

TerrSet

Geospatial Monitoring and Modeling System

What's New: A Guide for IDRISI Users

A NEW NAME, A NEW CONCEPT, AND A WEALTH OF ADVANCES

For close to 30 years, Clark Labs has been a pioneer in the development of geospatial software. The IDRISI GIS and Image Processing system set new standards for decision support in geographic analysis and remote sensing applications.

Then we added the Land Change Modeler (LCM) for the empirical modeling and future prediction of land cover change—a vertical application built on top of a GIS.

Next came the Earth Trends Modeler (ETM)—a radically new system for time series analysis of earth observation imagery for understanding climate and global environmental change.

TerrSet builds on this trajectory, adding new vertical applications and a range of important new features to the existing base.



The New TerrSet Interface

The IDRISI GIS Analysis and IDRISI Image Processing components provide access to the full IDRISI system along with new enhancements. The Land Change Modeler has now been split into two to allow for greater expansion. One part is still called the Land Change Modeler (LCM) and focuses on that task with the additional capability of estimating greenhouse gas emissions for the support of REDD (Reducing Emissions from Deforestation and forest Degradation) projects. The Habitat and Biodiversity Modeler (HBM) takes all of the habitat/landscape/biodiversity components from the previous LCM and puts them into a new system with room for growth.



The Completely New Elements of TerrSet include:

- The Ecosystem Services Modeler (ESM) for assessing the value of various ecosystem services such as water purification, crop pollination, wind and wave energy, and so on. ESM is based closely on the InVEST toolset developed by the Natural Capital Project.
- The Climate Change Adaptation Modeler (CCAM, pronounced “see cam”) – a tool for modeling future climate and assessing its impacts on sea level rise, crop suitability and species distributions.
- GeOSIRIS – a unique tool for national level REDD (Reducing Emissions from Deforestation and forest Degradation) planning, developed in close cooperation with Conservation International. With GeOSIRIS one can model the impact of various economic strategies on deforestation and carbon emissions reductions.

The interface for TerrSet has been completely reorganized around the eight components of the TerrSet constellation:

- IDRISI GIS Analysis
- IDRISI Image Processing
- Land Change Modeler
- Habitat and Biodiversity Modeler
- Ecosystem Services Modeler
- GeOSIRIS
- Earth Trends Modeler
- Climate Change Adaptation Modeler

