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Space-Time Analysis of Environmental Changes and your Reflection on the Development of Phenological of Vegetation of Mangrove

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Abstract

Mangrove forests represent important landscape and ecological aspects of coastal tropical and subtropical regions of the Americas, covering the extensive area of the Brazilian territory.The state of Pernambuco has a concentration of mangroves quite significant, but several authors emphasize the processes of constant human disturbance suffered by this ecosystem surrounding the Port of Suape. This study aimed to evaluate the relationship between changes in the environment and its effects on the phenological development of mangrove vegetation along of two decades (1989, 1998, 2007 and 2011) in the area near the Port Complex Suape. Was used in evaluating a variable biophysics (LAI-Land Area Index) revealed the decrease in biomass over the years, addition of net radiation and soil heat flux present significant changes during this period. The modification of mangroves in degraded area is reflected in the modification of the various processes at the interface atmosphere-vegetation, and consequently, the microclimate of the mangrove forest, affecting ecological processes such as regeneration and plant growth. It is necessary to limit the forms of exploitation of this ecosystem, because the conversion of mangrove forests in degraded areas exposes the surface to direct sunlight altering the radiative balance.

Keywords: Net radiation, soil heat flux, leaf area index, degraded areas

Introduction

Mangrove forests represent important landscape and ecological aspects of coastal tropical and subtropical regions of the Americas, Africa and Oceania, with ranges restricted to intertidal shore recesses and contours of bays and estuaries, because it works as an interface between the environments marine and terrestrial (Braga et al. 1989). Mangroves are generally systems young that follow the tidal dynamics in areas where they are located, producing a change in topography of this land, resulting in a series of advances and retreats of vegetation (Moura and Querino 2010). The world lost about half of its wetlands since 1900 and approximately 20 % of mangrove forests between 1980 and 2005 (FAO 2007). In Brazil, mangroves occur from Cabo Orange, Amapá - 02 ° latitude north to the coast of Santa Catarina, in the river Ararangá - about 29 ° south latitude (Lamberti, 1969 andLacerda, 1984), covering an area about 25,000 km2.

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As mangrove areas are characterized ecologically by presenting high biological productivity, being found in these ecosystems beings representative of all links in the food chain (Schaeffer - Novelli 1982). Comparing with other ecosystems, mangroves have a low number of plant species (Braga et al. 1989), circumscribed in five typical genres - Rhizophora, Avicennia, Laguncularia, Conocarpus, and Pelliciera, totaling 10 species. Along the extensive Brazilian territory, the mangroves of various states have similar characteristics of floristic composition, containing, however, fewer genera and species compared to other tropical countries (Rossi andMattos 2002), which are cited to the country characteristic genera Rhizophora, Avicennia, Conocarpus and Laguncularia (Cintrón and Schaeffer - Novelli 1983). Although mangrove ecosystems concentrate wealth floristic inexpressive, abundance, physiology and phytosociology these specimens, the physical and chemical characteristics of soils and intertidal position, currently in estuarine areas, producing environments highly conducive to the development of ecological webs very rich, which include series of animal species, especially in the early stages of growth, which are mangroves as big " nurseries " marine life of tropical and subtropical oceans (Schaeffer - Novelli 1995; Viana 2002 andOdum 2004). The environmental conditions of these areas especially favor the development of important planktonic communities, which are primary components of food chain and plays an effective and substantial in total primary production, serving as a key source of food for hundreds of species, including high economic value aggregate (Neumann-Leitão1995 andKoening 2002).

