Universidade de Aveiro Departamento de Ambiente e Ordenamento
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VIRGINIA FERNANDEZ RAMOS

AVALIAÇÃO DO RISCO DE INCÊNDIO FLORESTAL NA COSTA ATLÂNTICA DO URUGUAI

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Tese apresentada à Universidade de Aveiro para cumprimento dos requisitos necessários à obtenção do grau de Doutor em Ciências e Engenharia do Ambiente, realizada sob a orientação científica da Doutora Celeste Oliveira Alves Coelho, Professor of the Departmento do Ambiente e Ordenamento da Universidade de Aveiro e a co-orientação da Doutora. Claudia Natenzon, Professor Associado da Faculdad de Filosofia y Letras da Universidad de Buenos Aires.

Thesis presented to the Universidade de Aveiro for compliance with the requirements necessary to obtain the degree of Doutor em Ciências e Engenharia do Ambiente, conducted under the scientific guidance of Doutora Celeste Oliveira Alves Coelho, Professor of the Departmento do Ambiente e Ordenamento da Universidade de Aveiro and co-orientation of Dr. Claudia Natenzon, Associate Professor of the Facultad de Filosofía y Letras of the Universidad de Buenos Aires.

The jury

president	Doutora Ana Maria Monteiro de Sousa Professora catedrática da Universidade do Porto / Faculdade de Letras
	Doutor José Carlos Ribeiro Ferreira Professor auxiliar da Faculdade de Ciências e Tecnologia Universidade Nova de Lisboa/Departamento de Ciências e Engenharia do Ambiente
	Doutor António José Dinis Ferreira Professor Adjunto do Instituto Politecnico de Coimbra/ Escola Superior Agrária de Coimbra
	Doutora Filomena Maria Cardoso Pedrosa Ferreira Martins Professora associada da Universidade de Aveiro
	Doutora Celeste de Oliveira Alves Coelho (orientadora) Professora catedrática da Universidade de Aveiro

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palavras-chave

Risco de incêndio florestal; Sensoriamento remoto; Sistema de Informação Geográfica; Costa atlântica; Uruguai.

resumo

Os incêndios florestais são eventos complexos que colocam em risco bens econômicos, serviços ecossistêmicos e vidas humanas, além de produzir transformações indesejadas na paisagem. As perspectivas derivadas das mudanças climáticas prevêem um aumento na freqüência desses eventos, bem como uma maior gravidade. O Uruguai é um país onde predomina o ecossistema das pradarias. No entanto, o plantio de espécies florestais tem sido promovido em diferentes momentos: primeiro para a fixação de dunas de areia e subsequentes urbanizações, para a produção de celulose.

A zona costeira do Atlântico uruguaio é um dos destinos turísticos mais importantes do país. Nesta zona as florestas foram implantadas com o objetivo de fragmentação e venda de parcelas que criaram uma interface urbana florestal associada à paisagem de resorts costeiros, na maioria das vezes sem o cuidado apropriado. Os incêndios florestais freqüentes nesta área sublinham a necessidade de estratégias de redução de risco para a região. A crescente ocupação espalhada das viviedas gera situações mais complexas em áreas arborizadas que não são facilmente acessíveis. As opções de localização da residência e expansão urbana estruturan os ambientes naturais, induzindo e afetando a biodiversidade e, conseqüentemente, modificando a quantidade e a qualidade do combustível. Ao mismo tempo, la qualidade do ambiente natural e do paisagem influenciam a decisão da residenia e por encuanto participam do processo de expansão urbana. Essa interfase urbana-floresta cria vulnerabilidade; é um efeito combinado da exposição ao perigo, sensibilidade dos diferentes componentes do território e da sociedade, e o grau de resiliência. O objetivo desta pesquisa é conhecer o risco de incêndios florestais. Para isso, analisou-se a interação entre os perigos, identificados através dos incêndios florestais e suas áreas queimadas nesses eventos, e a vulnerabilidade obtida através da exposição das residências.

Os quatro primeiros capítulos da tese descrevem e analisam a ocorrência de incêndios florestais a nível nacional, a evolução da forestação no país e as características da zona costeira, cenário do problema estudado. O quinto capítulo usa técnicas de sensoriamento remoto para aplicar índices para identificar a melhor discriminação de áreas queimadas. O capítulo é complementado com o cálculo dos indicadores de ocupação, adjacência e dispersão das residências, para avaliar sua exposição através do SIG. O Capítulo 6 incorpora a percepção social sobre o risco de incêndios florestais nesta área modificada, e como a participação pública pode funcionar para reduzi-la. As opiniões foram coletadas através de workshos. Neles, participaram autoridades de diferentes agências e outras interessadas de um dos municípios mais populosos.

Também foi realizada uma pesquisa on-line as agências de turismo na área. O penultimo capítulo explora os regulamentos existentes em matéria de risco e ordenamento territoral para saber quanto esse problema está incluído nas políticas públicas. Finalmente, o Capítulo 8 apresenta as principais descobertas e conclusões da pesquisa que poderiam contribuir para melhorar as políticas e as ações públicas para reduzir o risco de incêndios florestais na costa atlântica.

Com uma política fraca e desatualizada, alguns resultados parecem ser inevitáveis. Sim os incêndios florestais e as paisagens estão mudando, a estratégia de gerenciamento de riscos para os incêndios florestais e–os regulamentos devem mudar. Além disso, ter uma única estratégia não parece ser o mais conveniente. A estratégia baseada unicamente na extinção do fogo ignora um aspecto fundamental que se refere à vegetação que se beneficia do fogo para sua propagação e aumenta o risco de incêndio. Enquanto, uma estratégia que integre a extinção com ações preventivas do manejo florestal torna-se mais efetiva para mitigar o risco. Parece necessário avançar para o manejo florestal sustentável para minimizar os impactos socioeconômicos do fogo e maximizar os benefícios ecológicos. Um gerenciamento inteligente dos incêndios florestais implica o planejamento e a realização de atividades de forma totalmente integrada, tanto nos níveis de vegetacao quanto na paisagem. Esta forma de gestao procura controlar o regime de incêndio, intervindo na vegetação como combustível para poder promover ambientes mais resistentes ao fogo e menos inflamáveis.

keywords

Forest fire risk; Remote Sensing; Geographic Information System; Atlantic Coast; Uruguay.

abstract

Forest fires are complex events which set economic goods, ecosystem services, human lives at risk, as well as produce unwanted transformations in the landscape. The perspectives derived from Climate Change foresee an increase in the frequency of these events as well as a greater severity. Uruguay is a country dominated by the prairie ecosystem; however, forestation has been promoted at different times: first for sand dune fixation and subsequent urbanization, later for the production of cellulose.

The Uruguayan Atlantic coastal zone is one of the most important tourist destinations in the country. There, forests were implanted with the purpose of fragmentation and sale of plots of land which have created an urban forest interface associated with seaside resorts landscape, most times without appropriate care. Frequent wildfires in this area underline the need for risk reduction strategies for the region. Growing sprawl housing generates more complex situations in wooded areas not easily accessible. Residence localization options and urban sprawl structure natural environments, inducing and affecting biodiversity, and consequently modifying the quantity and quality of fuel. In turn, natural environment quality and landscape influence the location housing decision and participate in the process of urban expansion. This interface creates vulnerability; it is a combined effect of exposure to danger, sensitivity of the different components of the territory and society, and the degree of resilience. The purpose of this investigation is to know forest fire risk by analysing the interaction between the hazards, identified through forest fires themselves, specifically analysing areas burnt in those events. Vulnerability was defined as residence exposure in forested areas.

The first four chapters of the thesis describe and analyse the occurrence of forest fires at national level, the forestation evolution in the country and the characteristics of the coastal zone, scenario of the problem studied. In the fifth chapter remote sensing techniques and indexes were applied to discriminate burned areas. The topic is complemented with the calculation of occupancy, adjacency and dispersion indicators of the dwellings, to evaluate their exposure through GIS. Chapter 6 incorporates the social perception about wildfire risk in this modified area and to know how public participation would work for its reduction.

The opinions were collected through workshops with authorities participation from different agencies as well as stakeholders to approach the subject in one of the most populated municipalities . Also an online survey of the tourism agencies in the area was applied. The second last chapter explores the existing regulations regarding risk and land planning to know how much this

problem is included in public policies. Finally, Chapter 8 presents the main findings and conclusions of the research that could contribute to improving public policies and actions to reduce the risk of forest fires on the Atlantic coast.