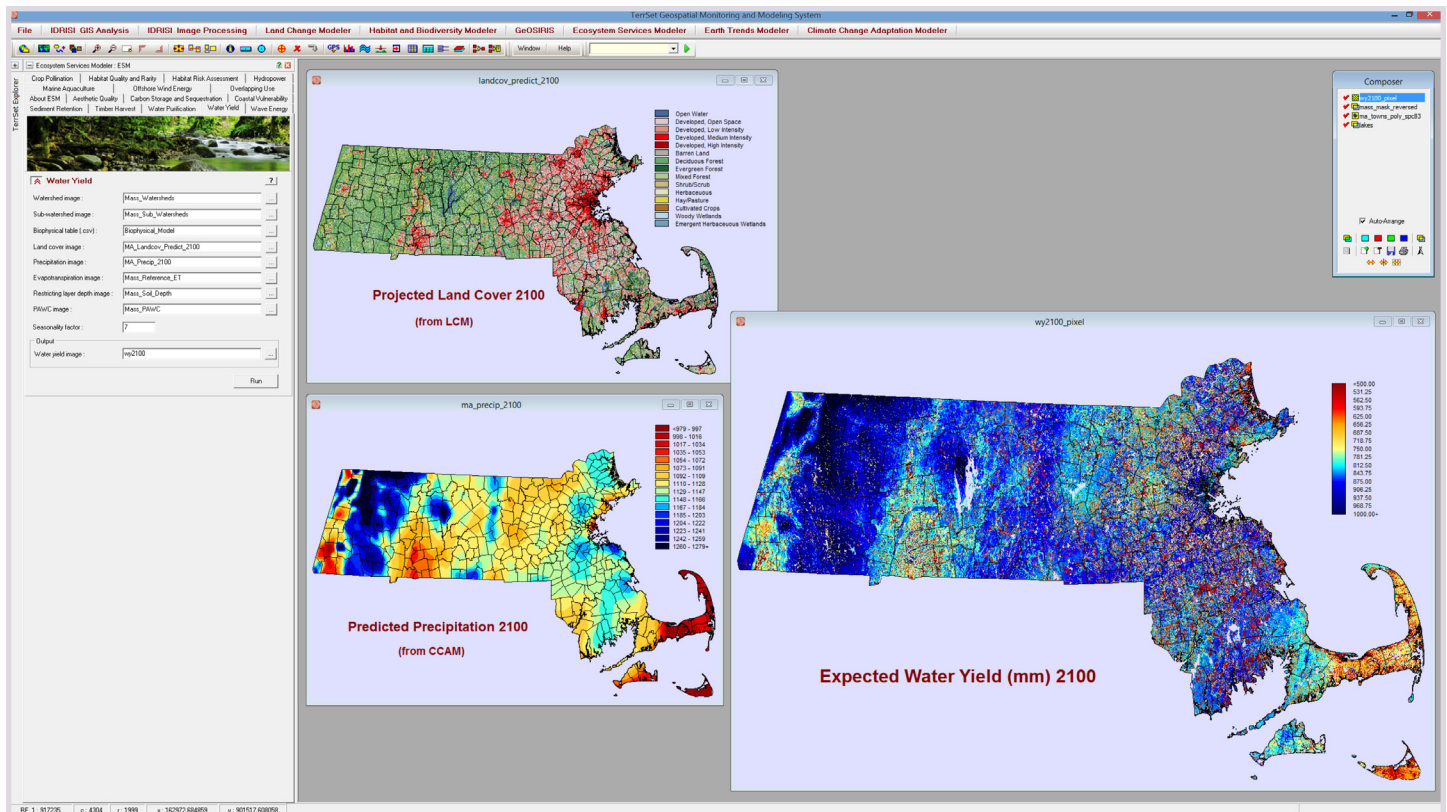
The Ecosystem Services Modeler

The Ecosystem Services Modeler is a spatial decision support system for assessing the value of the services ecosystems provide (known as natural capital). The intention is to provide a means for understanding the implications of land development. The Ecosystem Services Modeler (ESM) provides 15 ecosystem service models that are based closely on the InVEST algorithms developed by the Natural Capital Project. These include:

- **Water Yield:** measures the average annual yield based on inputs such as precipitation, land cover, evapotranspiration.
- **Water Purification:** calculates nutrient retention and the avoided cost of water treatment.
- **Sediment Retention:** estimates sediment retention in a watershed and the avoided cost of sediment removal.
- **Hydropower:** estimates the potential energy production from a reservoir and its value.
- **Carbon Storage and Sequestration:** estimates the amount of carbon currently stored or sequestered in the landscape and its value.
- **Timber Harvest:** models total biomass and net present value of harvested timber at the parcel level.
- **Habitat Quality and Rarity:** assesses the impacts of anthropogenic threats on the quality and rarity of habitats.

- **Crop Pollination:** evaluates the abundance and economic value of pollinators for agriculture.
- **Habitat Risk Assessment:** an alternative to the Habitat Quality and Rarity approach, the Habitat Risk Assessment (HRA) model focuses on management strategies and exposure/consequences.
- **Offshore Wind Energy:** evaluates potential wind energy sites and their economic value.
- **Aesthetic Quality:** models the visibility/visual impact of developments. The TerrSet approach includes a full consideration of atmospheric conditions on visibility.
- **Overlapping Use:** calculates the frequency and importance of human activities within a management zone.
- **Coastal Vulnerability:** evaluates the exposure of coastal communities to storm-induced erosion and inundation.
- **Marine Aquaculture:** estimates the productivity and economic value of existing aquaculture systems or identifies the best potential sites for new aquaculture projects.
- **Wave Energy:** evaluates wave-generated energy provision potential including consideration of the siting of wave energy conversion facilities.

Fully integrated into the TerrSet system, users can access a powerful platform for deriving the data for use in the 15 models, such as deriving future land use scenarios using the Land Change Modeler and predicted future precipitation using the Climate Change Adaptation Modeler to assess the impacts on water yield or sedimentation.



