APLICATION OF LOW RESOLUTION SATELLITE DATA FOR THE DETECTION AND MONITORING OF FIRE IN NICARAGUA

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ABSTRACT:

A PC – based –NOAA satellite receiver, installed at the Ministerio del Ambiente y los Recursos Naturales (MARENA) headquarter in Managua, enable daily observations to be made on vegetation fires in Nicaragua and Central America. These observations are used particularly to assist and support operational forest management activities in Nicaragua. The technical approach and findings are presented with reference to forest fire in Nicaragua during the last five dry season (January-May 1999 to 2003). A Geographic Information System (GIS) is used in order to attempt to identify fire activity patterns. Spatial and time distributions of hot spot are assessed with regard to forest/land use type, coverage, population density, and rural poverty levels. Some features of fire activity in Nicaragua are highlighted by considering some local cases in particular.

INTRODUCTION

Fire is a very well utilized and efficient tool for agricultural purposes. But, the inadequate use of fire have had an adverse effect on the environment, such as destruction of commercial loggings, loss of biodiversity and threats to the security of communities among others. On the other hand most of the developing countries have strong limitations for large area monitoring. Improvement in the collection and analysis of data through the introduction of remote sensing technology allow obtaining regular and timely information for most of the land areas of the world.

In MARENA headquarter, since 1995 and under the technical and financial cooperation from the National Resource Institute of England a PC-based NOAA satellite receiving ground station was established of the series NOAA/AVHR (National Oceanographic Atmospheric Administration/Advanced Very High Radiometer Resolution). This allows MARENA to produce information on a regular basis about the natural resources over the whole of Nicaragua.

Why using NOAA/AVHRR images in Nicaragua

Although NOAA satellites are widely used for weather forecasting purposes, the AVHRR sensor has proved their great potential for monitoring purposes. It has the following advantages:

1. Allows the global picture observation for the region of Central America, at an altitude of 850 km. Fig.2.
2. Provide a high temporal resolution, capturing 4 images per day.
3. Spectral resolution allows to derive a great variety of environmental information (five channels, from the visible to the infrared)
4. Sensor radiometric resolution is high; 10 bits. This means that within each spectral band it can be distinguished 2^{10} = 1024 levels of radiance.
5. Provide their data without charge and is available on a daily basis.

RESULTS FROM 1996 TO 2003

Fire Activity in Nicaragua

In Nicaragua, the majority of fires occur during the dry season, from December until the end of May. Five successive seasons had been monitored since the installation of the system and its products had been widely distributed under different forms: lists with coordinates, tables and regional maps. These activities have improved the awareness among the different stakeholders related with the management of natural resources and the early detection of the fire forest at national and local level as well.

Description of the data

The AVHRR (Advanced Very High Resolution Radiometer) of the NOAA satellites permit the monitoring of actives fires on large area coverage. The quantitative values given through thermal infrared channels of the AVHRR sensor are used to detect vegetation fire through the ignition effect above the irradiative temperature (Malingreau 1990). Proper detection of fire is made by using contextual algorithms that automatically extract and select hot pixels with the highest probability of being active fires (Flase et al 1996). All the results are expressed in terms of hot spot (Pixels) selected by the contextual algorithm.

The analysis of the data are made by using Geographic Information System and taken into consideration some contextual aspects (land cover, Type of forest, rate of poverty).

The table 1, shows the number of hot points detected during five monitored seasons (January-May 1999-2003). Fire activities differ from year to year and from region to region. This table present the early fire activities starting in 2003 (January) with a total of 5914 events for the whole season, meanwhile the activity for 1999 appear by February, this sensible drop in 1999 (2609 hot spot) probably was caused by the Niña event, which for the month of march caused unusual rainfall in the Atlantic Coast of Nicaragua. These analysis can be realized for the whole Meso America, since there is information available to this region. The figure 1 show the driest month (April) presenting the incidence of fire for the record of 1999 –2003), this month present an annual average of temperature of 38.5.

Although the NOAA satellite have demonstrated the possibility to delivering-up-to date information derived from the AHVRR, specially with regard to fire activity, underestimation still remain in regard to the real numbers of fires for several reasons:

Only the active fires at the moment of the image capture are really detected.

Cloudy conditions are a negative factor for fire detection.

The context algorithm always acts as a conservative system.