With a weak and outdated policy, some outcomes seem to be inevitable. If forest fires and landscape are changing, the risk management strategy for forest fires and thus the regulations should change. Also, having a single strategy does not seem to be the most convenient. The strategy based solely on the extinction of fire ignores a fundamental aspect that refers to the vegetation that benefits from the fire for its propagation and raise the risk of fire. Meanwhile, a strategy that integrates the extinction with preventive actions of the forest management becomes more effective to mitigate the risk. It seems necessary to move towards sustainable forest management to minimize the socio-economic impacts of fire and maximize its ecological benefits. An intelligent forest fire management implies planning and carrying out activities in a fully integrated manner, both at the vegetation and landscape levels. This kind of management aims to control the fire regime by intervening in the vegetation as fuel, to promote environments more resistant to fire and less flammable.

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AECID	Spanish Agency for International Development Cooperation
AFE	Trains and Tramways State Office
AQL 2004	Acceptable Quality Level 2004
AVC	Vulnerabilities and Capabilities Analysis
AVHRR	Advanced Very High-Resolution Radiometer
BAI	Burned Area Index
BID	Inter-American Development Bank (IDB)
CCI	Climate Change Initiative
CDE	Departmental Emergency Committee
CECOED	Departmental Emergencies Coordination Centre
CEPAL	Economic Commission for Latin America and the Caribbean
CONAF	National Forest Corporation of Chile
CPTEC	Weather Prevision Centre and Climate Studies
CRED	Centre for Research on the Epidemiology of Disasters
CRID	Regional Disaster Information Centre
DIEA	Agricultural Statistics Office
DINAMA	National Environment Office
DINOT	National Land Planning Office
DNB	National Fire Brigade

ECOPLATA	Integrated Coastal Zone Management of the Rio de la Plata Support Programme
EM-DAT	Emergency Events Database
ENCE	National Pulp Company of Spain
ENSO	El Niño Southern Oscillation
ESA	European Space Agency
ETM	Enhanced Thematic Mapper
FAO	Food and Agriculture Organization of the United Nations
FLACSO	Latin American School of Social Sciences
FREPLATA	Environmental Protection Project for the River Plate and its Maritime Front
FSC	Forest Stewardship Council
GDP	Gross domestic product
GIS	Geographic Information System
GWFN	Global Wildland Fire Network
HRV	High Resolution Visible
INE	National Statistics Institute
INPE	National Institute for Space Research
IPCC	Intergovernmental Panel on Climate Change
IRIF	Forest Fire Risk Index
IRS	Indian Remote Sensing Satellites
LA RED	Social Studies Network for Disaster Prevention in Latin America
LAPAN	Indonesian National Institute of Aeronautics and Space
METT	Management Effectiveness Tracking Tool

MGAP	Ministry of Livestock, Agriculture and Fisheries
MODIS	Moderate Resolution Imaging Spectroradiometer
MVOTMA	Housing, Land Planning and Environment Ministry
NASA	National Aeronautics and Space Administration
NBR	Normalized Burn Ratio
NDVI	Normalized Difference Vegetation Index
NGO	Non-governmental organization
NOAA	National Oceanic and Atmospheric Administration
OLI	Optical Land Imager
PATFOR	Land and forestry planning participative instrument from la Generalitat Valenciana
PROBIDES	East Wetlands Biodiversity Conservation and Sustainable Development Programme
PROBIO	Project for the Electricity Production from biomass in Uruguay
RRD	Disaster Risk Reduction
SAyDS	Secretary of Environment and Sustainable Development (Argentina)
SCP	Semi-Automatic Classification
SINAE	National Emergency System
SNAP	National Protected Areas System
SPOT	Probationary System of Earth Observation
SWIR	Shortwave Infrared
TM	Thematic Mapper
TOA	Top-of-the atmosphere
UE	European Union (EU)

UICN	International Union for Conservation of Nature
UN	United Nations
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational Scientific and Cultural Organization
UNIDDR	United Nations Office for Disaster Risk Reduction
UNISDR	United Nations International Strategy for Disaster Reduction
UN-SPIDER	United Nations Platform for Disaster Management and Emergency Response
UNWTO	United Nations World Tourism Organization
UPM	United Paper Mills Ltd.
USGS	United States Geological Survey
VGI	Volunteered geographic information
WGII AR5	Working Group II Fifth Assessment Report
WHO	World Health Organization
WUI	Wildland-Urban Interface

CHAPTER 1 INTRODUCTION

1.1. Scope of the investigation

This work aims at learning about forest fire risk on the Uruguayan Atlantic coast; as a relation established between the social group occupying a specific space in terms of its characteristics as well as the activities that are developed there. This is a particular bond built for almost a century and that can be summarized as nobody's forest becomes everybody's risk.

1.1.1. The forest fires problem

The Climate Change 2014 Report: Impacts, Adaptation, and Vulnerability has been endorsed this year. It was developed with contributions from the 5th Work Group II del IPCC (WGII AR5, 2014) and it addresses forest fires as climate-related extreme events that show how some ecosystems and a lot of human systems, are particularly exposed and also vulnerable to the current climate variability. In addition, the report states that countries at all development levels have a significant lack of preparation to face the aforementioned climate variability in several areas and spaces.

The Special Report - Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (Cuny, 1983; Blaikie et al., 1996; CEPAL &BID, 2000; Cardona, 2001) approaches this topic from disaster theory and the social concept of risk. It states that in those cases when exposure and vulnerability are high, non-extreme phenomenon may bring about extreme impacts or they may even worsen the phenomenon and their associated impacts, as well. It uses the drought chain as an example; drought, extreme heat and humidity increase fire risk related to different vulnerabilities. These, in addition to changes in the hydrologic cycle and biochemical alterations may result in quite relevant degradation processes (Dinis Ferreira *et al*., 2010).

The Food and Agriculture Organization of the United Nations (FAO, 2007) warns about an increase in the number of forest fires as a consequence of climate change. These events are increasingly larger and have more terrible effects in several parts of the world. Therefore, it calls countries to invest more in prevention and preparation to face fire events. Fires are frequently a consequence of human negligence or willful acts; they destroy millions of forested hectares, resulting in human and animal life losses and causing huge economic damage. This organization calculates that every year forest fires all around the world consume around 5 130 million tons of biomass and release 3 431 million tons of CO^2 in the atmosphere. These contribute to greenhouse effect emissions to increase climate change.

This organization finally suggests the need to implement preventive landscape management, comprising political, cultural, technical, social, financial, organizational, economic and market aspects. The concern regarding these events and their effects is noticeable because of variety of global and regional initiatives that have the aim of looking into them and improving their management.

In the Manual de Classificação de Incêndios Florestais used by the Instituto da Conservação da Natureza e das Florestas de Portugal (Buxo de Carvalho & Lopes, J., 2001), forest fires are defined as fire spreading uncontrollably on forested territory, affecting vegetation that was not meant to be burnt. Based on this definition, it can be understood that forest fires affect vegetation not used with agriculture and livestock breeding purposes and they do not comprise stubble burning. This definition is complemented by The National Forestry Corporation (CONAF) at Chile's Agriculture Ministry, as it adds a reference to the resulting damage and the differences between forest fires and controlled fires. In other cases, the term "rural fire" arises, to define fires affecting areas that aren't forested or apt for forestry. Instead, it takes place in other rural areas and affects brushwoods, bushes and grasslands. These events may result in important damages to the area's flora, fauna, hydric resources and soils, which may have a highly negative result on tourism-oriented areas. There are also interface fires. These take place in urban-rural areas where the vegetation mingles with building structures, such as houses, farm houses, etc.

The immediate effects of fire include the total or partial destruction of the area's vegetation, which is followed by an erosion process that depends on the atmospheric conditions present before and after the fire. The speed at which the area regenerates may vary, depending on what type of vegetation has been affected. In areas such as grasslands, for example, where the trees do not predominate, regeneration is quite quick. Consequences are more serious when the fire destroys a forest, the underbrush or ecological niches that are often unique. The ENSO Risk Management Project Report for Latin America states that forest fires are usually started on agricultural or livestock production lands and usually bring about severe environmental damage (Magaña *et al*., 1999).

In addition, forest fires have become a global issue because of their emissions to the atmosphere and also because sometimes they cross borders, as it has happened in the Mediterranean region (García - Hurtado *et al*., 2014) and more recently in Rio Paraná's delta (Salvia *et al*., 2012).

1.1.2. Forest fire risk integrated management

Even though forest fire risk is associated to natural variables such as vegetation, meteorological conditions and topography, it is specially linked to human activities that determine how fire starts and spreads. The fire's degree of danger depends on its risk level and its interaction with human activities. According to Hewitt (1996), and from the perspective of physics, fire is a "natural" risk; nevertheless, assuming a more integral perspective, fire can be related to human activities and can endanger assets such as infrastructures,

structures and productive dynamics as well as ecosystems and landscapes. In addition, there is a collective and individual dimension to these events that questions how the public budget is distributed regarding fire-fighting. This is because collective costs in high fire risk areas are more focused in urban development, only trying to make profit of the landscape's value (Napoléone *et al*., 2006).