Diverse fauna communities exist sharing one or more vital stages in these environments. Several species of fish and crustaceans use their calm waters for reproduction and early growth before migrating to deeper pelagic zones. The avifauna found in mangrove areas favorable conditions for nesting and reproduction, essential especially for migrant species. (Rodrigues 1995). The state of Pernambuco has a concentration of mangroves quite significant, due to its geographical position and altitude reduced, favoring the development of such coastal biome. Inserted in the area of mangrove ecosystem is a complex estuarine Suape. The mangrove industrial and the complex of Suape has five plant species typical basic behaved in three families and four genera recorded in Brazil - Rhizophora mangle L., LagunculariaracemosaGaertn., Avicenniagerminans (L.) Stearn., AvicenniaschauerianaStapf. Leechman and Conocarpus erectus L, plus optional peripheral and generalist species. The value found represents a higher species richness compared to that existing in other regions of Brazil, as recorded in the publications of Rossi andMattos (2002) describing two species of trees listed for the mangrove coast of the state of São Paulo and Soares et. al.(2003) describes three botanical species existing in areas of mangroves in Baia de Guanabara, Rio de Janeiro. The implantation of a port usually affects ecosystems and important environmental standpoint. The physical changes can cause changes in the flow of rivers and entry of sea water in mangrove. The alteration of water circulation in mangrove, in turn, may alter the temperature, salinity and water velocity, creating unfavorable conditions for the survival of some species. The loss of vegetation by landfill or flooding can result in the elimination of plant species, which may force the migration of some species of animals, causing possible imbalances population (EPA 2002 cited Adams 2003).

Accordingly, vegetation indices are one of the most commonly used parameters in monitoring seasonal and interannual structural and physiological parameters of different ecosystems and is obtained through the use of remote sensing. They consist of transformations, linear and nonlinear, in spectral bands chosen according to their specificity, to enhance contribution of properties of interest of vegetation (Souza et al. 2009). The leaf area index (LAI) defined by Watson (1947) as the integrated canopy leaf area per unit projected surface soil (m^2/m^2) is a major biophysical variables of a forest canopy, is directly related to productivity and evapotranspiration of forest ecosystems in the calculation considering the surface of only one side of the leaves (Lang andMcMurtrie1992). To estimate of evapotranspiration, researchers have developed models of interface forest- soil-atmosphere (Running and Coughlan 1988), in which LAI is the main variable describer the plant canopy (Xavier et al. 2002). Since the 1960s, the studies of spectral characteristics of vegetation, based on parameters such as biomass and leaf area index (LAI), mainly in the visible and near infrared, have developed important results in their applications, which provide data for analysis soil, climate and phenological time. Phenology seeks to study periodic phenomena of plant life on the basis of their response to environmental conditions such as temperature, light and humidity. According to Clough (1992), the LAI has great influence on primary production and growth of mangrove plants, and therefore useful in the analysis of the growth stage of the plants, adding to this analysis, climatic factors, such as radiation solar day length, temperature of air and soil, precipitation and potential evapotranspiration, as well as its seasonal variability are essential in damage to the growth of mangrove forests in the world. This is important vegetation index for quantifying the degree of variation of the biomass over the years, in view of the presence of vegetation is intrinsically correlated with the presence of moisture in the air, and thermal comfort having key role in regulating the microclimate.

Thus, the physiognomic characteristics of vegetation play a fundamental role in studies of microclimatic environments such as mangroves. Among the factors that interfere with the growth stage of the plants, the temperature is of vital importance as it will directly influence the growth and productivity of vegetation. The surface temperature is another variable used in determining the heat flow in soil (Basstiaanssen 1995). Among the climatic factors, the heat flow in the soil is a very important variable in studies involving plant water requirements, since the efficiency of water use varies throughout the growing season, depending on their phenological phases. Thus, heat flow in soil is a necessary component of the surface energy balance, able to justify the storage and transfer of heat into the soil, and also exchanges between the soil and atmosphere. The heat transfer mangrove soil originated by a complex combination of conductive and convective processes intraporoso (Silans et al. 1996). The soil surface is one of the decisive components of the microclimate of the plant (Sediyamaand Prates 1986) and serves not only as support for the plants, but also to the middle, through which the water and nutrients are transferred to the root system and on the other hand works the soil, physically, as the main mechanism of energy storage (Querino and Moura 2010). Thus, this work aims to analyze, over a sample period of approximately 20 years, the relationship between changes in the environment and its effects on the phenological development of mangrove vegetation in the area near the Industrial and Complex of Suape, through use of several variables: physical and biophysical among them LAI and ground flux heat applied in the area corresponding to the predominance of this system for identifying changes over time.

