

Project Report

TNC Threats Assessment Version 1.1 June 2006

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Background

During 2004 The Nature Conservancy's South America Conservation Region (SACR) carried out an assessment to determine conservation priorities at a continental scale. All 110 South American ecoregions were ranked in order of their relative priority regarding the need for taking immediate conservation action. The criteria used for ranking ecoregional priorities included (a) habitat representation within protected areas, (b) relative urgency for taking immediate conservation action, and (c) the level of irreplaceability of specific sites that are important for the survival of threatened, endangered, and endemic.

The component of this analysis dealing with relative urgency for conservation action was conducted via the use of surrogates for actual threats to biodiversity. The surrogate measures we used to assess urgency were (a) accessibility, (b) population density, and (c) past land conversion. Our original intent was to look at the extent of actual biodiversity threats across the continent.

Although TNC were not able in 2004 to collect information on the geographic scope and impact of important biodiversity conservation threats in South America, they wanted to at least to identify the most important threats that should be addressed through the Conservancy's conservation programs in South America, SACR science staff conducted a survey of other regional TNC staff to rank the relative magnitude of conservation threats in South America. The results of that survey are shown in Table 1.

Threat to biodiversity	Relative importance
Conversion to pasture	36.5
Conversion to agriculture	36.5
Infrastructure	30.2
Invasive species	26.8
Conversion by forestry activities	26.2
Fire	24.7
Pollution	19.5
Mining	16.8
Oil and gas exploration	14.0

Table 1 Threats to biodiversity in South America according to TNC.

In 2005, SACR, undertook a project to map the major threats to biodiversity conservation across South America. This project was meant to replace the surrogate analysis that had been conducted in 2004 with more accurate threat information. To that end, threat data was collected from national datasets in the countries where TNC works for the purpose of creating a unified dataset for South America for all threats. In addition to using national-level datasets, SACR science staff initiated a process to obtain more detailed local data regarding the extent of the major threats identified in Table 1.

To conduct this project, TNC joined forces with CIAT (Centro Internacional de Agricultura Tropical – Tropical Agricultural Research Institute based in Cali, Colombia). CIAT agreed to provide the Conservancy with additional research and data, data analysis and GIS analysis capacity.

During Phase 1 of the TNC-CIAT Threats Assessment, CIAT contributed to the project in the following areas:

- Development, with TNC staff, of the conceptual framework for the threats assessment
- Collation of basic spatial datasets of the principle threats to biodiversity in South America
- Cleaning and management of spatial datasets
- Generation of an accessibility surface for South America, and generation of a model in Arcinfo Macro Language (AML) and ArcGIS Modelbuilder.
- Acquisition and preliminary studies on the use of NDVI (normalized difference vegetation data) data for monitoring status and trends in habitat loss in South America
- Development of a generic threats assessment model in Arcinfo Macro Language (AML)
- Production of threat layers for principle threats to biodiversity in South America
- Aggregation of individual threat layers into a single surface representing the threats to biodiversity in South America

In November 2006 CIAT was contracted to make adjustments to the V1.0 threats assessment based on issues identified in the October workshop in Cartagena. The following was prepared for this version:

1. Re-calculation of grazing pressure threat layers based on double-weighting for cattle, and single weighting for sheep and goats
2. Re-calculation of conversion to agriculture threat layer based on separation of subsistence and industrial agriculture, giving double weighting to the latter
3. Improve infrastructure layer using new dataset on dams, provided by TNC
4. Re-calculation of accessibility threat layer through use of more detailed national road coverages
5. Inclusion of invasive species as a threat layer
6. Re-calculation of all threat layers using improved ecosystem coverage, and data for Argentina
7. Google Earth interface for visualization of threat analysis for non-GIS professionals
8. Training of TNC GIS expert on use of the AML model
9. Production of images, videos and tables from the threat analysis for use in Powerpoint presentations

Two other outputs were requested in the contract, but not delivered in V1.1 through mutual agreement between CIAT and TNC. One of these outputs was the inclusion of

mining as a threat layer, using a mining database that distinguishes between toxic and non-toxic, and superficial and subterranean mines. This was not completed due to the heavy burden of work it required from Science Coordinators. The second output relates to invasive species as a threat layer. Data was received, and a preliminary threat layer is presented in this report. However, a number of concerns relating to consistency in approach and double-counting of threats means it is not included in the aggregate threat calculation for V1.1. Future versions looking at potential future threats (rather than immediate threats) might capture the issue of invasive species better.

Conceptual Model

The conceptual model developed for this version of the threats assessment focuses squarely on immediate threats to biodiversity, that can be safely quantified without exercises in long-term prediction or speculation. A threat is deemed to exist if a natural habitat is located nearby to activity that degrades or destroys biodiversity, and if the natural system itself is sensitive to that activity.

The model is built around two key factors:

1. Quantification of the threat inside and immediately around sites of human activity that destroys or degrades biodiversity
2. Provision of the fact that ecosystems respond to different threats in different ways (scope) and in different magnitudes (severity).

A simple example illustrates these two factors. If there is a road running through a natural habitat, the space that the road occupies represents a complete loss of biodiversity. Under this conceptual model, the “current status” is therefore a map of roads. The areas immediately around the road may be natural but could be considered to be threatened as the road provides for access to the natural habitat and may permit colonization and/or degradation or destruction of the natural resource. Furthermore, the threat can be considered to diminish with greater distance from the road, as these sites become less and less accessible to humans. Therefore, the actual threat to natural systems is a function of the distance from the road and the decay function of that threat with distance. Once the potential threat is quantified, it is important to take into account that different ecosystems have different sensitivities and responses to different threats. In the case of a road, perhaps a desert ecosystem is less sensitive to the threat of a road when compared with a tropical forest ecosystem. Under this logic, the ecosystem response to a threat can be considered to be a function of the type of response (linear, exponential etc.) and the magnitude of that response (minimal total impact vs. significant impact).

Under this logic, the threat can be considered to be a function of:

1. Magnitude of the activity considered to represent a potential threat (current status)
2. Distance from the activity (maximum distance)
3. Decay function of the activity as you move further away from it (curve type)

4. Type of response of the ecosystem (sensitive, insensitive, dependent) (relation)
5. Magnitude of the ecosystem response to the threat (magnitude)

This conceptual model is captured in the process model displayed in Figure 1.

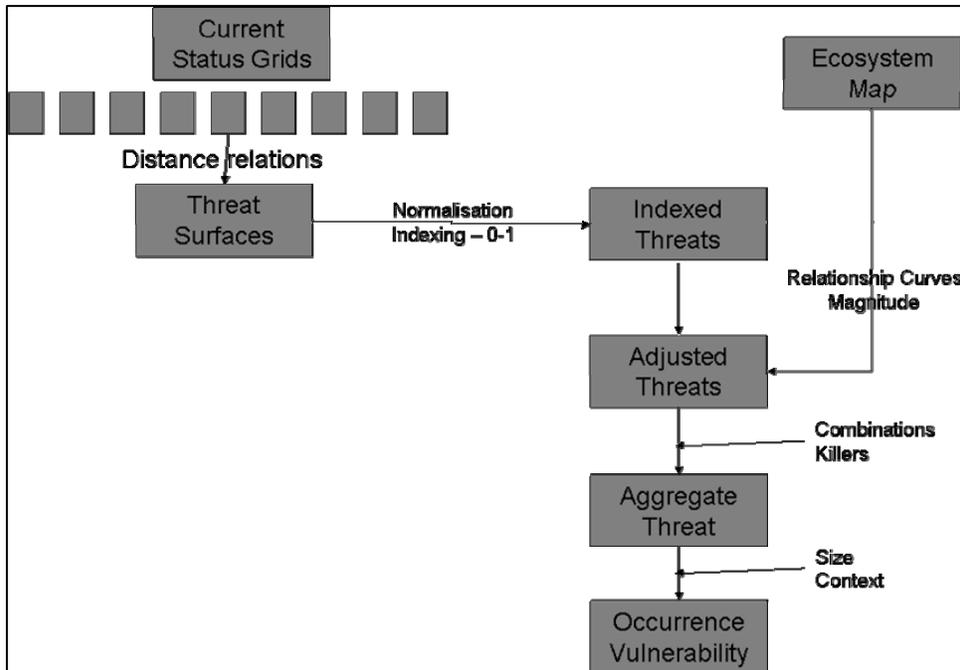


Figure 1 Flow diagram of threat assessment model

Stage 1 – Current Status to Threat

The current state of a threat is meant to represent geographically the actual known extent of each threat in the most accurate and complete manner possible. For that purpose, datasets for threats were collected in each South American country by SACR science staff. From these local datasets, homogenous continent-wide threat data sets were created with careful attention to matching features between countries, consolidating data tables and categorizing metadata. When local or national data sets were not available consistently for all countries, or data quality and quantity were poor, global datasets were used instead. As an example fire data is inconsistent throughout each of the countries in South America. For this assessment fire datasets will be used from global sources such as TNC’s Fire Initiative, the University of Maryland or others.

The current state of each threat (threat surface) is an important component of the analysis but it does not by itself tell us all we really need to know about these threats. We also need to know how these threats manifest themselves in relation to their “neighborhood” – the surrounding landscapes. For example, we need to know how far each threat reaches past it’s the current geographic extent (e.g., the impact of agricultural runoff as a consequence of agricultural conversion), how intensity of the threat decreases as a function of the distance from the actual geographic footprint of the threat, and the manner

in which its impact decreases (rapidly, gradually, linearly) are important elements to be modeled for each threat. This component of the threat assessment is aimed at defining the way each threat manifests itself spatially in relation to its immediate surroundings. It is intended to address two parameters of each threat: how far does a threat reach and how does its intensity decrease from its borders. Each threat was analyzed in detail for its impact on surrounding landscapes. Consensus among scientists in TNC and CIAT was reached in order to be able to model each threat. The four distance decay functions for the threats are shown in Figure 2, and the parameters agreed upon in the April workshop are displayed in Figure 3.

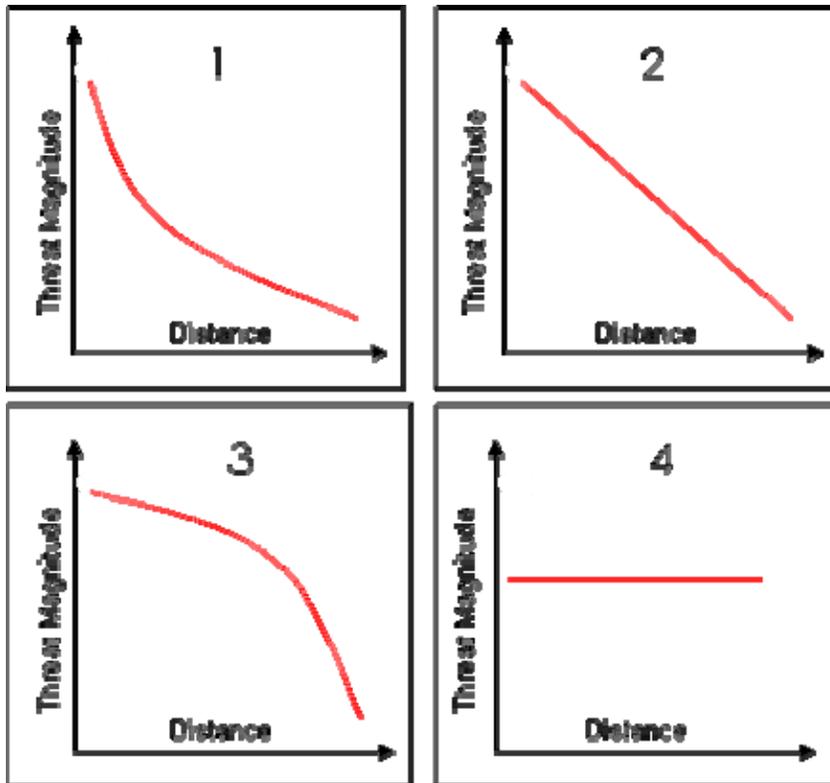


Figure 2 Distance decay functions for assessing the manifestation of a threat

Threat	Max Distance (km)	Curve Type
Grazing Pressure	5	1
Conversion to Agriculture	5	3
Infrastructure: Airports	5	3
Infrastructure: Dams	1	3
Recent Conversion	5	3
Fire	5	1
Oil and Gas: Drilling	5	3

Figure 3 Parameters used to calculate the manifestation of a threat for its current distribution

Stage 2 – Ecosystem response to a threat

Different ecosystems respond differently to different threats. In many cases there is a direct linear relationship between a threat and an ecosystem's response to it: the larger the expression of a threat the larger the impact of the threat upon an ecosystem. However, this is not always the case -- some ecosystems have different characteristics that govern the way they might respond to a given threat. For example fire in certain ecosystems can be a disaster and immediately destroy or highly degrade an ecosystem, such as rainforests in the Amazon. But in grasslands such as in the Orinoco Basin, it is necessary to have fire in certain intensities and frequencies. To little fire is bad for that ecosystem, and too much fire is equally bad. There is a non-linear response relationship between a grassland and fire that has to be identified and modeled.

With this aim, Science staff from SACR and CIAT identified the different types of relationships that occur between nine major threats and each ecosystem in South America (a total of 608 ecosystems). To identify each type of relationship 6 different potential response curves were identified (see Figure 4). A value for magnitude was estimated as well, in addition to the type of relationship. The range was from 1 to 3, being 1 low and 3 high. The aim was to address with magnitude the severity and irreplaceability of a specific threat when it occurs in an ecosystem in addition to the way that threat normally decreases its impact with distance (or curve showing this relationship). By providing information on magnitude, threats that could completely damage an ecosystem with difficult or impossible restoration were easily identified (commonly called "killer threats").

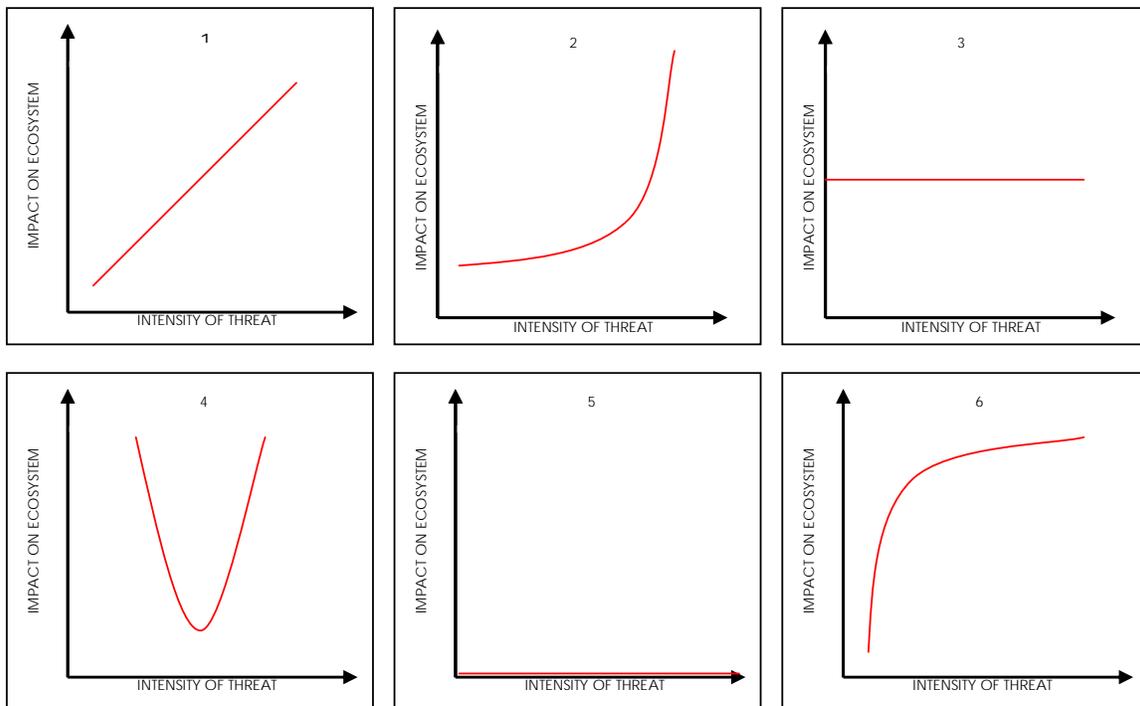


Figure 4 Ecosystem response curves to a threat

Model Implementation

The conceptual model was implemented into an AML model that performs the threats analysis from the current status through to the adjusted threat taking into account the ecosystem response. The full AML model is available in Annex I. The AML is designed for ease of use, prompting the user for input as to the names of the threat to be analysed, information about the input dataset, the distance relation and curve type for the specific threat and the location of some of the required datasets. The full process that the AML makes is shown in Figure 5.

```
Grid: arc w
Current location: g:\tnc threats\model
Grid: &rc tnc threats analysis

-----
      INC Threat Model for South America
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      Produced by CIAI 2006
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Please provide the name of the threat you wish to analyse (no spaces): ndv
WARNING: New location is not a workspace.
Is your current status data in "GRID" or "SHAPEFILE" format?: grid
Please type the name of the grid with full path info, e.g. c:\workspace\threatg
id: G:\INC_threats\model\status_data\recent_conversion\ndvi_change
Running... 100%

Please define the input and output map projections.
Use INPUT to define the input projection, OUTPUT
to define the output projection, and END to finish.
Inversibility is 100 per cent
Project...
What is the maximum distance that the threat might occur over (in km)? 5
What kind of curve over distance does the threat have? (1 - Fast Decay, 2 - Line
ar Decay, 3 - Slow Decay, 4 - No Decay): 3
Running... 100%

*****
* The INPUT projection has been defined. *
*****
Use OUTPUT to define the output projection and END
to finish.
Inversibility is 100 per cent
Project...
Running... 100%
The relations grid does not exist. Please generate the grid and provide the ful
l path and file name:: G:\INC_threats\model\relations\rel_fora
Running... 100%
The magnitude grid does not exist. Please generate the grid and provide the fu
ll path and file name:: G:\INC_threats\model\magnitudes\mag_fora
Running... 100%
Running... 100%
Killed TERNI with the ALL option

Finished calculating threat surfaces for ndv. Grids are found in ndv directory.

-----
      INC Threat Model For South America
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      Produced by CIAI 2006
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Grid: =
```

Figure 5 Example of the process that the AML executes, in this case producing the threat surface for recent conversion (NDVI).