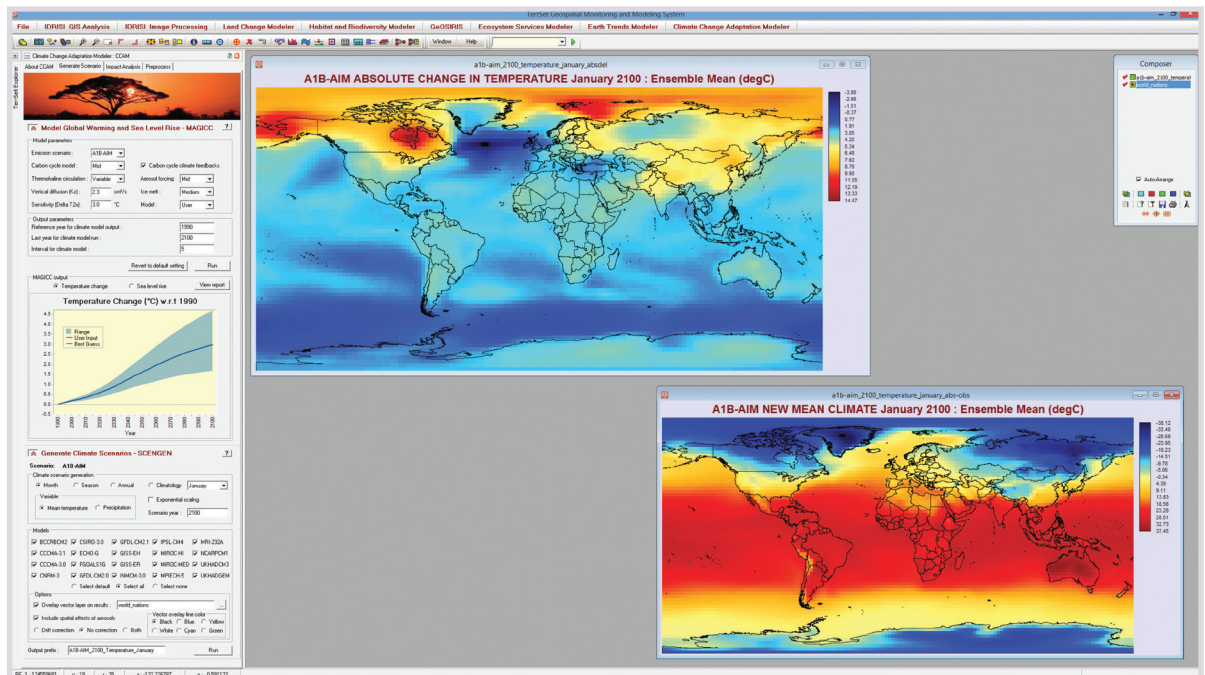
The Ecosystem Services Modeler (ESM) is closely based on the InVEST tools developed by the Natural Capital Project. Fifteen ecosystem service models have been implemented. In this illustration, ESM is used to evaluate water yield in the year 2100. The predicted land cover input was generated by LCM and the predicted precipitation was generated by CCAM.

Climate Change Adaptation Modeler

The Climate Change Adaptation Modeler (CCAM—pronounced “see-cam”) addresses the growing challenge of adapting to a rapidly changing climate. The Climate Change Adaptation Modeler is a suite of tools for modeling future climate and assessing its impacts on sea level rise, crop suitability and species distributions. It includes tools for climate scenario generation using the National Center for Atmospheric Research’s MAGICC and SCENGEN models (based on CMIP3/AR4), crop suitability modeling using the Food and Agriculture’s EcoCrop database, modeling sea level rise impact, downscaling climate projections, and the derivation of bioclimatic variables. With CCAM, you can, for example:

- Generate global temperature and precipitation climate scenarios using any one, or an ensemble, of 20 atmosphere/ocean general circulation models (AOGCMs) based on user-selectable greenhouse gas and sulfur dioxide emission scenarios.
- Derive up to 19 bioclimatic variables (such as maximum temperature of the warmest month, minimum precipitation of the driest month, etc.) for use in species distribution models (using HBM).
- Model the impact of future projections of temperature and precipitation on crop suitability. Crop parameters can be added for any crop, but the included database provides the parameters for almost 2000 crops.
- Model the effect of projected sea level rise incorporating both the uncertainty of the projection and the uncertainty in the elevation model.

