Evaluation of an extraordinary fire event in wetland area during 2008: Littoral Complex of the Paraná River

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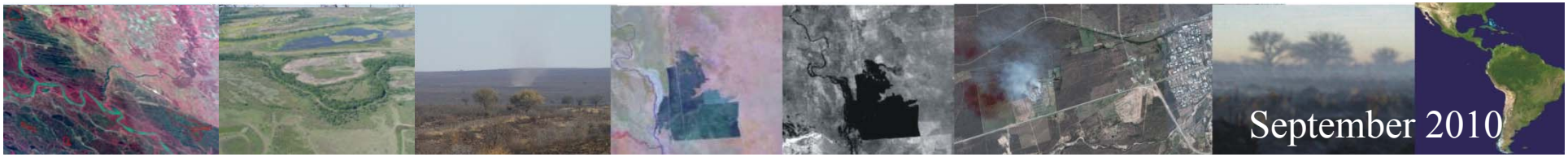

September 2010

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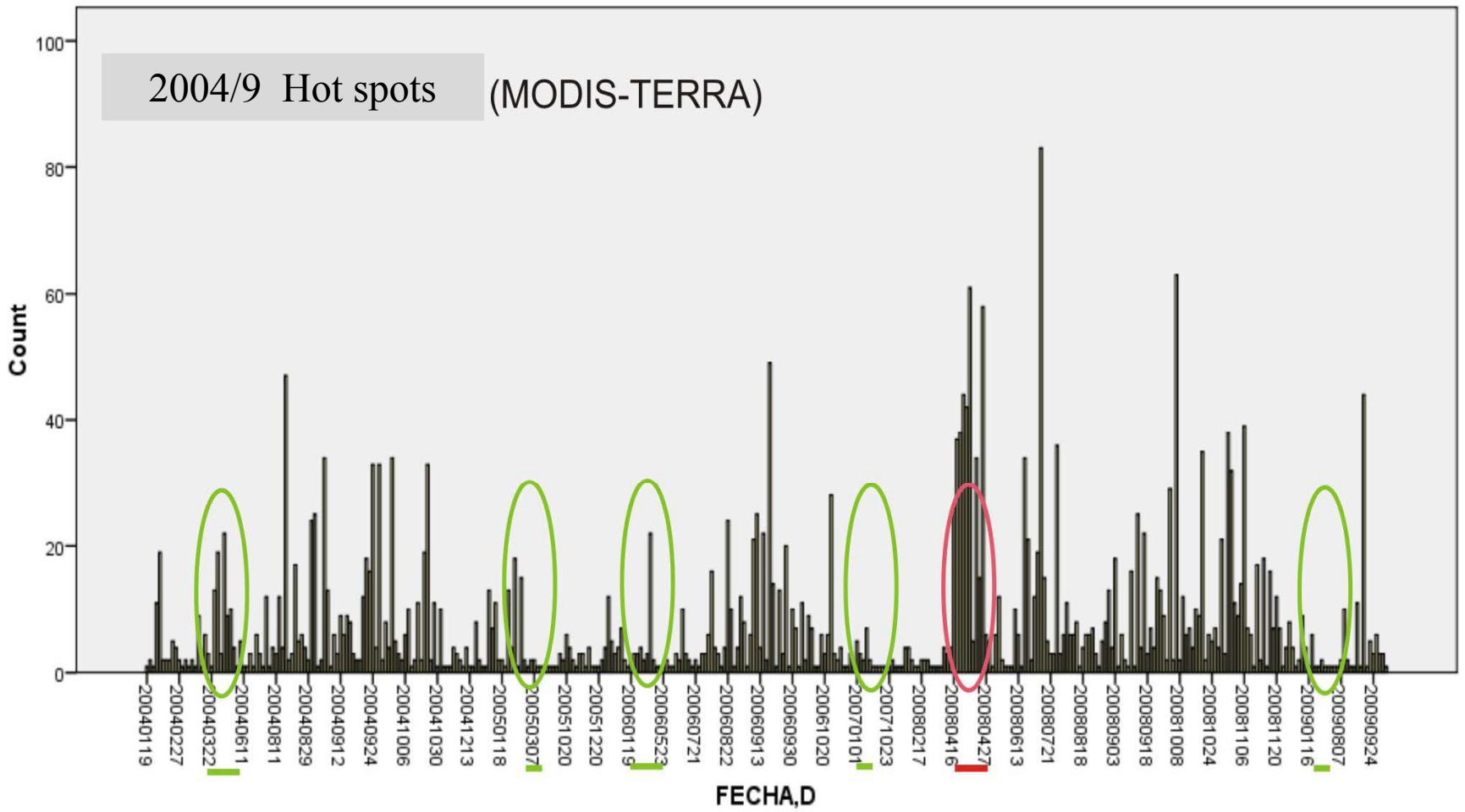
Introduction

- Fires in the island of the Paraná River Littoral Complex environments (R. Argentina) present recurrence controlled by anthropogenic, climatic and topographic factors.

- They generate local consequences (vegetation degradation, nutrient lost, soil erosion, change in biogeochemical cycles, impacts on human health, change in species composition) or global consequences (air pollution, climate). This last point could be presented as changes in emissions of greenhouse gases.



In red, studied period, and in green previous and posterior fire events

- At the regional level, particularly in these islands environment is still poor the knowledge that we have about the fire regime and its historical occurrence. Also how it has changed in the present due to the increased usage for livestock grassing and for better accessibility reasons.
- The determination of land coverage classes, burned areas, fire timing and frequently land coverage affected by fires, were almost not studied in the lower portion of the Paraná River. Understanding this will help us to recognize implication that it may have at a regional level, and make a proper assessment of regional and global environmental impact of this phenomenon.

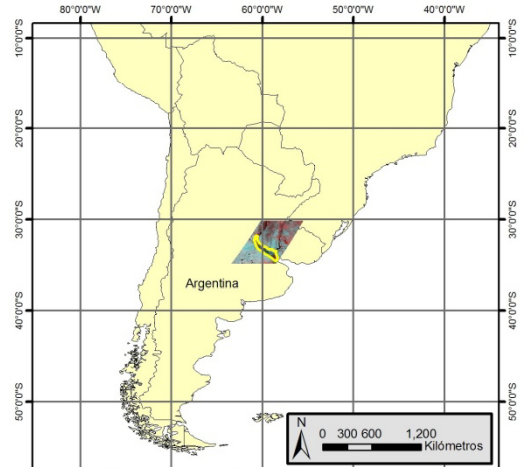
Objetives

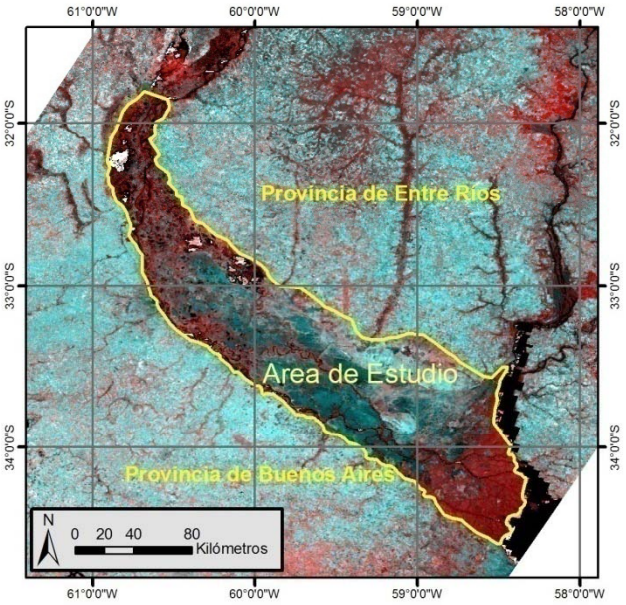
- Generate a land cover map for the region.

- Generate burned area map based on the application of composites images of MODIS MOD13Q1.

- Estimate the emissions of CO2 that occurred during the period February/ June 2008 due to the fire in the area.