Stage 1 – Current Status Grid to Threat Surface

There is a “Kernel Calculator” implemented in Excel to produce the distance decay curves for the distance analysis to go from the current status surface to the threat surface. The excel spreadsheet, shown in Figure 6, allows the user to change the distances and curve types to produce the “kernel” that the spatial model requires.

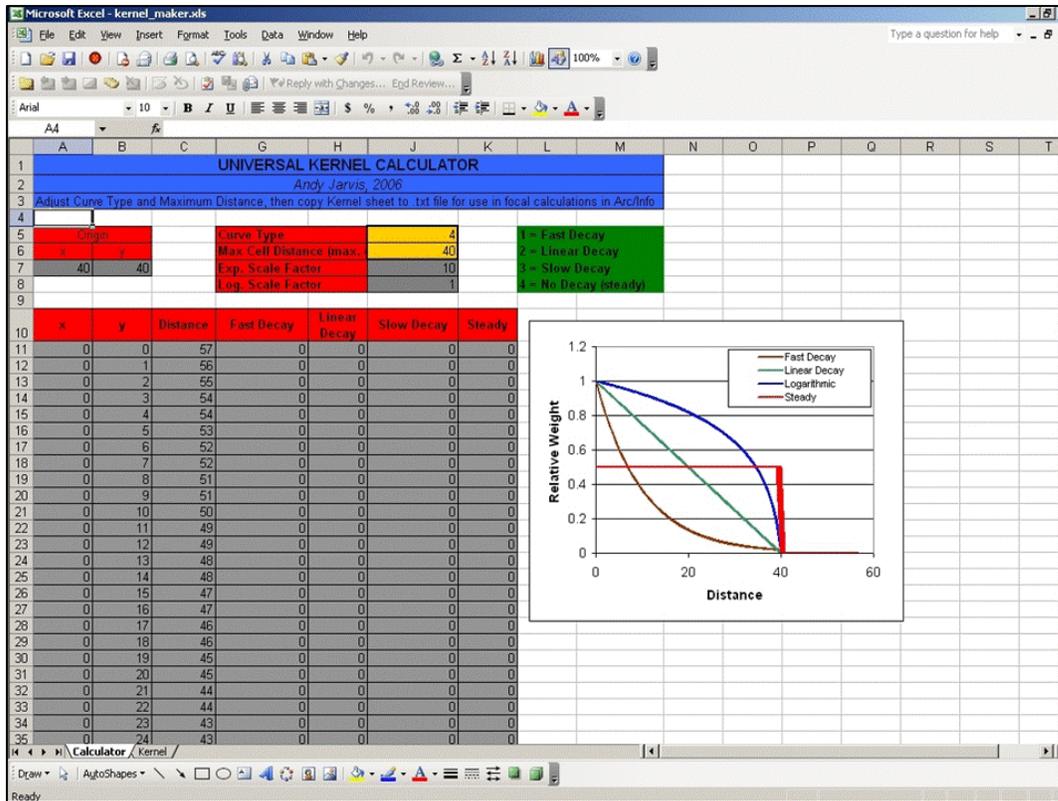


Figure 6 Screen dump of the kernel calculator

The AML model takes a current status dataset in grid or shapefile format, and produces a grid within the analysis extent and with the set 1km spatial resolution used in this analysis. The input dataset can be a set of points, vector lines, or polygons, or a grid surface with values representing the degree of severity of the current status of the threat (i.e. livestock density). The model reprojects the data to an equal area projection, and asks the user for the distance and curve type through which the threat might affect biodiversity. The model then makes the spatial neighbourhood operation, and reprojects back to decimal degrees (datum WGS84).

Stage 2 – Indexing the threat surface

In order to standardize each threat surface, the resultant grid from Stage 2 is subjected to indexation by simply dividing by the maximum value in the grid. The result is an indexed grid with values ranging from 0 to 1.

Stage 3 – Adjusting Threat Surface for Ecosystem Response

Once the indexed threat surface is produced, the ecosystem response to a threat is taken into account. First, the relation of the response to the threat is analysed. This in effect transforms the indexed data based on one of 6 curve types defined during the start-up workshop. Figure 7 shows the 6 types of curves identified as representing the ecosystem response to a threat, and alongside the mathematical representation of the curve that is

inside the model. During testing of the model curve type 3 was dropped and replaced with curve type 6 as areas with zero threat (0) would become high threat (1) under this transformation, but by definition if there is no presence of a threat there should not be any threat in the final surface.

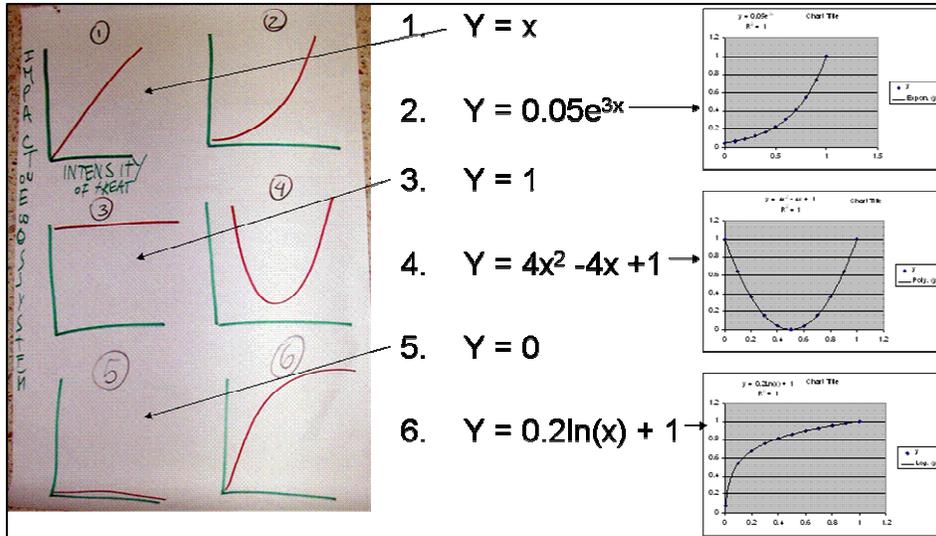


Figure 7 Mathematical representation of the ecosystem response curves

Once the transformations are executed, the resultant grids are adjusted for magnitude the threat has on the ecosystem by simply multiplying by the magnitude (between 0 -3). This results in the final adjusted threat surface, having a value between 0 -3.

Input Datasets

TNC collated spatial data for South America representing each of the identified threats and CIAT consolidated this data by joining, cleaning, assessing data quality and generating metadata. This report does not provide a detailed description of all input datasets, but the reader is directed to the online geonetwork node where metadata for all datasets are available online: <http://gisweb.ciat.cgiar.org:8080/geonetworkTNC/>. Metadata is also accessible through the Google Earth interface.

The threats modeled and the datasets used for each threat in Version 1.1 are described in Table 2.

Threat to biodiversity	What it means	Data
Grazing Pressure	Grazing of different livestock on natural pastures	Density of livestock – cattle, sheep and goats
Recent Conversion (NDVI)	Vegetation loss levels	NDVI changes 1998 – 2005
Accessibility	Time to populated place	Roads, railways, rivers, land cover
Infrastructure	Elements of infrastructure not captured in other layers	Dams, airports
Conversion to agriculture	Natural areas surrounding existing agricultural systems	Distribution of 22 major crops
Fire	Frequency of fires	Satellite derived fire events 2000 -2005
Oil and gas exploration	Drill sites	Points of drill sites

Table 2 Threat layers used in the analysis

Description of Threat Layers

Accessibility

The production of an accessibility layer involves a significant amount of modelling in itself. The process is described here, and on the data disk delivered to TNC the files used to create this surface are provided.

The data and all documentation are zipped up into a single file. You should unzip them all from C: root directory. It will put them in a new directory called C:\access. You can run the model in either ArcGIS ModelBuilder or in workstation ArcInfo at the GRID prompt using AML. After you run it, open the map document (tnc.mxd) in ArcGIS. Then you can use the included LAYER file by assigning the model output as the source data. This will give you an output in a pre-classified legend.

NOTE: The models are not in the data that you unzip. You will need to create them with either ModelBuilder or by running the AML.

The notes below briefly describe the method to produce the accessibility surface and how to change parameters.

Files Included in the project

ArcGIS files

AccessModel.aml – the process in AML format
Access.tbx – toolbox with the TNC Access Model in ModelBuilder format
Tnc.mxd – map document with Accessibility files
Time to cities.lyr – layer file for displaying legend in ArcGIS

GRIDS

Surmask – study area in Lambert projection
Glcsur – the GLC2000 for South American in Lambert projection
surnight – the night lights for South America in Lambert projection
frontera – the international borders with 1km per hour velocities
surnet – the transportation network with assigned velocities
sa1km_dem – the 1km² digital elevation model
acctar – this is an empty grid that is needed for merging together the velocity surfaces
city1000 – the target grid of settlements of 1000 or more human population

COVERAGES

Network – this is the coverage of the transport network.

Lookup Tables

Altitude.txt – assigns values for inhibiting access according to elevation
 Landreclass.txt – used to assign velocities to land covers of GLC2000
 Smap.txt – assigns values for inhibiting access due to slope
 Time.txt – converts km/hr to time to cross a 1 km² cell

Other files

Speed.xls – worksheet for calculate time to cross a 1 km² cell
 Readme.doc – this file

The Method

This method is based on routines that are common in GIS packages. Much of this was based on the work of Andy Nelson and Andy Farrow at CIAT. It consists of 3 general processes:

1. Estimate travel times on land and transportation surfaces
2. Reduce travel times in step 1 where slope and elevation are obstacles to travel
3. Calculate the “cost distance” between any point on the surface and all target cities

Travel times on land and transportation surfaces

We assumed that if you are traveling on water, roads, railways or an urban surface, you will be traveling by boat, motor vehicle or train. The road data used is described later in this section, but is derived from national coverages and complemented with the Digital Chart of World (DCW). Railway data is from DCW. The navigable rivers data is from the USGS VMAP series of 1:1,000,000 data sets. The urban data is from the nighttime lights data set (Elvidge et al., 1997). We used a threshold of 30% for considering nighttime lights as urban areas. This was done to account for bias in the sensor that overestimates urban area (Small, 2004). We assigned the following velocities to road, rail and waterways:

Primary roads (highways)	60 km hr ⁻¹
Secondary road (paved)	35 km hr ⁻¹
Tertiary road (unpaved/seasonal)	25 km hr ⁻¹
Waterway (navigable rivers)	10 km hr ⁻¹
Railway	40 km hr ⁻¹

If you are not on the transportation surface, walking velocities were assigned according to Table 3. We assumed you would only travel 2 km per hour in natural forest landscapes. Cleared on open canopy areas were given travel velocities between 3 and 5 km per hour. Water surfaces were given a velocity of 10 km per hour.

Land Cover	Km/hr
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All Natural Forest	2
Mosaic: Tree cover / Other natural vegetation	3
Tree Cover, burnt	3
Shrub Cover, closed-open, evergreen (Examples of sub-classes at reg. level *: (i) sparse tree layer)	3
Shrub Cover, closed-open, deciduous (Examples of sub-classes at reg. level *: (i) sparse tree layer)	3
Herbaceous Cover, closed-open (Examples of sub-classes at regional level *: (i) natural, (ii) pasture, (iii) sparse trees or shrubs)	3
Sparse Herbaceous or sparse Shrub Cover	3
Regularly flooded Shrub and/or Herbaceous Cover	3
Cultivated and managed areas (Examples of sub-classes at reg. level *: (i) terrestrial; (ii) aquatic (=flooded during cultivation), and under terrestrial: (iii) tree crop & shrubs (perennial), (iv) herbaceous crops (annual), non-irrigated, (v) herbaceous crops (annual), irrigated)	4
Mosaic: Cropland / Tree Cover / Other natural vegetation	4
Mosaic: Cropland / Shrub or Grass Cover	4
Bare Areas	4
Water Bodies (natural & artificial)	10
Snow and Ice (natural & artificial)	1
Artificial surfaces and associated areas	5

Table 3 Walking velocities over the land surface assigned to the GLC2000 land cover map.

All pixels on international borders were assigned a value of 1 km per hour to reflect the time that it might take to cross the border, given customs and passport checks.

Topographic obstacles to travel

The method assumes that times are reduced in areas in high elevations and with sloping lands. The elevation factors accounts for poor roads, greater likelihood of weather problems and overall greater difficulties of transport at high elevations. If you are walking at higher elevations, weather and lack of oxygen would slow you down. The slope factor accounts for reduced velocity climbing hills. However, you may go faster downhill. This could depend on different factors. Often you go slower downhill to avoid losing control. Incorporating travel direction would have been highly complex to model, and was considered outside the scope of this project.

We assumed that if you are below 2500 m elevation there is no effect on travel velocity. Between 2500 and 3500 m you would travel twice as slow. Between 3500 and 4500 you would travel 3 times as slow. Over 4500 m elevation you would travel 4 times as slow. If you are traveling on slopes of less than 5 percent, we assume there is no reduction in travel velocity. On slopes between 5 and 10 percent, you would travel half as fast. Slopes greater than 10 percent would represent a 3-fold reduction in velocity.

Setting up the target or source settlements

Accessibility models calculate the cost distance from any point on the surface to any target pixel. The target pixels could be a market, city, port or any other point features that are the destinations of interest. For this project we are using settlements of over 1000 people as the target. The settlement data is taken from the Gridded Population of the World Version 3 (CIESIN et al., 2004). Due to errors in spatial representation, many towns from the settlement data set do not fall exactly on transportation networks. We used the POINTNODE command in ArcInfo to automatically shift those towns to the nearest transportation link. We did not put this step in the AML or the ModelBuilder model because there are some interactive steps that need to be taken to make sure that the POINTNODE command works correctly.

First, select the size of the towns that you want the model to include. The shapefile is *sacity.shp*. Then convert this shapefile to a coverage using the SHAPEARC command. Next use POINTNODE command, which will assign values from the town point coverage to nodes on the transport coverage. Once they have been assigned you need to select all the nodes that have an assignment of town data. Then export the selected nodes to a new shapefile. This shapefile is your new settlement point map with all the points falling somewhere on the transportation network. The next step is to convert this file to a grid at 1km pixel resolution. This grid is the input to the costdistance function, described in the next section.

Calculating cost distance

Cost distance algorithms calculate the least cost path between any pixel and a target destination. We express the cost as travel time between any pixel and the closest settlement of 1,000 or more human population. This function only requires two input data sets. One is the target or source grid – the settlement points described in the previous section. The other input grid is the friction surface, which is a combination of the travel velocities and the topographic obstacles. The model and the AML show some intermediate unit conversions that are needed to make sure that the final result is in hours.

How to change parameter values

To change the velocities for the land surface and transportation network, you should go to the *landreclass.txt* and *time.txt* lookup tables to change values. Lookup tables for reclassification in ArcInfo have 2 numbers representing the lower and upper bounds of

the values you want to reclass, followed by a colon and the new value for everything in the specified range. *landreclass.txt* assigns velocity values to the land cover map. The SURNET grid holds travel velocities for the transportation network. *Time.txt* calculates the time to cross a 1km² cell for each travel speed. Another file called *speed.xls* can be used to calculate time to cross the cell.

To change the topographic factors go to *slmap.txt* and *altitude.txt*. The final number is the “number of time slower” you will travel for that elevation range.

