- ANALYZING CHANGE
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- REDD MODELING CAPABILITIES
- PLANNING FOR FUTURE SCENARIOS

Land Change Modeler™

FOR ARCGIS®
Analyzing Change

Land change analysis is critical in areas such as environmental and resource management, land use planning, biodiversity conservation and REDD (reducing emissions from deforestation and forest degradation). Clark Labs has produced a set of tools organized in a stepwise fashion to facilitate such analysis. The first step in the process is to analyze historical change between two land cover maps of different time periods. The user specifies two land cover maps of different dates and Land Change Modeler (LCM) rapidly assesses the changes between the two. The user can immediately review and evaluate area gains and losses, net change, persistence and specific transitions both in map and graphical form. A change abstraction tool is also included, based on trend surface analysis, to uncover the underlying trends of complex change.

Modeling the Potential for Change

After reviewing the historical changes between the two maps, the user must identify the driver variables that may be contributing to the transitions being analyzed. These variables, in map format, can be tested to confirm whether or not they hold explanatory power for the transition and then selected and incorporated into the model. Such driver variables may include maps of distance to roads or accessibility to forest, for example. Using past land transition information with environmental, physical and socio-economic variable maps that might drive or explain such change, the Land Change Modeler can create a GIS data layer expression of transition potential—the likelihood that a land use will transition in the future. These transitions may be modeled with Logistic Regression, a Multi-Layer Perceptron neural network, or the Similarity Weighted Instance-based Learning algorithm, resulting in a potential map for each transition—an expression of time-specific potential for change.

The explanatory variables can be static, expressing aspects of basic suitability for the transition under consideration, or dynamic, time-dependent drivers, such as proximity to existing development or infrastructure. Dynamic variables are recalculated at each iteration during the course of a prediction.
Predicting Change

The change prediction process relies on these historical transitions and models forward to a specified future date. The quantity of change can either be modeled through a Markov Chain analysis or by providing a transition probability matrix from an external (e.g., econometric) model.

For the dynamic variables, Land Change Modeler allows for the specification of the number of reassessment stages during which they are updated. At each stage, the system also checks for the presence of planning interventions, important parameters that may alter the course of development in the change prediction process. Interventions include constraints and incentives, such as proposed reserved areas, and infrastructural changes, such as roads or developments. Interventions are specified in the Planning tab.

For the actual prediction output, a “hard” prediction based on a multi-objective land competition model with a single realization is created. The option of creating a “soft” prediction output, a continuous map of vulnerability to change for the selected set of transitions, is also provided. The soft prediction model is generally preferred for habitat and biodiversity assessment since it provides a comprehensive assessment of change potential.

To test your model, tools are also provided to validate or determine the quality of the predicted land use map in relation to a map of reality. The validation tool however does require another map (time period 3 that matches the date of the prediction), a map of reality. This is an important modeling process as it allows the user to compare the maps, assess the robustness of their model and refine if necessary. For example, the user may wish to incorporate another explanatory variable.

The use of land involves a variety of stakeholders. It is therefore extremely important that the land cover change analysis and prediction process account for as many components and variables as possible if it is to be an effective tool.
Impact Assessment for Habitat and Biodiversity

A wide range of tools is provided for assessing the implications of land use change for ecological sustainability. These include tools for species-specific habitat assessment, habitat change analysis, gap analysis, landscape pattern analysis, species distribution modeling, and biodiversity analysis. Integrating species data, you may utilize LCM in the following ways.

▶ Species-specific habitat assessment. Based on existing or predicted land cover maps and a map of species-specific habitat suitability, the habitat assessment tool develops a map with primary and secondary habitats and primary and secondary potential corridors. Important parameters that control this process include the home range size, buffers based on sensitivity to humans, and the ability to cross gaps within home ranges and during dispersal.

▶ Habitat change. Detection of changes in habitat status and gap analysis by comparison to a map of protection status.

▶ Land cover pattern and change process analysis. Tools are available to assess patterns in the landscape (e.g., edge density or relative richness) or to characterize the nature of change underway between two land cover maps.

▶ Species range polygon refinement. This exploratory tool allows for the refinement of species distribution maps through the analysis of environmental variables.

▶ Species distribution modeling. Tools are available for developing species-specific habitat suitability and distribution maps through presence-absence, presence-only algorithms, or through a theoretical model. Includes an interface with MaxEnt.

▶ Biodiversity assessment. Using collections of species range polygons (such as those provided by NatureServe), this tool permits the development of maps of alpha diversity (local species richness), gamma diversity (regional richness), beta diversity (Whittaker’s and Sorensen’s) and relative range restriction.

Land cover change represents one of the major threats to biodiversity worldwide. Habitat destruction is the dominant threat. One must therefore integrate land cover change maps with species distribution data to inform conservation strategies.
Impact Assessment for REDD

Initiatives to implement REDD at the national or regional level require the development of a scenario of greenhouse gas emissions that would occur in the reference region if a project were not to happen. The calculations for the reference region must include the proposed project area as well as the surrounding leakage area, adjacent land where displaced deforestation may likely occur as a result of the REDD project. This estimate of emissions helps determine whether the potential carbon offset project will provide additionality, carbon offset that would not have occurred if a “business as usual” scenario were maintained. When a project is implemented, the actual emissions are compared to the calculated emissions in the reference scenario to calculate the creditable emissions reductions.

Included in LCM is a facility for modeling the impact of land cover change, specifically deforestation, on carbon emissions. The calculation of emissions is a requirement for the implementation of a REDD project.

An important component of REDD analysis is the assessment of historical land cover change rates and patterns, in particular deforestation, along with the driving forces of change. LCM’s land change prediction modeling is cost-effective and automated, providing the necessary steps for the development of calculations for a project’s potential for carbon sequestration.

The REDD facility is intended to support the various methodologies being reviewed and approved by the Verified Carbon Standard (VCS) for the voluntary market.

- Estimates baseline emissions.
- Calculates deferred emissions and carbon credits.
- Creates formatted table in an Excel spreadsheet.

The REDD tool within LCM allows for the calculation of carbon additionality needed to develop a REDD project. The images show the land cover in the Mantadia region in Madagascar for the year 1990, the change that occurred between 1990 and 2000 and the projected deforestation vulnerability (soft prediction) for the year 2030. This information, together with the specification of carbon pools and carbon content within pools, allows for the calculation of all tables needed for REDD.
Land Change Modeler for ArcGIS delivers results based on a synthesis of historical land change information with the analyst’s knowledge of the variables that drive such change.

Planning Interventions

The Land Change Modeler allows the user to specify and incorporate planning intervention maps that may alter the course of development. Planning interventions may be static or dynamic. Interventions include constraints and incentives, such as proposed reserved areas, infrastructure modifications, such as the development of roads and policy initiatives, along with the year such changes will become effective.

The Planning section of LCM also includes a tool to define species corridors based on habitat suitability as well as the specification of the areas to be connected. It includes an interface with Marxan, a spatial conservation planning software widely used and available freely from the University of Queensland.

System Requirements

The Land Change Modeler software is intended for professional-level planning use on platforms employing the Microsoft® Windows operating system and the ESRI® ArcGIS® software. Any Windows system that supports ArcGIS 10.2 SP2 or later can run Land Change Modeler. 500 MB of hard disk space is required.

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