Study area



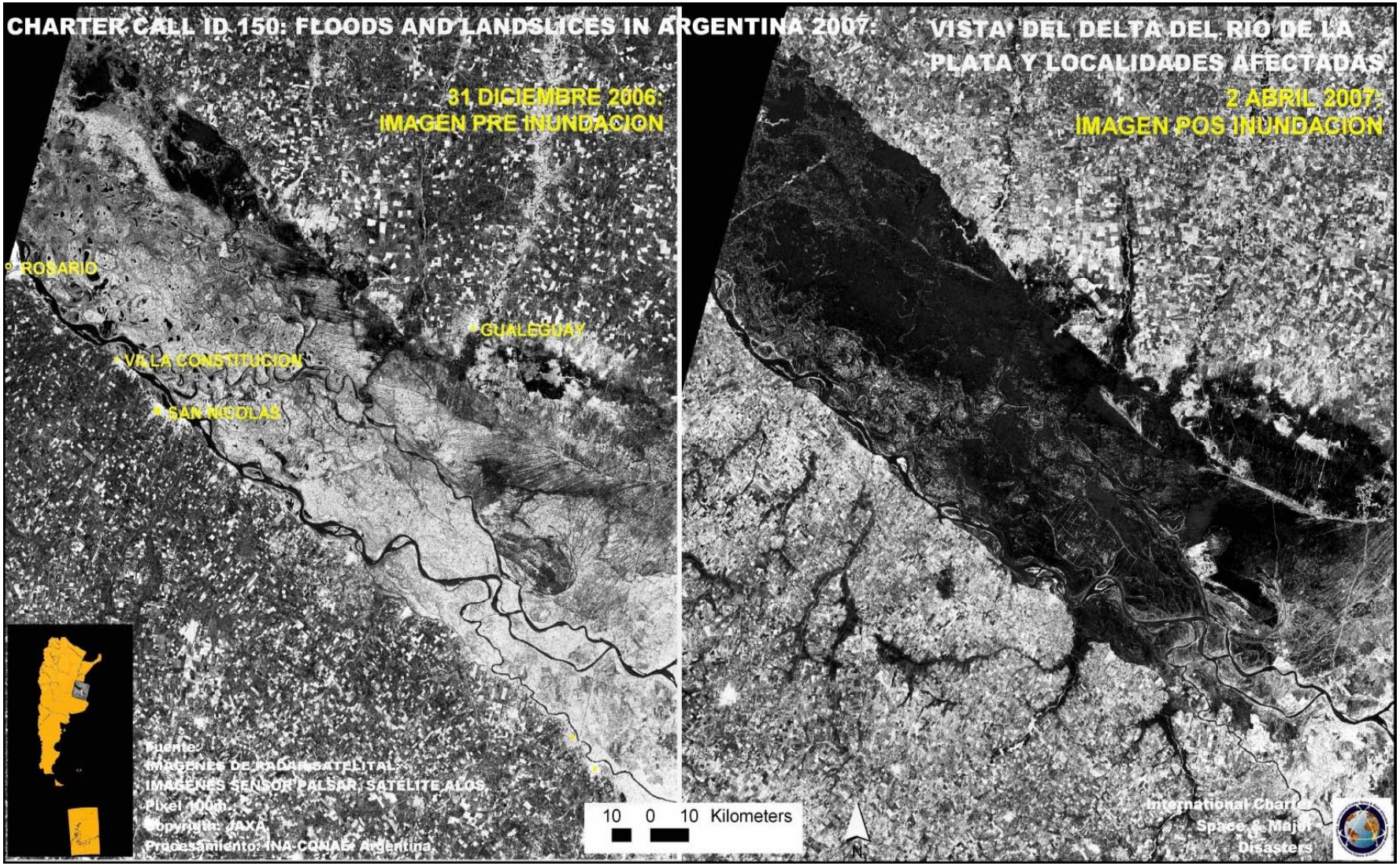


Paraná River: 3900 km (2400 mi), basin 1.414.132 km² (546.000 mi²), medium caudal 15/20.000 m³/s (peak 60.000). Autumn.

Littoral Complex

The area covered by this study has close to 17.500 km2 (6.800 mi²). 900 mm year and 20°C (68°F) annual medium temperature.

Floodplain has annual and multiannual flood events. Those events can present different intensities, duration and recurrence.


CHARTER CALL ID 150: FLOODS AND LANDSLICES IN ARGENTINA 2007:
31 DICIEMBRE 2006:
IMAGEN PRE INUNDACION
ROSARIO
GUALEGUAY
VILLA CONSTITUCION
SAN NICOLAS
Fuente:
IMAGENES DE RADAR SATELITAL
IMAGENES SENSOR PALSAR, SATELITE ALOS,
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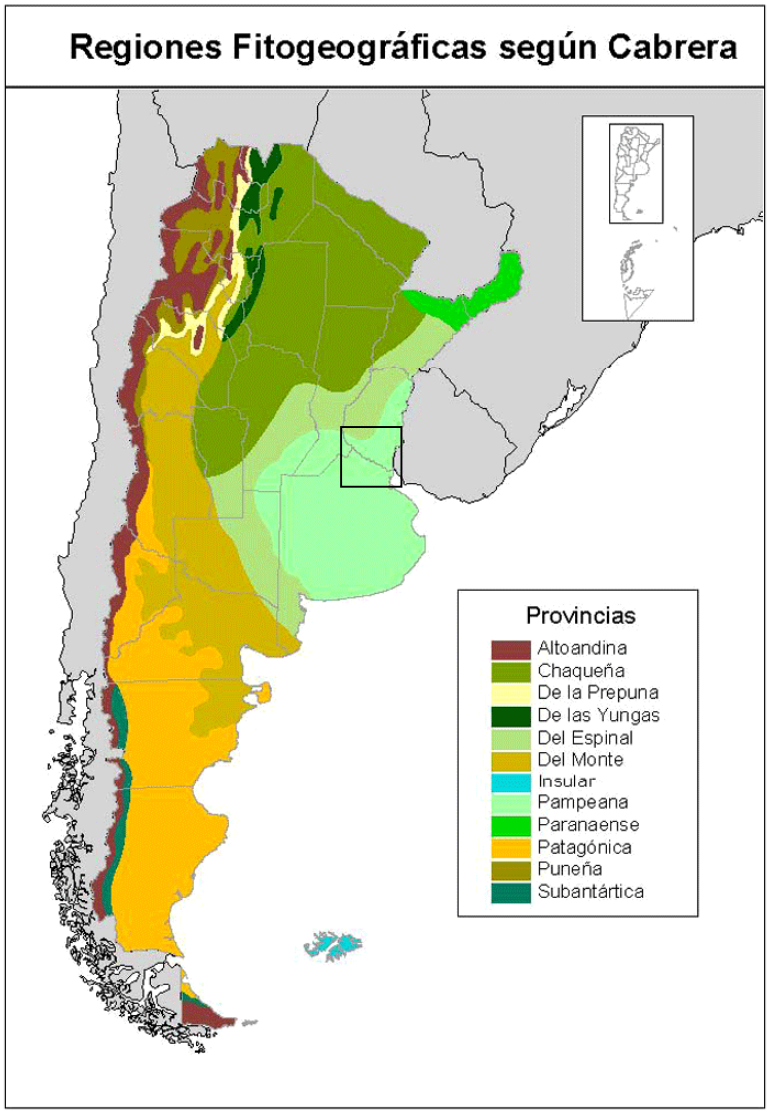
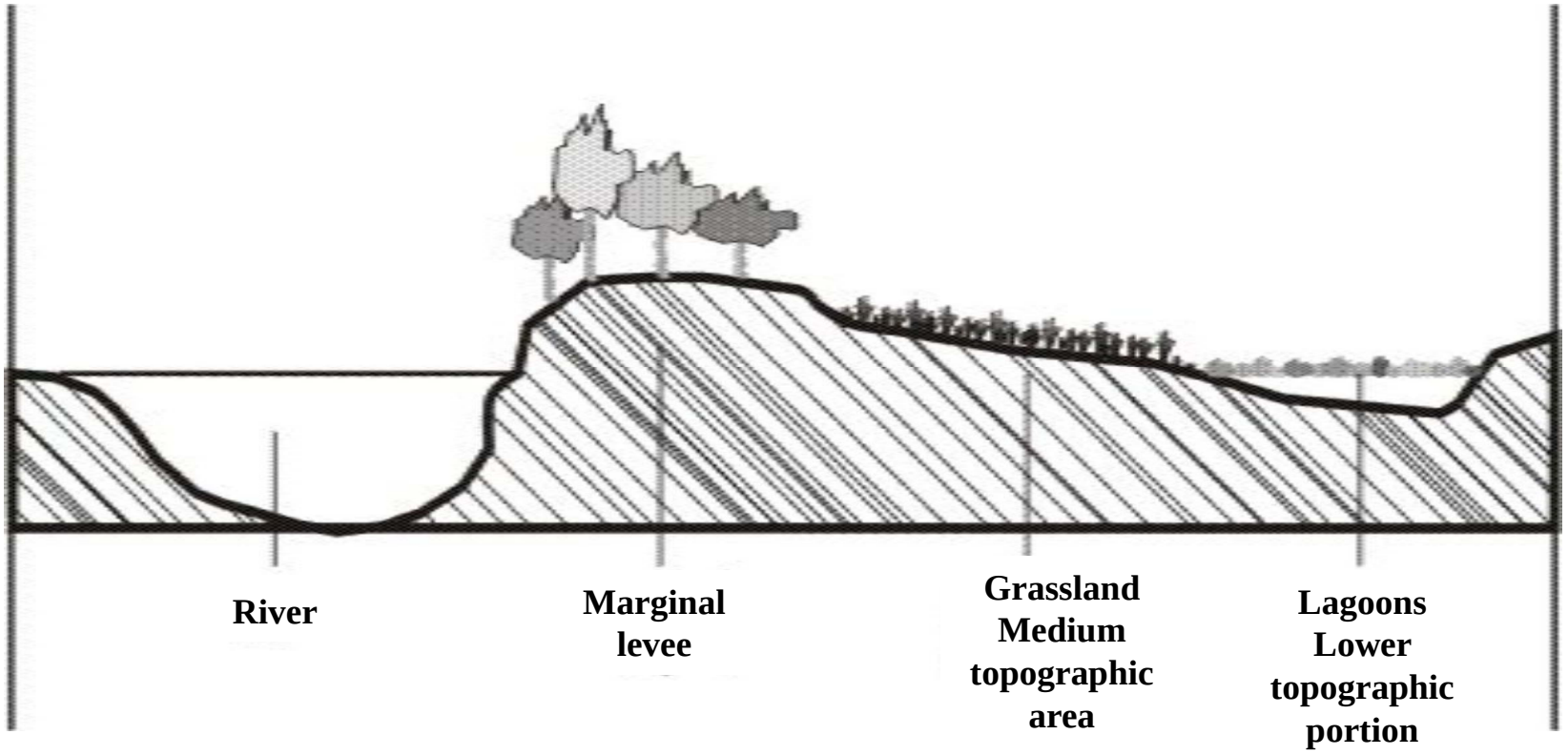
VISTA DEL DELTA DEL RIO DE LA PLATA Y LOCALIDADES AFECTADAS
2 ABRIL 2007:
IMAGEN POS INUNDACION
International Charter
Space & Major
Disasters