Road data used in the accessibility map

The accessibility layer used for V1.1 took advantage of national level road coverages for almost all countries in South America. Where national level data was missing, DCW was used. The roads data used in the accessibility surface is shown in Figure 8, and the source of the roads coverage data is shown in Table 4.



Figure 8 Roads coverage used in the generation of the accessibility surface

ACCESIBILIDAD								
Datos CIAT					Datos TNC(Leo)			
Pais	Escala	Tipo_Via	Detalle de Vias	Fecha	Escala	Tipo_Via	Detalle de Vias	Fecha
Argentina					Esc: 500.000	30102 30103 30101	Caminos Consolidados Caminos de Tierra Rutas Pavimentadas	2001
Bolivia					Esc: 500.000	1 2 3 4	Camino principal (mucho tráfico, varias flotas y camiones grandes por día) Camino secundario (movilidades diarias, transporte público y de carga) Camino (transitable con movilidad pero con poco tráfico) Camino / sendero (no transitable con movilidad)	sd
Brasil					Esc: 1.000.000	sd	No pavimentadas Pavimentadas Vías por ser pavimentadas	2003
Colombia					Esc: ???	0 1 2	??	????
Chile					Esc: 250.000	??	??	????
Ecuador					Esc: 250.000	??	Caminos de verano y senderos (Jeep) Línea Ferrea Vías de primer orden Vías de segundo orden Vías de tercer orden	2002
Perú					Esc: 250.000	??	AF AS EC EP NF TC	????
Paraguay	Esc: 2000000	22 5 33 3	Pavimentado dos vías Sin pavimentar una vía Sin pavimentar dos vías Camino Carretero	1993				
Uruguay	Esc: 1000000	sd	Vías de comunicación Carretera Principal Sin Dato (DCW)	sd				
Venezuela					Esc: 250.000	??	Autopista; Camino Carretero/Sendero o Pica Carretera De Tierra Carretera Engrazonada De Dos Vías o Mas Carretera Pavimentada De Dos o Mas Vías Ferrocarril De Trocha Ancha Puente De Angostura	????

Table 4 Source of roads coverage data used in the accessibility surface.

Integration of Accessibility with Population

The threat surface actually used in the threat assessment combines accessibility with population. An occurrence is deemed to be under greatest threat if it is both highly accessible (low travel time to the nearest populated place) and in the vicinity of high population. This logic attempts to capture the fact that there is likely higher threat to an occurrence found 15 minutes travel time from Sao Paolo in Brazil (population > 10m) compared to an occurrence 15 minutes travel time from the town of Villa de Leyva (population approx. 50,000) in Colombia.

This integration of population with accessibility is modeled in the following way :

1. A spatial neighbourhood analysis of population density is made (using data derived from <http://gisweb.ciat.cgiar.org/population/index.htm>). The total population in a 45km radius is calculated, using a distance weighted neighbourhood analysis (curve type 3).
2. Accessibility and the resultant neighbourhood population density surfaces are normalized using natural logarithmic transformations.
3. Accessibility is represented in an index from 0-1, and population as an index from 1-2.
4. The resultant two normalized surfaces are multiplied by each other.

The rationale behind the values for the two indexed files was to ensure that accessible areas without population nearby keep some level of threat, whilst accessible areas with high population density get double that level of threat. The previous version of the threat analysis indexed population from 0 – 1, meaning that highly accessible areas with very low population density practically experienced no threat at all. This was deemed to be an inappropriate representation of threat from accessibility and population and was resolved with the current indexing system.

The resultant surface is the threat status layer for accessibility/population, and is displayed in Figure 9.

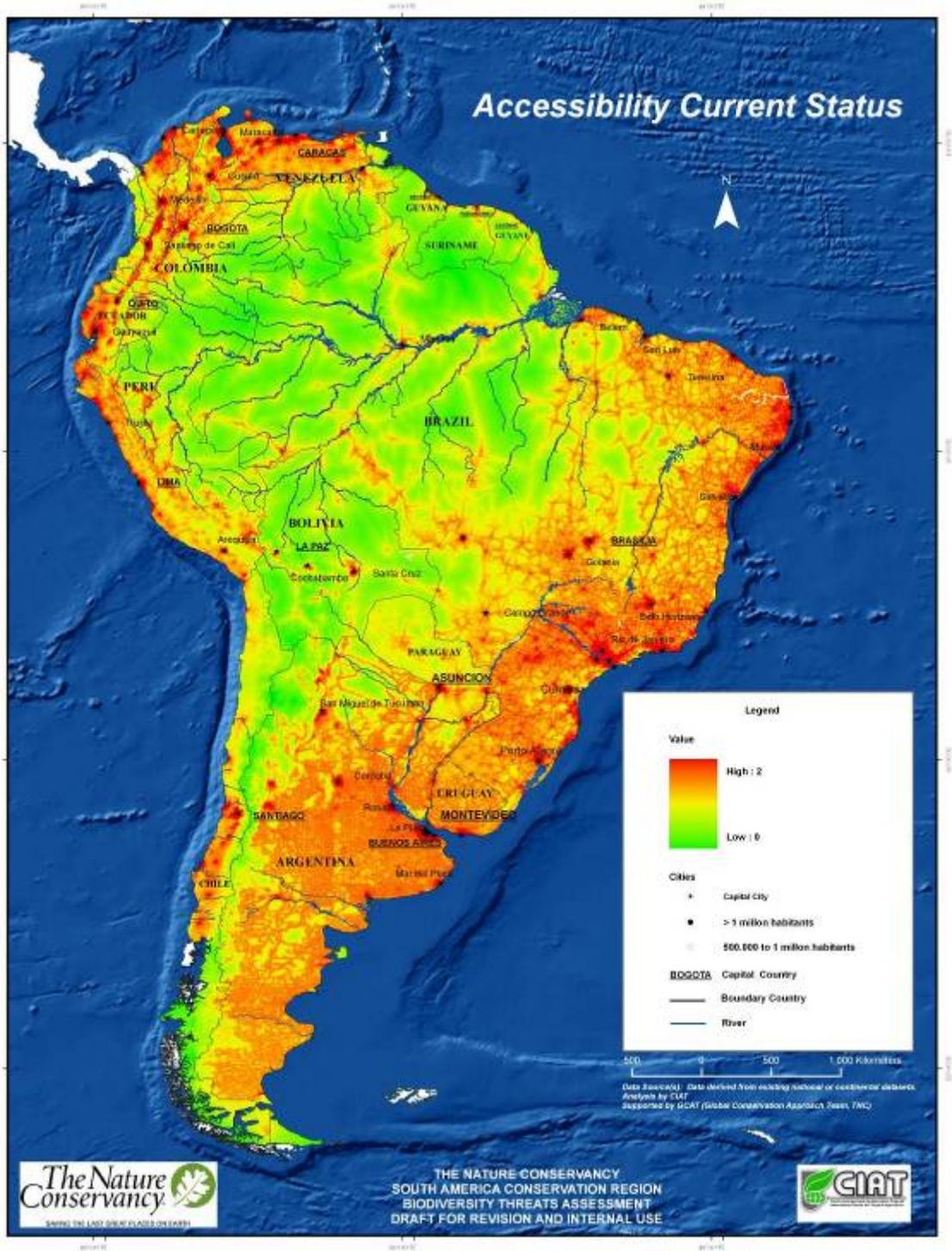


Figure 9 Threat status layer for accessibility/population

This threat layer differs from other threat layers in that it is not subjected to the neighbourhood analyses based on the distance and distance decay functions through which the threat acts on biodiversity. Instead, the accessibility/population threat layer is

only subjected to the adjustment based on the relation (scope) and magnitude (severity) that each ecosystem has to accessibility/population. The resultant adjusted threat layer is shown in Figure 10.

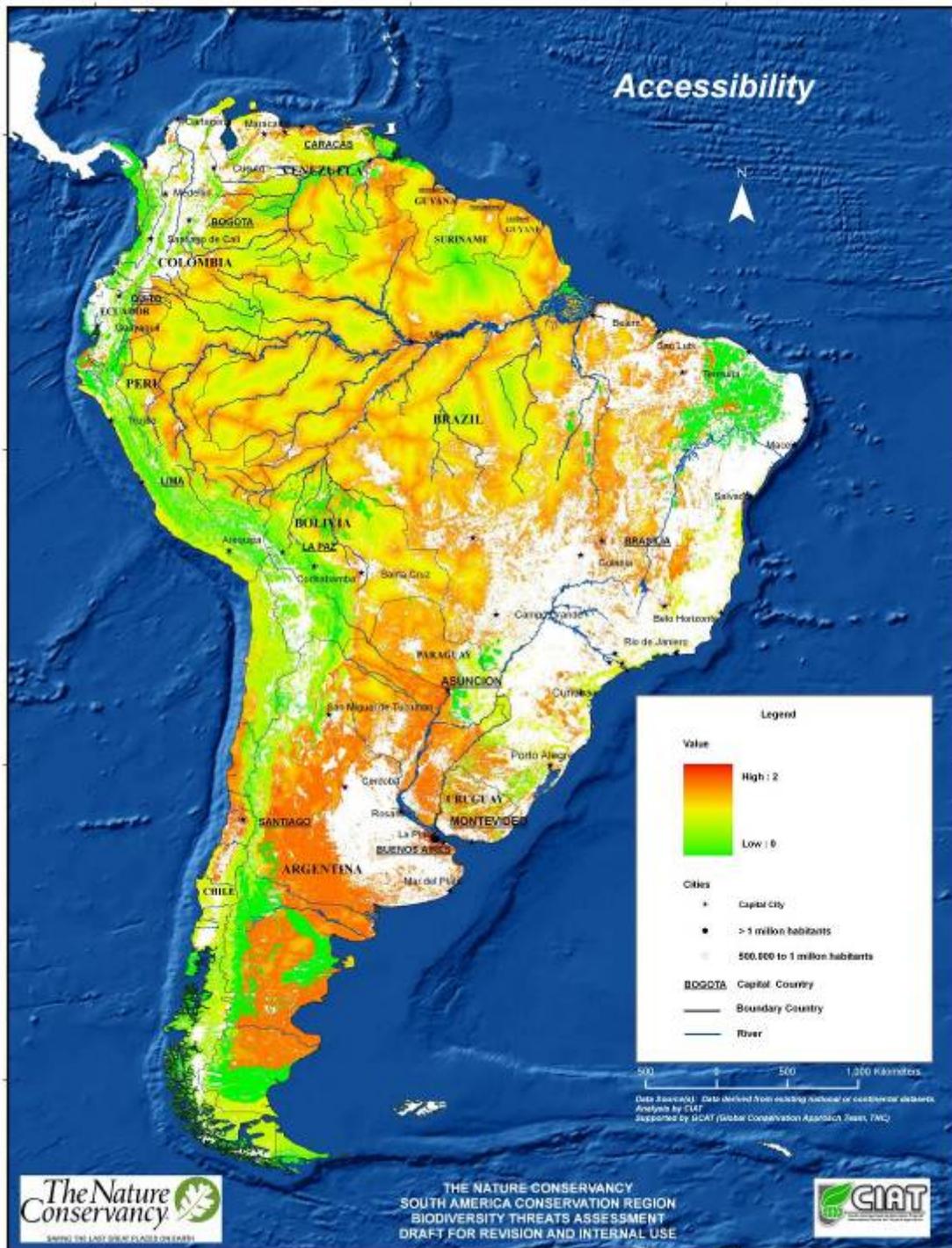


Figure 10 Adjusted threat layer for accessibility/population

Conversion to Agriculture

The agricultural layer was based on global surfaces of agricultural area and production at 10 km spatial resolution (You and Wood, 2006). Agricultural census and survey statistics form the basis of these global surfaces, combined with global maps of crop suitability. The statistical data was compiled at sub national administrative levels, usually the first or second subdivision of the national boundary of each country. These data are adjusted to the year 2000 using the official national figures that each country reports to FAO. Within administrative districts, the area and production for each 10 km pixel is spatially allocated based on the suitability of each pixel to each individual crop.

In V1 of the threat analysis, all crops were treated equally. For V1.1 CIAT and TNC scientists separated the crops into subsistence and industrial crops in order to capture the different levels of habitat destruction that each crop might cause. For example, many coffee farms have much more negative impacts on natural ecosystems than an industrial soy bean field.

The crops and their classification into subsistence and industrial are shown in Table 1.

Commodity	Industrial/Subsistence	Threat
Wheat	Industrial	High
Rice (paddy)	Subsistence	Low
Maize	Subsistence	High
Barley	Industrial	Low
Millet	Subsistence	Low
Sorghum	Subsistence	Low
Potato	Subsistence	Low
Sweet potato	Subsistence	Low
Cassava	Subsistence	Low
Plantain and banana	Subsistence	High
soybean	Industrial	High
Beans	Subsistence	Low
<i>Other Pulse</i>	Subsistence	Low
Sugar cane	Industrial	High
sugar beets	Industrial	Low
Coffee	Subsistence	Low
Cotton	Industrial	High
Groundnuts	Subsistence	High
<i>Other oil crops</i>	Subsistence	Low
Industrial	Industrial	
Subsistence	Subsistence	
Both	Both	
Threat		
High	High	
Low	Low	
Note:		
Other Pulse mainly includes: peas, chick peas, cow peas, pigeon peas		
Other oil crops mainly include: coconuts, sunflower seed, sesame		

Table 5 Crops used in the conversion to agriculture threat layer and the type assigned by TNC and CIAT scientists (industrial or subsistence)

Three categories are aggregations of several crops. “Other pulses” include cowpea, chickpea, pigeon pea and lentils. “Other oil crops” include coconut, sunflower, sesame, rapeseed and linseed. “Other fibres” include cottonseed, flax hemp, jute and others.

For the input layer, the area for each of the two crop types was summed to calculate the total agricultural area for each 10 km pixel, and then industrial area was combined with subsistence area with double-weighting given to industrial.

The weighted total agricultural area for each pixel was then fed into the threat model, using a distance factor of 5km and a curve type of 3, and resulted in the adjusted threat surface shown in Figure 11.

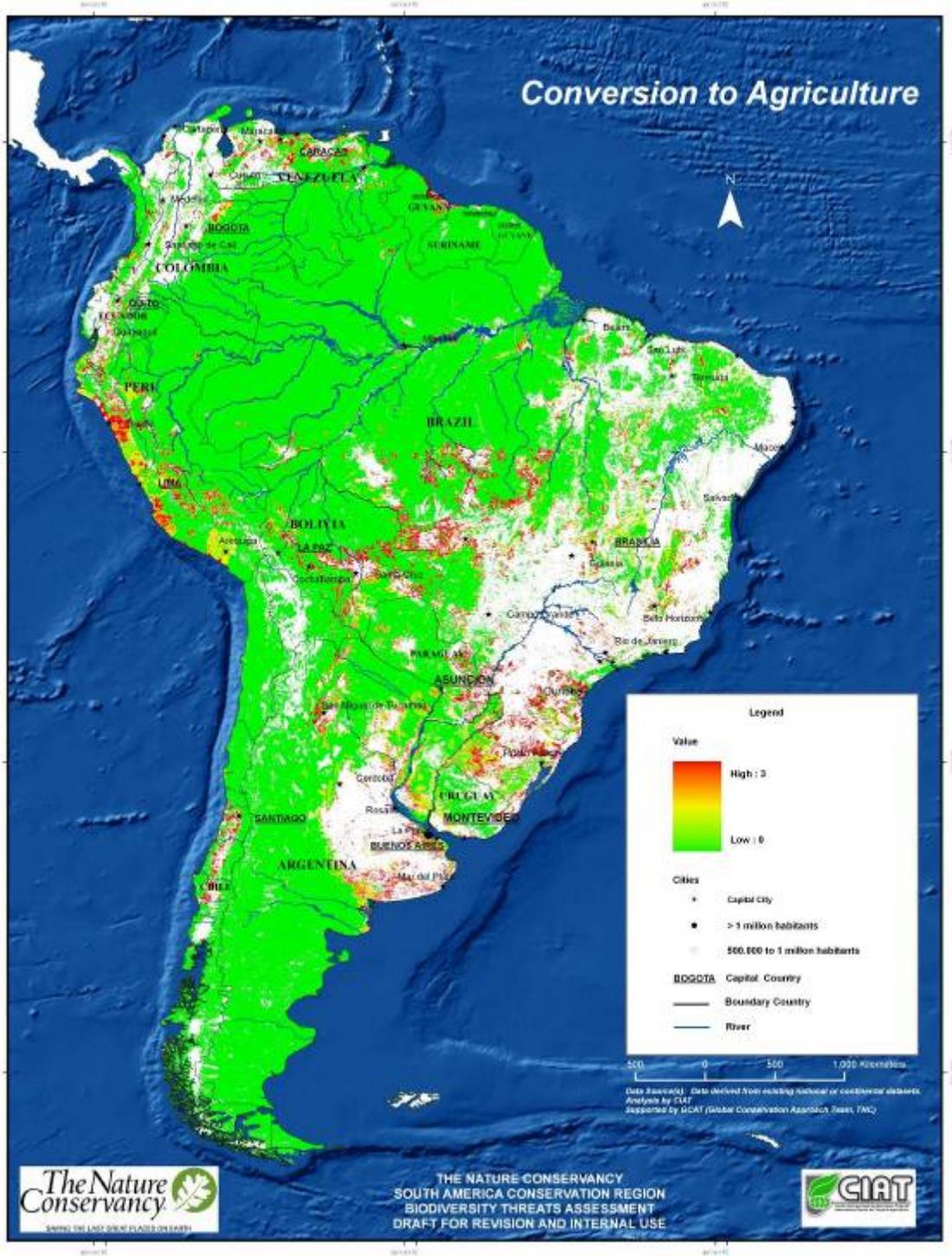


Figure 11 Adjusted threat layer for conversion to agriculture

Recent Conversion

Originally conceptualized as “conversion to forestry”, this threat layer evolved significantly during the development process of this threats assessment. Due to insufficient data on forestry activities and non-consistent policies and definitions of forestry throughout the continent this threat layer changed to try to capture aspects of vegetation removal, specifically directed at activities such as extraction and selective logging from natural forests. Finally, the threat layer was conceptualized as representing “recent conversion”, reflected in the loss of green vegetation in the land surface from 1998 to present. This captures both deforestation in forests and degradation of natural ecosystems due to conversion or extraction. Given that many other threat surfaces used in the model represent the status in 2000, this layer effectively captures changes that have occurred more recently. As can be seen in the final result, expansion of soy bean in many parts of Brazil is captured by this layer.