Even though natural disasters are increasingly frequent and damaging mainly because of global climate change and variability (Baas, S. et al., 2008), the specific case of forest fires can be analysed as a social phenomenon highly linked to a historical construction of socioeconomic, environmental and institutional vulnerability (Gasparotto, 2002). Olcina (2006) defines risk as 'human actions happening in disagreement with their environment's features; it is, therefore, a man's violation on the land by inadequately implanting activities or settlements'. This is a changing, evolving and dynamic condition that is affected by social and environmental processes (Lavell, 2001) and is expressed in the possibility of future losses.

In the case of forest fires and taking into account the anthropic action of the settlement, Napoléone *et al*. (2006) conclude that natural environments are structured by the houses' location and the urban expansion, affecting the biodiversity and therefore, the combustible's quantity and quality. They also state that the landscape and natural environment's quality affect the decision of where to locate houses and, consequently, the urban development. These interactions make us aware of the need to take into account the prevailing natural and social conditions in a certain territory in order adequately analyse its fire risk conditions.

Napoléone *et al*. (2006) also state that in the Mediterranean region the structure and composition of forested areas determined their sensitivity to forest fires. Such sensitivity is expressed through the concepts of combustibility and inflammability. Combustibility is understood as the forested mass' quality to start and keep and oxidation reaction and it determines the fire's intensity. Inflammability, on the other hand, is the set of conditions present in that forested mass' surroundings that allow fire to start when a heat source is applied. However, the territory is also affected by anthropic space structures. The more scattered houses are, the more contact between human activities and the environment takes place. Considering that most fires have anthropic causes and vulnerability is strongly linked to the presence of houses, the limits of urban structures acquire considerable impact on fire risk. Also, the difficulties in accessing those areas and in keeping the surrounding zones clean add up to the risks.

It seems critical for fire prevention policies to include the space patterns in fire generation and spreading as well as their relation with geographical and socioeconomic variables, especially, the settling and urbanization processes. Chas-Amil et al. (2010) analyse fire reports for the 1988-2006 period in Galicia, España. They explore fire risk space distribution considering human activity, causes and subjacent motivations related to those events. The differences that arise in their investigation emphasize the need to have some valuable information available. Such information leads to detect some non-random variable groups that permit a better knowledge of fire causes in certain places. This would be essential information to thoroughly assess and later integrate in fire management planning.

In Uruguay, the institutions in charge and the funding available for forest fire control are public. This means that forest fire risk is linked to those institutions' capacity to control fire, that is to say, to develop an integral risk management plan that considers the forest fire threats and vulnerabilities placed by settlement's shapes and activities. Within management, individual incidence depends on how fire-fighting institutions are funded and on the availability of insurance options. This brings along a dilemma regarding the individual nature of housing options, which are part of the causes of risk, and the public structure of fund risk management. From the perspective of vulnerability, risk may be compared to the variation in the value of assets or individual profit associated to these events happening. Napoléone (2006), nevertheless, concludes that there is no mechanical relation between the objective value of goods and risk; the real nature of risk lays on the occurrence that individuals assign to such risk.

Risk is a concept close to that of uncertainty, as risk probabilities can be calculated. Assuming that individuals have the same and sufficient information, risk results from a relationship between the uncertainty of factors and the impacts of that risk's occurrence. From this point of view, and assuming that there is an aversion to risk, risk is tightly linked to the prevention of individuals. Consequently, and regarding risk occurrence and the resulting costs distribution, Napoléone (2006) observes that those depend on "individual sensitivity levels" towards fire risk.

The circumstance surrounding fires may bring along severe risk or disaster situations that require risk planning and management; those situations require special planning for some territories. (National Emergencies System creation Law Nº 18.621, Decree 436/07 within the General action Plan of Forest Fire Prevention, Alert and Response).

To take adequate prevention and response measures and, therefore, reduce the effects of fire on the most vulnerable zones, it is indispensable to analyse the territorial distribution of vulnerability and the potential fire danger level as well as its components. On the other hand, assessing an area that has been affected by a forest fire is paramount to understand the event, from a preventive point of view as well as from the perspective of planning and restoration. Analysing the effects of fire on a certain territorial reality helps understanding the incidence that the different variables within this problematic have.

1.1.3. Geographic information technologies applied on burnt areas.

The relevance of forest fires stems mostly from two factors: they deteriorate the environment (destroying forest mass, eroding the soil, affecting the atmosphere), and they also have socioeconomic impacts. Burnt areas cartography is an acknowledged and useful ex-post tool when planning palliative actions to address their effects (Blas Morato, R.et al., 2006). In addition, cartography can fulfill the need to assess vulnerability (degrees of damage and loss in the population, goods and environment resulting from a forest fire) and to assign –based on the forestry system intrinsic and extrinsic factors - potential degrees of gravity in case of fire to each spot of the territory.

Moreover, the forestry system's combustibility is defined by its capacity to keep and spread fire. Each kind of vegetation has its own specific degree of combustibility and flammability, which vary according to the biomass' type and amount and its space distribution or stratification. Combustibility analyses may be carried out using visually identifiable structural models called combustible models (Rothermel, 1972; Albini, 1976, Scott & Burgan, 2005). Such models allow forecasting how fire will behave.

Current Geographic Information Technologies enable a more successful approach to this topic. Remote sensing is a highly useful tool to assess areas that have been affected by forest fires. Satellite images supply updated space information, and their digital improvement provide highly precise cartography of burnt areas that enables to spot the affected perimeter, tell burnt areas from the ones that are not, quantify the main affected species, etc. (Blas Morato, R.*et al*., 2006).

In order to define the threat placed by forest fires, burnt areas can be outlined so as to find out the events' dimension and frequency; it is also possible to search for possible distribution patterns and types of combustibles affected (Diaz-Delgado *et al*., 2004; Curt *et al*. 2013). Landsat satellite images can be digitally improved in order to obtain indexes and classifications that discriminate burnt from not burnt areas. Those indexes include: Normalized Difference Vegetation Index (NDVI), Normalized Burn Ratio (NBR), Burned Area Index (BAI), or more complex ones, for example: Burn Severity and AQL 2004. Strengths and weaknesses of each technique to develop cartography of burnt areas become evident when comparing results obtained through different methods. Such comparison states how convenient it might be to apply each technique to identify the burnt zones inside the study area.

1.1.4. Specific features of forestry on the coastal area.

Forest fires take place regularly in Uruguay's coastal area during the summer season and they result in large economic and environmental losses. Reports about Climate change state an increase in the frequency and intensity of forest fires as a consequence of external climatic effects, such as the droughts that take place in the region (Proyecto URU/00/G31, 2004). Forest fires are environmentally relevant events because they have a negative impact on every action taken towards the conservation of the environment and its natural resources; they bring about vegetation losses, and have short, medium and long-term consequences as they reduce biodiversity and cause erosion. An analysis of forest and field fires regarding their number and affected surfaces is crucial in order to keep environmental values in Uruguay's regions.

In Uruguay, forestry has greatly developed as a productive activity in the last twenty years encouraged by State's policies (Law 15939 and its following decrees). However, the most aggressive forest fires have taken place on the coastal area, far from forestry production fields; they have usually been hard to put out and have caused severe damage. They destroy the landscape; cause panic in inhabitants and tourists (that concentrate in the area in the summer season); affect some infrastructure; and mobilize equipment and personnel to fight the fire, among other consequences. Even though human lives are not usually lost, that is a potential danger. There are, however, other harmful effects to human life and to the environment derived from the fire's emissions.

Fog and smoke can negatively affect aviation, sailing and vehicles circulation, and this means security hazards and economic losses (FAO, 2007). The Atlantic coastal region, where most of these events have taken place, has a high tourism value and comprises many spaces included in the National Protected Areas System.

Forests began being implanted on the Atlantic coast over a century ago; exotic species were introduced with the aim of fixing sands and then selling the land. The landscape's characteristics then changed, turning into what today many see as the Eastern seaside resorts typical scenery. Furthermore, a scattered type of land occupation was encouraged by poor planning, uncontrolled land divisions and a lack of services. As time goes by, exotic forestry starts competing aggressively with native vegetation and some species that are well-adapted to fire colonize areas that used to be covered by indigenous forest; along this process the coast turns into a more combustible area.

1.1.5. Public participation in forest fire management.

According to FAO Forestry Paper 166 “Community-based fire management. A review” (2011), the participation of communities in forest fire management is paramount, mainly because most of those events are a result of human activity. Such perspective is also encouraged by the “Instructor’s Forest Fire Management Manual” (2010). The underlying idea is that when local communities profit from protecting their natural resources, they are more likely to work on fire prevention.