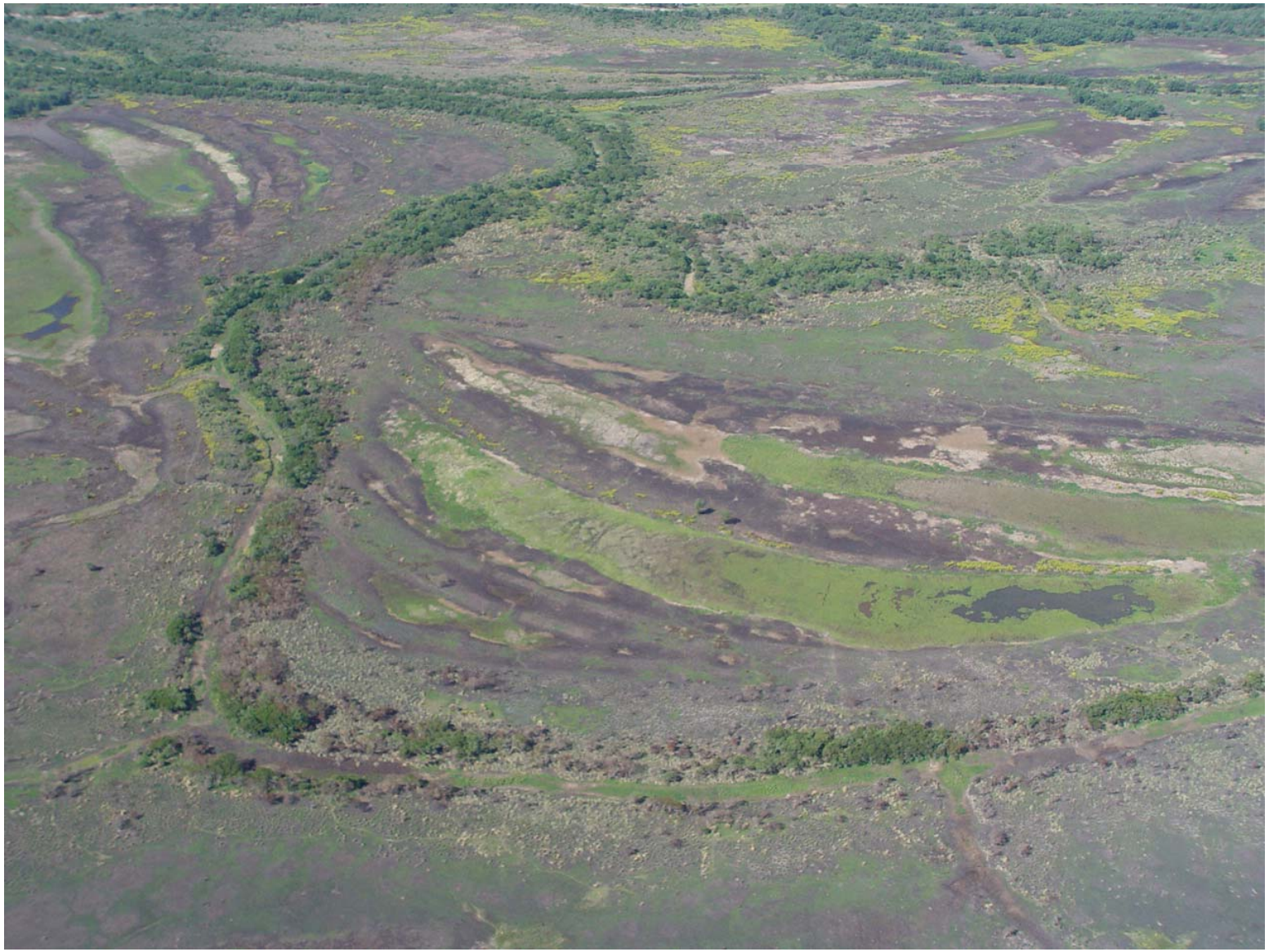


Vegetation: the area correspond to a wide river corridor that came from 15° to 34° S. This is an important biological corridor for plants and animals.

At this area is sorrounded by grassland and secondary by forest.

Schematic profile of an island





Materials and methods

The stages of this study were:

- Imagen acquisition
- Land cover processing,
- Determination of burnt area using index (BAI)
- Emission estimation

A. Imagen acquisition

- We use data from MODIS (Moderate-Resolution Imaging Spectroradiometer) instrument aboard the Terra and Aqua satellites. It has the possibility to acquire data every 1-2 days in 36 spectral bands located between 0.4 μm and 4.14 μm, and with different spatial resolutions: 250m, 500m and 1000m.

For land cover classification and estimation of burned area, we used 16 days (MOD13Q1) and 250 m resolution products. These are generated from standard composite reflectivity (MOD09Q1) (MODIS-TERRA), which were provided by EOS Data Gateway (EOS, 2004). These compounds include those pixels with the best observing conditions, considering the absence of clouds and shadows, aerosol, low angle and have wide coverage.