The input data for this threat layer is derived from NDVI (normalized difference vegetation index) surfaces captured from satellite every 10 days, 1998 to present with a spatial resolution of 1km (<http://free.vgt.vito.be/>). Essentially the data measures the greenness of the land surface. For the eight year period, a regression line was fitted to the yearly mean NDVI, and the gradient of this line calculated on a pixel-by-pixel basis (AML model provided in Annex IV). This in essence captures the change in NDVI value per year. Areas losing greenness can be considered to be undergoing some kind of alteration, with the degree of change representing the magnitude of the alteration.

Originally forestry activities were identified as acting over large distances (20km), but this was later revised when the threat was conceptualized to represent recent conversion and the same distance and curve types as conversion to agriculture were used (distance 5km, curve type 3). The data was fed into the model, and the resultant adjusted threat layer is shown in Figure 12.

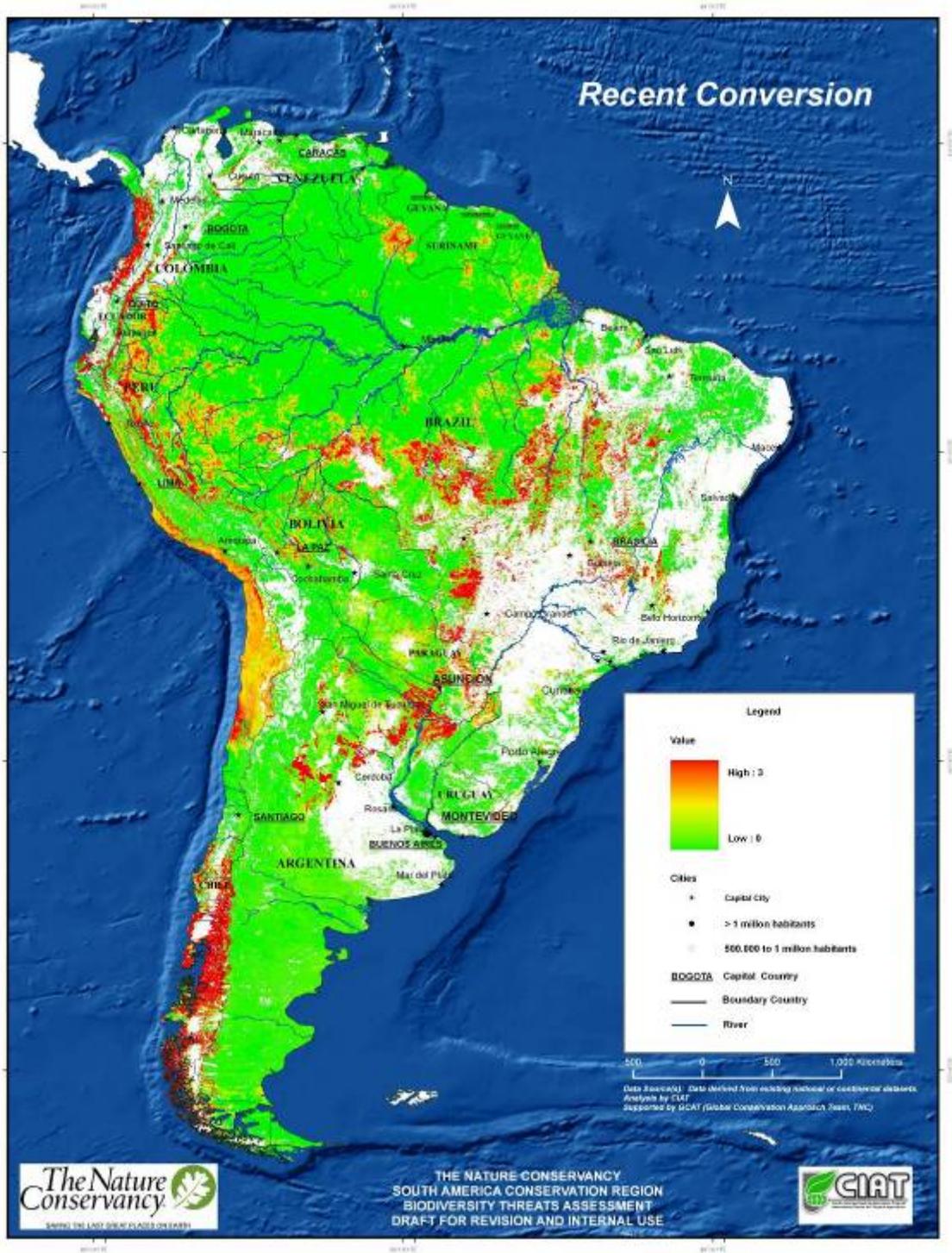


Figure 12 Adjusted threat layer for Recent Conversion.

Future versions of this threat will take advantage of improved vegetation greenness data derived from the MODIS satellite, 2000 to present.

Grazing Pressure

Originally conceptualized as “conversion to pasture”, this threat layer was renamed to “grazing pressure” to recognize that the input data does not reflect the threat of conversion but more the direct effect that grazing might have on natural ecosystems. The input data is derived from the FAO Atlas of Livestock, and consists of surfaces of livestock density for:

- Cattle
- Sheep
- Goats

Each livestock type was modeled separately, and due to skewedness in the input data were subjected to one round of normalization using the natural logarithm. Each layer was then fed into the threat analysis model, using the same ecosystem response curves and magnitudes for each livestock type, and combined with double weighting to cattle to produce a final adjusted threat layer for grazing pressure, displayed in Figure 13.

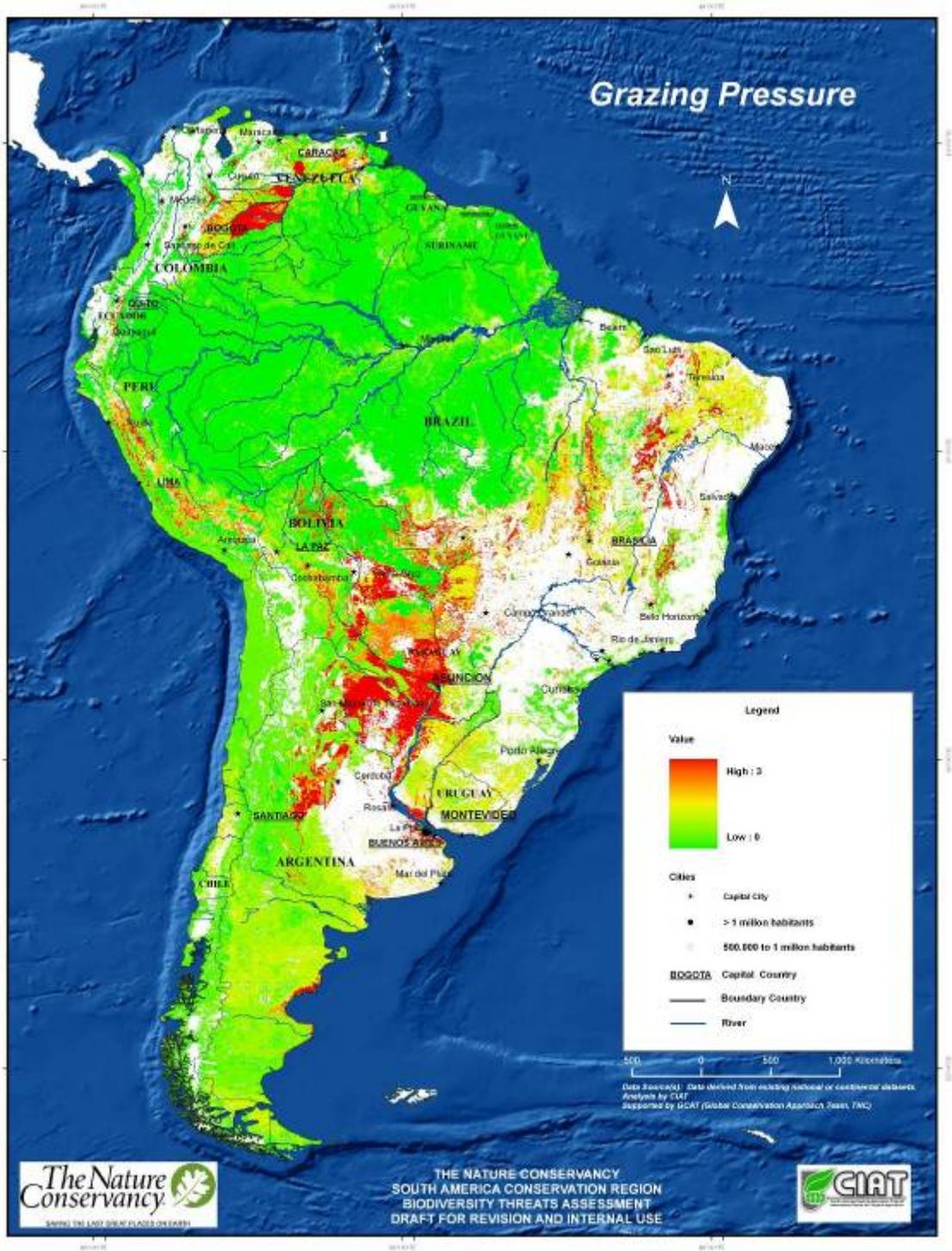


Figure 13 Adjusted threat layer for grazing pressure.

Livestock density data is also available for chickens and pigs, but these surfaces were not used in the model as they were deemed of less importance, and also due to the observation that they act differently on a natural ecosystem and hence merit some

separation. Future versions may consider use of these surfaces, and also adjust the ecosystem response curves and magnitudes to reflect each individual livestock type rather than generic response curves and magnitudes to livestock as a whole.

Fire

The fires layer is constructed based on MODIS data documenting some 2.46 million individual fire events registered from 2000 – 2005. Firstly, the point dataset was converted to a raster layer of fire frequency within each of the 1km pixels used in the modeling. The total number of fires over the 5 year period of the data varied between 0 and 257 for each area of 1km x 1km. It would be preferable to examine not only the frequency of fires over 5 years but also the regularity of fire events during the 5 year period, but for Version 1.1 this is not taken into account as there is little information at the ecosystem level to truly use this kind of temporal frequency fire data.

The fire frequency layer exhibited heavy skewedness in the distribution, and so was subjected to normalization by applying the natural logarithm twice.

The normalized fire frequency layer was then fed into the model, using distance curves of 5km and a curve type 1, resulting in the adjusted threat layer presented in Figure 14.

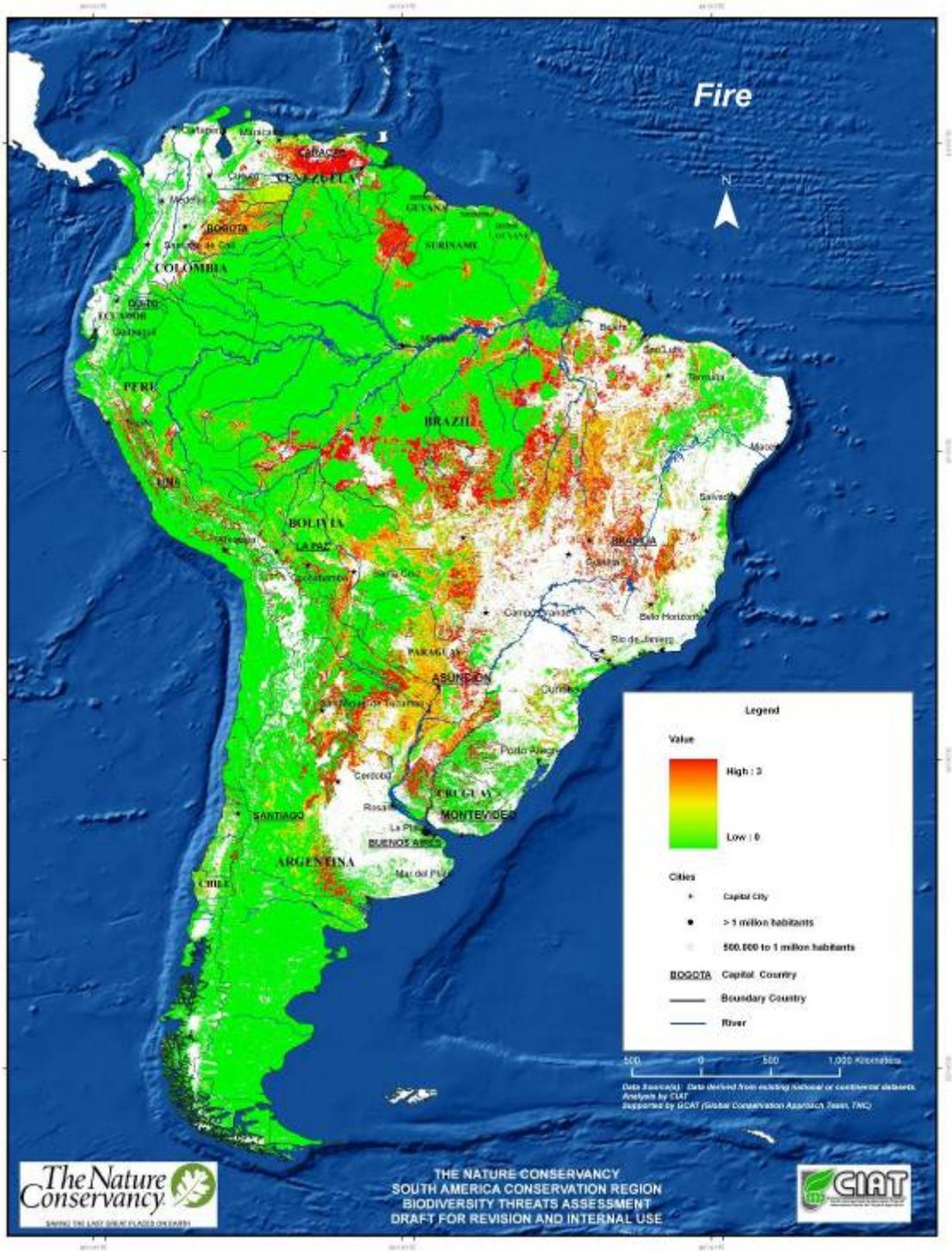


Figure 14 Adjusted threat layer for fires.

Originally, a number of fire dependent ecosystems were classified as responding to fire using a curve type 4 (smiley face, or polynomial). For the final version all ecosystems with curve type 4 were changed to respond with a curve type 2. This was due to the

observation that in 5 years even the most fire dependent systems would be degraded by any more than 1 single fire. Further work and improved fire data may permit the use of curve type 4 in future versions, but for this version curve type 2 corresponds to fire dependent ecosystems.

Infrastructure

The infrastructure layer contains threats that are not included in other layers. This means roads, railways, waterways, and oil and gas drill sites are not included. The infrastructure threat layer uses the following two datasets:

- Airports, Distance 5km, Curve Type 3
- Dams, Distance 1km, Curve Type 3

The threats model was applied, and the adjusted threat layers for each of the two threats were then averaged to produce the final threat layer of infrastructure (Figure 15).