Materiale Methods

Study Area

TheSuapeestuarine complexis locatedin a region thatcoverspartsof the municipalities ofCabo de SantoAgostinhoandIpojuca, between latitudes8°20'00'' S and 8 °29'00'' S and longitude 34º56'30'' W and 35º 03 '00''W, lying about 40km from the cityof Recife (Sampaio and Souza2001), being formed by the estuaryof the rivers Massangana, Tatuoca, Ipojuca and Merepe. The regionpresentsa face geomorphologicalcommonlyfl attened, medially divided by outcrops offracture dvolcanicmasses of Cabo de Santo Agostinho (Santos andCosta1974).

Data

Were used in this study images of the years 1988 to 2011 were obtained from the sensor TM (Thematic Mapper), point 214 and orbit 66 (06/21/1988) (02/28/1998) (07/19/2007) and (03/17/2011) aboard the Landsat-5 obtained by the Imaging Division of the InstitutoNacional de PesquisasEspaciais– INPE of Brazil.

Methods

This study was utilized the Surface Energy Balance Algorithm for Land (SEBAL) model. With algorithm SEBAL is possible compute: LAI, Net radiation, Soil Heat flux, Latent Heat flux and evapotranspiration. The equation of SEBAL can see in Santos(2009) and Oliveira et al. (2010).

Results and Discussion

It’s possible to observe that the lowest values of net radiation (Figure 1) occurred in the area with exposed soil, Figure 2. In the four years analyzed is visible spatial change in net radiation. This suggested that net radiation can be indicated for monitoring of the area.It was observed that the values of Rn in 1989 showed a predominance of values between 620 and 680 W/m, indicating that the wet area is presented by presence of vegetation and moisture characteristic of this area, since presents a high rainfall, typical equatorial coastal areas. Over the years the predominance of wetter areas was decreasing, given the increase in industrial in Complex of Suapeand increase of areas focused on agriculture until the last image of the year 2011. The wetter areas have Rn in 1989 was 560-620 W/ m^2.

