**LandCell – a tool for landscape change analysis**

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**Abstract:** LandCell is an open source software for landscape change analysis. It allows to reduce error propagation when comparing raster maps with categorical legends. We present LandCell and its main functionalities: input data parametrisation, transition matrix statistics, identification of false transitions and Markov chain modelling.

**Key words:** LandCell, landscape analysis, Markov chain modelling

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**Introduction**

LandCell is an open source software for landscape change analysis, free for any purposes, developed in 2005 (LandCell 1.0, Giętkowski 2005) and expanded in 2011. The newest version (LandCell 2.0 trunk) enables to:

- Compare raster maps with categorical legends using Cell-by-cell overlap;
- Create transition matrix, generate transition map and view result statistics;
- Fuzzify categorical maps in order to identify false transitions, remove them from transition map and correct transition matrix;
- Perform Markov chain modelling.

LandCell is a plug-in for Quantum GIS, which helps to integrate it with other tools. It’s suited to work under any operating system Quantum GIS works on, including Linux, Mac OS X and Windows. The input data are stored in ASCII raster format, however, any of dozens of raster formats supported by Quantum GIS can be easily imported. The source code is written in Python with NumPy for easy development and installation without significant loss of performance. The application is built in a way that allows the partial results to be visualized and saved at any stage of the process. All visualizations are done by nice and interactive Qwt5 plots.

The main functionalities of LandCell, such as (i) input data parameterisation, (ii) transition matrix statistics, (iii) identification of false transitions and (iv) Markov chain modelling, were presented below.

**Input data parameterisation**

At first the project environment needs to be defined. Selecting, downloading and displaying the maps (e.g. land cover layers) for the comparison can be done from here. The dialogue allows to define the input settings: data storage directory, project name, data source and categorical legend class descriptions (number, colour and name).
Transition matrix statistics

This tool performs a Cell-by-cell comparison method, which considers each pair of cells on two categorical raster maps to be either ‘equal’ or ‘not equal’. This results in a two-classes transition map demonstrating the spatial distribution of agreement (e.g. change in land cover in a given time period). The result statistics are available in two formulas – as an amount of raster cells ascribed to particular transitions or as transitions’ probability. The former is suitable for further predictive modelling with Markov chains.

Identification of false transitions

False transitions tool helps to reduce the uncertainty stemming from dissimilar quality of source data (e.g. archival maps) and to make a distinction between ‘true’ and ‘false’ changes (e.g. in land cover). The fuzzy reasoning (Zadeh 1965) has been applied here. This way of reasoning takes into account the possible existence of grades of similarity between pairs of cell in two categorical raster maps (instead of strict distinction to ‘equal’ or ‘not equal’, as it is in the case of the Cell-by-cell method).

The comparison algorithms account for fuzziness of neighbouring cells, described by so called membership vectors. In the view of that, the fuzzification process depends on the: cell itself, distance to the neighbours, neighbours’ classes and weights (Hagen 2003). Weights of the neighbours decrease with the distance from the central cell, that is in accordance with the Tobler’s Law (First Law of Geography: Everything is related to everything else, but near things are more related than distant things, Tobler 1970). An algorithm introduced in LandCell goes beyond the Hagen’s (2003) method in the area of neighbourhood rules – here, all neighbouring cells from a given range influence the value of the element belonging to the fuzzy membership vector.

To begin with, the user sets the parameters by choosing the membership function (linear, linear decay or exponential decay), preferred neighbour rule, the range of neighbourhood and the comparison method for membership vectors (e.g. Kochy’s or Williams & Steele method).

The similarity of two maps is assessed by pairwise comparison of membership vectors assigned to the cells. The result map indicates a level of probability to which each cell belongs to the particular category (e.g. of land cover). The cells representing high values of similarity (high probability the cell did not change the category) are attributed as: ‘false changes’ (i.e. certain stable areas), while the low values are considered to be ‘true changes’ (i.e. certain changes). In between of them there occur a range of uncertain cells, which are considered as belonging to so called ‘range of general uncertainty’ (RGU). The threshold values of RGU result from distortions and inaccuracies of the source data and thus depend on the values of rectification error (the higher RMSE values, the wider RGU).

The corrected transition matrixes are generated to the exclusion of cells belonging to the RGU. Just as in the case of Transition matrix statistics tool, the result statistics can be saved and is available in two formulas (as an amount of raster cells ascribed to particular transitions or as transitions’ probability), with the second one appropriate for Markov modelling.

Markov chain modelling

Markov chain is a simple and easy to prepare non-spatial distributional model, based on probability theory. It undertakes transitions from one state to another in a step-by-step manner. The Markovian process is random and memoryless. The next state depends only on the current state and not on the entire past (Grinstead & Snell 1997).

The simulation is based on the transition probability matrix and the starting vector (which means: starting class distribution, e.g. starting moment in land cover change analysis). The results may be visualized and saved as a step-by-step distribution chain or in a form of a diagram. The Markov modelling can be run using both: ‘the raw’ (result of Transition matrix statistics tool) and ‘the corrected’ (result of False transition tool) transition matrixes. LandCell is being continually developed and some new functionalities (including further adjustment of the membership function’s parameters to the rectification error value, new membership functions and validation
methods) are predicted for the nearest future.

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References

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