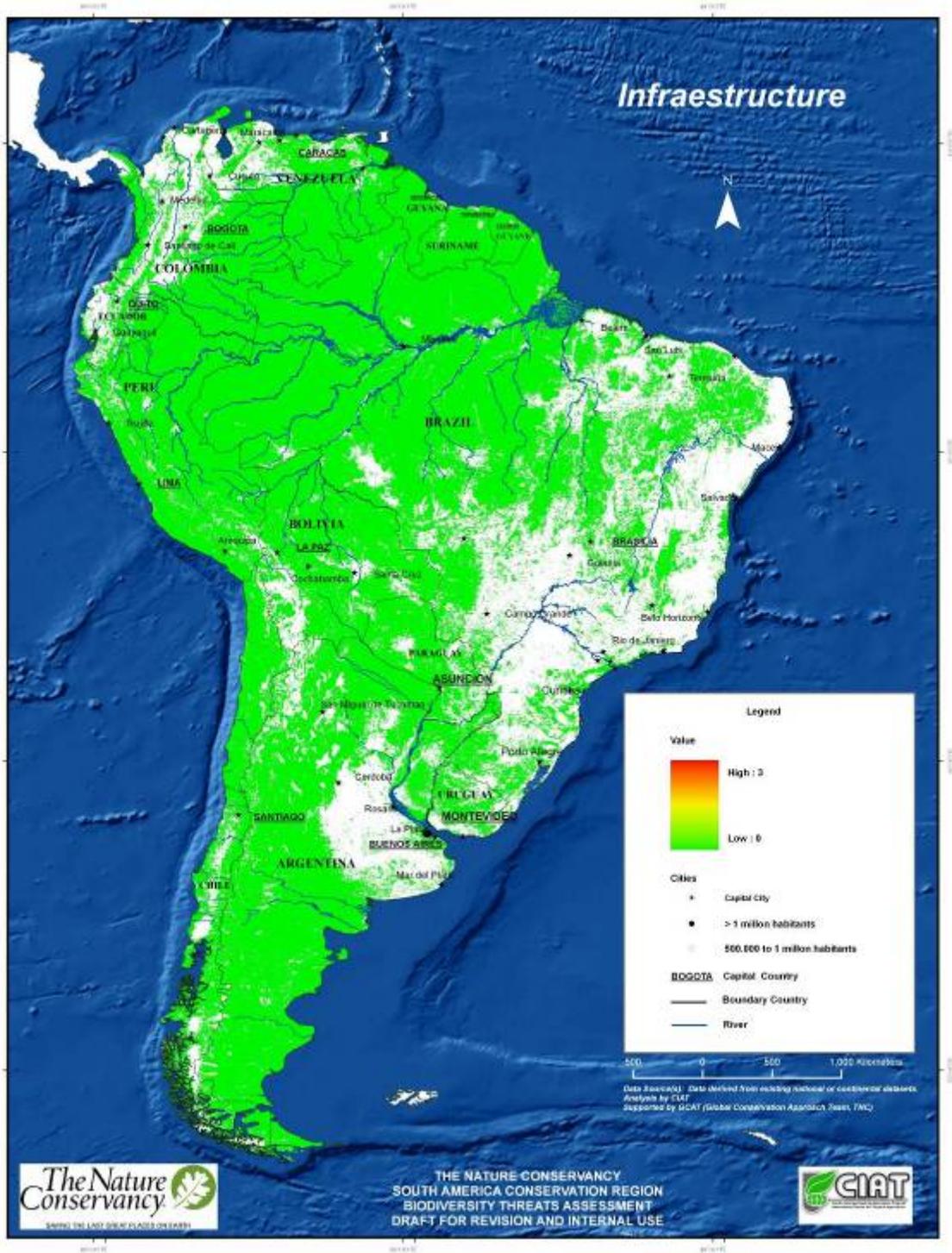


Figure 15 Adjusted threat layer for infrastructure.

Determination of Aggregate Threat

Aggregation of the seven threat layers can be performed using a number of different methods:

1. A simple additive model
2. An additive model with weighting
3. A mechanistic model including weighting, combinations and killers

For Version 1, a simple additive model with weighting is used whereby the weighting is captured in each individual threat layer through the magnitude (severity) measure for each ecosystem. Future versions might endeavor to take a more mechanistic approach, but for the current version it was difficult to identify the potential combinations and killers without further analysis and expert consultation.

Two aggregate threat layers were produced, one at the pixel level and the other aggregating threats to the occurrence level. The pixel approach simply calculates the aggregate threat by averaging the seven individual threat layers.

The occurrence approach sums the total threat for each layer inside each individual occurrence, and divides by the number of pixels. In essence, this represents the mean threat inside the entire occurrence. The AML for calculating this is available in Annex II.

The final aggregate threat layers are displayed in Figure 17 (pixel based) and Figure 18 (occurrence based).



Figure 17 Pixel based aggregate threat for South America

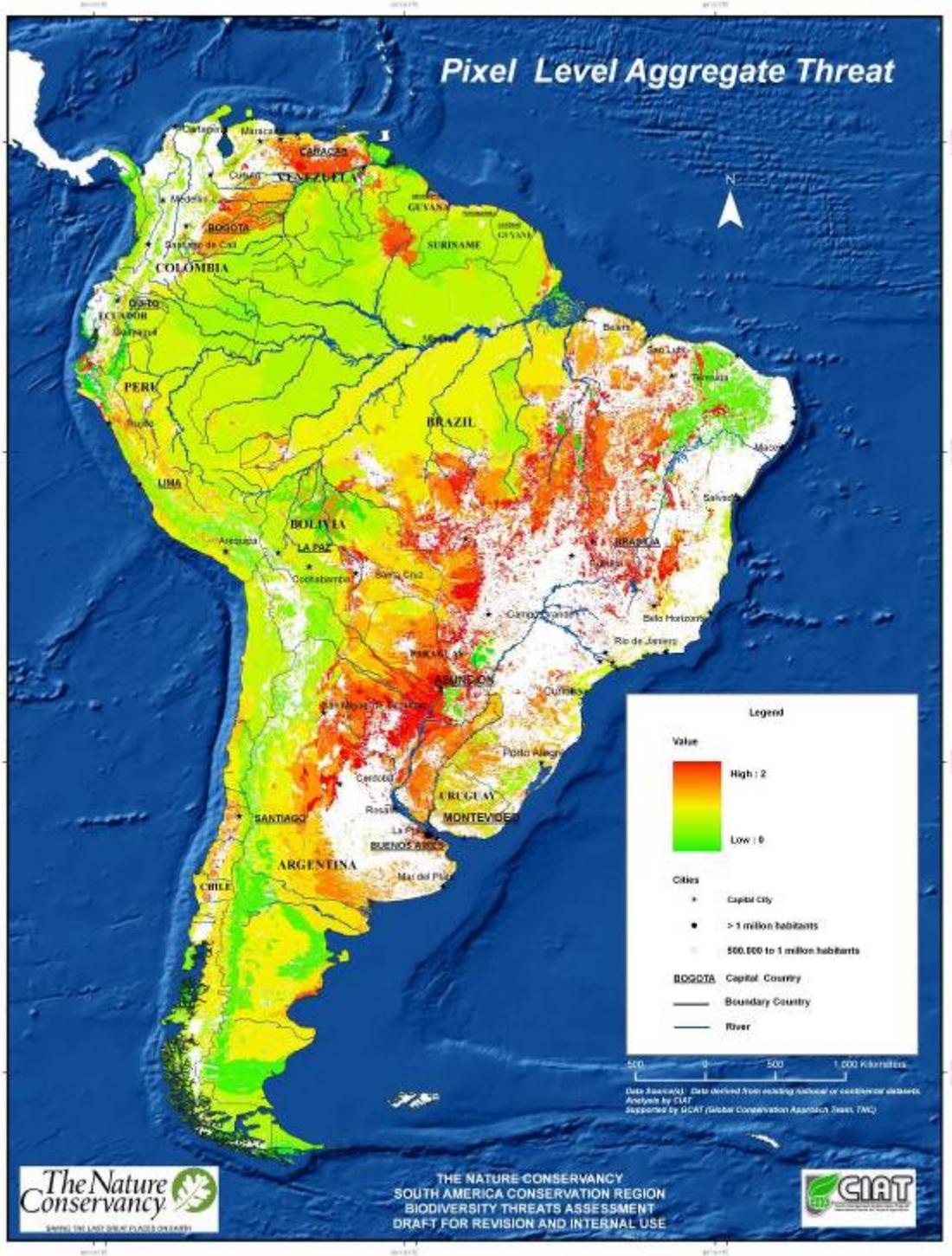


Figure 18 Occurrence based aggregate threat for South America

Sensitivity Analysis of Individual Threat Layers

In order to get to grips with the contribution that each threat layer provides to the aggregate threat, it is useful to perform a sensitivity analysis on a threat by threat basis. This consists of looking at the difference in the resultant aggregate threat layer by including and excluding each threat one by one. This was performed for all 7 threats, and the results are shown in Figure 19. Areas shown in gradations of blue are places where the threat contributes negatively to the aggregate threat (i.e. lowers the total threat), whereas areas shown in red represent areas where the individual threat contributes positively to the final outcome (i.e. increased threat). This is a useful exercise for reviewing the results of the threat analysis and ensuring that the ecosystem response curves, magnitudes and scope and severity levels for each threat make sense and represent the reality that ecosystems are facing on the ground.

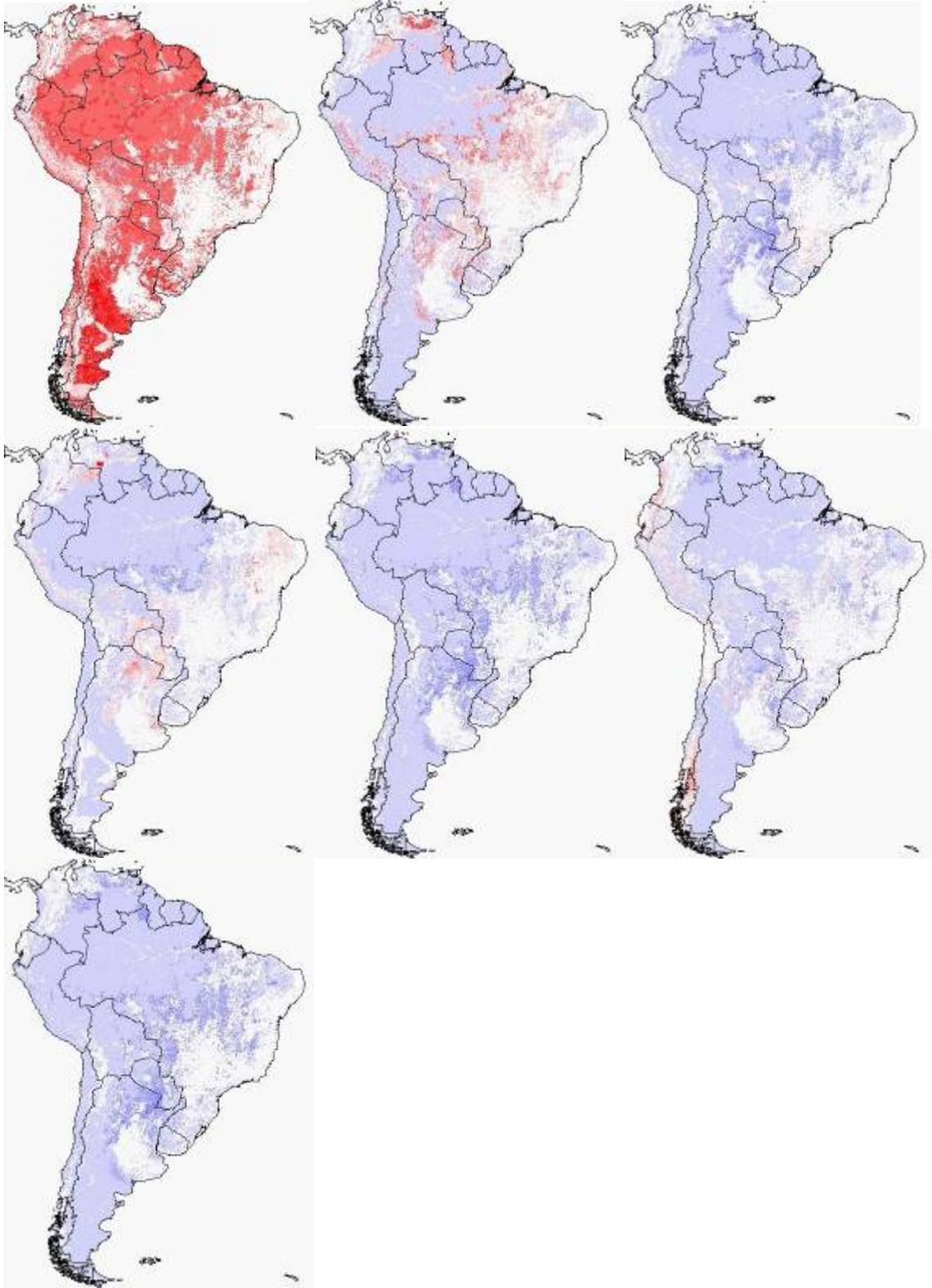


Figure 19 Sensitivity analysis threat by threat of the final threat surface. From left to right, top to bottom, accessibility (top left), fires (top-middle), agriculture (top right), grazing (middle-left), infrastructure (middle middle), recent conversion (middle right), oil and gas (bottom left).

Threat Layers Not Used in Version 1 and 1.1

The following threat layers were developed during the elaboration of this project, but were not used in the final analysis:

Mining – the input dataset was deemed incomplete and unsuitable due to the lack of differentiation between actual mines (immediate threat) and mine concessions (future threat), and the lack of information as to type of mine (toxic vs. non-toxic, large vs. small).

Oil Exploration – the input dataset on oil concessions was deemed unsuitable due to poor data quality and the fact that this represents a more distant future threat rather than an immediate threat

Infrastructure layers – Powerlines, power plants, and big industry were omitted from the analysis due to poor data quality

Other threat layers were identified as being desired but were not included in this version of the threat assessment. These include climate change, and pollution.

Invasive species

TNC scientists provided CIAT with a grid of potential species richness for 18 invasive species. This dataset could be used in the final threat model as is, but is not fully consistent with the conceptual framework of the immediate threat assessment. Firstly, the grid is based on climate envelope models, and hence maps the potential distribution of the invasive species, regardless of migration to suitable areas. It therefore represents a future potential threat in many regions, rather than an actual immediate threat. For example, remote parts of the Amazon basin are found to have high threat, yet without accessibility, disturbance and/or introduction of the species into these natural ecosystems it is highly unlikely to materialize.

For the purposes of exploratory analysis, the invasive threat layer was produced, and included in the aggregate threat calculation, and the results are shown in Figure 20.

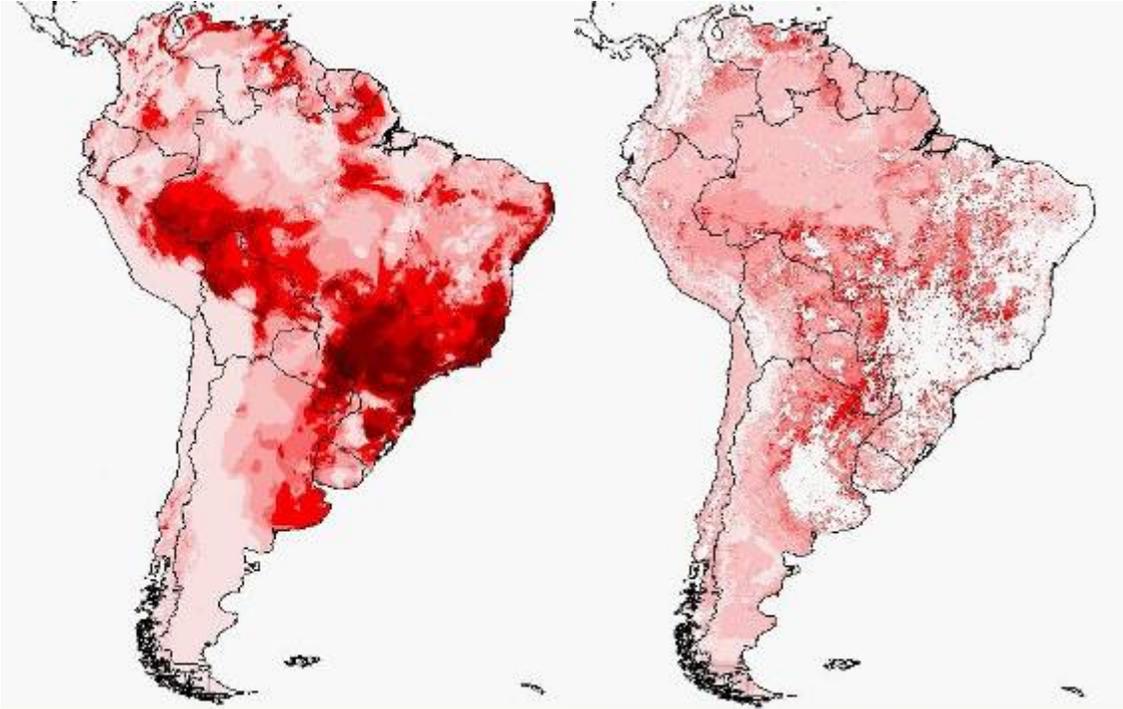


Figure 20 Potential species richness of invasive species (left) and the aggregate threat when invasive layer included in analysis (right)

It is difficult to visualize the impact that the invasives layer has on the final aggregate threat, but an analysis of the contribution of the invasives layer was performed, and the results of which shown in Figure 21. As can be seen, the invasive layer has the greatest positive impact (increased threat) in the south-western Amazon and Paraguay. Much of the Andes, the Colombian llanos, northern Amazon and Patagonia are negatively impacted (lower threat). This is questionable, as these ecosystems also have noxious invasive species and so reconsideration of the species modeled is recommended.

