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LecoS — A python plugin for automated landscape ecology analysis

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ABSTRACT

The quantification of landscape structures from remote-sensing products is an important part of many analyses in landscape ecology studies. This paper introduces a new free and open-source tool for conducting landscape ecology analysis. LecoS is able to compute a variety of basic and advanced landscape metrics in an automatized way. The calculation can furthermore be partitioned by iterating through an optional provided polygon layer. The new tool is integrated into the QGIS processing framework and can thus be used as a stand-alone tool or within bigger complex models. For illustration a potential case-study is presented, which tries to quantify pollinator responses on landscape derived metrics at various scales.

1. Introduction

The use of free and open-source software in ecological research has gained increasing attention in the last years (Baker and Cai, 1992; Boyd and Foody, 2011; Cagnacci and Urbano, 2008; Saura and Torné, 2009; Steiniger and Hay, 2009). Freely available open-source software has several advantages in research such as that the computational and statistical background of the analysis can be independently investigated and verified (Khanjani and Sulaiman, 2011). Furthermore free software can enhance biological research and knowledge transfer in developing countries, where financial constraints often prevent the access to proprietary alternatives (Steiniger and Hay, 2009).

Within ecological research the field of landscape ecology features a number of free and open-source tools (Brown, 2014; Etherington et al., 2015; Saura and Torné, 2009; Steiniger and Hay, 2009). Landscape ecologists study the relationship between patterns and ecological processes on a variety of spatial and organizational levels (Turner, 1989; Wu, 2006). Landscapes are here often seen as mosaics of differently structured and composed land-cover patches which are potentially connected by spatial dynamics (Pickett and Cadenasso, 1995). The landscape structure can be quantified by size, shape, configuration, number and position of land use patches within a landscape. Those quantified values and metrics are important for various fields of ecological research like for instance studies on the influence of habitat fragmentation on wildlife (Fahrig, 2003).

Landscape metrics are usually derived from classified land-cover datasets using specialist software and graphical information systems (GIS). See Steiniger and Hay (2009) for an extensive overview of freely available open-source software for landscape ecologists. Out of those software products FRAGSTAT is most likely the most comprehensible software package for the calculation of landscape and patch metrics (McGarigal and Marks, 1995; McGarigal et al., 2012). However the analysis in FRAGSTAT is separated from the visualization in a GIS program and does not run natively on all operating systems such as Mac-OS or Linux derivatives. Other widely used open-source software suites include the r.li extension for GRASS GIS (Baker and Cai, 1992; Neteler et al., 2012) and SDMTools for the R software suite (VanDerWal et al., 2012). Those solution however depend on prior raster formatting and cropping or cannot be used in complex hierarchical models without knowledge of programming or scripting.

Here a new tool is introduced which is capable of analyzing various landscape and patch metrics within a freely available open-source GIS suite and is thus being able to combine the ability of calculating complex landscape metrics within sophisticated GIS models.

2. Landscape ecology analysis in QGIS

The QGIS project provides a free and open source desktop and server environment and ships with all functionalities of a modern GIS system (QGIS Development Team, 2015). It furthermore allows the easy extension of its core functions through user-written plugins, which can be downloaded within the desktop suite. Since the last stable version – codename 'Wien' – the popular spatial data processing framework SEXTANTE has been integrated into QGIS. This new 'Processing toolbox' not only integrates existing geoprocessing functions into a similar toolbox as in the prominent ArcGIS suite, it also allows the creation of automatized models, which are able to combine several individual spatial

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calculations into single sequential models. Additionally, users are able to add their own python or R scripts to the Processing toolbox.

Here a new plugin for QGIS called LecoS (*L*andscape *eco*logy *S*tatistics) is introduced. It makes heavy use of the scientific python libraries SciPy and Numpy (Jones et al., 2001; Oliphant, 2007) to calculate basic and advanced landscape metrics and provides several functions to conduct landscape analysis. Up to now over 16 different landscape metrics are supported. LecoS comes with two different interfaces with core functions like the computation of landscape metrics having their own graphical interface, while more advanced functionalities are only supported in the QGIS Processing toolbox.

Since LecoS version 1.9 the set of available functions can be divided into the categories *Landscape preparation*, *Landscape modification*, *Landscape statistics* and *Landscape vector overlay* (Table 1). Landscape preparation functions allow the user to prepare and match input layers to each other, while landscape modification functions can modify or generate derivatives of raster layers. Users can calculate landscape metrics or raster properties with the Landscape statistics functions and are also able to automatize those calculations for all features of a given vector layer (Fig. 1). In addition, newer functions such as the integration of neutral landscape models via the python library NLMpy (Etherington et al., 2015) can optionally be enabled and are integrated into the processing framework.

