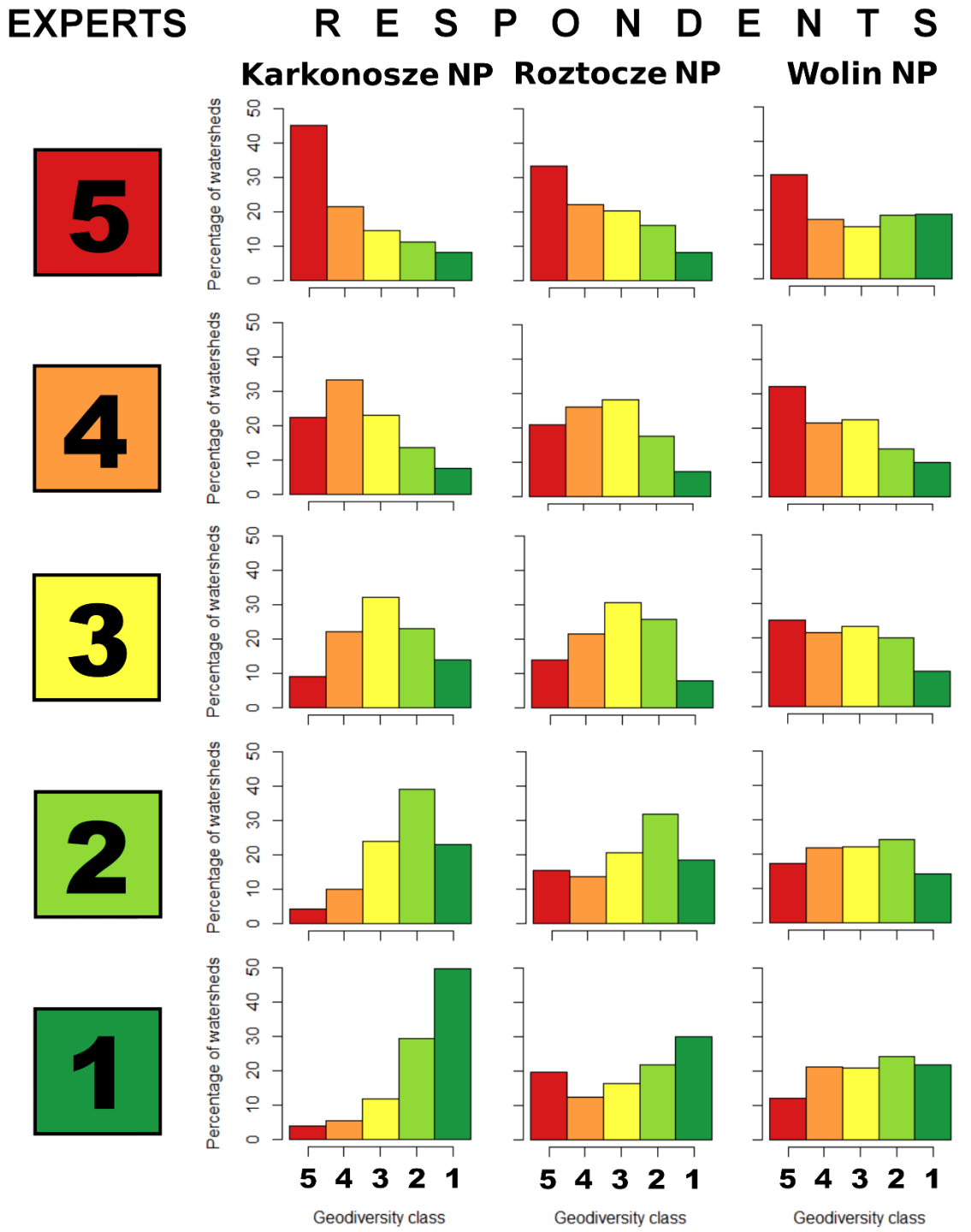
The percentage of exact matches between these two maps is 27 catchments (out of 289 in total).

- Very low
- Low
- Medium
- High
- Very high

Results

Accuracy of crowdsourced geodiversity classification

The diagram rows in figure represent geodiversity classes and the columns correspond to the national parks. Each cell in the diagram, represented by a histogram, shows the distribution of watersheds (catchments) obtained from crowdsourcing data. Comparing the histograms in each row with the corresponding class value in the far-left column of the diagram, one can quickly assess the level of agreement between the expert-based and crowdsourced classifications. The first row in the diagram corresponds to the highest geodiversity class value (5), and approx. 45% of watersheds in Karkonosze NP fall into this class (see the red bar in the 1st column histogram).



