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## LUA - IAM AXISL DATA SET

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## **Land Use in the Amazon – Institutional Analysis and Modeling (LUA-IAM), Axis 1 Data Set on the Co-Evolution of Territorial Units, Land-Cover and Roads in the Lower Tapajós of the Amazon: 1975 to 2010**

Link to Data Set:

<http://urlib.net/8JMKD3MGP5W/3HAR4S5>

### **Introduction:**

This database created by Nathan Vogt during a post-doctoral position within Axis 1 of the Land Use in the Amazon – Institutional Analysis and Modeling (LUA-IAM) project at the National Institute of Space Studies (INPE) of Brazil. The goal of this database is to allow the reconstruction of landscape changes in the Lower Tapajós from 1975 to 2010. It is also intended to be used with a the time-series of the territorial units and roads/trails for the Lower Tapajós between 1975 and 2010 included in this data set for analysis of how creation of different types of territorial units and expansion of the road network affect the landscape trajectories.

This polygon shapefiles of territorial units contained in the data set are those created in this time period in the municipalities of Aveiro, Belterra, Juriti, Medicilândia, Placas, Prainha, Ruropolis, Santarem and Uruara. Using census data collected on the dates in the time-series collected by the Instituto Brasileiro de Geografia e Estatística (IBGE) it is possible to analyze the role of socio-economic and land-use changes in the landscape trajectories. It was intended to be used in intensive field studies coupled with ethnographies with key elder informants to reconstruct landscape histories. However, it may also be used for modeling purposes. The extent can be used to link to regional-level climate models of relation of hydrological and energy fluxes that are typically coarse scale to link to studies in individual territorial units, communities or landscapes.

It contains polygon shapefiles of all territorial units created in the Lower Tapajós between 1975 and 2010, it contains Landsat satellite images for 1975, 1985, 1990, 1995, 2000, 2005 and 2010, and it contains line shapefiles of the roads and trails that existed during these same dates.

### **Data Set Overview:**

The database contains three folders. Folder Territorial\_Units\_1975\_2010 contains the polygon shapfiles of territorial units, folder Land\_Cover\_1975\_2010 contains the time-series of landsat images both pre-processed and classified, and folder Road\_Network\_1975\_2010 contains the line shapefiles for the roads/trails of the study area. The meta-data for data in each folder is below.

## **Folder Metadata**

### **1) Folder Territorial\_Units\_1975\_2010**

This folder contains a time-series of polygon shapefiles of territorial units contained in the municipalities of Aveiro, Belterra, Juriti, Medicilândia, Placas, Prainha, Ruropolis, Santarem and Uruara created between 1975 and 2010. It includes Indigenous territories, Glebas, Settlements of all categories, conservation units and timber concessions.

## **Folder Hierarchy**

### **Territorial\_Units\_1975\_2010**

- 1978: Territorial Unit shapfiles for use with the 1975 image mosaic and later
- 1985: Territorial Unit shapfiles for use with the 1985 image mosaic and later
- 1990: Territorial Unit shapfiles for use with the 1990 image mosaic and later
- 1995: Territorial Unit shapfiles for use with the 1995 image mosaic and later
- 2000: Territorial Unit shapfiles for use with the 2000 image mosaic and later
- 2005: Territorial Unit shapfiles for use with the 2005 image mosaic and later
- 2010: Territorial Unit shapfiles for use with the 2010

## **Data Set Background Information**

Shapefiles of territorial units are available to the public through solicitation from the Instituto Nacional de Colonização e Reforma Agrária (INCRA), Instituto de Terras do Pará (ITERPA) and Instituto de Desenvolvimento Florestal do Estado do Pará (IDEFLOR). Where possible the legislation and date the unit was created is included in the attribute tables.

The shapefiles are organized by the date that territorial units were created. This will allow a comparison of landscape patterns and limits of territorial units for each date in the satellite image time-series, and analysis of the impact of the creation of territorial units on land-cover trajectories.