Banda	Resolución (mts)	SET DE DATOS (HDF Layers) (12)	UNIDADES
1	250	16 días NDVI	NDVI
2	250	16 días EVI	EVI
3	250	16 días VI Quality detailed QA	Bits
4	250	16 días	Reflectancia (Banda del Rojo (Banda 1 de MODIS - 620-670 nm))
5	250	16 días	Reflectancia (Banda del Infrarrojo Cercano (Banda 2 de MODIS – 841-876 nm))
6	250	16 días	Reflectancia (Banda del Azul (Banda 3 de MODIS - 459-479 nm))
7	250	16 días	Reflectancia (Banda del Infrarrojo medio (Banda 7 de MODIS - 2105-2155 nm))
8	250	16 días	Grados (ángulo de visión zenital)
9	250	16 días	Grados (ángulo solar zenital)
10	250	16 días	Grados (ángulo azimutal relativo)
11	250	16 días	Dias Julianos del año
12	250	16 días	Ranking de calidad

A. Image acquisition and pre-treatment **…..**

B- Soil Coverage study

For island land cover classification, we used a multitemporal composition of EVI bands for the year 2007

$$EVI = G \frac{\rho_{NIR} - \rho_{red}}{\rho_{NIR} + C_1 \rho_{red} - C_2 \rho_{blue} + L}$$

The EVI takes into consideration the near infrared band (MODIS 841-876 nm) the red band (620-670 nm MODIS), the blue band (459-479 nm MODIS), the adjustment factors of soil L = 1 and for the correction of atmospheric scattering effects C1 and C2 = 6 = 7.5 and a gain factor G = 2.5

From the 16-day MODIS products we generated an image composition of EVI for the period January 1 to December 31, 2007. In this composition 23 EVI indices were included, corresponding, each band, to a period of 16 days.

The enhanced vegetation index (EVI) is an 'optimized' index designed to enhance the vegetation signal with improved sensitivity in high biomass regions and improved vegetation monitoring through a de-coupling of the canopy background signal and a reduction in atmosphere influences. EVI is computed following this equation:

:

where NIR/red/blue are atmospherically-corrected or partially atmosphere corrected (Rayleigh and ozone absorption) surface reflectances, L is the canopy background adjustment that addresses non-linear, differential NIR and red radiant transfer through a canopy, and C1, C2 are the coefficients of the aerosol resistance term, which uses the blue band to correct for aerosol influences in the red band. The coefficients adopted in the MODIS-EVI algorithm are; L=1, C1 = 6, C2 = 7.5, and G (gain factor) = 2.5.

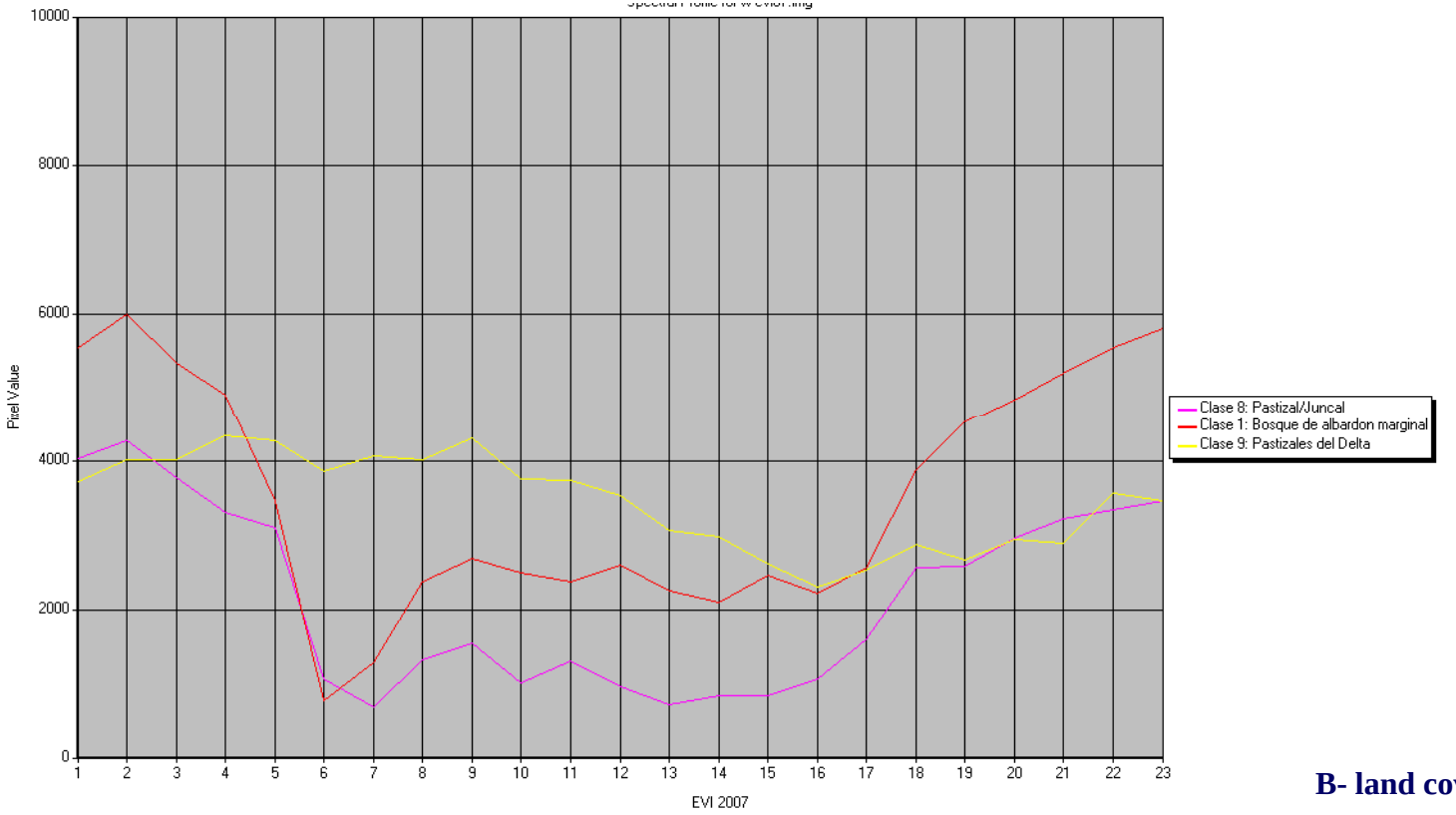
Whereas the Normalized Difference Vegetation Index (NDVI) is chlorophyll sensitive, the EVI is more responsive to canopy structural variations, including leaf area index (LAI), canopy type, plant physiognomy, and canopy architecture. The two VIs complement each other in global vegetation studies and improve upon the detection of vegetation changes and extraction of canopy biophysical parameters. [1]

EVI was adopted as a standard product

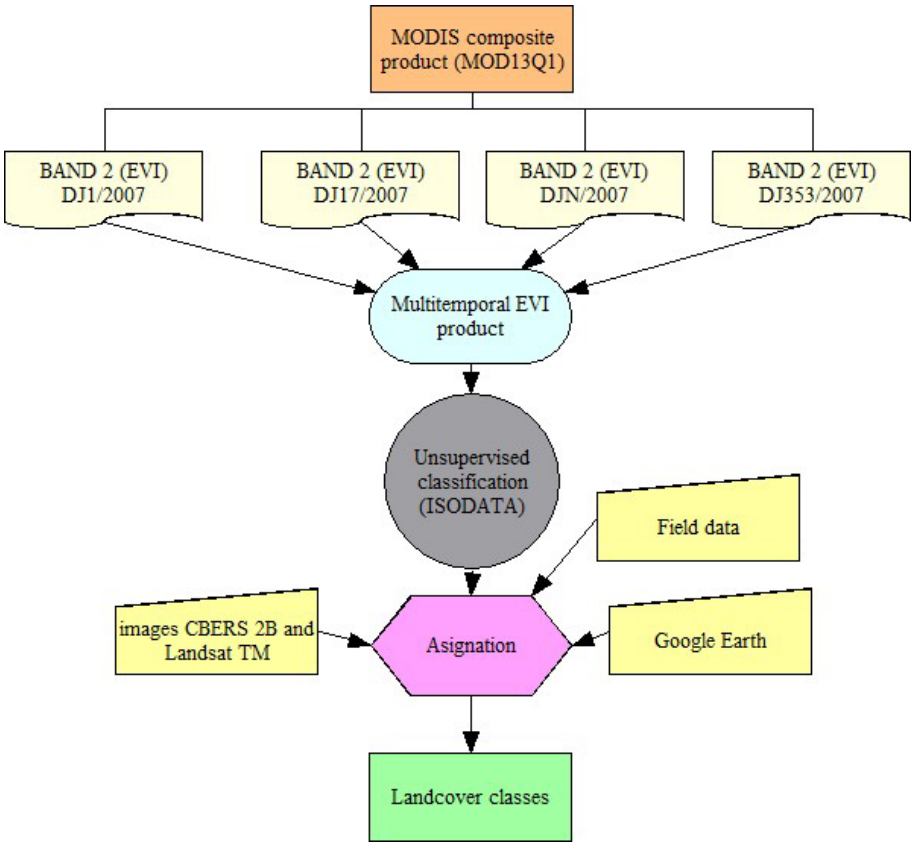
by NASA and became extremely popular with users due to its ability to eliminate background and atmosphere noises, as well as its non saturation, a typical NDVI problem