Several authors agree that complex problems, such as forest fires, require public participation (Carreiras *et al*., 2014; Parkinson *et al*, 2003). A multi-sector approach becomes valuable as it allows learning about the interests of different sectors and stakeholders, and it helps to acknowledge and understand the economically weakest groups’ logic, interests, motivations and strategies, granting their participation in negotiations where they can stand up for their interests. The main aims of these actions are: bringing about the sensitivity of those in charge of outlining and managing public policies; reaching agreements regarding the scope and negative effects of not acting; and identifying and approaching together the causes of unplanned forest fires. The stakeholders’ participation (including the local community and the private sector), may contribute to a long-term financial sustainability. Fair and productive partnerships between companies and communities can have a strategic value for investors, going beyond the companies’ corporate social responsibility objectives.

The concept of social perception and its contribution to public participation research is becoming more and more crucial when defining the management of goods or resources of public use. Muhamad, D. *et al*., (2014) use as examples the perceptions that local inhabitants, administrators and victims of their degradation have of ecosystem services. Understanding this becomes fundamental to apprehend the sociocultural dimension of ecosystem services, identifying which of those services are the most appreciated and preferred (Martín-López *et al*., 2012) so as to implement a successful conservation plan (Kari & Korhonen Kurki, 2013) while fulfilling the people’s everyday needs.

On the other hand, this author warns about the possibility of different perceptions arising. Such multiplicity may be result of housing locations, cognitive aspects and implicit categorizations underlying people’s interpretations of their surroundings, based on different space and time scales (Hein *et al*., 2006; Rodríguez et al., 2006) that are grounded on their own personal experiences (Berkes, 1999; Campos *et al.*, 2012). This heterogeneity may bring along richness and more solution options, though.

Finally, it is worth mentioning the new communication options supplied by the 3.0 web. A large number of people who are interested in interchanging opinions can be questioned easily, without time or mobility restraints. This technology supplies new participation channels, not only by forums and surveys, but also by voluntary geographic information (VGI) and by using mobile phones to pass information picked by sensors. Even though these new participation methods are being discussed and are only partially accepted, they seem to be not only supplying data, but also promoting a type of social behaviour that encourages connectivity, a better understanding local forest fire risk and higher participating in risk reduction actions (Granell & Ostermann, 2016; Haworth *et. al*., 2016).

1.2. Aims and objectives

The aim of this investigation is to know forest fire risk on Uruguay's Atlantic coastal strip by analysing the interaction of its two dimensions: on one hand, the threat, which will be identified through forest fires themselves, and specifically analysing areas burnt in those events; on the other hand, the vulnerability that is a result of populated areas' exposure. The study area has a surface of 3 500 km^2 and it is one the country's most visited tourist destinations (32% according to the Tourism and Sports Ministry data, 2014). It has a variety of landscapes (protected areas comprise 20% of its surface: Cerro Verde, Cabo Polonio, San Miguel Park, Rocha Lagoon and El Potrerillo de Santa Teresa National Park and Fauna and Flora Reserve), and it will go through major productive changes in the near future, such as the construction of a deep waters port. Forest fires take place in these surroundings and mainly in the summer season, usually with anthropic causes.

This investigation aims at learning about the characteristics that breed forest fire risk on Uruguay's Atlantic coast. How has the area evolved to give birth to the current vulnerability matrix? What perceptions do its inhabitants have regarding that transformed landscape and the different government levels management? Is it recommendable to use geographic information technologies to locate the main forest fires and to know a small proportion of the present vulnerability through indexes? What policies and regulations are there to contribute to risk reduction?

A territory's vulnerability can be seen as the result of the interaction between environmental conditions and society; it is a combined effect of exposure to danger, different territorial component's sensitivity and the resilience or capacity to recover. The present investigation looks into the population settlements' vulnerability resulting from their exposure. In addition to traditional variables, for instance, number of inhabitants, housing quality or socioeconomic aspects, it is relevant to analyse the houses' degree of exposure to forest fires. Geoprocessing indexes – occupation, adjacency and dispersion - are applied in order to know how houses are distributed within the forested matrix.

By looking into current public policies and regulations regarding forest fire as well as the communities' forest fire risk perception it is possible to know: which areas are perceived as having the highest risk; the main factors that the local population associates to such risk; and how that population values policies and regulations regarding risk in their area.

The hypothesis underlying this investigation is that the outset of forest fire risk reduction can be at approaching the issue from a perspective that involves scientific knowledge and public participation, and is based on the different actors' participation, specially administrators and local inhabitants, in order to set up decision-making processes to prevent these events within the land planning regulations.

1.3. Investigation design

The investigation is composed of two stages:
Evaluating risk through the use of geographic information technologies. First, identifying burnt areas in order to calculate the threat and then, recognizing the forest through a supervised classification in a test region that comprises the whole study area. This task uses Landsat 8 images from the two major fires of the last 10 years. Then, vulnerability is expressed by human settlements present in the area; their distribution is taken as a measure of their exposure (analysing their occupation, adjacency and dispersion regarding the forested mass).

Secondly, public participation and the community's perception are analysed through workshops and surveys. According to a variety of authors, a participative community is crucial in decision-making processes that aim at environmental and technological risks fighting and management (Figueiredo, E. *et al*, 2009). According to Ribeiro, C. *et al* (2014), although Portugal's government policies include a variety of measures to reduce forest fires, the frequency of those events keeps high. The article's conclusion is that technicians as well as local inhabitants have varied perceptions about forest fires and forestry management. Such differences, that are a result of their varied interests and different intervention scales, must be minimized in order to achieve risk reduction. Current public policies regarding forest fires as well as the actors' perceptions about them are looked into at this stage and also later, through a specific analysis.

1.4. Thesis structure

After this introduction chapter (Chapter 1), Chapter 2 includes a review of forest fires at a global level, then in Latin American and, finally, looks at the events taking place in Uruguay. At this stage, the Atlantic coast area is acknowledged as the most affected by not programmed forest fires.

Chapter 3 analyses the structural transformations of the territory as a result of the forestry policy developed in the 80s. Then, it focuses on the study area, as it depicts an uneven evolution in terms of stages, types of exotic forestry and its uses and current results regarding forest fire generation.

Chapter 4 develops a more thorough look at the Atlantic coast region, where there are remarkable ecosystem values within a major tourist attraction area. This chapter shows how incompatible those two features have become, in addition to the unplanned urban development of forested areas.

Chapter 5 presents the results obtained from applying tele-detection in the recognition of burnt areas and soil uses. The areas with the highest risk within the test study area are determined by crossing vulnerability indexes. These tools are applied with the aim of contributing with a perspective that had never been used in forest fire analysis in Uruguay.

Chapter 6 presents observations collected in the participative workshops - which had the aim of outlining a forest fires management plan - as well as results from the online survey applied to agents in the tourism area. These findings were the result of the joint work of administrators from different areas and decision levels, inhabitants from La Paloma and La Pedrera municipalities interested in the topic, and researchers from Science School and the NGO Cultura Ambiental.

Chapter 7 presents and analyses rules and regulations regarding risk management, forestry and land planning in Uruguay, with the aim of spotting deficiencies and conflicts in regulations, tools and management plans.

Finally, Chapter 8 presents the investigation’s main findings and conclusions that could contribute to improving public policies and forest fire risk-reduction actions on the Atlantic coast. It also includes difficulties and obstacles faced along the development of this thesis as well as open future research lines.

CHAPTER 2 FOREST FIRE RISK

2.1. Introduction

Forest fires result from an interaction between the physical environment and anthropic actions and they have major effects on the population as well as on the environment. It is because of this two-way relation that studying forest fire risk from the perspective of geography is paramount. In addition, the geographical character of some main fire risk factors, such as the vegetation's conditions, climate conditions, land's topography and anthropic activity – which is the main cause of these fires – makes an integrated territory analysis necessary (Chuvieco *et al*., 1998).

When studying risk – understood as a combination of vulnerability and threat - a historical analysis of forest fire events becomes a relevant starting point. On one hand, the number of events and their space distribution may allow to identify how the threat behaves, and on the other hand, studying the effects of these fires may provide an idea of how vulnerable to these events some areas are. As Rodríguez (2012) states for Bolivia's case, not having precise information makes control and prevention incomplete actions and this, in turn, results in the need to study forest fires space and time patterns.

This chapter includes a first approach to a historical analysis of forest fires in Uruguay, beginning with a brief analysis of the world's context and ending in the national reality.