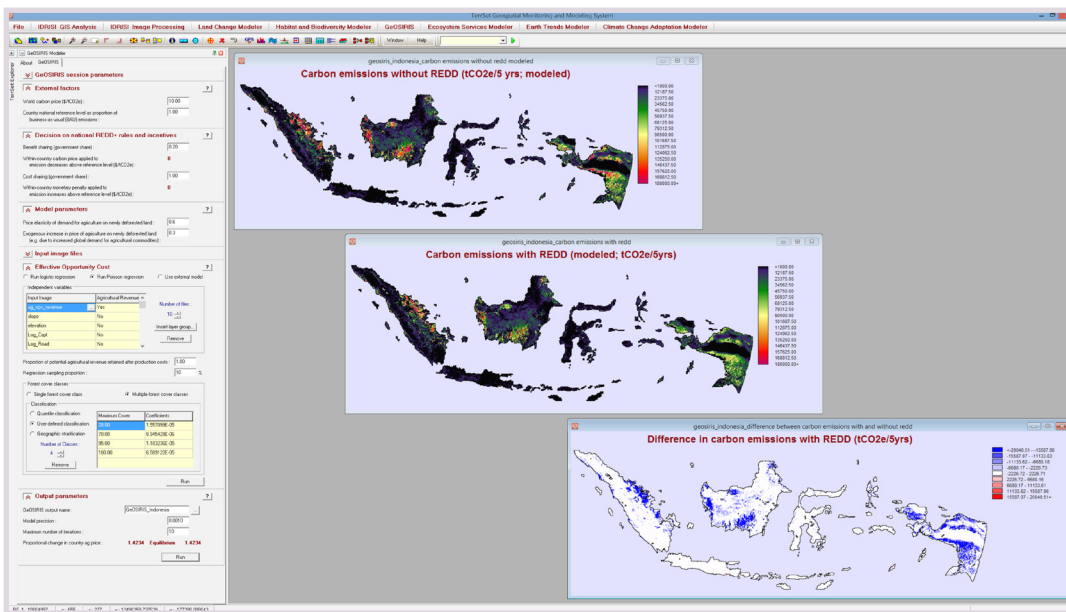
The Climate Change Adaptation Modeler includes an interface to the National Center for Atmospheric Research’s MAGICC and SCENGEN models for generating climate scenarios (based on CMIP3/AR4). In this illustration, the MAGICC suite of coupled gas-cycle, climate and ice-melt models was used to determine changes in greenhouse-gas concentrations and global-mean surface air temperature (the graph) using the A1B-AIM scenario. SCENGEN was then used to generate an ensemble forecast for January 2100 based on 20 atmosphere/ocean general circulation models.



GeOSIRIS

GeOSIRIS is a national-level REDD (Reducing Emissions from Deforestation and forest Degradation) planning tool that quantifies and maps the impacts of REDD policies on deforestation, carbon emissions, agricultural revenue, and carbon payments. Whereas LCM’s tools are appropriate for the development and assessment of individual projects, GeOSIRIS is oriented to the evaluation of alternative economic policy decisions for reducing greenhouse gas emissions and distributing REDD revenues. This application is a spatial implementation of the OSIRIS economic model created by Conservation International, the World Resources Institute and the Environmental Defense Fund. The model requires map layers of forest cover, forest cover change (which can be output from LCM), biomass, soil carbon, peat, potential agricultural revenue, site accessibility

and administrative divisions (at multiple levels). Parameters include the global price of carbon, the national reference level for emissions as a proportion of business-as-usual, national/sub-national proportional cost/benefit sharing, price elasticity of demand for agriculture on newly deforested land and exogenous increases in price due to changes in demand. With these inputs, users can calculate the effective opportunity cost to establish the relationship between deforestation and potential agricultural revenue. Following this, a wide variety of map outputs can be produced including expected carbon emissions with and without the REDD policy in place, agricultural revenue, expected deforestation, cost efficiency of emissions reductions, and so on.



GeOSIRIS is a national-level planning tool for REDD (Reducing Emissions from Deforestation and forest Degradation). Developed in partnership with Conservation International, GeOSIRIS allows the user to specify the price of carbon, national level objectives for carbon emissions, the distribution of offset income between national and local levels, and a variety of economic parameters such as price elasticity of demand for agriculture on newly deforested land. GeOSIRIS empirically determines the effective opportunity cost based on a set of environmental variables and a provided map of potential agricultural revenue. Outputs include maps of expected carbon emissions with and without the proposed REDD policy as in the example for Indonesia to the left.

Habitat and Biodiversity Modeler

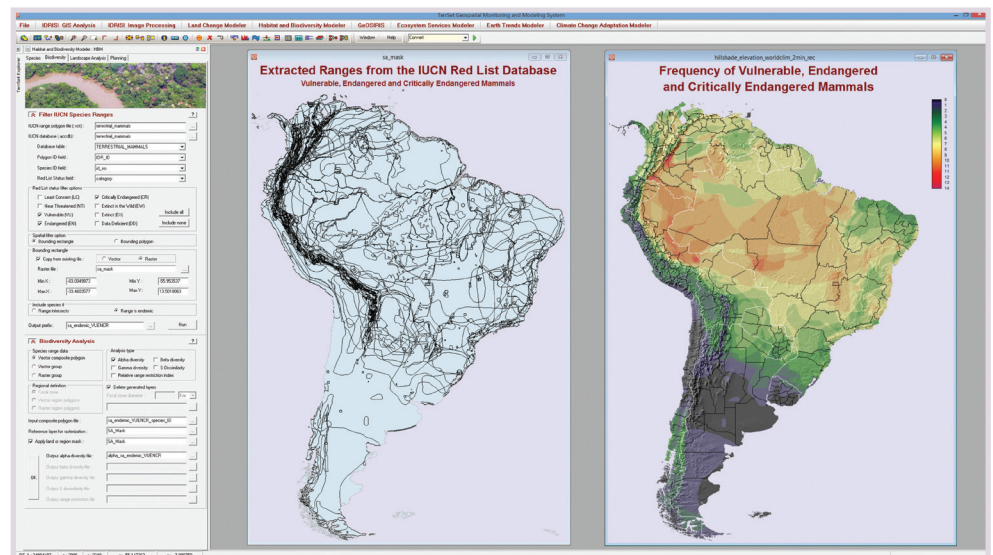
The Habitat and Biodiversity Modeler (HBM) is a toolset designed for Conservation GIS professionals. It provides tools for the modeling of species distributions, habitat assessment, habitat change and gap analysis, biodiversity analysis, and the planning of reserves and biological corridors.