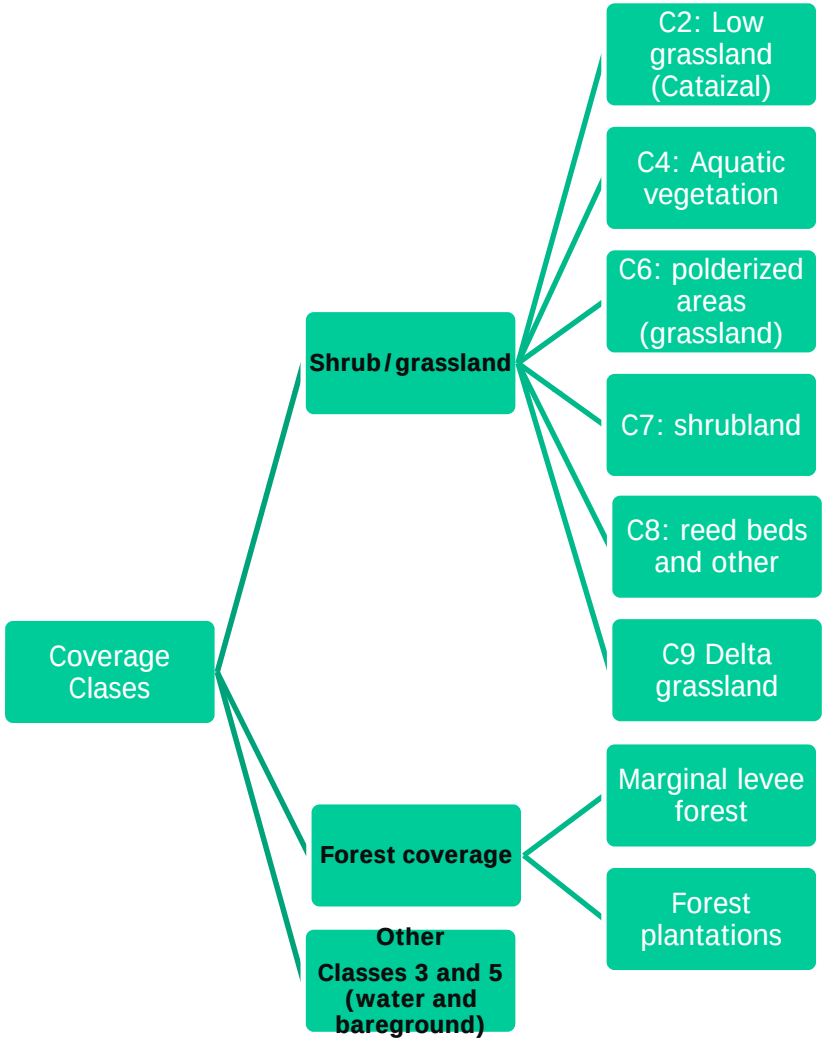
•From this multitemporal composition, the seasonal variation in EVI was assessed for different coverages.

•We performed an unsupervised classification (ISODATA (Iterative Self-Organizing Data Analysis Technique) of the compound of 23 bands in the EVI. 60 classes were defined. After the classification we proceed to reallocation these classes to 10 types of soil cover; this was based on available field data, data from Google Earth, CBERS and Landsat TM images.



B- land cover study . . .





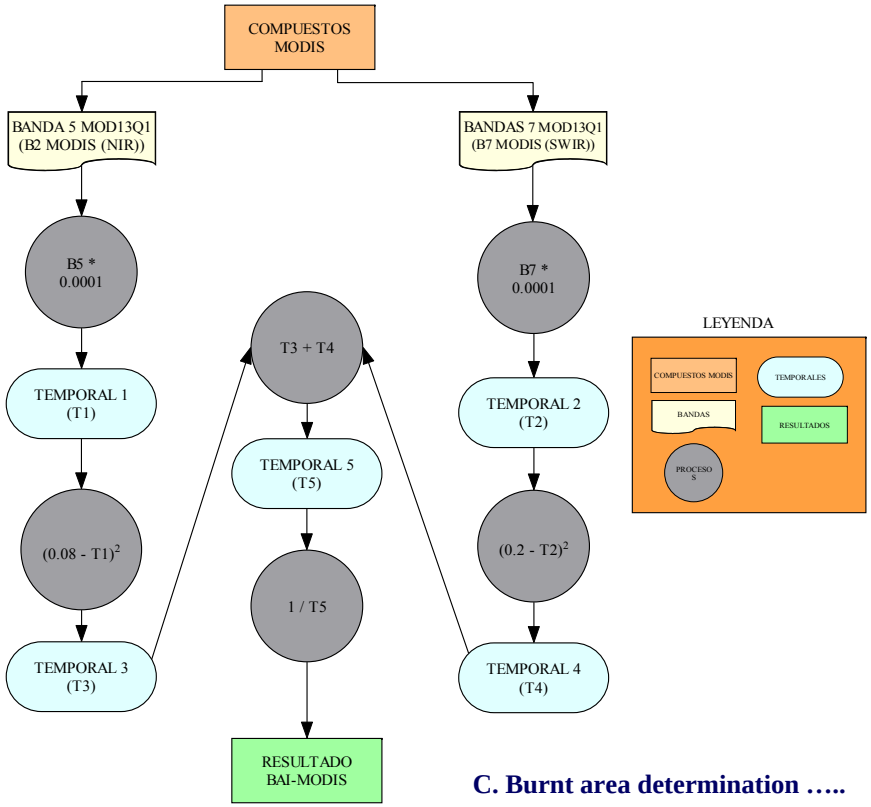
B- land cover study . . .

C. Burn Area Index (BAI)

For the determination of burned area, the BAI (Burnt area index) was used. This index is for AVHRR images (Martin et al., 1998, 2005) using the red and near infrared bands. For MODIS Image, a proposed a variant of the BAI was used, taking in account the NIR bands and SWIR. The index is based on maximizing the spectral distance between coal/charcoal and other land covers, specially those potentially confused with burned areas

$$BAI = \frac{1}{(Pc_{SWIR} - \rho_{SWIR})^2 + (Pc_{NIR} - \rho_{NIR})^2}$$

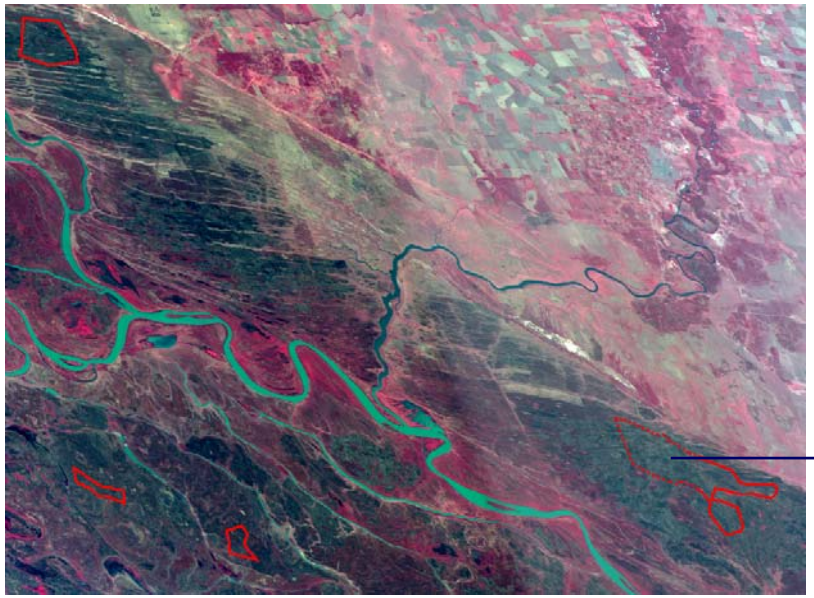
Where:
nir = Band 2, MODIS composite
swir = Band 7, MODIS composite
pcnir = Convergency limit for Carbon signal in nearIR band. (0,08) .
pcswir = = Convergency limit for Carbon signal in medium IR band. (0,2)