2.2. Forest fires, a complex issue.

2.2.1. The beginning of the threat, physical characteristics that contribute to starting a forest fire.

Fire works as a natural ecological regulator for terrestrial ecosystems, shaping the planet's biomes. However, it does not only work as a great herbivore (Mataix-Solera & Cerda, 2009) contributing in the short term to species' selection and to the vegetation formations composition (Navarro *et al*., 2008), but also contributes to speeding up geomorphological process through its effects on soil infiltration and, as a consequence, its runoff. This way, fires generate changes in erosive processes as well as participating in soil formation processes by modifying their nutrients cycle and their physical and chemical properties (Mataix-Solera & Cerda, 2009).

There have been fires on planet earth for the last 350 million years (Scott & Glaspool, 2006; Mataix-Solera & Cerda, 2009), but human activity has added up to the natural fire regimes. The first records date back to

1.5 million years; in the beginning fire was used for defence, hunting, and as an energy and food-production source. Nevertheless, as time went by, it became increasingly relevant as a way of opening crop-growing areas. Such was the case that a controlled use of fire had already begun in Neolithic, while it was no longer used for hunting purposes. Even at present day, fire is used in agriculture for burning crops leftovers and controlling plagues (Mataix-Solera & Cerda, 2009).

There are three necessary components to start a fire: oxygen, some combustible material and heat: these three are known as “the fire triangle”. All these elements can easily be found on the earth’s surface, turning fires into ordinary events. Even though thunderstorms and volcano eruptions are fire’s most frequent “natural” causes (Castillo, Pedernera, & Peña, 2003), it is the current anthropic activity the main cause of fires. It is believed that human beings start 95% of forest fires due to their economic, recreational and war activities (Vélez, 1995). Human-started fires take place worldwide and it is believed that between 10 and 15 million hectares of words are lost yearly as a consequence (Castillo, Pedernera, & Peña, 2003).
There are some risk factors for forest fires, being one of them the vegetation’s hydric conditions. These conditions are determined by variables that include: air’s temperature and humidity, wind’s speed and direction and rainfall (Chuvieco *et al*., 1998). However, the same meteorological setting may have variable effects depending on the conditions of the vegetable combustible.

2.2.2. The El Niño Phenomenon and forest fires

Meteorological conditions are frequently affected by the Southern Oscillation-el Niño (ENSO), known as El Niño, which is a phenomenon that begins in the south of the Pacific Ocean and impacts in several parts of the world. It is characterized by a warm phase – El Niño – followed by a cold one – La Niña. When the equator’s characteristic trade winds weaken, they make Polynesia’s warm waters move to the East and high temperatures bring about convective activity, which results in periods of intense rain in South America’s coasts. On the other hand, during La Niña phase trade winds grow stronger, allowing colder waters from the ocean’s bottom to rise. Even though this process seems to be local, along its warm phase makes tropical areas in northern South America go through a drought stage, while there are heavy rains in southern areas. In Uruguay there are drought periods during its cold phase.

Why does drought have such relevance in the origin of forest fires? The explanation lies in the three combustion stages of vegetable materials. In the first stage, warming-up takes place and materials reach 100ºC, marking the beginning of water vapour loss. In the second stage, there is gas combustion and temperature reaches 300º, flames start and heat keeps the combustion process going. Finally, the carbon combustion phase takes place, where heat and oxygen are used up, generating ashes which no longer burn. This final point does not only depend on meteorological conditions, but also on the summation of all previous conditions. This is how the humidity content is crucial to starting as well as to spreading fire. This means, in turn, that the longer the drought, the less humidity there will be in the vegetable material and, as a consequence, there are higher chances of fires beginning and spreading (Vélez, 1995).

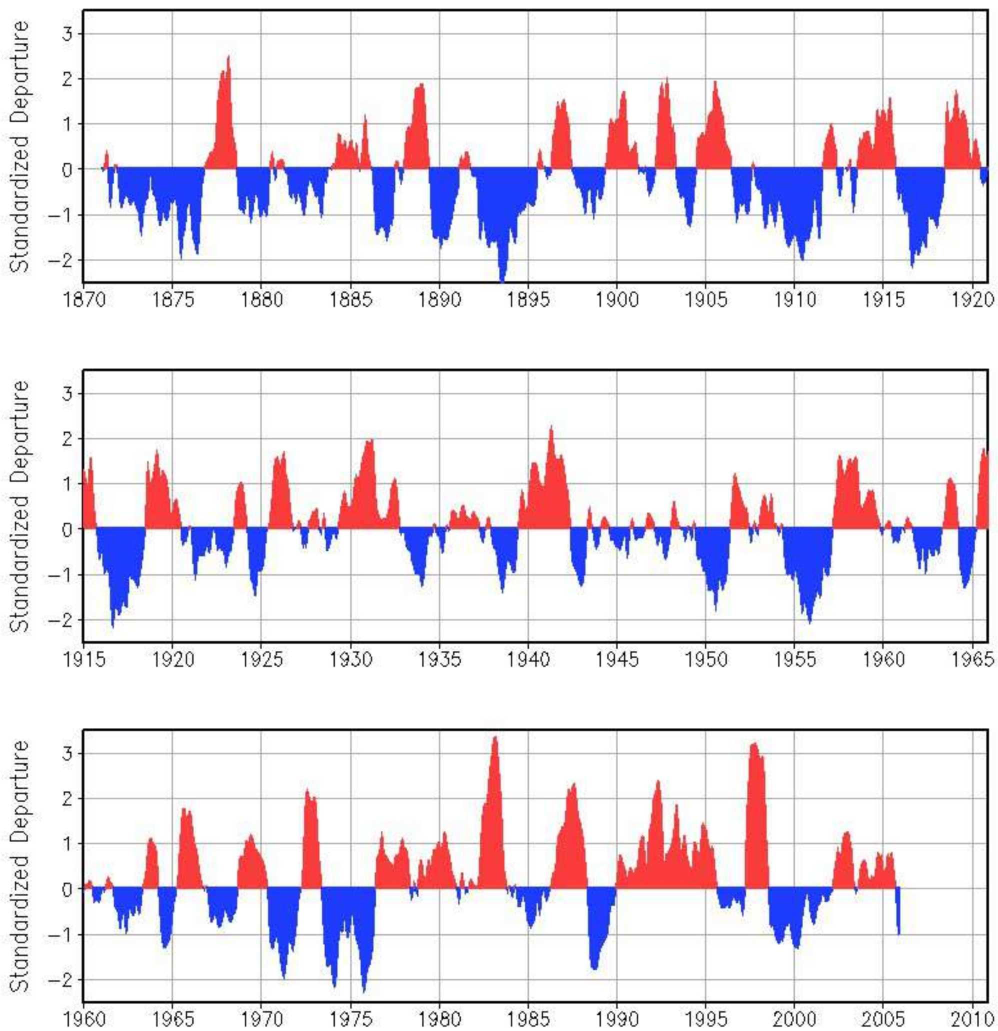

Figure 1: ENSO phenomenon phases. Source: NOAA

It is for this reason that the ENSO phenomenon and the development of forest fires bear direct relation. It is possible to observe El Niño and La Niña periods along the last century measured by the Multivaried ENSO Index1: warm periods in read and cold ones in blue (Figure 1). In 1998 its warm phase reaches a peak known as MegaNiño. According to FAO data, only in Roraime State (Brazil) 1.1 million hectares of virgin

1 The Multivariate ENSO Index combines the most important variables in the tropical Pacific: sea level atmospheric pressure, zone and southern wind component, surface-level sea temperature, air temperature and cloudiness, supplying a starting point to measure the events' magnitude.

woods were on fire in that year, and this clearly illustrates the relevance of this event for the development of fires.

2.2.3. Environmental effects and Global Warming

The emission of gases and particles resulting from the combustion of biomass comes as the most immediate effect of forest fires. In such fires, carbon dioxide that has been stored in trees for decades is released to the atmosphere and therefore, if the vegetation cover is not regenerated, carbon dioxide will remain there (Castillo, Pedernera, & Peña, 2003). This is how greenhouse effect gases emissions in forest fires greatly contribute to global warming, not only by releasing carbon dioxide but also methane and other gases and aerosols, some of which are even air contaminants (e.g. van der Werf *et al*., 2010; Spracklen *et al*., 2009 en Huang, Wu, & Kaplan, 2015). This is probably one of the most critical consequences of forest fires, as they contribute to greenhouse gases emission and thus, to global warming. Meanwhile, the planet's increase in temperature builds up the conditions necessary for the development of further fires. This is how an increase in forest fire impacts on climate change while climate change contributes to a rise in forest fires (FAO, 2005). According to NASA (2012) and FAO (2012), global warming will lead to an increase in fires and periods of drought in some regions as well as to a decrease in rainfall (Rodríguez *et al*., 2012).