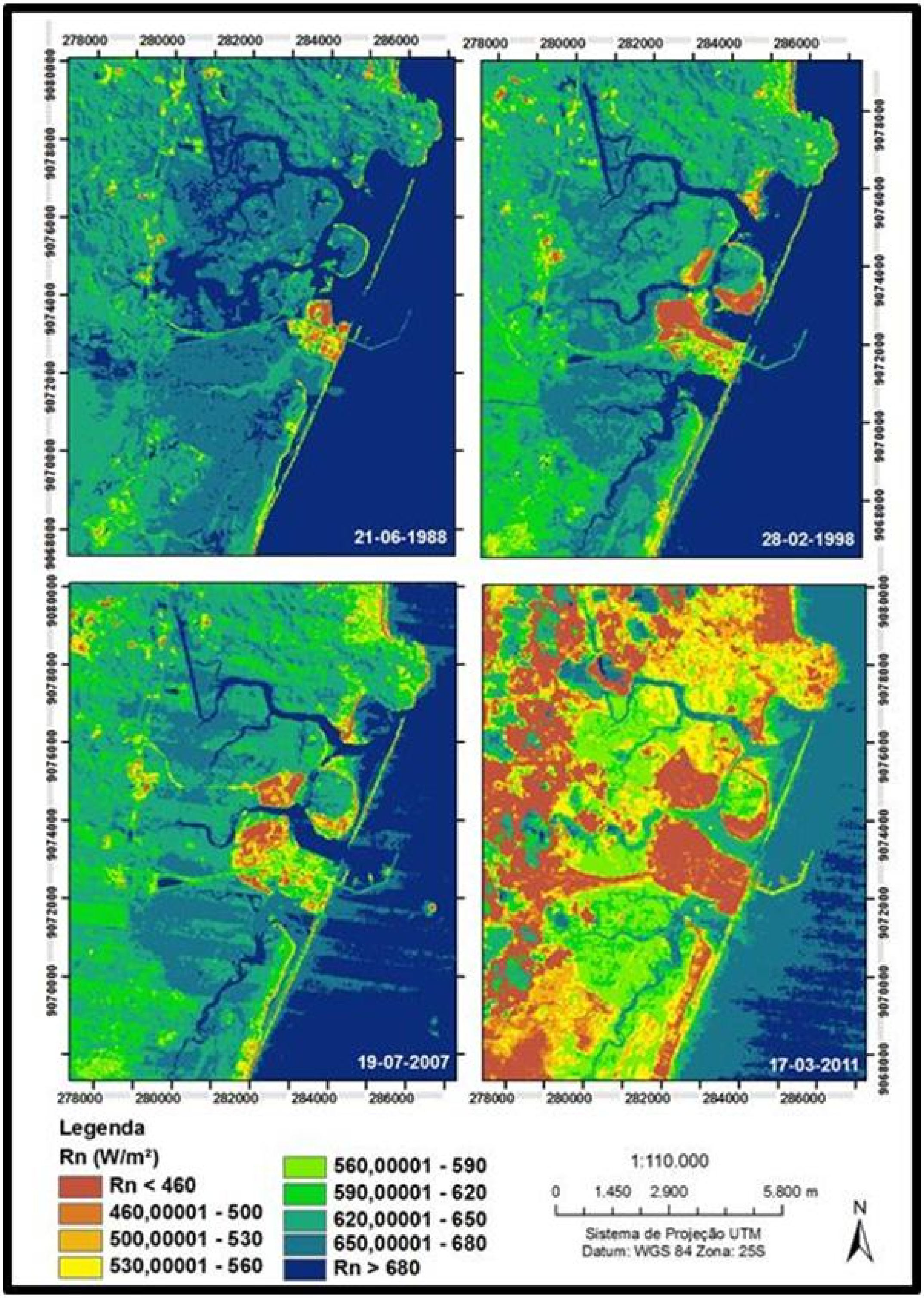

Figure 1 -Net Radiation

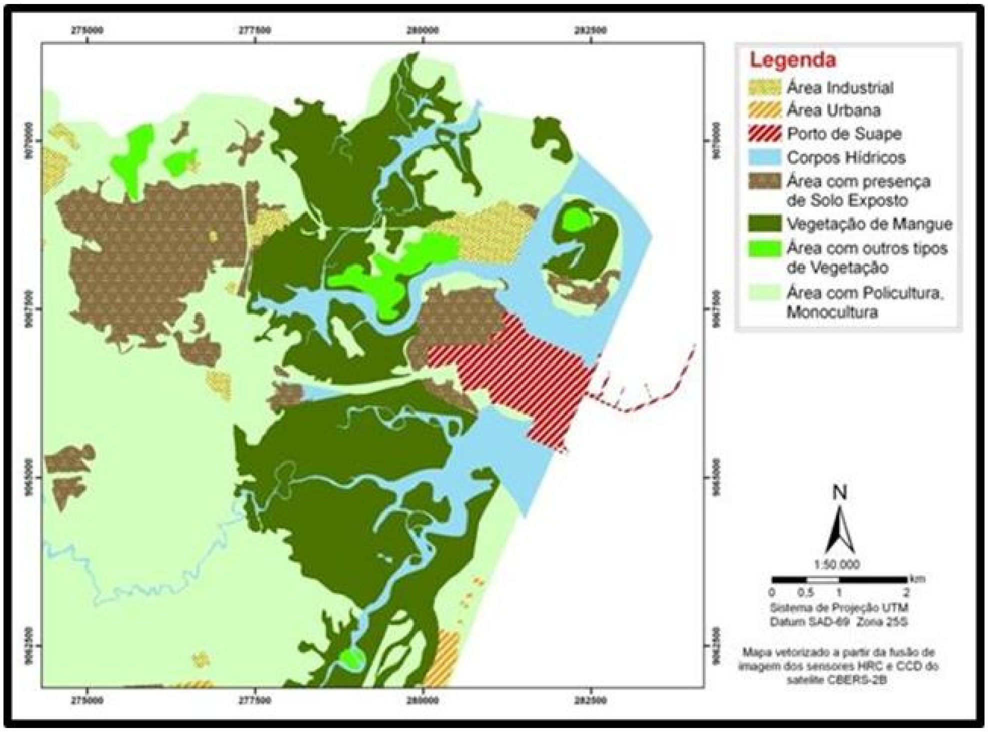

Figure 2 –Land Use

The solar radiation that passes through canopy tends to decrease as density increases, influencing total energy accumulated inside woods, where during day in response to protective effect of canopy, there is a reduction in accumulated energy (Villan et al. 2009). The mangrove canopy and atmosphere interact dynamically through physical processes that produce energy and mass transport. Abiotic factors directly influence the existence of mangroves can lead him to extreme physiological changes, sometimes causing their disappearance (Ribeiro 2001). Thus, it becomes necessary to limit the forms of exploitation of mangroves, as heat transferred from plant to atmosphere comes from solar radiation falling on the surface during the daytime.The removal or replacement of vegetation alters the radiation balance, the main factor interaction surface with the Atmospheric Boundary Layer. As the vegetation also stores energy, changes in coverage result in greater or lesser availability of heat to atmospheric processes (Querino et al. 2006). The net radiation (Rn) is amount of energy available to physical and biological processes that occur on Earth's surface and is defined as the radiation balance of all radiative fluxes coming to and from a surface (Klein et al. 1977 andWeligepolage 2005). According to Moura and Querino (2010), heat flow in soil is a property that affects the microclimate of an ecosystem, it heat exchanges occurring between surface of soil and atmosphere, both by irradiation and by conduction and is exchanged of heat between ground surface and atmosphere in processes of evaporation and condensation of water. The heat flow in soil in the area, it can be seen that in 1988 was predominance of pixels between 40 and 60 W / m², with the prevalence in 2011, values between 50 and 80 W / m² (Figure 3).