Species

At the species level, HBM provides a wide variety of options for the modeling of species distributions based on observed locations and bioclimatic variables. Options are provided for presence only data (Mahalanobis Typicality and MaxEnt), presence/absence (Logistic Regression and a Multi-Layer Perceptron neural network) and abundance data (Multiple Regression). For individual species, the Habitat Assessment tool allows the mapping of primary and secondary habitat as well as potential corridor areas. Facilities are also provided for the assessment of habitat change and gaps in the protection system.

Biodiversity Analysis

HBM's Biodiversity tab provides a special utility for working with the IUCN (International Union for Conservation of Nature and Natural Resources) Red List of Threatened Species database. Subsets of species ranges can be extracted based on the Red List threat level, location and endemism. Given a set of extracted ranges (typically hundreds to thousands of ranges), maps of alpha diversity, gamma diversity, beta diversity, Sorensen's dissimilarity, and range restriction can be generated.



The Habitat and Biodiversity Modeler (HBM) includes a wide range of tools for habitat assessment and species distribution/biodiversity modeling. In this illustration, the IUCN Red List species database for terrestrial mammals (freely available on line) was scanned to extract the range polygons of species endemic to South America. Once extracted, the polygons were then used to create a map of frequency using the alpha diversity mapping option.

Landscape Analysis

At the landscape level, a facility is provided for landscape pattern analysis that maps normalized entropy, relative richness, edge density, patch area and patch compactness. In cases where land cover maps from two dates are available, the process of change can be mapped. For example, a landscape may not be particularly fragmented, but may be actively fragmenting. Other processes that can be detected include deformation, perforation, shift, shrinkage, enlargement, attrition, aggregation, creation and dissection.

Planning

For planning, tools are provided for biological corridor analysis and reserve planning. The corridor tool allows you to specify the target width and number of branches as well as produce maps of development suitability and conservation value. It then maps corridors of least biological risk. For reserve planning, we have provided an integrated interface to the well-known Marxan reserve planning tool.

Land Change Modeler

Land cover change is one of the largest imprints of humans on the Earth system. Understanding and projecting transitions into the future is critical for smart development, biodiversity conservation and managing climate mitigation strategies such as REDD (Reducing Emissions from Deforestation and forest Degradation). The Land Change Modeler (LCM) analyzes historical land cover data to assess, model and predict land cover change using powerful machine learning procedures. Major components of LCM include:

Land Change Analysis

Given two historical land cover layers, quickly generate graphs and maps of land change, including gains and losses, net change, persistence and a breakdown of contributors to each transition. LCM includes the ability to generalize complex transitions using trend surface analysis.