Not only the meteorological modifications derived from climate change foster a multiplication of fires, but these also depend on the vegetation cover; in the next years, climate change as well as an increase of carbon dioxide in the atmosphere can lead to major disturbances in the vegetation cover (Wu *et al*., 2012; Bachelet *et al*., 2003 in Huang, Wu, & Kaplan, 2015). These changes result in a variation of combustible availability and consequently, in the development of fires (Huang, Wu, & Kaplan, 2015).

Even though changes in the uses of the soil have had an impact in the multiplication of forest fires, it is also believed that global warming plays a paramount role (Meyn *et al*. 2007 Holz, Kitsberger, Paritsis, & Veblen, 2012). Climate change in conjunction with social variables, such as the introduction of fire in areas that are not fitted out for agriculture or an increase in their frequency in fitted-out areas, have transformed the natural cycles of fire (Bowman *et al*., 2009 in Holz, Kitsberger, Paritsis, & Veblen, 2012). As well as their global-level impact, fires have local impacts related to life and infrastructure losses, soil degradation and changes in vegetation and bio-diversity (Harrison *et al*., 2010 in Holz, Kitsberger, Paritsis, & Veblen, 2012). Moreover, fires bring along landscaping and edaphic consequences (Chuvieco *et al*, 1998) as soil's erosion processes are accelerated by the lack of vegetation cover.

Castillo, Pedernera and Peña (2003) put together a list of forest fires' consequences, dividing them into socioeconomic and ecological. Among the ecological impacts there is the aforementioned effect on climate together with some local consequences, for example: changes in winds, oxygen availability, air humidity, loss of soil's physical and chemical properties as well as nutrients, loss of micro-fauna, death of vegetation tissue, an increase in plagues, entrance of invading species, an increase of superficial runoff, water contamination, a decrease in the aquifers' reload, landscape fragmentation, loss of habitats and breaks in the food chain. Socioeconomic impacts include: the effects on health – water and air contamination and life losses -, damages in property, delay or stop of productive processes, loss of jobs and direct economic costs due to crops, machinery or cattle losses.

2.2.4. Vulnerability, creation of socioeconomic and cultural development?

An acceleration of urbanization processes in areas close to forest surfaces has led to the need to rethink forest fire prevention mechanisms (Badia, Tulla, & Vera, 2010). In the early 90's, and with the aim of analysing the problem of forest fires in a disperse-shaped urbanization, Anglo-Saxon countries developed the concept of wildland-urban interface, WUI (Stewart *et al.*, 2007 en Badia, Tulla, & Vera, 2010).

Interface or peri-urban fires develop in areas where urban and forestry activities come together. The relevance of these events lies in those characteristics that put them apart from other types of fires. Interface fires bring together the need to control and protect forestry areas and the need to protect human lives, houses and other urban structures, such as industries, roads, services, etc. There is also a lack of knowledge in the population regarding the fragility of forest eco-systems which are used with recreational purposes, as well as the damage resulting from some vandalism cases (Vélez, 1995).

It is also relevant to bear these events in mind, because although it is becoming increasingly critical to identify urban-forestry interface areas, there is no clear integration among their identification, current legislation, risk perception and prevention plans (Badia, Tulla, & Vera, 2010). Due to Uruguay's territorial characteristics, it can be thought that most forest fires take place in this kind of areas – or very close to them – leading to an impact on the vegetation and on the population, as well. In the last decades, interface fires have become a critical issue for many cities in the continent, mainly in Argentina, Chile, Ecuador and Uruguay (Viegas, 1977; López *et al*., 2002 in FAO, 2006).

2.3. A review of events: international level, regional level and the Uruguayan territory.

2.3.1. Forest fires in the world.

National and international development and emergency aid organizations acknowledge the vital role that data and information hold in fighting the effects of disasters on vulnerable populations. Systematic data collection and analysis provide governments, disaster prevention and civilian protection organizations with vital information. Nevertheless, there is no international agreement yet on data collection best practices. A wide variety of definitions, methodologies, tools and sources adds up to the complexity that collecting reliable information already has.

The USA's National Aeronautics and Space Administration (NASA) daily develops maps showing the location of active fires around the world, based on spectral response observations of moderate resolution imaging (MODIS) from Terra satellite[2;]. This cartography depicts the number of fires but not their size. These events' distribution shows that some global patterns in fire maps result from natural cycles of rain, drought and illumination along the time.

According to NASA, Africa is the continent experiencing most forest fires in the world[3]. Such fires occur when vegetation gets dry and, although some of them are related to agriculture activities, they mostly affect prairie areas. There's an East-West stripe of agriculture-related fires that moves from North to South as the dry season develops. On the other hand, fires in Asia tend to take place in agricultural areas of some South-East countries such as China, Thailand and India, where major forest fires have broken out. Russia, in turn, has fires in wood areas that take longer to re-grow.

In Northern America fires are related to woods management and agriculture; in Canada's boreal forest most fires take place in the summer, as well as in Northern Europe and Asia. In contrast, fires in wood areas that go from Southern Canada to Central America are produced by lightning, negligence in urban areas and agriculture activities (Central America) (Vélez, 1999). Fires are started in the South so as to keep grazing lands in the Amazon basin and also due to agriculture and cattle breeding activities.
In Oceania, and mainly in Australia, fires take place in areas located far from populated centres and they mostly affect woods and the Savannah.

2 https://earthdata.nasa.gov/earth-observation-data/near-real-time/firms/active-fire-data

3 https://svs.gsfc.nasa.gov/10832

The Centre for Research on the Epidemiology of Disasters (CRED) in Louvain University has been developing a data base on emergency events (EM-DAT) since 1998[4]., which has become another worldwide information source. This database, which was originally supported by the World Health Organization (WHO) and the Belgian government, supplies information necessary to assess vulnerability and decision-making in disaster situations. It also helps to identify disasters that are most frequent for specific areas and that have had a relevant impact on human populations. The database consolidates information from a variety of sources, such as the UN, NGOs, insurance companies, research institutes and press agencies. EM-DAT comprises data regarding the occurrence and effects of over 22 000 disasters from 1900 to present day. 398 of those events are forest fires. According to EM-DAT's criteria an event will be included in the database if: 10 or more people have died, 100 or more people are affected, there's a state of emergency or if there has been a request for international aid. Forest fires –including bushes and pastures – are included within the climatologic natural disasters. Such fires include any sort of uncontrolled and not prescribed plant combustion or incineration in a natural environment, such as woods, bushes or tundra, where natural combustibles are burnt and fire spreads according to the environmental conditions (i.e. wind, topography). Wild fires can be started by lightning or human action.

There are wide differences between information supplied in this context – where more relevance is given to those events that have had severe consequences or are reported by some institution or press agency - and the information supplied by satellites. America and Europe hold over 57% of the recorded cases while Africa represents less than 8% (Figure 2).

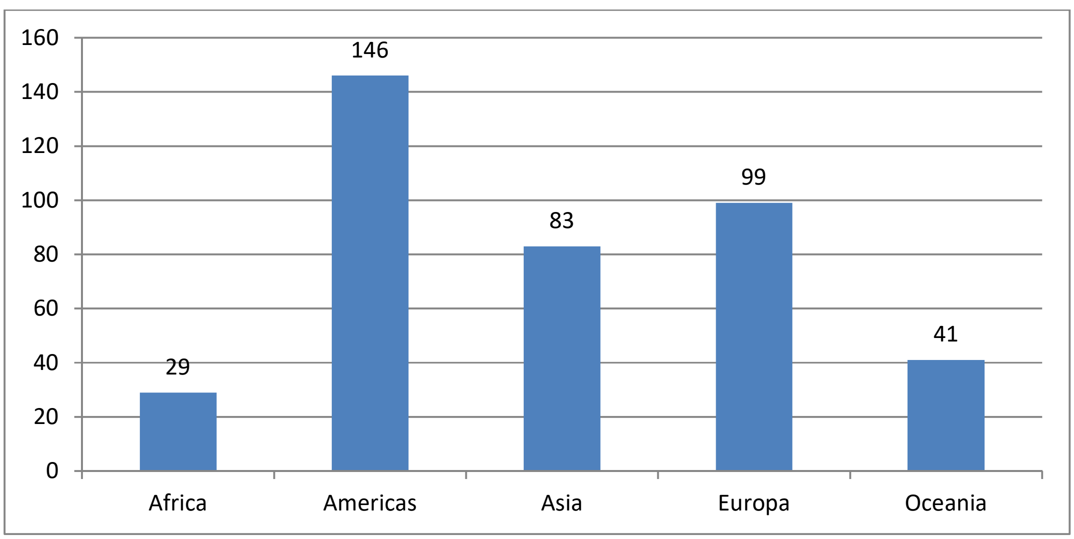

Figure 2: Forest and field wildfires by continent: EM-DAT database

4 http://www.emdat.be/

When analysing relevant events along time, it is possible to spot years when events took place in all the areas: 1985 - 7 events, 1994- 5 events, 1999 - 11 events, 2000 - 9 events, 2002 - 8 events and 2015 - 5 events. However, in some other years, fires were concentrated in some areas: 1983 - 8 cases, 1987 - 7 cases, 2003 and 2005 - 8 cases each (Figure 3).