Furthermore, without adjustment of this layer to represent places where the invasive species are actually found, it is difficult to justify its inclusion in this (immediate) threats analysis. However, this layer does represent a perfect fit into a future potential threats analysis, alongside climate change, and agricultural expansion.

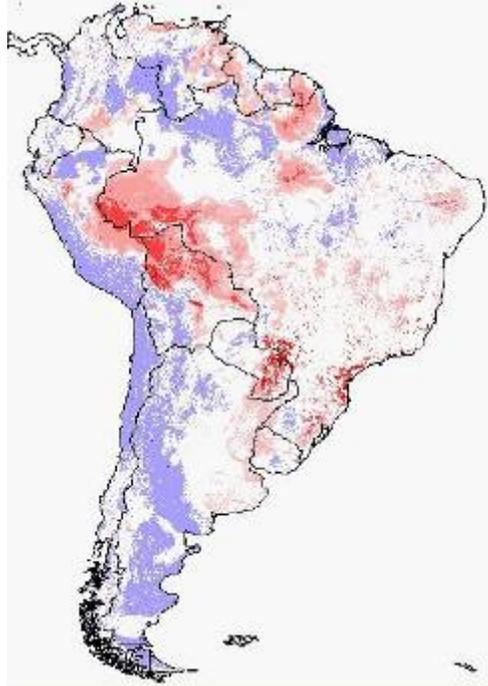


Figure 21 Sensitivity of the aggregate threat on the invasives layer. Sites in red are significantly increased in threat level due to invasives, whilst white areas represent where the layer makes little difference and blue areas where the threat level is reduced.

Google Earth interface

The results of this Version 1.1 threats analysis were put into a Google Earth KML interface, permitting non-GIS professionals to visualize and interact with the results of the threats analysis. All input datasets, final threat layers and aggregate threat layers were included (except for invasives) in the interface, each dataset linking to the metadata and a description of the threat. The data itself is stored in over 50,000 files on a CIAT server, where an intricate set of KML files with differing levels of detail permit users to zoom-in to full resolution and zoom-out to broad-scale visualization with the minimum of bandwidth. The interface is distributed through a single 25kb KML file which links to the online data, although this could be modified to represent only a hyperlink where the KML is then loaded into Google Earth. A screen dump of the Google Earth interface is shown in Figure 22, and other images have been provided for ftp download. A brief manual and tutorial for producing KML interfaces is also provided in Annex V.



Figure 22 Image of the threats analysis Google Earth interface.

Training of TNC GIS-expert on use of the model

In November 2006 Leo Sotomayor visited CIAT and received training on implementation of the AML model for the threats analysis. The model is fully integrated, and permits a

GIS user to perform all steps of the threats model from start to finish. Leo was shown and example analysis, and then practiced the exercise himself. Support should any problems arise is available from CIAT staff.

Description of Data Directory Structure

Inside the “model” directory are all the files that contributed to the final results of this threat assessment. The following is a list and description of the files found in the directory:

Input Data:

status_data – this directory contains the threat status data used for each of the 7 threats. These are in both shapefile and grid format.

Occurrence – this is a grid with unique Ids for each occurrence in South America. This grid is used in aggregating threats using the occurrence level approach.

Mask – this is a grid that defines the analysis window and area of study for the entire threat assessment. Changing this will change the analysis area.

Kernels – this is a directory with ready made kernel files, generated from the kernel calculator. The model looks first here to see if the kernel exists for the distance and curve type specified. If the file is not available, the user should generate the kernel file and place it in this folder adhering to the file naming conventions.

Magnitude – this contains grids of the magnitude (severity) that each threat would potentially have on the ecosystem. It is derived from the occurrence shapefile, with the grid values representing the magnitude assigned to the ecosystem during the expert consultation process. These grids are requested whilst running the threat analysis model. Should the user wish to change the magnitude for an ecosystem, the grid should be regenerated and placed in this directory.

Relations - this contains grids of the curve type (scope) that each threat would potentially have on the ecosystem. It is derived from the occurrence shapefile, with the grid values representing the relation assigned to the ecosystem during the expert consultation process. These grids are requested whilst running the threat analysis model. Should the user wish to change the relation for an ecosystem, the grid should be regenerated and placed in this directory.

Occurrences.shp – this is a shapefile of the occurrences, placed in the directory for informational purposes only. This is not used at any time in the model.

Country.shp – this is a shapefile of global countries, again only placed in the directory for informational purposes.

Tnc_threats_analysis.aml – this is the threat analysis model, for analyzing the a single threats layer.

tnc_threat_aggregate_occurrence.aml – this is the model for aggregating threats once all have been produced.

TNC_Threats_assessment.apr – an ArcView project with all the data organized and visualized for rapid viewing.

Threat layer data:

For each individual threat, the model produces a directory with a three letter code (the first three letters of the name of the threat that the user provides whilst running the model). Inside each directory, there are a number of files corresponding to the following:

"threat"_dd	- grid of current status in decimal degrees, WGS84
"threat"_mt	- grid of current status in equal area meters projection (Lambert)
"threat"_foc_mt	- grid of the threat surface taking into account neighbourhood cells using the kernel, meters projection
"threat"_foc_dd	- grid of the threat surface taking into account neighbourhood cells using the kernel, decimal degrees projection
"threat"_ind_dd	- indexed threat surface 0 - 1 of unadjusted focal result
"threat"_rel_dd	- threat surface having taken into account the ecosystem relation to the threat
"threat"_mag_dd	- threat surface having taken into account the ecosystem relation and magnitude to the threat

The “mag” layer is effectively the final result that should be used, whilst the other grids permit the user to examine the results of each individual process performed during the threat analysis.

The directories in the “model” directory for individual threat surfaces are as follows:

Acp – Accessibility/population
Agd – Conversion to agriculture
Apt – Airports
Cat – Cattle density
Dam – Dams
Fir – Fires
Goa – Goat density
Ndv – Recent conversion (NDVI)
Ogd – Oil and gas drilling
She – Sheep density

Final result data:

Final_threats – this directory contains a grid for each of the seven final threat layers. In some cases this is the result of the combination of a number of layers (e.g. for infrastructure this is the average of dams and airports).

Vulnerability_pixel – this directory contains the final aggregated threat layer based on the pixel approach. This is calculated by averaging the seven threat layers.

Vulnerability_occurrence - this directory contains the final aggregated threat layer based on the occurrence approach. There is a grid for each of the seven threats representing the threat “score” aggregated to the occurrence level. These grids are the output of the `tnc_threat_aggregate_occurrence.aml` model. The vulnerability grid is the average of the seven individual `threat_score` layers.

References

Center for International Earth Science Information Network (CIESIN), Columbia University; International Food Policy Research Institute (IPFRI), the World Bank; and Centro Internacional de Agricultura Tropical (CIAT), Global Rural-Urban Mapping Project (GRUMP): Gridded Population of the World, version 3, with Urban Reallocation (GPW-UR). Palisades, NY: CIESIN, Columbia University. Available at: <http://beta.sedac.ciesin.columbia.edu/gpw>, 2004.

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Annex I – Threat Analysis AML Model

```
/*
/* AML model to identify threats to biodiversity in South America, based on the TNC
/* threats model developed during 2006.
/*
/* In order to run, type the following at the GRID prompt:
/*
/* &run tnc_threat_analysis.aml
/*
/* And follow onscreen instructions
/*
/* The model performs 7 processes towards the production of a single threat surface for
/* any given threat.
/*
/* Required input to the model:
/*
/* - Map of current status of the threat, in grid or shapefile format, decimal degree
/* projection
/* - Kernel text file produced using the Universal Kernel Calculator (some kernels built
/* in)
/* - Shapefile of occurrences with associated table data with threat relation and
/* magnitude
/*
/* Output of the model
/*
/* The model will create a directory named after the first 4 letters of the threat
/* Within that directory it creates the following grids, in order of generation:
/* "threat"_dd - grid of current status in decimal degrees, WGS84
/* "threat"_mt - grid of current status in equal area meters projection (Lambert)
/* "threat"_foc_mt - grid of the threat surface taking into account neighbourhood
/* cells using the kernel, meters projection
/* "threat"_foc_dd - grid of the threat surface taking into account neighbourhood
/* cells using the kernel, decimal degrees projection
/* "threat"_ind_dd - indexed threat surface 0 - 1 of unadjusted focal result
/* "threat"_rel_dd - threat surface having taken into account the ecosystem relation
/* to the threat
/* "threat"_mag_dd - threat surface having taken into account the ecosystem relation
/* and magnitude to the threat
/*
/*
/*
/*
/* Written by Andy Jarvis, CIAT, August 2006
```

```
/* CREATION OF DIRECTORY OF SPECIFIC THREAT
```

```
&type -----  
&type -----TNC Threat Model for South America-----  
&type -----Produced by CIAT 2006-----  
&type -----
```

```
&s threat_long = [response 'Please provide the name of the threat you wish to analyse (no  
spaces)']
```

```
&sv threat = [substr %threat_long% 1 3]
```

```
&amlpath .
```

```
&sv path = [show &amlpath]
```

```
&IF NOT [ EXISTS %threat% -DIRECTORY ] &THEN &sys md %threat%
```

```
arc w %path%\%threat%
```

```
/* CREATION OF THREAT GRID FROM USER DEFINED GRID OR SHAPEFILE
```

```
&IF NOT [ EXISTS %threat%_dd -GRID ] &THEN
```

```
&do
```

```
&type
```

```
&s gridshp = [response 'Is your current status data in "GRID" or "SHAPEFILE" format?']
```

```
&type
```

```
&if %gridshp% = GRID or %gridshp% = grid &then
```

```
&do
```

```
&s gridname = [response 'Please type the name of the grid with full path info, e.g.
```

```
c:\workspace\threatgrid']
```

```
&type
```

```
setwindow %path%\mask
```

```
setcell %path%\mask
```

```
setmask %path%\mask
```

```
%threat%_dd = %gridname%
```

```
&end
```

```
&else
```

```
&do
```

```
&s shapename = [response 'Please type the name of the shapefile with full path info, e.g.
```

```
c:\workspace\threatshapefile']
```

```
&type
```

```
setwindow %path%\mask
```

```
setcell %path%\mask
```

```
setmask %path%\mask
```

```
&IF [ EXISTS temp1 -GRID ] &THEN kill temp1 all
```

```
temp1 = shapegrid(%shapename%)
```

```
setmask temp1
```

```
%threat%_dd = 1
&IF [ EXISTS temp1 -GRID ] &THEN kill temp1 all
&end
&end
&else
&do
&type
&type Threat status grid already generated, skipping to next step
&type
&end
```

```
setwindow maxof
setmask off
setcell maxof
```

```
/* REPROJECTION OF THREAT GRID TO EQUAL AREA METERS PROJECTION
```

```
&IF NOT [ EXISTS %threat%_mt -GRID ] &THEN
&do
%threat%_mt = PROJECT(%threat%_dd)
INPUT
PROJECTION GEOGRAPHIC
UNITS DD
DATUM WGS84
PARAMETERS
OUTPUT
PROJECTION LAMBERT_AZIMUTH
UNITS METERS
PARAMETERS
0
-85 00 00.0
13 00 00.0
0
0
END
&end
&else
&do
&type Reprojection to meters already performed, skipping to next step
&type
&end
```

```
/* NEIGHBOURHOOD CALCULATION OF THREAT BASED ON KERNEL FILE
```

```
&IF NOT [ EXISTS %threat%_foc_mt -GRID ] &THEN
&do
```

```
&s maxdist = [response 'What is the maximum distance that the threat might occur over (in km)?']
```

```
&type
```

```
&s curvetype = [response 'What kind of curve over distance does the threat have? (1 = Fast Decay, 2 = Linear Decay, 3 = Slow Decay, 4 = No Decay?']
```

```
&type
```

```
&IF [ EXISTS %path%\kernels\kernel_%maxdist%km_type_%curvetype%.asc -FILE ]  
&THEN
```

```
&do
```

```
%threat%_foc_mt = FOCALSUM(%threat%_mt, WEIGHT,
```

```
%path%\kernels\kernel_%maxdist%km_type_%curvetype%.asc, DATA)
```

```
&end
```

```
&else
```

```
&do
```

```
&type
```

```
&s kernelfile = [response 'The kernel file does not exist. Please generate the file and provide the full path and filename: (e.g. c:\workspace\kernelfile.asc) ']
```

```
&type
```

```
%threat%_foc_mt = FOCALSUM(%threat%_mt, WEIGHT, %kernelfile%, DATA)
```

```
&end
```

```
&end
```

```
&else
```

```
&do
```

```
&type Neighbourhood calculation already performed, skipping to next step
```

```
&type
```

```
&end
```

```
/* REPROJECTION OF NEIGHBOURHOOD THREAT SURFACE TO DECIMAL  
DEGREES
```

```
&IF NOT [ EXISTS %threat%_foc_dd -GRID ] &THEN
```

```
&do
```

```
%threat%_foc_dd = PROJECT(%threat%_foc_mt)
```

```
OUTPUT
```

```
PROJECTION GEOGRAPHIC
```

```
UNITS DD
```

```
DATUM WGS84
```

```
PARAMETERS
```

```
END
```

```
&end
```

```
&else
```

```
&do
```

```
&type Reprojection back to decimal degrees already performed, skipping to next step
```

```
&type
```

```
&end
```

```
/* INDEXING OF THREAT LAYER TO RANGE FROM 0 TO 1
```

```
setwindow %path%\mask  
setcell %path%\mask  
setmask %path%\mask
```

```
&IF NOT [ EXISTS %threat%_ind_dd -GRID ] &THEN  
&do  
&DESCRIBE %threat%_foc_dd  
%threat%_ind_dd = MERGE(FLOAT(%threat%_foc_dd /  
%grd$zmax%),%path%\mask)  
&end  
&else  
&do  
&type Indexing of threat surface already performed, skipping to next step  
&type  
&end
```

```
/* ADJUSTMENT OF THREAT LAYER BASED ON THE SPECIFIC RELATION  
BETWEEN THREAT AND ECOSYSTEM
```

```
&IF NOT [ EXISTS %threat%_rel_dd -GRID ] &THEN  
&do  
&IF [ EXISTS %path%\relations\rel_%threat% -GRID ] &THEN  
&do  
DOCELL  
if (%path%\relations\rel_%threat% == 1 or %path%\relations\rel_%threat% == 888 or  
%path%\relations\rel_%threat% == 999) %threat%_rel_dd = %threat%_ind_dd  
else if (%path%\relations\rel_%threat% == 2) %threat%_rel_dd = 0.05 * pow  
(2.718281828459, (3 * %threat%_ind_dd))  
else if (%path%\relations\rel_%threat% == 4 & %threat%_ind_dd == 0)  
%threat%_rel_dd = 0  
else if (%path%\relations\rel_%threat% == 4) %threat%_rel_dd = 4 * pow  
(%threat%_ind_dd, 2) - (4 * %threat%_ind_dd) + 1  
else if (%path%\relations\rel_%threat% == 5) %threat%_rel_dd = 0  
else if ((%path%\relations\rel_%threat% == 6 or %path%\relations\rel_%threat% == 3)  
& %threat%_ind_dd < 0.006737947) %threat%_rel_dd = 0  
else if ((%path%\relations\rel_%threat% == 6 or %path%\relations\rel_%threat% == 3)  
& %threat%_ind_dd > 0.006737946) %threat%_rel_dd = 0.2 * ln(%threat%_ind_dd) + 1  
else if (%path%\relations\rel_%threat% > 6 ) %threat%_rel_dd = setnull (  
%path%\relations\rel_%threat% > 6 )  
else %threat%_rel_dd = 0  
END  
&end  
&else
```

```

&do
&s relations = [response 'The relations grid does not exist. Please generate the grid and
provide the full path and file name:']
DOCELL
if (%relations% == 1 or %relations% == 888 or %relations% == 999) %threat%_rel_dd =
%threat%_ind_dd
else if (%relations% == 2) %threat%_rel_dd = 0.05 * pow (2.718281828459, (3 *
%threat%_ind_dd))
else if (%relations% == 4 & %threat%_ind_dd == 0) %threat%_rel_dd = 0
else if (%relations% == 4) %threat%_rel_dd = 4 * pow (%threat%_ind_dd, 2) - (4 *
%threat%_ind_dd) + 1
else if (%relations% == 5) %threat%_rel_dd = 0
else if ((%relations% == 6 or %relations% == 3) & %threat%_ind_dd < 0.006737947)
%threat%_rel_dd = 0
else if ((%relations% == 6 or %relations% == 3) & %threat%_ind_dd > 0.006737946)
%threat%_rel_dd = 0.2 * ln(%threat%_ind_dd) + 1
else if (%relations% > 6 ) %threat%_rel_dd = setnull ( %relations% > 6 )
else %threat%_rel_dd = 0
END
&end
&end
&else
&do
&type Ecosystem relations already calculated, skipping to next step
&type
&end