Transition Potential Modeling

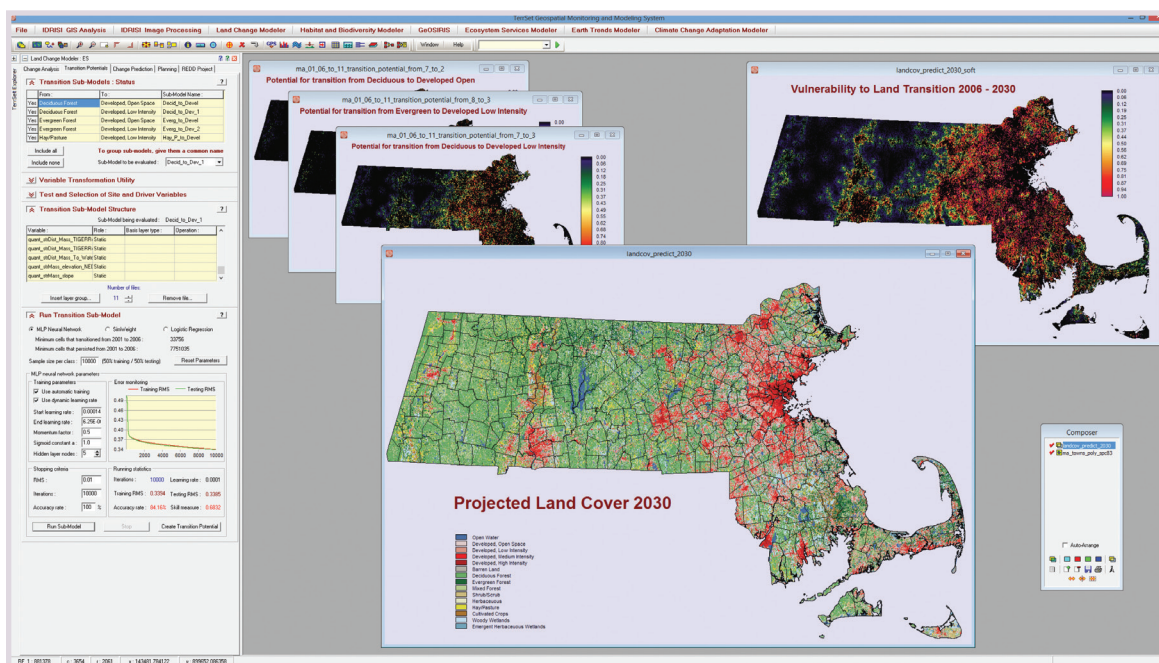
Modeling the potential of land to experience specific transitions (such as deforestation for agricultural development) lies at the very heart of LCM. Using historical land cover layers along with a set of potential explanatory variables (such as proximity to roads, soil type and slopes), LCM uses empirical modeling tools to establish the relationship between them. LCM currently supports logistic regression, a modified KNN (K-nearest neighbor) and an exceptionally powerful Multi-layer Perceptron (MLP) neural network for model development. In the latter case, a very detailed accounting is provided of model skill and the degree of contribution of each explanatory variable.

Change Prediction

Using transition potential models as a foundation, LCM uses Markov Chain analysis to project the expected quantity of change and a competitive land allocation model to determine scenarios for a specified future date. Options exist to incorporate planning interventions such as incentives and constraints, proposed reserve areas and infrastructural changes.

REDD Analysis

REDD—Reducing Emissions from Deforestation and forest Degradation—is a climate change mitigation strategy that offers developing countries incentives to reduce their forest carbon emissions. Critical to the development of a REDD project is the ability to model expected land cover change in the absence of intervention. LCM is the ideal tool for this purpose and provides additional tools to quantify baseline carbon stock changes, including both CO2 and non-CO2 greenhouse gas emissions, and the possible associated leakage from displaced baseline activities. LCM's REDD tools follow the World Bank's BioCarbon Fund methodology and have been successfully employed in establishing approval for projects submitted to the Verified Carbon Standard program.



The Land Change Modeler (LCM) in TerSet uses map layers of historical change in combination with layers of potential explanatory variables (such as slope, proximity to roads, and so on) to develop empirical models of change. From these, projections can be made of the expected land cover at a future date. The LCM dialog to the left shows the process of specifying explanatory variables associated with a specific transition and the use of the Multi-Layer Perceptron (MLP) neural network to learn their association with the transition. The result is a series of transition potential maps (upper left). These are then used in combination with Markov Chain analysis to generate a projected land cover map for a future date (lower-center). In addition, LCM can generate a soft projection—a map of the vulnerability to land transition (upper-right).

Enhancements — IDRISI GIS Analysis

The biggest enhancement to the IDRISI GIS Analysis component is in the area of decision support. Clark Labs has always been a leader in the provision of multi-criteria and multi-objective decision tools, having provided the first viable multi-objective solver for raster GIS. With the release of TerrSet, we have also added the important ability to achieve multi-objective solutions that are spatially contiguous and have a user-specified degree of compactness. This can be achieved either with the radically new implementation of the MOLA (Multi-Objective Land Allocation) module or the new Spatial Decision Modeler (SDM).

With the new MOLA, allocations can be non-contiguous or contiguous. When contiguous allocations are chosen, one can also control the degree of compactness and the number of separate clusters. Further, allocations can be specified either in terms of their desired area or in terms of their maximum cost based on a specified land price image. Single allocations are also allowed with these options.

SDM is a graphical modeling interface similar to Macro Modeler. However, it has been specially designed for multi-criteria and multi-objective decision problems. Data objects are categorized as variables, factors, constraints, objectives and allocations. Operations include RECLASS, FUZZY, MCE and MOLA.