### **2) Folder Land\_Cover\_1975\_2010**

This folder contains a time-series of pre-processed landsat images (raster files) for 1975, 1985, 1990, 1995, 2000, 2005 and 2010 and a time-series of classified images for 1985, 2000, 2005 and 2010 for the study area.

Note: 1975 MS image for path/row 245/062 is corrupted, preventing pre-processing. Only the raw image is included.

## File Hierarchy

### Land\_Cover\_1975\_2010

#### Classified Images

1985: Classified images for 1985 mosaic

2000: Classified images for 2000 mosaic

2005: Classified images for 2005 mosaic

2010: Classified images for 2010 mosaic

#### PreProcessed Images

1975: Pre-processed images for 1975 mosaic

1985: Pre-processed images for 1985 mosaic

1990: Pre-processed images for 1990 mosaic

1995: Pre-processed images for 1995 mosaic

2000: Pre-processed images for 2000 mosaic

2005: Pre-processed images for 2005 mosaic

2010: Pre-processed images for 2010 mosaic

## Data Set Background Information

A time-series of landsat satellite images was created for four path/rows in the Landsat WRS that cover the study area. The Landsat image path/rows for the WRS1 system that cover our study are 244/62, 244/63, 245/62, and 245/63. The Landsat image path/rows for the WRS2 system of the study area are 227/62, 227/63, 228/62, and 228/63. The time-series includes images from 1975, 1985, 1990, 1995, 2000, 2005 and 2010. Landsat Multispectral Scanner (MSS) and Thematic Mapper (TM) images were downloaded from either the INPE website (<http://www.dgi.inpe.br/CDSR/>) or the EarthExplorer web page (<http://earthexplorer.usgs.gov/>) of the United States Geological Survey website. If a cloud free image did not exist for the above dates, images from 2 years prior to 2 years after the date could be selected and used. The dates each image were collected are in the name of the image.

This temporal depth of the time-series was chosen to capture co-evolution of institutional and landscape change from the implementation of military government development-oriented settlements to the nature conservation-oriented SNUC creation of the 1990s, to the sustainable development-oriented collective settlement creation of the mid 2000s. The temporal interval was also chosen to both coincide with the dates of the agricultural and demographic census collection dates to correlate socio-economics and land-use with the land-cover patterns observed in the images.

The goal was to create a time-series with a 30 meter resolution and a high co-registration accuracy to allow “from-to” analysis of land-cover at the pixel level. It would also contain five land-cover classes including Water, Bare Soil/Impervious Surface, Agro-Pasture, Secondary Vegetation, and Forest (see Table 1 below) to allow studies of not only deforestation but also reforestation trajectories within and around territorial units and roads/trails after their creation.

## Methods for Processing Satellite Images

### *Image Pre-Processing:*

Images were co-registered to the GeoCover images created by the Global Land Cover Facility ([http://glcfapp.glcf.umd.edu/library/guide/techguide\\_geocover.pdf](http://glcfapp.glcf.umd.edu/library/guide/techguide_geocover.pdf)) at the University of Maryland Department of Geography with a Root Mean Squared Error (RMSE) of less than 0.5. A basic atmospheric and radiometric calibration of each co-registered image was performed. This method was created at the Center for the Study of Institutions, Population and Environmental Change (CIPEC).

### *Image Classification:*

The first phase of running the ISODATA classification algorithm, producing 100 spectrally unique land-cover classes for each image in the time series, was recently completed. Now, the following steps will be followed to complete the classification and quantification of land-cover change in the study area:

- 1) Use unsupervised classification algorithm ISODATA to produce 100 classes, using Maximum Iterations set to 100 and the Convergence Threshold set to 0.99
- 2) Collapse the 100 classes created in ISODATA method into those 5 classes identified in Table 1 using visual assessment of the pre-processed images to determine the land-cover class to assign each ISODATA class.
- 3) Run 3x3 smoothing filter to remove spurious and lone pixels
- 4) When a cloud free image does not exist, but two images for the same date in the time series that together are cloud free, subset and mosaic images
- 5) Mosaic all 5-class and filtered images of each date to create a mosaic with least amount of cloud cover.