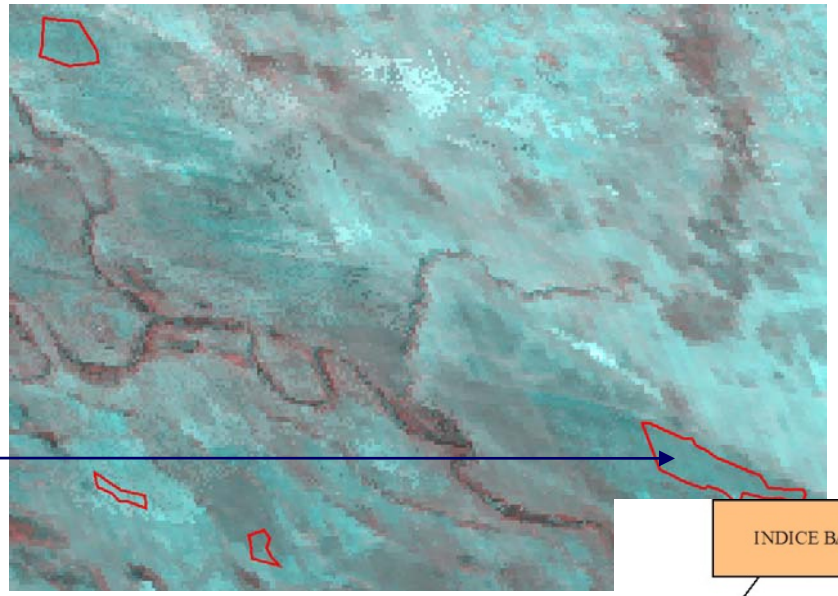


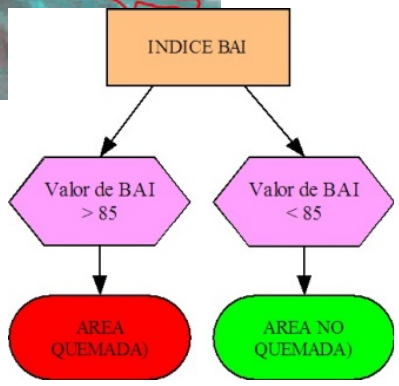
C. Burnt area determination …..

On a sample of 981 pixels with BAI values for burned areas, we proceeded to calculate the percentile of 5% which was used as a cutoff threshold for determining the burned area. The condition was:

BAI MODIS > 85







C. Burnt area determination …..

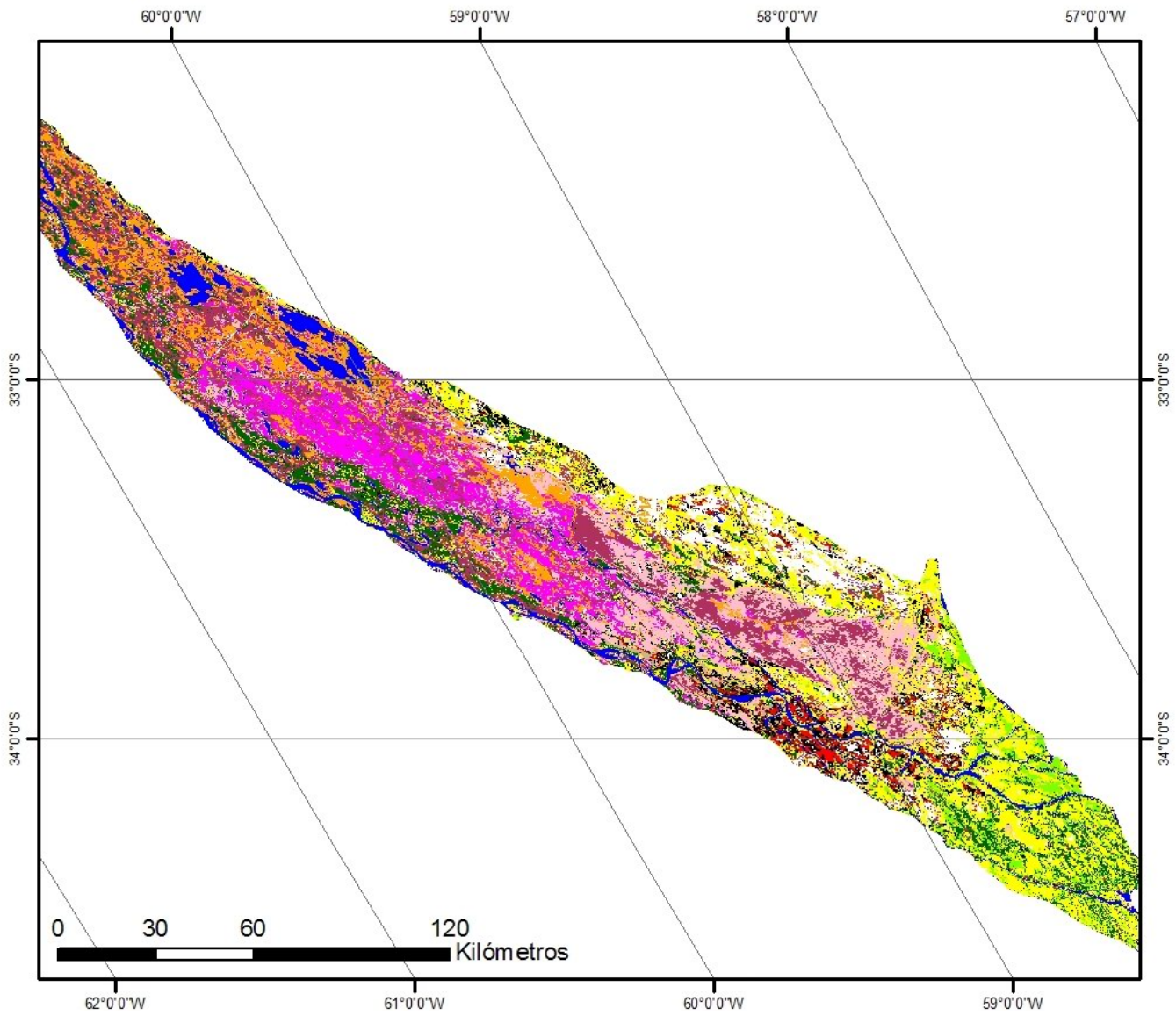
D. Estimated emissions

The methodology used to obtain values of C (Mg C ha-1) was from previous DM field data and bibliography data. To this information we apply a conversion factor equal to 1.84 (the values of DM) under the assumption that the content of C is approximately 46% of the DM . One we have the C values (Mg C ha-1), CO2 values was estimated by multiplying the value of C by 44/12 (3.67) (Bravo et al., 2007).

Due to other data that we obtained before this event, we assume that the proportion of biomass burned during the fire was assumed as 60% of the total biomass in each vegetation unit. Other authors indicate that about 20% of the carbon is part of the biomass is released during the fire (immediate release) essentially as CO2 (Seiler and Crutzen, 1980); while for necromass (litter) the estimated percentage of this emission is close to 60 percent (CORINAIR, 2000).

Some results

Land cover study:



The compound of EVI images allow us to discriminate 10 land cover classes in this island environment.