The limited spatial resolution permits detection of fires with a minimum size of 50 x 100 meters (Belward et al 1993).

Mes/año	1999	2000	2001	2002	2003
Enero	-----	202	170	209	544
Febrero	94	402	523	364	545
Marzo	222	627	1022	488	1715
Abril	1,328	3909	2498	2821	2659
May	965	-	-	1391	451
Total	2,609	4213	4213	5273	5914

Table 1 Number of hot spot detected in Nicaragua during five monitored seasons.

CONTEXTUAL ANALYSIS OF THE FIRE ACTIVITY

With the purpose to know and understand the fire dynamic related to other aspects, were selected five municipalities of each region presenting the highest density of hot spot (table 3) . Aspects such as Number of hot spot, percentage of forest coverage, population density, percentage of rural poor population and Municipality Human Development Index (MDHI) were analyzed.

The table 3 show the an relations between the municipalities with highest forest coverage and the incidence of hot spot, being the municipalities of the Atlantic coast presenting this characteristic despite of the high rate of humidity and the low density population (10 inh/km²). However, the Atlantic Region owns the largest forest coverage of the country, and since 1989, have experiencing an illegal timber harvesting and the clearing of large forest area for cropland and pasture. One of the municipality seriously affected each year for the fire activity is Prinzapolka, which have occupied during the years of 2001 and 2003 the first place in numbers of events, in comparison with the others municipalities (table 3).

Worldwide is recognized the strong relationship between the threaten of the fire resources and poverty in the developing countries. Nicaragua is no the exception above all, 45.6 % of its population is below of the limit of the poverty (EMNV 2001). In the table 3 is perceived the strong link between fire incidence and the phenomena of poverty and low Human development, Most of the municipalities showed in the table, present a rate of poverty over the 50 % and low MHDI as well (0.376-4.86).