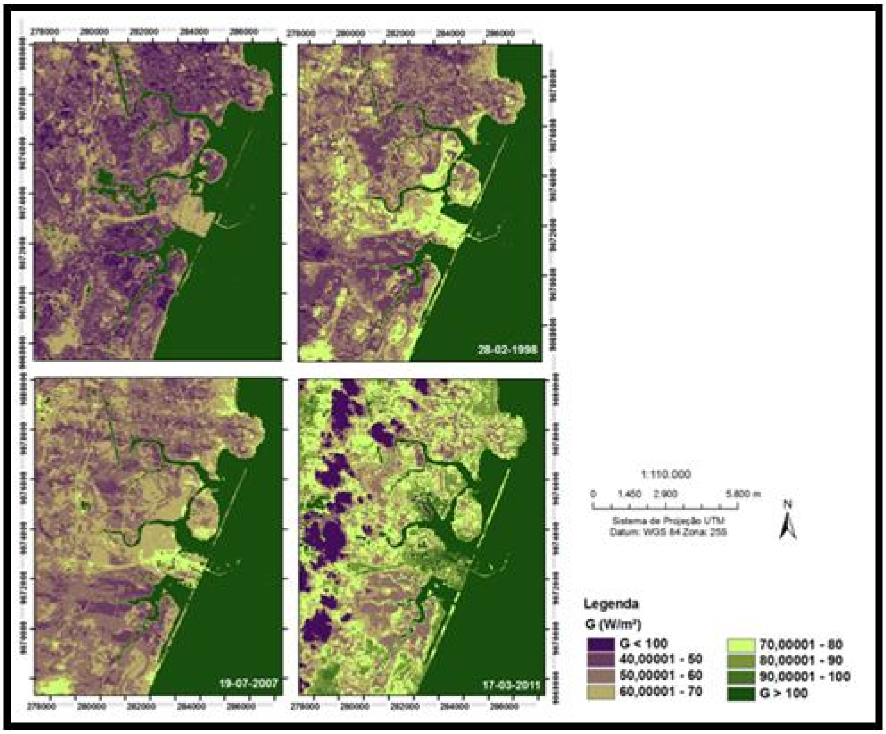

Figure 3 – Soil Heat Flux

In work done by Oliveira et al.(2009), in the Moxotóbasin,Pernambuco, using satellite images, it was verified that the values of heat flow in soil varied according to several factors, such as sunlight, in which the target is subjected to the type soil, whereas clay soils have higher thermal conductivity than sandy soils, and the type and distribution of vegetation cover. The heat flow in soil varies with the type of coverage on surface as it affects supply of energy coming from the sun. Silva and Herz (1987) apudVillani et al. (2009), mangrove has a characteristic thermal regulation due to the accumulation of radiation on substrate, where high water content is always available to be used by plants in evaporation process, coverage promoted by canopy controls the quantity, quality and temporal and spatial distribution of solar radiation, determining different levels of humidity, temperature and soil moisture conditions, and promote the interception of rainfall, reducing the direct impact of soil therefore cover acts directly on microclimate conditions of the environment. Thus, coverage is one of the determinants of "micro-habitat" of a forest, affecting the growth and survival of seedlings, influencing processes of oxidation of organic matter in metabolic activity of cells of roots, root growth, as well as in germination of seeds, so the coverage is directly involved in microclimatic conditions of environment (Villani et al. 2009). The effects of constant drainage processes, landfills and impoundments in which the region of Suape, especially in mangroves, has in the last decades, reflected directly in a gradual and accelerated loss of biodiversity ecosystem.