LecoS can be acquired through the QGIS plugin manager or directly downloaded from the QGIS plugin hub (http://plugins.qgis.org/plugins/LecoS/). The python libraries SciPy, NumPy and the imaging library PIL have to be installed, correctly configured and be available in the QGIS python path beforehand.

3. Case-study

In the following paragraphs an exemplary use-case of LecoS is demonstrated using real sampled field data. Pollinators are of increasing concern in recent ecological studies due to their reported declines, which might endanger ecosystem service provisioning worldwide (Klein et al., 2007; Potts et al., 2010). The drivers of pollinator decline are various and habitat loss is certainly one of many reasons (Potts et al., 2010). Semi-natural habitats provide resources and nesting opportunities for many pollinators such as bees or hoverflies. However not only the primary habitat, but also the surrounding landscape is important as resource due to their mobility. In the past it has been shown that different taxonomic units of pollinators show opposing responses to landscape structure and remoteness from their primary habitat (Jauker et al., 2009; Meyer et al., 2009). The goal of this case-study will be to characterize the heterogeneity and characteristics of the landscape at various scales using an automatized model framework within QGIS.

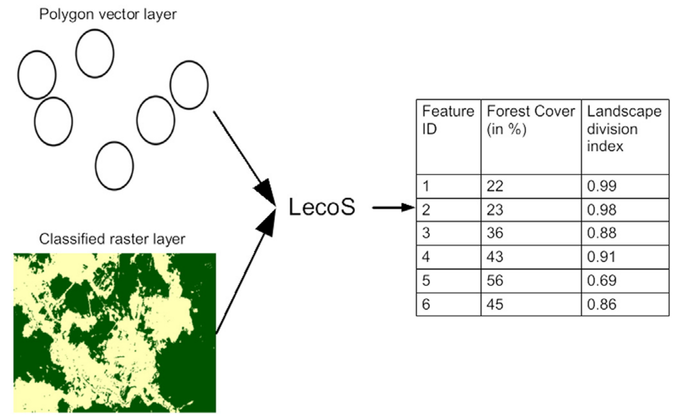

Fig. 1. Illustrating the power of the Landscape vector overlay functions. In this example the intended goal is to calculate the proportion of forest cover and Jaegers landscape division index (Jaeger, 2000) for every single study site here displayed as circles. Using the vector overlay function LecoS is able to automatically compute the selected landscape metrics for every feature of a provided vector layer.

3.1. Methodology

All locality and species data was taken from Mudri-Stojnić et al. (2012), who conducted an assessment of pollinator abundance and diversity in 16 grassland habitats in northern Serbia. The study sites

Table 1
List of functions to date (Version 1.9.8). All functions need installed python-osgeo, python-scipy and python-pil bindings within QGIS 2.8 Wien.

Name	Interface (graphical|processing)	Description
Landscape preparation		
Create random landscape (distribution)	No|Yes	Allows to create a new raster layer based on a chosen statistical distribution. The user can specify the extent of the output and distribution parameters.
Intersect landscapes	No|Yes	Takes a source and target raster layer as input and calculates the intersection of both layers.
Match two landscapes	No|yes	Reprojects and interpolates a raster layer to the projection and extent of a target raster.
Landscape statistics		
Count raster cells	No|Yes	Returns the number of cells per unique cell value inside a raster layer
Landscape wide statistics	Yes|Yes	Allows to calculate various landscape metrics for an input raster layer
Patch statistics	No|Yes	Computes patch metrics for a given land cover class.
Zonal statistics	No|Yes	Performs a zonal statistics analysis with a raster layer containing zones and a raster layer containing values as input.
Landscape vector overlay		
Overlay raster metrics (polygons)	Yes|Yes	Allows to compute landscape or patch metrics for each polygon feature of an input vector layer. Results can be generated as new separate table or added to attribute table of the vector layer.
Overlay vector metrics (polygons)	Yes|No	Can calculate basic metrics for attribute derived classes inside a polygon vector layer.
Query raster values (points)	No|Yes	Returns all raster values of the cells below a given point layer
Landscape modifications		
Clean small pixels in patches	Yes|Yes	Cleans a given classified raster layer of small isolated pixels.
Close holes in patches	Yes|Yes	Closes holes (inner rings) in all patches of a specified land cover class.
Extract patch edges	Yes|Yes	Extracts the edges from each patch of a given land cover class.
Increase/decrease patches	Yes|Yes	Allows the user to increase or decrease all landscape patches of a given land cover class.
Isolate smallest/greatest patches	Yes|Yes	Returns a raster layer with the greatest or smallest identified land cover patch. If multiple patches fulfill this criteria, than all of them are returned.
Label landscape patches	No|Yes	Conducts a connected component labeling (chessboard structure) of all raster cells with a given value. The output contains a raster layer where all individual patches have a single unique identifier.
Neighborhood analysis (moving Window)	No|Yes	Calculates statistics for cells in a raster layer using a moving window approach.