RECLASS converts variables into constraints. FUZZY converts variables into factors. MCE creates objectives from factors and constraints. MOLA creates allocations from one or more objectives using the various options indicated above. Using SDM, for example, one could design a set of reserves for species protection. Perhaps the design called for two separate but internally-contiguous reserves with a minimum span of 1 kilometer up to a maximum expenditure of two million dollars.

Other enhancements in the IDRISI GIS Analysis components include:

- A major modification of VIEWSHED to include considerations of earth curvature, refraction and atmospheric clarity. For example, one can evaluate the impact of a new construction under conditions of slight haze.
- A new utility for the creation of photo layers. Now the user can ask that all of the photos in a designated resource folder be incorporated into a photo layer. The utility then looks for and reads the EXIF metadata for each photo to access the location and orientation of each photo.
- New and much more efficient Thiessen polygon algorithm incorporated into the DISTANCE module.
- Database Workshop now fully supports Microsoft Access .accdb format.
- PROJECT now includes cubic convolution resampling in addition to nearest-neighbor and bilinear.

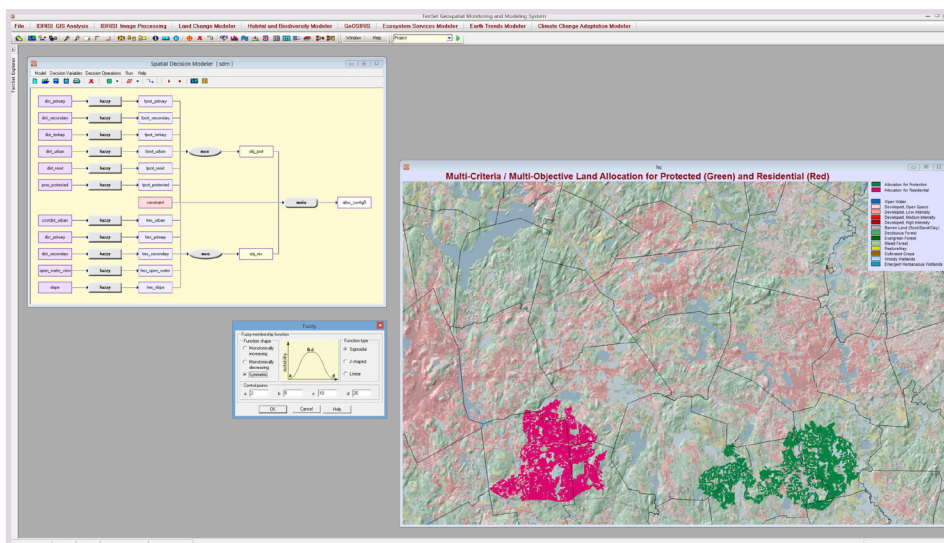
Enhancements — IDRISI Image Processing

With the successful launch of Landsat 8 and the consolidation of the entire Landsat archive at the USGS Earth Explorer site (earthexplorer.usgs.gov), we have completely revised our LANDSAT module to capitalize on the strengths of this archive. After downloading a scene from Earth Explorer, the LANDSAT module reads the metadata file, lists all the associated files and provides options, in a single integrated sequence, to:

- Convert the images from GeoTiff to TerrSet format.
- Convert the multispectral images to raw DN, top of atmosphere (TOA) radiances or reflectances or surface reflectances. Reflectance corrections include solar elevation angle, dark object subtraction and COST.
- Convert the thermal bands to raw DN, TOA radiances or at-satellite brightness temperatures.

We've also overhauled several of our previous modules including:

- PANSHARPEN – we've replaced previous approaches with a superior regression-based IHS method and a hyperspherical model for multiband sharpening.
- RESAMPLE, like PROJECT, now adds cubic convolution resampling to the previous support for nearest-neighbor and bilinear.
- The TASSCAP module has been updated to include the transform for OLI (Landsat 8) data.
- VEGINDEX now provides support for the EVI.



The Spatial Decision Modeler in TerrSet is a graphical modeling interface similar to Macro Modeler. However, it has been specially designed for multi-criteria and multi-objective decision problems. Data objects are categorized as variables, factors, constraints, objectives and allocations. Operations include RECLASS, FUZZY, MCE and MOLA. Also, there is the added ability to achieve multi-objective solutions that are spatially contiguous and have a user-specified degree of compactness.