Table 1. Land-Cover Classes

<b>Land-Cover Class</b>	<b>Description</b>	<b>Land-Uses Included in Land-Cover Class</b>
Water	All water bodies	
Bare Soil/Impervious Surface	Bare soil and urban cover as cement, asphalt, buildings, short grass pastur	Urban, industrial agriculture field as soybean, clean pasture with sparse grass cover, new and clean <i>roça</i>
Agro-Pasture	Mix of vegetation cover and bare soil	Industrial agriculture field with extensive crop cover, dirty pasture, tall-grass pasture, old <i>roça</i>

Secondary Forest Succession	Complete vegetation cover, with younger species and more even canopy	Managed fallow, old abandoned pasture, selectively harvested forest, old abandoned field
Forest	Mature forest or advanced secondary succession with closed and varied canopy cover	Mature forest unutilized, forest managed for NTFPs

### 3) Folder Road\_Network\_1975\_2010

This folder contains a time-series of line shapefiles of the roads/ trails observable in the time-series of landsat images above for 1975, 1985, 1990, 1995, 2000, 2005 and 2010.

#### Folder Hierarchy

##### Road\_Network\_1975\_2010

- 1975: Road Network for use with image mosaic of 1975 and later
- 1985: Road Network for use with image mosaic of 1985 and later
- 1990: Road Network for use with image mosaic of 1990 and later
- 1995: Road Network for use with image mosaic of 1995 and later
- 2000: Road Network for use with image mosaic of 2000 and later
- 2005: Road Network for use with image mosaic of 2005 and later
- 2010: Road Network for use with image mosaic of 2010

#### Data Set Background Information

Timber trails are notoriously difficult to be captured and mapped using remotely sensed products. This is because they are often more narrow than the resolution of most instruments, and don't open the canopy enough to expose the bare soil below, so moderate resolution images as the Landsat (30meter) images in our time-series are difficult, and even more so in the PRODES (90 meter) products. Yet, to conduct an analysis of the evolution of roads we created maps of roads and trails in each date in our time-series of Landsat images from 1975 to 2010.

To create a map of roads in each date of our time-series based on visual interpretation of the time-series of pre-processed. To begin, we overlaid a shapefile of the roads/trails in the study area in 2010 created by researchers at Imazon (<http://www.imazon.org.br/>) in 2010, the last date in our time-series. This product was created with SPOT images that have a resolution (20 meter). This shapefile was overlaid on each date of images in our time-series, and digitized over when the criteria created below were met.

To begin, landsat images that were pre-processed were utilized as visual interpretation is often easier. It also sharpens the image making detection of roads or evidence of them easier. We also displayed the image in different band combination as RGB:453 and

RGB:666 to assist visualization of forest/bare soil edges. In some cases image enhancement methodologies were attempted such as Tassled Cap transformation and edge enhancement filters.

The criteria for choosing to digitize a road, or remove a digitized road, in a given date of the time-series of images were as follows:

- 1) Digitize a road whenever a road is visible in both the image and in the overlaid Amazon road shapefile.
- 2) Digitize a road if a road was obviously visible in an image, even if doesn't exist in the Amazon road shapefile. Assume the canopy grew over the trail between the time the image was collected and 2010 when the Amazon product was created.
- 3) Digitize a road when a road exists in the Amazon road shapefile between a river or road and a disturbed area requiring access of a trail, even though none is visible. Particurlry digitize where geometric patterns exist along the road in the Amazon road shapefile, giving further evidence a trail exists but the canopy is covering the bare soil below making unobservable.
- 4) Do not digitize a road that exists in the Amazon road shapefile if a) not observable in any image in the time-series or no geometric patterns giving evidence of a road.
- 5) Do not digitize a road to connect the end of a visible road and a geometric pattern (small field or pasture) beyond it. There could be a trail, or there could be only a foot path of a small colonist opening new land.