```

/* ADJUSTMENT OF THREAT LAYER BASED ON THE SPECIFIC MAGNITUDE
BETWEEN THREAT AND ECOSYSTEM

```

&IF NOT [ EXISTS %threat%_mag_dd -GRID ] &THEN
&do
&IF [ EXISTS %path%\magnitudes\mag_%threat% -GRID ] &THEN
&do
&IF [ EXISTS temp1 -GRID ] &THEN kill temp1 all
temp1 = con(%path%\magnitudes\mag_%threat% > 3, 1,
%path%\magnitudes\mag_%threat%)
%threat%_mag_dd = %threat%_rel_dd * temp1
&IF [ EXISTS temp1 -GRID ] &THEN kill temp1 all
&end
&else
&do
&s magnitudes = [response 'The magnitudes grid does not exist. Please generate the grid
and provide the full path and file name:']
&IF [ EXISTS temp1 -GRID ] &THEN kill temp1 all
temp1 = con(%magnitudes% > 3, 1, %magnitudes%)

```

```
%threat%_mag_dd = %threat%_rel_dd * temp1
&IF [ EXISTS temp1 -GRID ] &THEN kill temp1 all
&end
&end
&else
&do
&type Ecosystem impact magnitude already calculated, skipping to next step
&end
```

```
&type
&type
&type Finished calculating threat surfaces for %threat_long%. Grids are found in
%threat% directory.
&type
&type -----
&type -----TNC Threat Model for South America-----
&type -----Produced by CIAT 2006-----
&type -----
```

```
arc w %path%
```

```
&return
```

Annex II – Threat Aggregation (occurrence scale) AML Model

```
/*
/* AML model to aggregate threats to biodiversity in South America, based on the TNC
/* threats model developed during 2006.
/*
/* In order to run, type the following at the GRID prompt:
/*
/* &run tnc_vulnerability_analysis.aml
/*
/* And follow onscreen instructions
/*
/* Required input to the model:
/*
/* - Threat surface in grid format, decimal degree projection
/*
/* The model outputs the threat score, based on aggregation of the threat surface to each
/* occurrence.
/*
/* Written by Andy Jarvis, CIAT, August 2006
```

```
&type -----
&type -----TNC Vulnerability Model for South America-----
&type -----Produced by CIAT 2006-----
&type -----
```

```
&amlpath .
&sv path = [show &amlpath]
```

```
&s threat_long = [response 'Please provide the name of the threat you wish to analyse (no
spaces)']
&sv threat = [substr %threat_long% 1 3]
```

```
arc w %path%\vulnerability_andy
```

```
/* Reclassify threat layer to 4 categories
```

```
&s gridname = [response 'Please type the name of the grid with full path info, e.g.
c:\workspace\threatgrid']
```

```
&IF [ EXISTS %threat%_reclass -GRID ] &THEN kill %threat%_reclass all
```

```
&IF [ EXISTS %threat%_sum -GRID ] &THEN kill %threat%_sum all
```

```
%threat%_sum = zonalsum(%path%\occurrences, %gridname%, DATA)
```

```
setwindow %gridname%
setmask %gridname%
setcell %gridname%
```

```
&IF [ EXISTS temp1 -GRID ] &THEN kill temp1 all
&IF [ EXISTS %threat%_pix -GRID ] &THEN kill %threat%_pix all
```

```
temp1 = 1
%threat%_pix = zonalsum(%path%\occurrences, temp1, DATA)
```

```
&IF [ EXISTS %threat%_score -GRID ] &THEN kill %threat%_score all
```

```
%threat%_score = %threat%_sum / %threat%_pix
```

```
&IF [ EXISTS %threat%_sum -GRID ] &THEN kill %threat%_sum all
&IF [ EXISTS temp1 -GRID ] &THEN kill temp1 all
&IF [ EXISTS %threat%_pix -GRID ] &THEN kill %threat%_pix all
```

```
&type
&type
&type Finished calculating threat surfaces for %threat_long%. Grids are found in
%threat% directory.
```

```
&type
&type -----
&type -----TNC Threat Model for South America-----
&type -----Produced by CIAT 2006-----
&type -----
```

```
arc w %path%
```

```
&return
```

Annex III – Accessibility AML Model

```
/* Accessibility Model for South America
/* AML script to calculate accessibility in South America for the TNC
/* threats mapping work during 2006.
/*
/* open Workstation ArcInfo, at ARC prompt type "w c:\access" to get in the right
directory
/* In order to run the AML, type the following at the GRID prompt:
/* &run AccessModel.aml
/*
/*
/*
/* INPUT GRIDS
/*
/* - surmask - this is the South American study area mask
/* - surnet - this is the grid with velocities of the transport network.
/*           this includes roads, rivers, railroads
/* - frontera - this is international borders given a velocity of 1 km/hr
/* - sa1km_dem - 1 km DEM in lambert for South America
/* - glcsur - this is the GLC2000 cut out for just South America
/* - surnight - this is the South American night light surface, lambert projection
/*           - sagrid - surface with target points
/*
/* INPUT LOOKUP TABLES
/* - slmap.txt - this is the lookup table for the slope map
/* - landreclass.txt - this the lookup table for assigning velocities to the GLC
/* - time.txt - the table that converts velocities to time to cross the cell
/* -
/*
/* MODEL OUTPUTS
/*
/*           - surmodel - travel time to populated places in hours
/*
/* contact: Glenn Hyman, CIAT, g.hyman@cgiar.org or Mauricio Castro, TNC,
mcastro@tnc.org
/* -----
```

```
setmask surmask
setwindow surmask
```

```
/* create the slope grid
slpsur = slope(sa1km_dem, percentrise)
```

```
/* reclassing the slope grid
slclass = slice(slpsur, table, slmap.txt)
```

```
/* reclassing the elevation grid
elevclass = slice(sa1km_dem, table, altitude.txt)

/* reclassing the landcover grid
landreclass = slice(glcsur, table, landreclass.txt)

/* create the urban grid
urban = con(surnight gt 30, 25)

/* in this step we merge the grids into friction or velocity surface. Each pixel is velocity
in km/hr
friction1 = merge(frontera, surnet, urban, landreclass)

/* now we convert the merged grid to time to cross each cell in minutes
friction2 = reclass(friction1, time.txt)

/* factor in the effect of slope
friction = friction2 * slclass * elevclass

/* run the costdistance model
surmodel1 = costdistance(city1000, friction)

/* divide by 60 to convert to hours
surmodel2 = surmodel1 div 60

/* divide by 1000 to convert meters to km
surmodel = surmodel2 div 1000

kill friction all
kill friction1 all
kill friction2 all
kill surmodel1 all
kill surmodel2 all
kill landreclass all
kill elevclass all
kill slpsur all
kill slclass all
kill urban all
```

Annex IV – NDVI Trend Analysis AML Model

```
&terminal 9999
```

```
&s grids := [listfile mean_* -grid]
```

```
&if [EXISTS meanx -grid] &then kill meanx all  
meanx = mean(%grids%)  
&s many = 3.5
```

```
&if [null %grids%] &then &type There are no DEM files  
&else  
&do
```

```
  &s num := [token %grids% -count]  
  &do i := 1 &to %num%  
    &sv name = [extract %i% %grids%]  
    &s year [SUBSTR %name% 6 4]
```

```
    &if [EXISTS prod_%year% -grid] &then kill prod_%year% all  
    prod_%year% = (mean_%year% - meanx) * (%i% - %many%)  
    &if [EXISTS prodn_%year% -grid] &then kill prodn_%year% all  
    prodn_%year% = prod_%year% / %num%
```

```
    &if [EXISTS %year%_diffsq -grid] &then kill %year%_diffsq all  
    setwindow mean_%year%  
    setcell mean_%year%  
    %year%_diffsq = pow((%i% - %many%),2)
```

```
&end
```

```
  &s prodnlist := [listfile prodn_* -grid]  
  &if [EXISTS covar -grid] &then kill covar all  
  covar = sum(%prodnlist%)
```

```
  &s diffgrids := [listfile *_diffsq -grid]  
  &if [EXISTS sumdiffs -grid] &then kill sumdiffs all  
  sumdiffs = sum(%diffgrids%)  
  &if [EXISTS variance -grid] &then kill variance all  
  variance = sumdiffs / %num%  
  &if [EXISTS trend -grid] &then kill trend all  
  trend = covar / variance
```

```
&end
```

```
  &if [EXISTS sumdiffs -grid] &then kill sumdiffs all
```

```
&if [EXISTS variance -grid] &then kill variance all
&if [EXISTS covar -grid] &then kill covar all

&s kill_grids := [listfile mean_* -grid]
&do
  &s num2 := [token %kill_grids% -count]
  &do i := 1 &to %num2%
    &sv killname = [extract %i% %kill_grids%]
    &s year [SUBSTR %killname% 6 4]
    &if [EXISTS prod_%year% -grid] &then kill prod_%year% all
    &if [EXISTS prodn_%year% -grid] &then kill prodn_%year% all
    &if [EXISTS %year%_diffsq -grid] &then kill %year%_diffsq all
  &end
&end

&return
```

Annex V – Tutorial on creation of Google Earth interface

This document describes the basic procedure used to create a KML document for use in Google Earth (GE) involving data created by CIAT and the Nature Conservancy. The project is intended to make available to a community of users the results of a series of models describing seven different threats to biodiversity across the continent of South America. This document is not intended as an in-depth technical reference, but rather a framework of how to go about creating or modifying similar Google Earth (GE) projects in the future. A wealth of very good technical information regarding GE and KML is available on line, through both Google itself as well as other third party users and developers. URLs to this on line documentation will be provided throughout the document, as well as in a section at the end of the document.

This document will explain sequentially the process steps used to create a Google Earth KML file called TNC_threats.kml. It will describe the process of preparing ESRI raster as well as vector data for use in Google Earth. It will also briefly describe the use of networklinks to greatly expand the amount of data that can be offered through GE, as well as using KML styles, and the inclusion of metadata in GE. A brief description specific to TNC_threats.kml will also be provided, describing the file/directory structure of the data as it resides on the Uso de Tierra http server. At the end of the document a list of useful KML reference URLs will be provided.

Convert GRID to PNG Image

In order to display ESRI GRID data in Google Earth, a GRID must first be converted to a true image format. Though GE supports a number of different image formats, .png is the best image type to use because .png alone supports transparency within the image (i.e. NoData cells can appear transparent). Unfortunately, ArcMap can only export GRID data as a .tif or .img file, so the GRID must first be exported from ArcMap as a .tif file, and subsequently converted to .png with another piece of graphics software.

Two points merit discussion on exporting a GRID to a .tif file within ArcMap. First, the display of raster data in ArcMap is greatly enhanced by applying a stretch to the data, wherein a color scheme is applied to the real data values in a manner such that the maximum number of colors are applied to the variation present within the data. ArcMap does this by default, but it is important to include these stretched color values in the exported image product. Secondly, when a color scheme (i.e. red monochromatic) is applied to a GRID, the exported .tif product must be saved as a three-band (RGB) image in order to preserve the color scheme in the final image product. Exporting from ArcMap as a three-band image greatly increase the image size (triples it), as well as the processing time required for export, but it is essential in order to preserve the desired appearance. Command line ArcInfo/GRID is much faster at exporting a GRID as a .tif file, however the time required to set up both the color stretch as well as the color scheme (i.e. creating a colormap file) within ArcInfo/GRID makes this option undesirable. Figure 1 below is a screen dump of a correctly formatted GRID export dialogue within ArcMap. This export function can be accessed by right clicking on the target GRID in the ArcMap layers list,

and selecting Data > Export Data. Notice that the “Use Renderer” and “Force RGB” check boxes are selected, and the selected format is “TIFF”.

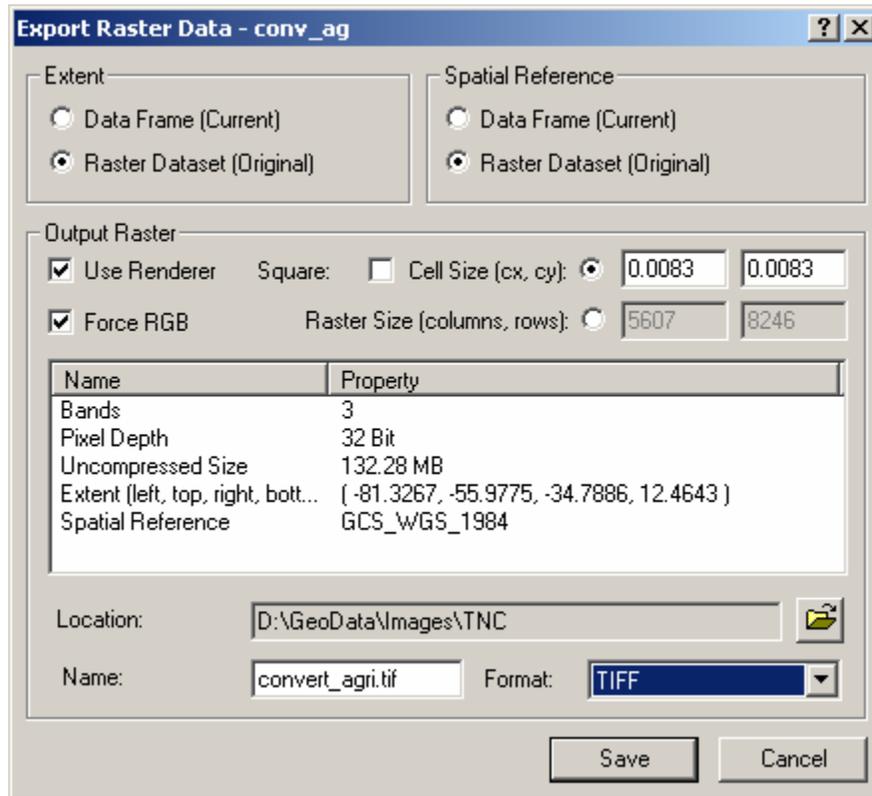


Figure 1 GRID export interface, ArcMAP

Once a three-band .tif image has been successfully exported, it must then be converted to a .png file with the appropriate RGB combination identified as transparent (usually 0,0,0). IrfanView is an easy to use and free piece of image software that can easily accomplish the conversion to .png. IrfanView can be downloaded for free at <http://www.irfanview.com/>.

Create an Image Super Overlay

With a little bit of finesse, and some knowledge of KML, images can be easily viewed within Google Earth. However, GE has real trouble dealing with images greater in dimension than 2000 x 2000 pixels (according to Google), and such images, if imported into GE, will suffer a severe deterioration in resolution. Actually, the problem is not so much GE as it is the capacity of the typical graphics card and the resolution of most monitors. Despite Google’s claim regarding 2000 x 2000 dimension images, to retain the resolution of the original product, any images used in GE should not exceed about 400 x 400 in dimension. Obviously, this presents a problem when a developer wants to include large continent-wide or global raster data sets.

Fortunately, recent versions of KML offer a nice solution to this problem. By using the KML elements <Region> and <NetworkLink>, along with a technique known as Super

Overlay (and some inexpensive software that automates the process), larger high-resolution imagery can easily be made available in Google Earth. This document will not present a detailed explanation of the aforementioned KML elements and techniques, as a wealth of very thorough documentation on these subjects is available on line. See the following URLs for a good discussion of these topics:

http://earth.google.com/kml/kml_21tutorial.html#workingregions ,
http://earth.google.com/kml/kml_21tutorial.html#superoverlays ,

In essence, Super Overlay is the process of taking a single large image file, and breaking it up into many smaller sub-images or tiles. Some of these sub-images retain the resolution of the original image, and others have been re-sampled to varying degrees of reduced resolution. Using the <Region> and <NetworkLink> elements in KML, a Super Overlay displays sub-images of different resolutions to the client depending on the scale at which the client is viewing the data. At a very small scale, where the client is viewing a large area (such as an entire continent), only the sub-images of the coarsest resolution are displayed. As the client zooms in farther, viewing less and less area at an increasing scale, higher resolution images are displayed. Finally, when the client is zoomed into a large enough scale (elevation in Google-speak), the full resolution sub-images are displayed. At any one time, no more than four to six image tiles are displayed on screen.