Enhancements — Import/Export

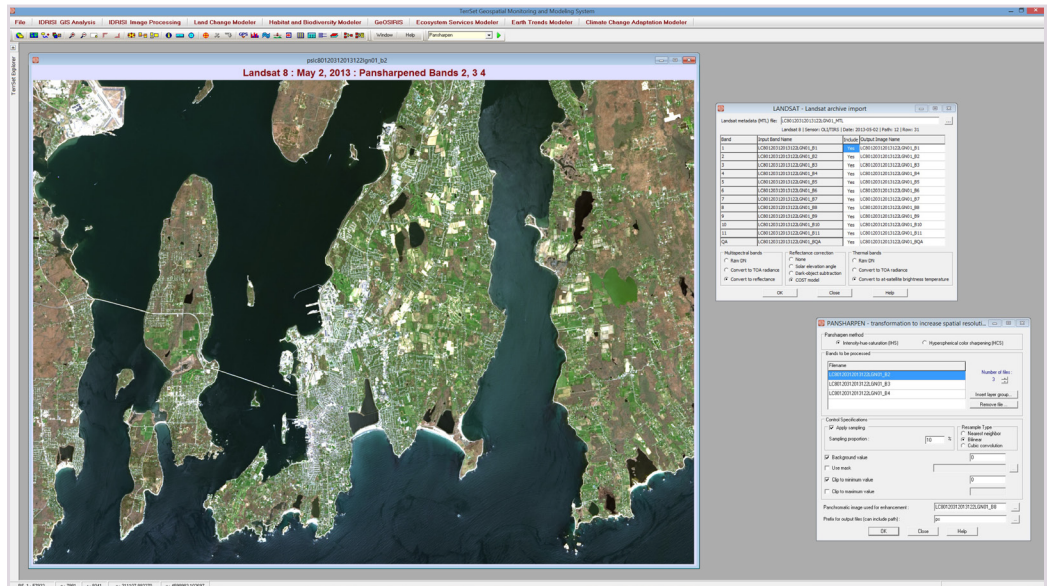
- Import of Shape files now has full support for multi-part structures.
- GeoTiff has been revised to include full reference system information in exported files.
- As described in detail above, a major new tool for Landsat import and processing has been created.
- KML import/export now includes support for point, line and polygon layers as well as raster.
- A new and improved version of GDAL is also included.

Display

With this release we have made some important adjustments to the interface. In prior versions of the IDRISI system one had to toggle between Pan mode and Feature Inquiry mode (similar to most other geospatial software systems). With TerrSet we have integrated these two modes. The system senses automatically what you want to do by the nature of your action. Click the mouse down on a feature and it will show the value at that position from the layer highlighted in Composer. However, if you click on a feature and hold the left mouse button down, it switches into Pan mode, allowing you to move the composition.

Options have also been streamlined for digitizing features on the screen. Two new modes allow you to digitize multiple features without having to use the keyboard—a very handy feature when you're digitizing training sites for classification of remotely sensed imagery.

We've also added a new Identify mode that drills down through all the layers listed in Composer to identify the values and/or features at that location. Previously this was offered only for layers belonging to the same raster group. However, we've found that drilling through all layers listed in Composer is far easier and includes both raster and vector layers.



The LANDSAT module in TerrSet reads the metadata file, lists all the associated files and provides options, in a single integrated sequence, to: convert the images from GeoTiff to IDRISI file format; convert the multispectral images to raw DN, top of atmosphere (TOA) radiances or reflectances or surface reflectances (reflectance corrections include solar elevation angle, dark object subtraction and COST); convert the thermal bands to raw DN, TOA radiances or at-satellite brightness temperatures. The Pansharpen module includes two techniques for panchromatic band merge: a superior regression-based HIS method and a hyperspherical model for multiband sharpening.

Under the Hood

Some of the most significant changes in the TerrSet system aren't visible at all—they're in the native binary code of the software itself. Over the past two years we have changed to a new compiler that allows us to keep up with the latest developments in the evolving Windows system, including the basis for a 64-bit system in the future. We've also been busy revamping modules to optimize their speed.

A Major Upgrade

TerrSet is, without question, the most significant release in the 28 year history of Clark Labs' geospatial software development. If you are working with an older version, we strongly recommend that you upgrade to the TerrSet constellation. Attractively priced with free technical support, the system offers an exceptionally comprehensive set of tools for monitoring and modeling the Earth system.

System Requirements

- Windows 7 and above, or Windows Server 2003 and above.
- Microsoft ACE 2010 or Microsoft Office 2010 or later.
- 1.3 GB hard drive space for application.
- 7.4 GB for Tutorial data.
- 4 GB RAM, 8 GB or more recommended.
- HD display (1920 x 1080) or greater recommended.

For more information, visit www.clarklabs.org



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