Color	Clase	Referencia
	Clase 1	Bosque Albardon Marginal
	Clase 2	Pastizal cataizal
	Clase 3	Agua
	Clase 4	Vegetación acuática
	Clase 5	Suelo descubierto
	Clase 6	Area polderizada con vegetación herbacea
	Clase 7	herbaceo/arbustal
	Clase 8	Herbáceo Pastizal/Juncal
	Clase 9	Pastizales del delta
	Clase 10	Bosque de salicáceas

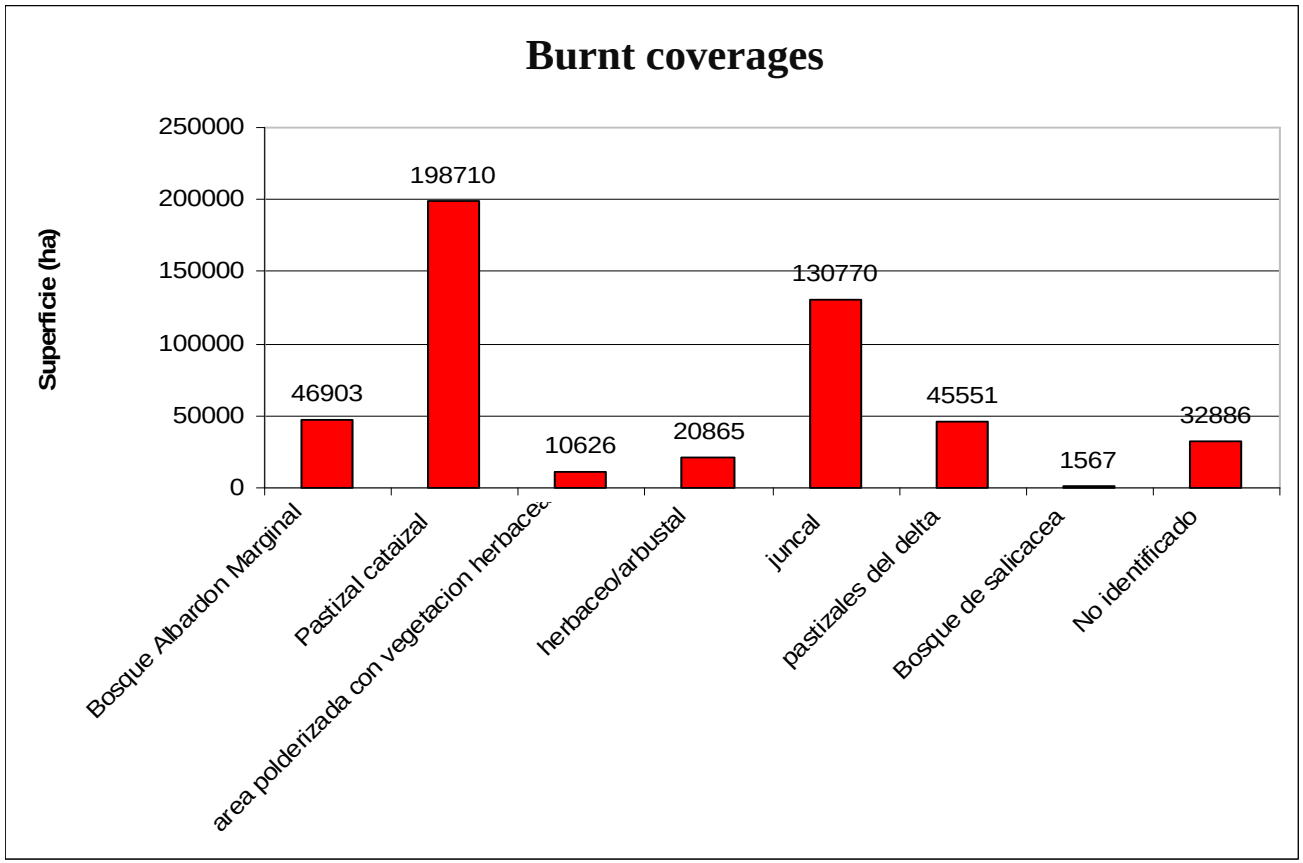
B. Soil cover…..

From the total area under analysis, we determined that 13 % correspond to forest; 2.1% to different shrub-like vegetation and 69 % to herbaceous/grassland types.

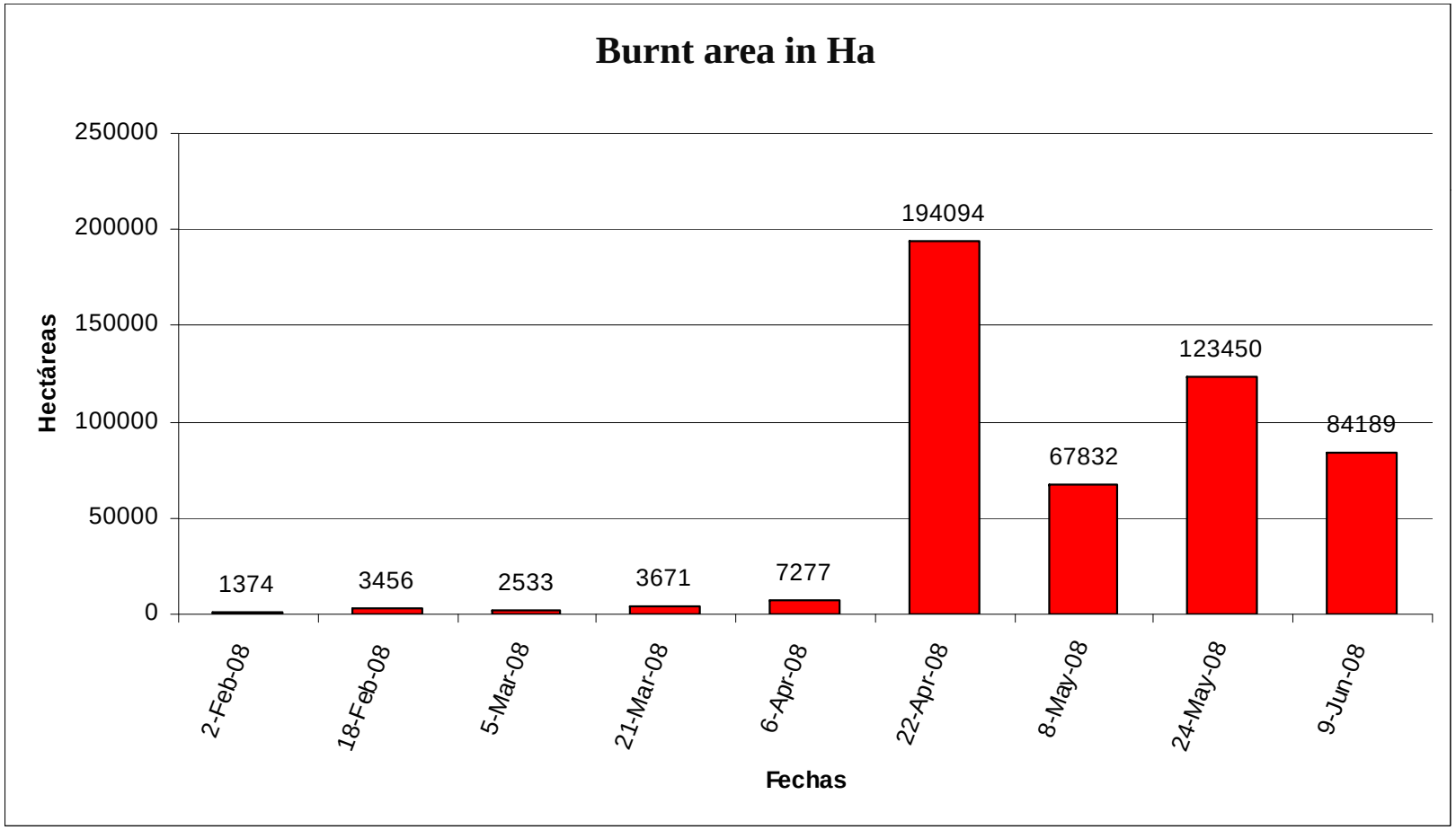
Referencia	%
Marginal levee forest	10,3
Grassland/ cataizal	25,9
Water	7,6
Aquatic vegetation	11,6
Bareground	8,0
Herbaceous vegetation in poder area	0,6
Shrubland/grassland	2,1
Aquatic grassland/ reed beds	13,3
Delta grassland	18,0
Forest plantations	2,6

Determination of burnt area:

It was determined that the area affected by fires since the beginning of January to June 9, 2008 was 4550 km2 (1124329 acre or 1757 mi^2).