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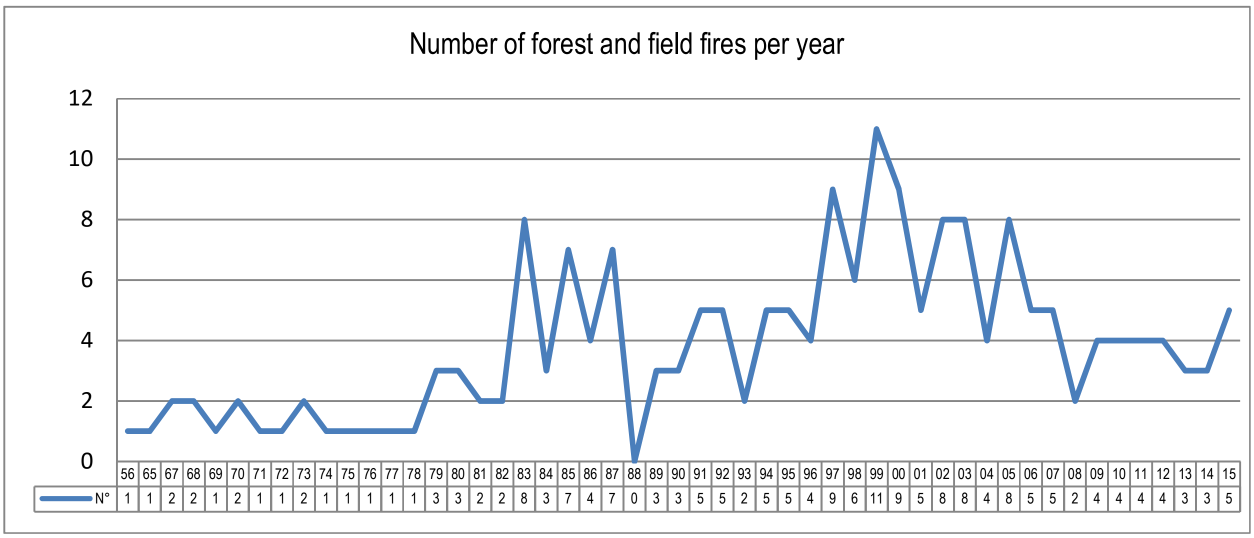
Even though forest fires take place all round Europe, the most violent and environmentally, socially and economically damaging happen in southern countries. In this context, Portugal is one of the countries with the largest burnt surface. According to Ribeiro *et al.* (2015), in the last 30 years the average forest area burnt per year has reached a 3% (CCI/UE 2010). Mandatory forestation of high lands and agriculture and grazing land areas in the first decades of the XX Century, and the fast demographic and social changes that resulted from quitting the rural practices of the 50's, have led to a higher risk of fire. As a consequence, Portugal faces an atypically high incidence of forest fires in the context of Southern Europe.



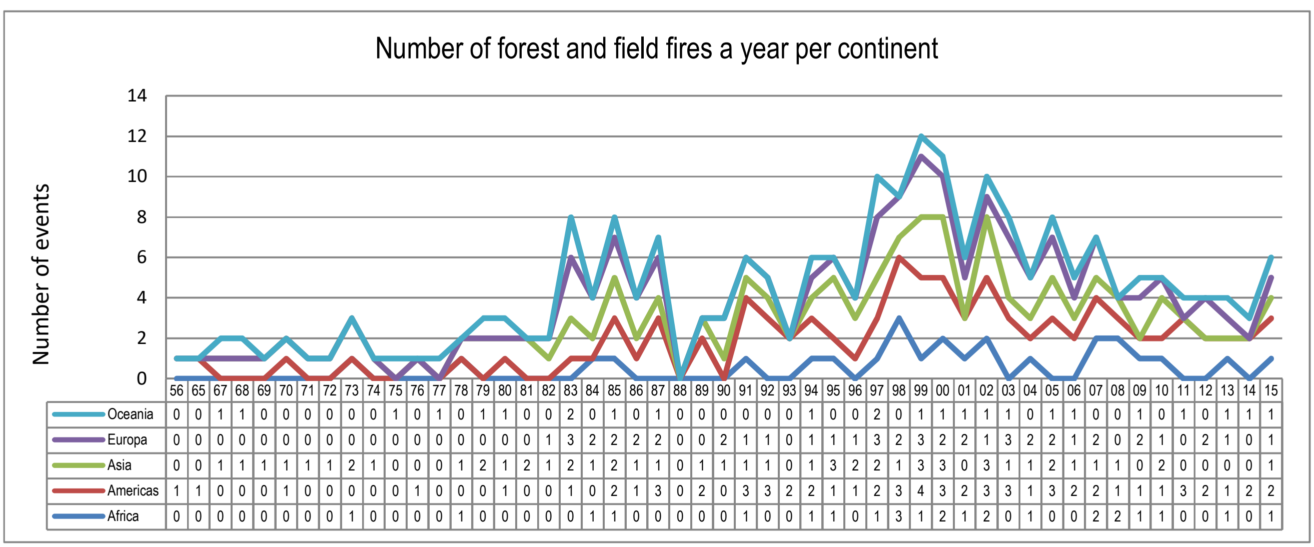


Figure 3: Forest and field fires records per year - EM-DAT database

Large-scale forest fire history does not date back long in this country and it has become increasingly visible since the early 1980s. In the last three decades there has a remarkable variation in fires, in terms of number as well as in burnt surface. From 2003 to 2005 damage was particularly catastrophic, with an area climbing from 40.000 to 350.000 hectares. Most of those events took place in central regions and, to a lesser extent, in the Algarve region. According to Mourão and Martinho (2016) -who applied a time series analysis to forest fires official data - fire-related legislation comes about as a reaction to the fire occurrence.

2.3.2. Forest fires in the South of Latin America.

Forest fires and their consequences on the environment gain special relevance in South America, where the world's largest concentration of tropical forests is located. The main concentration takes up 885 million hectares and is located in the Amazon River basin, while the Orinoco and Paraná basins hold 85 million hectares (Manta, 2007). In addition to this, there is the continent's especially large biodiversity with Brazil as the country with the greatest biodiversity in the world, Colombia as the fourth and Peru as the seventh (FAO, 2006).

Moreover, there are large extensions of warm temperate forests in more southern locations (mainly Argentina, Chile, Paraguay and the South of Brazil) as well as cultivated forests (Manta, 2007). The latter would be the Uruguayan case, where the forestry policy of the last 20 years has led to a multiplication of the country's forested area. Figure 4 shows a growing tendency in the number of fires per year in the continent. According to FAO's information (2006), 51.7 million hectares have been affected by fires in the last three decades and only in the 90's there were around 25.000 forest fires which burnt 4.3 million hectares a year. Prairies in Argentina, Chile, Bolivia and Uruguay were the most affected (20%), followed by intensively managed Savannah areas in Brazil (*cerrados*), Bolivia, Colombia and Venezuela (13%) (Figure 4; Figure 5). Regarding species, pines and eucalyptus were the most affected by fire.