The evaluation of use and occupation of land by employing image fusion techniques made it possible to obtain preliminary results and more recent studies concerning the effects generated by various tensors in the study area as evidenced by the map of land use surrounding of theSuape (Figure 2). It was verified, high coverage of surface by mangrove vegetation biome; however it is possible to note also areas devoid of vegetation cover in their central parts.In meteorological aspect, it is necessary to limit the forms of exploitation of this ecosystem, because the conversion of mangrove forests in degraded areas exposes surface to direct sunlight altering the radiative balance. It is known that the effects of degradation of mangrove directly influence the microclimate. Amends its various processes at the interface atmosphere - vegetation and, consequently, the microclimate of mangrove forests, therefore, affect ecological processes such as growth and regeneration of plants, soil respiration cycle of nutrients and formation natural habitat (Motzer 2005). Analyzing the data LAI temporally is possibleto visualize the existence of some larger areas of exposed soil despite being known that the mangrove areas have a high power of regeneration, and LAI over the years presented a decrease.This can be explained by the greater use of these areas for crops and as a result of urban growth and increase of industrial area of Suape (Figure 4).

Note that the LAI decreased over years, especially regarding the areas where mangrove vegetation predominates, however there was an increase in mangrove areas between the years 2007 and 2010. The LAI has been related to luxuriance of plant canopy, because it takes into account the size, number and developmental stage of vegetation, ie , an area may have increased coverage area of vegetation, but not reflect an increase in the same proportion with respect to structure of vegetation. This reduction in LAI, together with the results of mapping of net radiation and soil heat flux in some mangrove areas of Industrial and Complex of Suape shows that there are large differences in meteorological variables in natural areas and degraded mangroves.An empirical analysis in the area in question reveals that biomass loss caused by various tensor acting in mangrove forest loss may be causing the duties of mangrove ecosystem, among them litterfall. The LAI is result of ecophysiological responses of plants to chemical conditions, physical and biological soil properties (Wandelli and Marques Filho 1999). The knowledge of this index is useful for physiological and ecological studies; it constitutes an important indicator of vitality of trees, reflecting in rates of assimilation and transpiration of canopy gas exchange and water balance. According Lemaire (2001), the direct effect of defoliation in degraded areas is reduction in leaf area. Therefore, the light interception capacity is reduced, resulting in a decrease in supply of carbon to magnitude of effect depending on proportion of removed tissue, degree of peeling of neighboring plants and photosynthetic capacity of remaining leaves.