Setting up a Super Overlay by hand for anything more than a few images would be a time consuming and tedious process. Thanks to a prolific and generous GE user community, there are a number of software tools that have been developed to automate the Super Overlay process for the developer. The best among these is SuperOverlay (v1.3.2), which provides a nice graphical user interface with several useful options for easily setting up a Super Overlay. SuperOverlay can be downloaded as a free 7-day trial, or can be purchased for \$20 USD at <http://gis.mi-perm.ru/programs/superoverlay>. This same URL contains a very useful set of instruction on how to use the software, and a list of all the settings available and what they mean. This tool is highly recommended. Figure 2 below is a screen dump of SuperOverlay as it was set up to run a continent-wide image data file for South America.

The settings used below will not be described in detail here, as a sound explanation of each is provided at the URL above. However, there are a couple of important settings to point out. The location of the new images and .kml files must be explicitly defined in the upper right corner. Also required are the bounding coordinates of the extent the image covers (taken from the original GRID data set). Also, make sure that if transparency is desired in the output that PNG is selected as the format (the input image must also be .png). A number of different options are available for the re-sampling type, with slightly better results noticed using bicubic sampling. As far as LOD (level of detail, explained in the user instructions), between four and six is probably most appropriate, but this will depend on the size and geographic extent of the image being processed. Finally, under "Packing into KMZ" the user has a number of options. If the resulting data is to be hosted on an http server, then the "Don't pack" option is most appropriate, as it ensures that all path names will be correct on the http server.

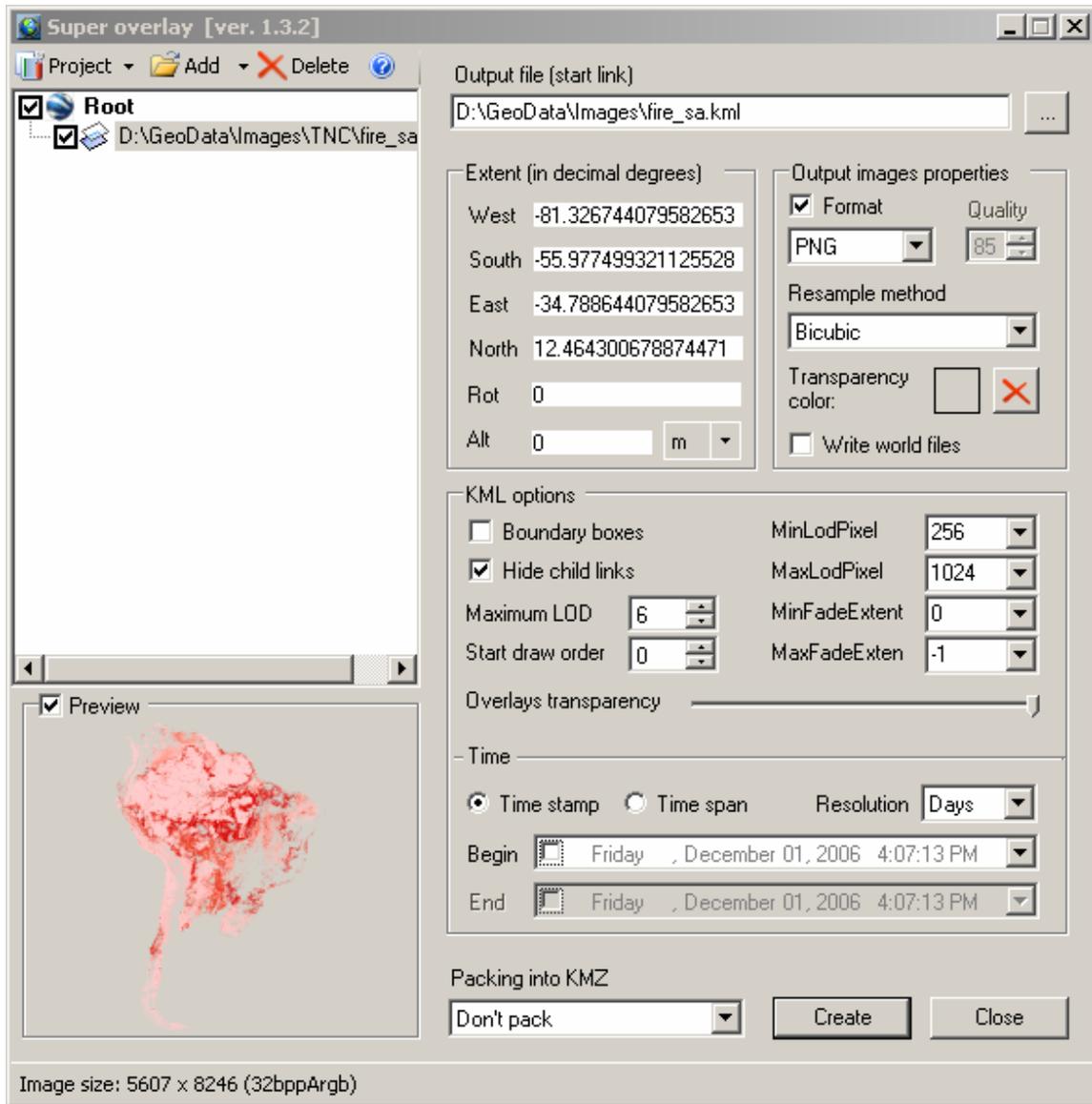


Figure 2 SuperOverlay ready to run a continent-wide data set for South America

As an example of the output produced by this process, a 1km resolution image file of all of South America (5607 x 8246 pixels) was processed by SuperOverlay v.1.3.2. The output produced consisted of 1,368 .png files and 1,368 accompanying .kml files. Each individual .kml file contains a <Region> element describing the “scale” at which the associated image should display, and a <NetworkLink> element identifying the .kml file(s) to access once either the maximum or minimum scale for that image has been exceeded.

Convert Shapefile Vector Data for Use in Google Earth

Preparing shapefile vector data for use in GE is a much simpler and faster process than preparing raster/imagery data. Once again, there are a number of tools that have been created for this process. One good option is a product called Arc2Earth, which has been

created as an extension for ArcMap (<http://www.arc2earth.com>). This extension is available as a free 30-day trial, or can be purchased for \$99 USD. The extension is straightforward and easy to use, and provides many options regarding how the data should be exported. A .pdf document providing detailed information on the extension is available at http://www.arc2earth.com/products/A2E_Brochure.pdf. A screen dump of Arc2Earth is presented below in Figure 3. Again, to understand all that this extension can do, the documentation should be referenced.

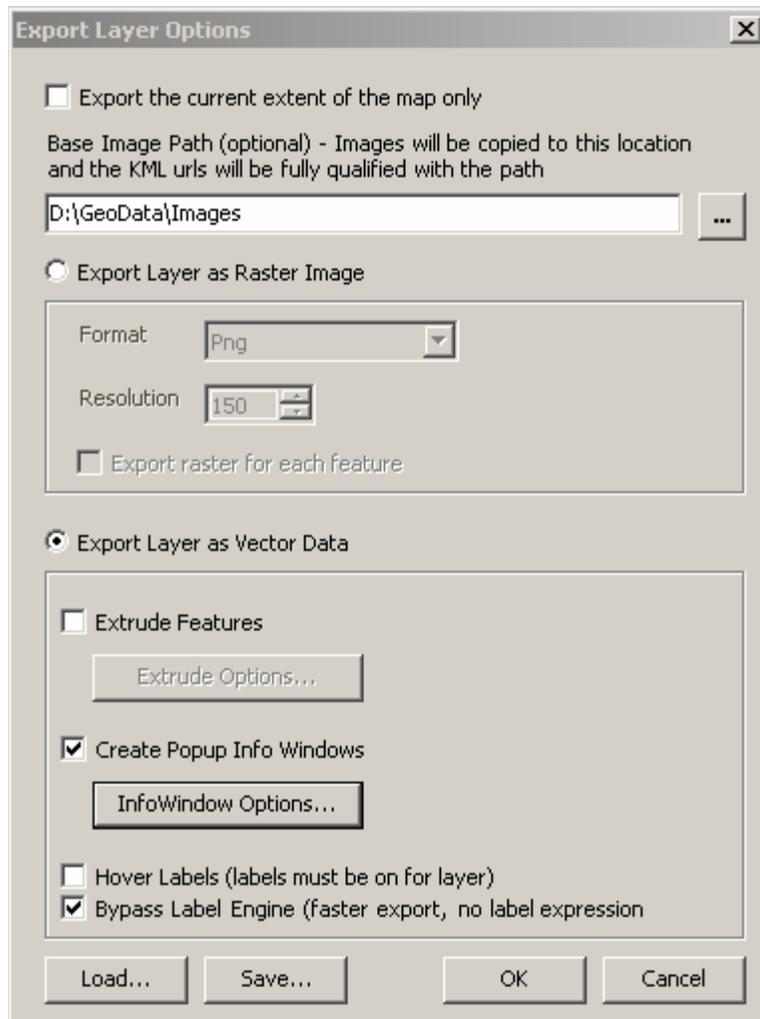


Figure 3 Arc2Earh ready to export vector point data

The result of running vector data through the Arc2Earth extension is a .kml file which contains a reference to every feature in the data set (in this case a Placemark for each point in the layer), as well as a graphics file used to display each feature in GE, and, optionally, information from the shapefile attribute table which is available as a pop-up balloon in GE when the user clicks on a point feature in the display.

While Arc2Earth works very well, the output product can be substantially improved by wading into the resulting .kml file and tweaking some of the KML code that Arc2Earth produces. The possibilities in this regard are endless, but a few essential improvements will be described here.

One annoying thing this tool does is place an “Arc2Earth” text string in each and every balloon that pops up in GE when the user clicks on a feature in the viewer to examine available attribute data. This little bit of self-promotion on the part of Arc2Earth can be easily removed by locating the reference in the .kml file and removing it completely. This bit of extra code will be included with every individual feature (point, line, or poly), so it is best to use a search and replace tool in a text or code editor to remove every instance of it. Another odd twist is that Arc2Earth saves a graphic file (.png) for each and every feature that it is exporting for use in GE. In the case of point data in which all features are symbolized identically, this results in hundreds or even thousand of identical graphic images being produced (depending on the number of records in the original shapefile). Besides being a waste of space on a server, GE performance is seriously degraded by having to download, cache, and draw hundreds of different graphic files which all display exactly the same thing. This can be solved by altering the .kml code so that all points refer to the same .png file, rather than each point referring to its own individual .png file. Doing so greatly improves the speed at which a vector layer displays in GE. Once this is accomplished, all extra .png image files can be removed from the server.

Using NetworkLinks to Create a Master KML File

Once you have created a series of .kml files, for either image or vector data, all of these .kml files can be referenced from a single “master” .kml file using the KML element <NetworkLink>. A networklink basically allows an external .kml file to be referenced from within a local .kml document. There is no limit to the number of networklinks that a single .kml file can reference. The syntax for setting up a networklink is very simple, and an excellent description can be found on line in Google’s KML (2.1) tag reference, http://earth.google.com/kml/kml_tags_21.html. The only requirement for a network link is that the client who is attempting to utilize the file must have access to the location where the network linked .kml resides, preferably on an http server.

One big advantage of using networklinks, in addition to the convenience of not having to store massive amounts of information within a single .kml file, is that networklinked .kml files are dynamically updated. When a user accesses a network link, they are getting the most updated version of the linked .kml file on the server. This represents a big advantage over simply distributing zipped .kmz files, which are static and in no way dynamic. When a .kml file is updated on an http server, any network links that point to that .kml file will always return to the client the most current version of the .kml file.

Using KML Styles

One really nice formatting feature available in KML is the use of styles. Though distinct from cascading HTML styles, the concept is exactly the same. There are over ten style elements available in KML, dealing with everything from labels, to icons, to list items, to pop-up balloons. Each style element dictates the appearance and behavior of a particular

component within GE. The KML tag reference URL listed above contains a thorough description of all the style elements available in KML. Of particular usefulness is the <ListStyle> element. The <ListStyle> element provides the developer a lot of flexibility in how items in the Places panel (a.k.a. Table of Contents) appear in GE, as well as other functionality that can be added to list item headings, such as hyperlinks, image rollovers, additional/alternate icons, etc.

Metadata

If access to metadata is to be included with the .kml you are developing, there are a number of ways to achieve this. The simplest way is to simply include a <description> tag inside of your feature reference. This can be done regardless of whether you are using a networklink, placemark, point, etc. The <description> tag causes a pop-up balloon to appear in the GE viewer when the client clicks an item heading in the Places panel. The content within the pop-up balloon is all HTML derived, so you can add just about anything you want within the balloon, including text, images, hyperlinks, image rollovers, etc.

An example of how you might include metadata in GE would be to include the <description> element within a <networklink>. When the user clicks on the networklink item in the Places panel, a pop-up balloon appears which contains the exact text from the abstract section of the metadata file, below which is a hyperlink that will open up a web page in a browser window containing the complete metadata file. See Figure 4 below for an example of how such a pop-up balloon would appear in GE. Metadata could also be made available by clicking a check box on and off in the Places panel.

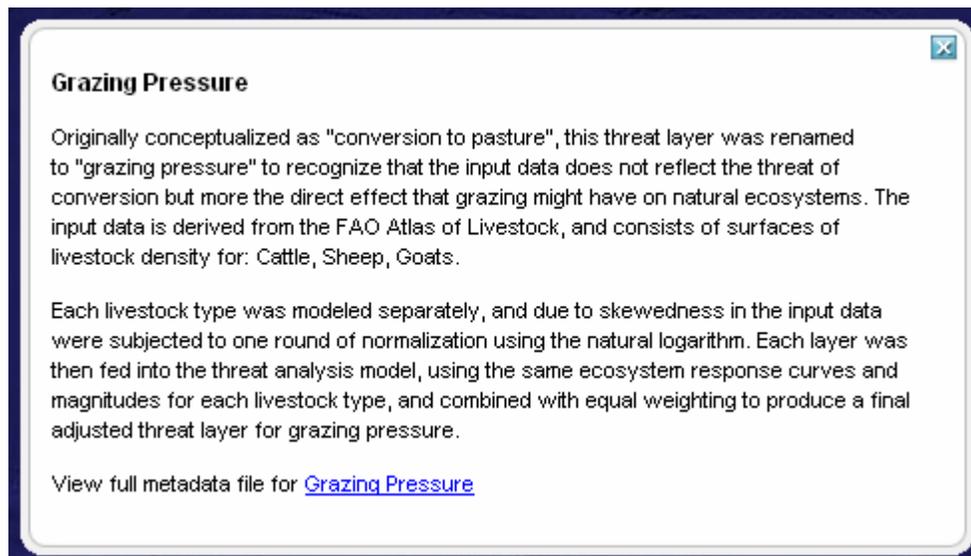


Figure 4 Pop-up balloon in GE containing metadata abstract and hyperlink

Directory Structure Behind TNC_threats.kml

Now a brief description of how the data itself is stored. The directory structure containing the data that supports TNC_threats.kml is fairly straightforward, and could be easily re-organized as long as the .kml file itself is altered to reflect the new data and folder locations. See Figure 5 for a screen dump of the directory structure as it appears in the root website directory of the Uso de Tierra http server.

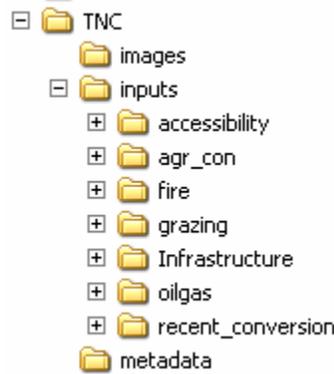


Figure 5 Directory structure behind TNC_threats.kml

All of the image data and supporting KML files for the seven threat models (as well as the aggregate threat layer) are located within the root folder called TNC. This consists of thousands of tiled images and their supporting .kml files. The directory TNC/images contains the logo images used in the sight, as well as other miscellaneous image files such as icons and markers. The TNC/inputs directory contains seven folders, each of which contain images and supporting .kml files which provide access to the data layers used as inputs to the seven threat models. Finally, the TNC/metadata folder contains HTML metadata files for each of the seven threat models as well as the aggregate threat layer. These are the metadata files that are accessed when the client clicks on the threat headings in the Places panel in GE.

Google Earth On Line Documentation

KML tag reference: http://earth.google.com/kml/kml_tags_21.html

KML tutorial: http://earth.google.com/kml/kml_tut.html

Getting started with GE: <http://earth.google.com/userguide/v4/>

GE on line help: http://www.keyhole.com/GoogleEarthHelp/wf_startfs.htm

GE Community (user blog): <http://bbs.keyhole.com/ubb/ubbthreads.php/Cat/0>

SuperOverlay tool: <http://gis.mi-perm.ru/programs/superoverlay/>

Arc2Earth download & documentation: <http://www.arc2earth.com>

IrfanView image software: <http://www.irfanview.com>