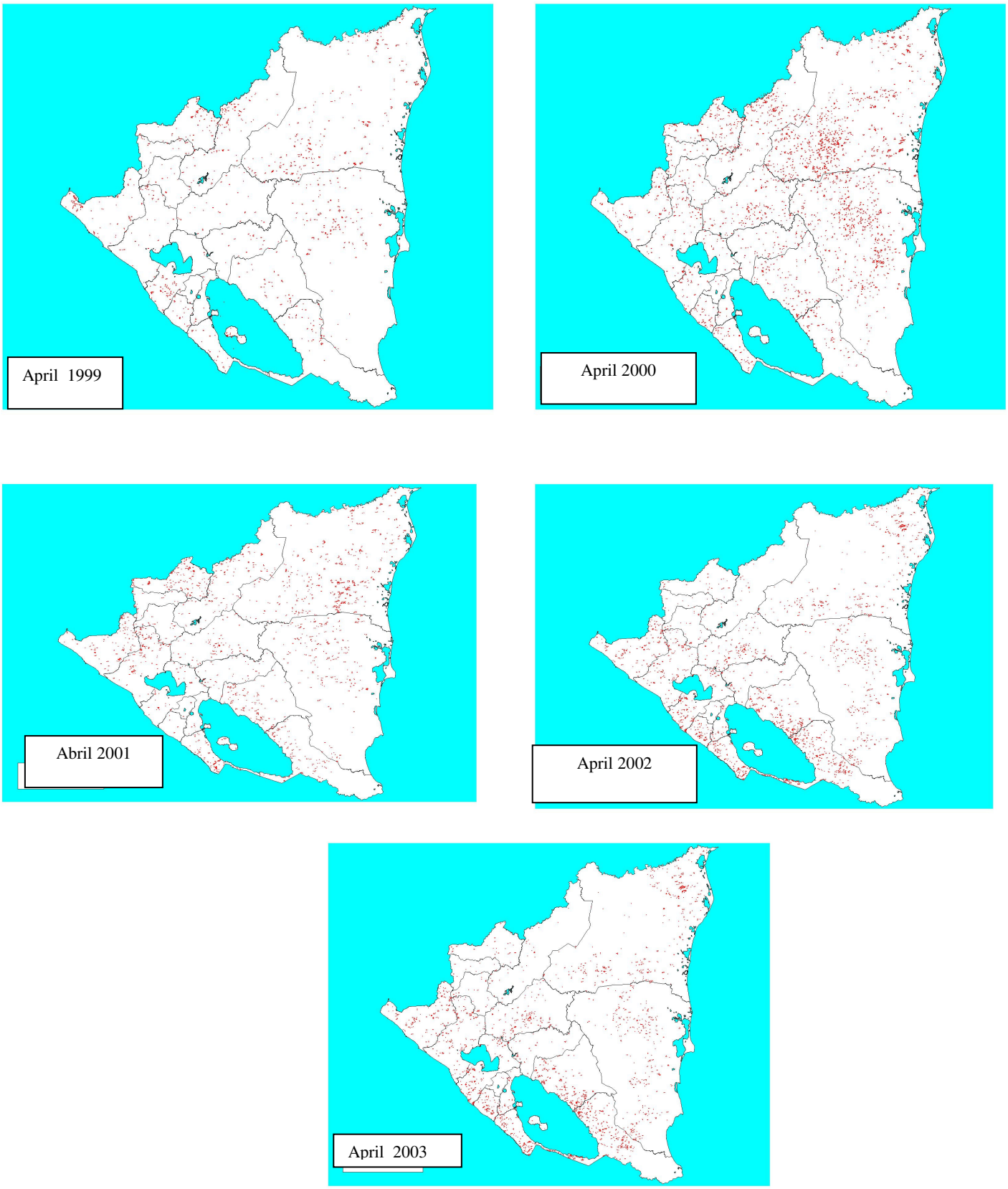

Figure 1. Incidence of fire spot during the month of April for the year of 1999 - 2003

Year	Municipality	Region	Number of hot spot	% forest	Population density km^2	% Rural poverty population	MHDI
1999	Cruz de Rio Grande	Atlántica	262	75.21	2	93.4	0.410
	Siuna	Atlántica		80.15	12	90.2	0.417
	Prinzapolka	Atlántica	235	92.55	1	94.0	0.376
	El Rama	Atlántica	220	45.36	13	78.2	0.482
	Waspan	Atlántica	233	83.62	5	88.3	0.466
			197				
2000	Siuna	Atlántica	563	81.15	12	90.2	0.417
	Prinzapolka	Atlántica	383	92.55	1	94.0	0.376
	El Tortuguero	Atlántica	270	67.23	43	88.9	0.415
	Puerto Cabezas	Atlántica	238	72.89	92	53.1	0.608
	La Cruz de Río Grande	Atlántica	211	75.21	2	93.4	0.410
2001	Prinzapolka	Atlántica	385	92.55	1	94.0	0.376
	Puerto Cabezas	Atlántica	213	72.89	92	53.1	0.608
	Waspan	Pacifico	198	83.62	5	88.3	0.466
	El Viejo	Pacifico	142	31.86	541	62.7	0.583
	Villa Nueva		135	15.88	286	91.0	0.537
2002	Puerto Cabezas Siuna	Atlántica	279	72.89	92	53.00	0.608
	El Viejo	Atlántica	231	81.15	12	90.2	0.417
	Prinzapolka	Pacifico	230	31.86	541	62.7	0.583
	Acoyapa	Atlántica	225	92.55	1	94.0	0.376
		Central	202	11.56	122	68.1	0.599
2003	Prinzapolka	Atlántica	352	92.55	1	68.1	0.376
	Puerto Cabezas	Atlántica	247	72.89	92	53.00	0.608
	Waspan	Atlántica	210	83.62	6	88.3	0.466
	El Castillo	Central	131	96.85	6	98.1	0.486
	La Paz Centro	Pacifico	120	17.63	397	47.6	0.664

Table 2 Shows the five Municipalities per region with the highest occurrence of fire spot during five seasons.

MHDI: alto (0.800-1)medio alto(0.651-0.799)medio bajo(0.501-0.650)bajo (0-0.500)

CONCLUSIONS

The results obtained in the five seasons observed, clearly shows the incidence of the fires severity and their variation on time and regions.

The availability of historic series (annual/monthly), permits the analysis of trends and comparisons of fires activity, as well as to know theirs spatial distribution through the territory.

The satellite information offers considerable potential for providing timely information to planners, decision-makers and environmental and natural resource managers.

The low resolution of NOAA image need to be supplemented by high resolution image (Landsat, Spot) and ancillary data as well, in order to achieve the maximum benefit of its temporal frequency and applicability.

Exist a strong association between the fire incidence and the high rate of poverty and low Municipality Human Development Index as well.

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