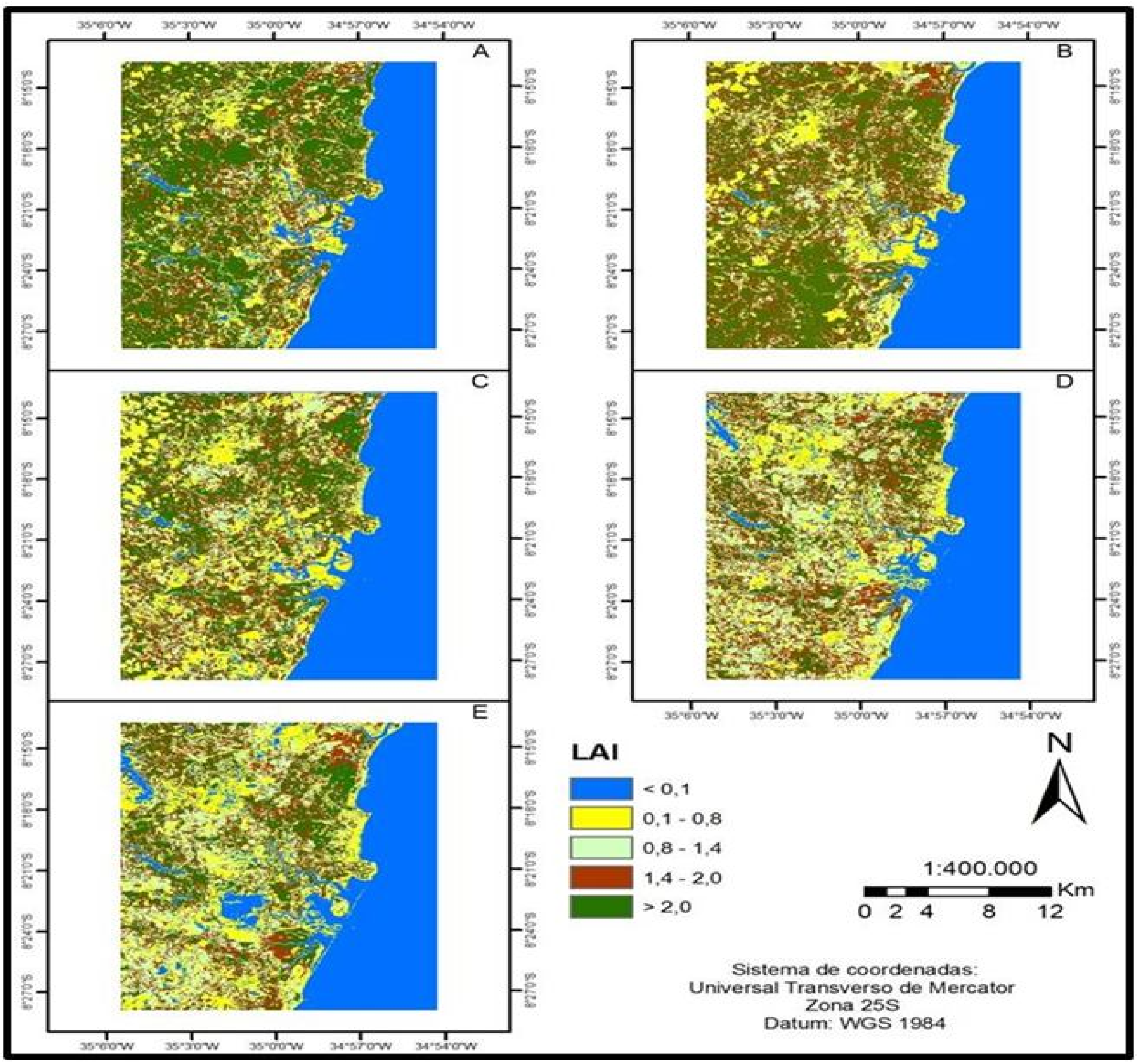

Figure 4 –LAI- Land Area Index.

In studies to characterize the phytosociological parameters of mangrove areas closed areas of influence of pole of Suape, through delimitation and systemic analysis of multiple installments generating various sampling stations throughout the area, it was shown that, considering the specificities of each phytosociological station and searched absence of floristic zonation patterns well established, the mangrove Suape although with generally high abundance of specimens Laguncularia racemosa and Rhizophora mangle (in some sampling stations reaching 95% and 75% of individuals in the plot, respectively), their shares in total biomass are small aspect conditioned by specific morphological and anatomical characteristics such that the species Avicennia schaueriana and A. germinans match most basal area, setting the basic typology landscape mangrove. According to these studies, it is reported that the few individuals Conocarpus erecta were evident peripherally in the mangrove areas of Suape (Sampaio and Souza 2001).

Conclusions

There are major differences in the meteorological variables in natural and degraded areas of mangroves in the area with a predominance of the mangrove ecosystem. The natural area, maintaining its vegetation protects the soil by shading, which offers lower variability of air temperatures, soil and air humidity. The role of vegetation in this process is to maintain a more stable power. In more degraded areas is higher amplitudes because there are many variations of energy. Due the accelerated rate of change of landscape components experienced by the region, measures to protect the fauna and flora were necessary and that the region is currently the focus of studies on environmental impacts and management policies, and despite the urban growth over the interior territory, mangrove areas have undergone regeneration, due to its own regenerative potential.

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