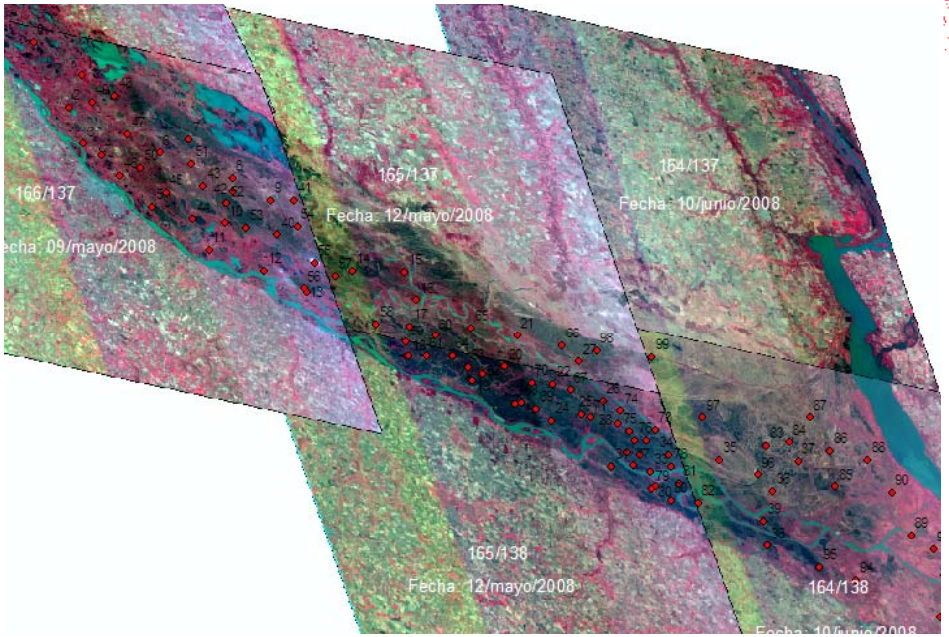


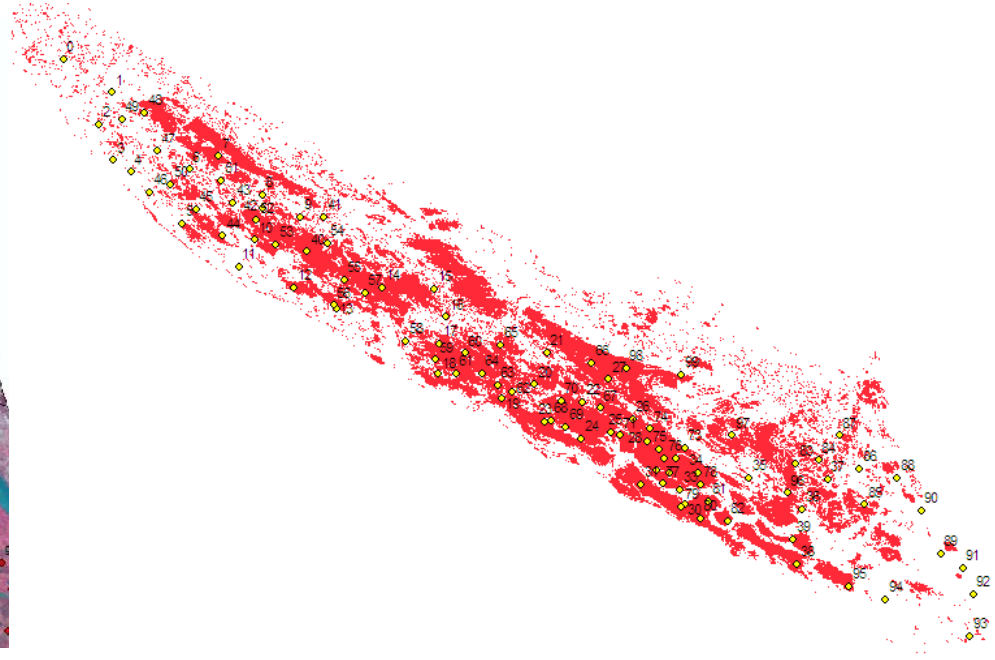
Chronological evolution of burnt areas



Validation

We conducted a random selection of 100 points of verification which were assessed for the presence / absence of area burned. For this we compare CBERS 2B images and burned area product obtained from MODIS.





From the analysis of burned areas for MODIS composite and CBERS 2B (INPE - Brazil) were calculated omission and commission errors, obtaining an accuracy of 82%.

Estimated emissions

Referencia	Area representada por la unidad (%)	Has quemadas por unidad	% Has Quemadas por unidad	unidades muestreadas	Biomasa Mg Ms Ha^{-1}	Biomasa quemada Mg Ms Ha^{-1}	C Mg C/Ha^{-1}	CO_2 Mg CO_2/Ha^{-1}	Emisiones Totales CO2 g CO2/Ha-1	Fuentes
Bosque Albardón Marginal	10.3	46903	10.3	Bosque Albardón Marginal Salix humboldtiana	225	135	67.5	248	11619046	datos propios
Pastizal cataizal	25.9	198710	43.7	canutillar	12	9.6	4.8	18	3500475	
Área polderizada con vegetación herbácea	0.6	10626	2.3	sd	sd	sd	sd	sd	sd	
herbácea/arbustal	2.1	20865	4.6		sd	sd	sd	sd	sd	
Juncal	13.3	130770	28.7	SG Scirpus giganteus	18	10.8	5.4	20	2680785	(Vicari *et al.*, 2006)
			0.0	SC Solenoplectus californicus	19	11.4	5.7	21		
Bosque de salicáceas	2.6	1567	0.3	Plantación de sauce	115	69	34.5	127	198406	
pastizales del delta	18	45551	10.0	Pajonal	23	18.4	9.2	34	1537984	datos propios
agua	7.6	0	0.0	nc	nc	nc	nc	nc		
vegetación acuática	11.6	0	0.0	nc	nc	nc	nc	nc		
suelo decubierto	8	0	0.0	nc	nc	nc	nc	nc		
total	**100**	454992	91.5							

sd sin datos
nc no corresponde

Emis. Totales	19536696 Mg CO2/l
Emis. c/herbacea	7719244 Mg CO2/Ha-1
Emis. c/arborea	11817451 Mg CO2/Ha-1

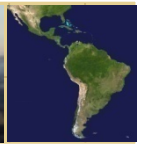
Some conclusions

•Fires at Paraná River Littoral Complex produced CO2 emissions calculated in 20 and 34 Mg C ha-1 depending on the sites and vegetation cover types. Estimated emissions for the period, and considering the extent of burned vegetation units, are superior to 7.6 Tg C-CO2, for herbaceous vegetation. If the calculations also include emissions of tree cover, we have more than 19.5 Tg C-CO2 emitted.

•According to data published by the United Nations 2007, in the Millennium Development Goals Indicators website, CO2 emissions for Argentina until 2004 were approximately 3.7 metric tons per capita and per year.

•Only the emission produced during the burning of the herbaceous cover during the study period is comparable to annually produced by an Argentina city of about 2 million inhabitants. If we also include in this calculation the total emissions (with burnt tree coverage), we estimated emissions higher than those of a city of 5 million inhabitants.

- La utilización de compuestos generados a partir del índice EVI para la clasificación de cobertura de suelo a escala regional, permite generar una **cartografía fiable** para este tipo de ambientes y para esta escala.
  - Para el área de estudio, es de especial interés continuar con evaluaciones para períodos mas extensos a los efectos de lograr **caracterizar de manera precisa los ciclos** a los que está sujeto este ambiente y en base a ello plantear estrategias de aprovechamiento sostenible de los mismos que permitan conservar el recurso.
- El producto **MOD13Q1 resultó apropiado** para la determinación de área quemada a escala regional. El umbral sobre el BAI, estimado para este ambiente, permitió discriminar de manera confiable el área quemada y su evolución para cada período.
  - Resulta de interés **explorar nuevos umbrales de corte sobre el índice BAI**, para diferentes ambientes.
- Las técnicas de teledetección y el trabajo de campo permitieron estimar el CO2 emitido por cada una de las unidades de vegetación identificadas en la región



Gracias por su atención….