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Monitoring deforestation to evaluate Mexico's payments for ecosystem services and assess land use change effects on jaguar habitat

Introduction

Mexico has experienced high deforestation rates since 1990, when it was estimated a loss of 600 ha of forest per year.

Forest loss is detrimental to both its diverse ecosystems and human well being.

In 2003, the Mexican National Forest Commission (CONAFOR) established a Payment for Ecosystem Services (PES) program to diminish forest loss and fragmentation, improve water catchment and promote sustainable forest management.

However, assessing the effectiveness of the PES program is difficult because of its large extent, Mexico's diverse vegetation types and complex terrain conditions.

Research goals

1. **Map deforestation in enrolled and unenrolled properties before and after the payment for ecosystems services program was instituted.**
2. **Detect degradation processes in different forest ecosystems in Mexico.**
3. **Integrate forest change patterns with jaguars habitat in central Mexico.**

Approach:

1. Produce annual Support Vector Machines classifications for 13 Landsat footprints across Mexico from 1990 to 2010. Make post-classification comparisons to map deforestation and summarize it by region, forest types and cut sizes.
2. Create fraction maps using Spectral Mixture Analysis in 5 years intervals between 1990 and 2010 for 3 footprints containing different forest types. Map forest degradation for several forest ecosystems in Mexico.
3. Model potential habitat for jaguars using MAXENT in Sierra Gorda biosphere reserve in central Mexico and relate it to the deforestation and degradation patterns.

Study area

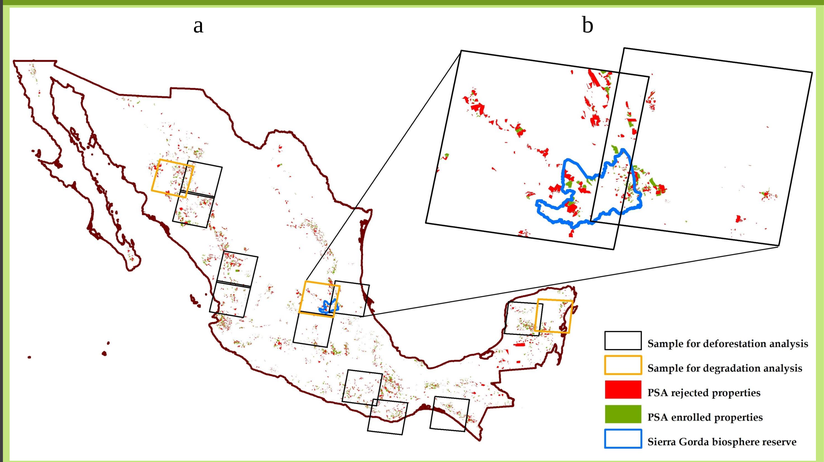

Figure 1: a) Location of the 13 sample Landsat footprints in Mexico used for detecting deforestation and the 3 footprints used to evaluate degradation; b) Detail of Sierra Gorda biosphere reserve which is reported to provide jaguars habitat. Applicant properties for the PES program between 2004 and 2010 are also shown in detail.

Preliminary results for goal 1

A total of 1,373 Landsat TM and ETM+ scenes have been downloaded and processed through LEDAPS.

Because of persistent clouds, Fmask has been applied to all images to mask clouds out.

All the images from the same year on each footprint were used to produce yearly image composites (Figure 2).

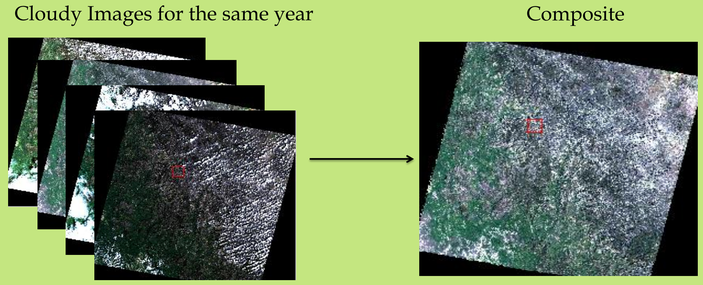

Figure 2: Image composites using multiple partially cloud covered images.

A total of 9980 training points have been collected in the 13 footprints to train classifiers and for accuracy assessment.

All footprints have been examined for deforestation patches in a stratified sampling grid using historic high resolution imagery in Google Earth (Figure 3).

Preliminary results for goal 1

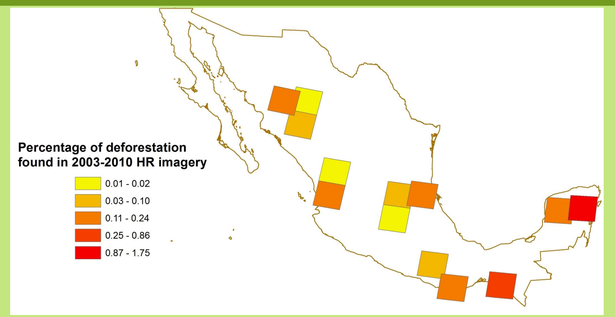

Figure 3: Estimates of deforestation rates according to high resolution imagery in Google Earth from 2003 to 2010.

Table 1: Cross validation accuracies of our training data in a northern footprint.

Training Data	Accuracy	SR + Single variables	Accuracy
2500 Points/Class	92.2%	SRTM Elevation	93.6%
562 forest /381 nonforest Points/Class	92.8%	Slope	93.6%
350 Points/Class	90.7%	Aspect	93.7%
300 Points/Class	90.0%	Hillshade	93.6%
200 Points/Class	88.0%	Dry Season Image	95.0%
100 Points/Class	89.5%		
Terrain corrected image	**Accuracy**	**Multiple Variables**	**Accuracy**
TIC Image	85.8%	DEM + Slope + Aspect + Hillshade	96.25%
		Dry Season + DEM + Slope + Aspect + Hillshade	97.91%

Classification errors are caused by terrain illumination, clouds not detected in Fmask, sparse forest types, and missing data in Landsat ETM+ SLC-off imagery.

Preliminary Conclusions

Mexico shows different deforestation rates depending on geographic location and forest type. Deforestation occurs in smaller patches and less intensity in northern Mexico where forests are sparse, and in larger patches and more frequent in southern tropical forest types. Classification accuracies are improved with the use of ancillary data.

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