Conclusions

- Local Weighted Linear Combination (L-WLC) technique appears to give better results in mountainous areas whereas Weighted Linear Combination (WLC) technique works better in morphogenetically and morphometrically less diverse areas such as uplands and lowlands.
- This conclusion must be treated with caution due the limited number of assessment cases employed in this research.
- Future studies could employ the presented herein methodology to geodiversity assessment of other diverse study areas.
- Future research could also address the issue of geodiversity map sensitivity in response to the selection of spatial analysis units, e.g. catchments. Developing guidelines for selecting a proper size and shape of analysis unit would be an important step in advancing geodiversity mapping and assessment.

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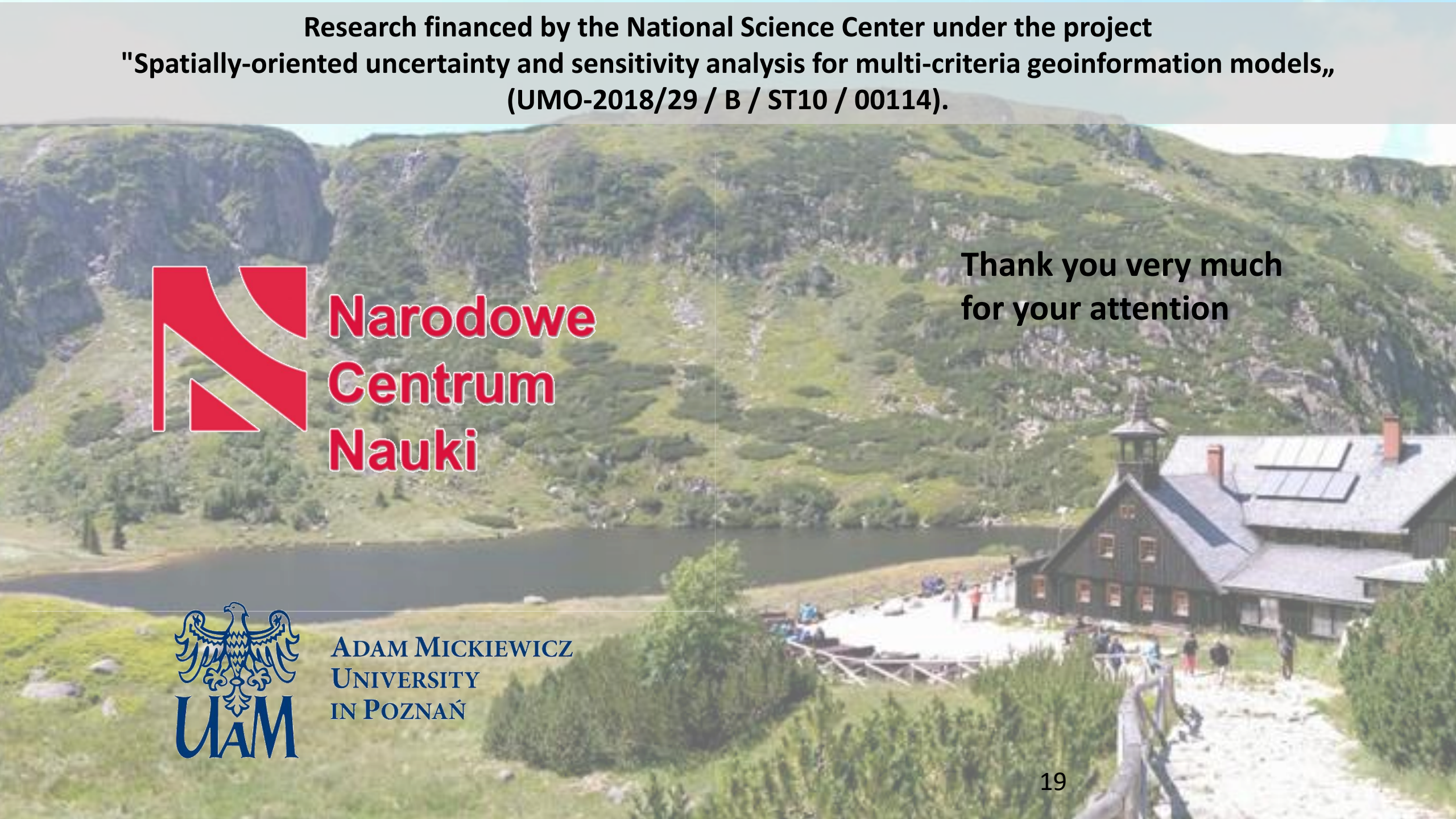

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Thank you very much
for your attention

Adam Mickiewicz University in Poznań