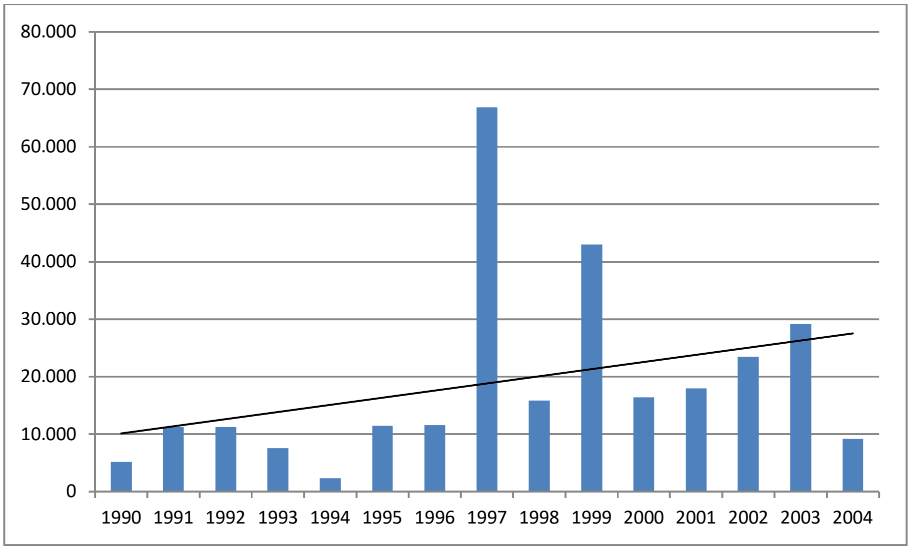


Figure 4: Number of forest fires in South America. Source: FAO

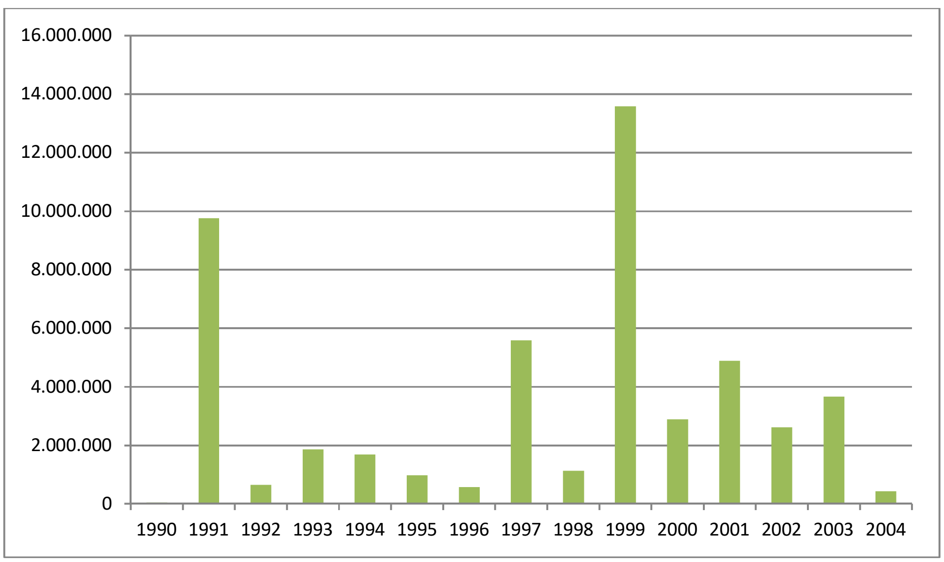


Figure 5: Number of burnt hectares in South America. Source: FAO

Fire season in the continent varies according to the dry season. In North Argentina, Bolivia, Brazil, Colombia, Chile, Ecuador and Peru fires take place mostly between autumn and winter while in South Argentina, Uruguay, Colombia, Chile and Venezuela they take place in spring and summer. Figure 6 depicts available data from the DesInventar[5] platform for the last 35 years. The highest number of fires took place in Ecuador

[5] The DesInventar platform was created by the Social Studies Network in Disaster Prevention for Latin America (LA RED). It brings together disasters' data bases for Latin America and other parts of the world.

(6 364 events) followed by Colombia (3 145). It is worth mentioning that this platform does not have available information for Brazil.

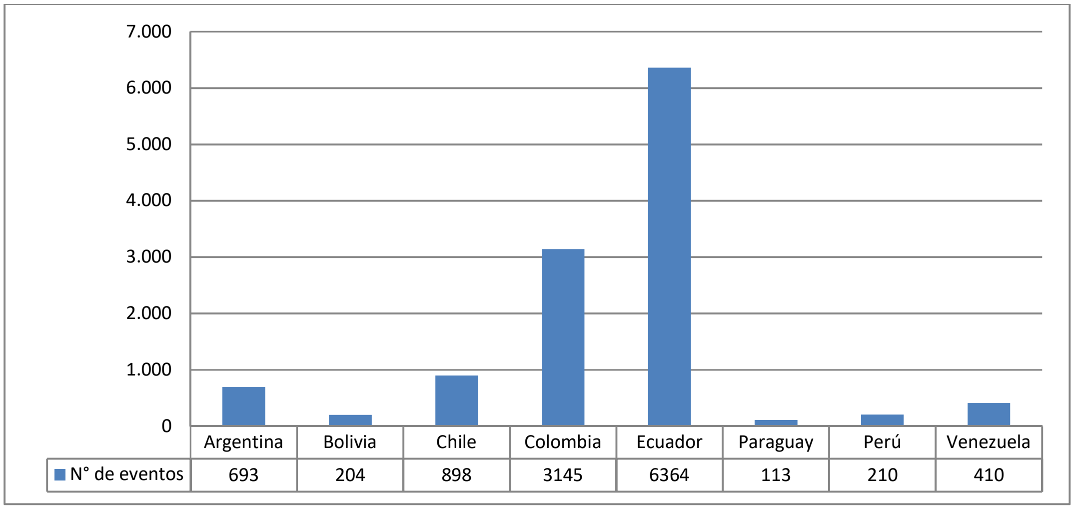


Figure 6: Number of fires between 1980 and 2015. Source: www.desinventar.org/es/.

Although Ecuador holds the largest number of fire events, data in Figure 7 shows that the major amount of affected hectares was in Argentina -7.4 million-, while in Ecuador they were just 43 000 hectares. Bolivia's case is also to be highlighted, where just 204 events burnt over 2 million hectares. These figures may be showing how vulnerable some areas are regarding fire.

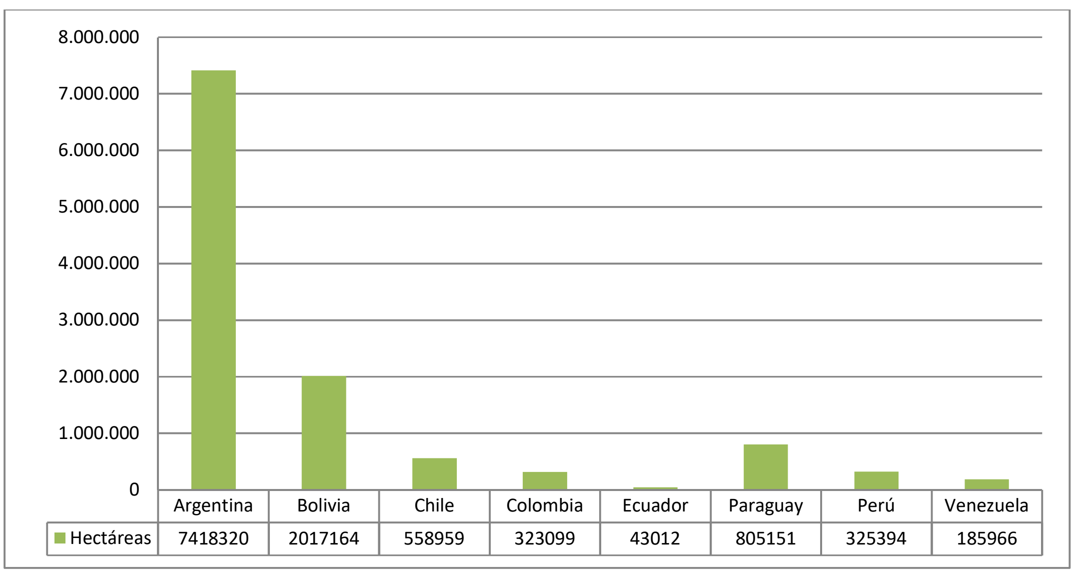


Figure 7: Hectares affected between 1980 and 2015. Source: www.desinventar.org/es/r

Another situation which stands out is that, over the last years there has been an increase in how intensively fire spreads in Argentina, where since 2007 there has been a rising tendency in the average burnt surface. 28394.3 km^2 of native forest were affected by fire between 2002 and 2014; that surface comprises around 9.44% of the total native forest in Argentina in 2001 (Egolf, 2016). Beyond the debate regarding those fires' causes –intentional or negligence, natural or derived from some activity – these events have had great impact in the media.

Kandus *et al*., (2011) states that fire is frequently used with cattle breeding and hunting purposes in the islands located in Paraná River's lower course. In 2008 that area went through an exceptional number of simultaneous fires during a tough drought period. The Directorate of Forests (Environment and Sustainable Development Office, SAyDS) estimates that the burnt surface reached over 200 000 hectares of extensive wetlands, which comprise about 11% of the Delta. Fires spread rapidly in several provinces (Córdoba, San Luis, Tucumán) in 2013, when high temperatures and strong winds added up to a vast amount of dead combustible lying on the ground. On the other hand, in 2015 the province of Chubut was affected by a destructive event which spread to 30 000 hectares of Andean-Patagonian forest; later, in the summer of 2016, there were over 30 intentional forest fires in the same jurisdiction. Some of the aforementioned situations were related to speculative interests. Although there are laws protecting the native forest and restricting the use of the land, property of those forest areas is mainly private.

As it has been mentioned previously, human activities are the main cause of those fires. It is estimated that 60% of the events in South America start when using fire as a technique to renew cattle pastures and to control plagues. In addition, 30% result from agricultural use and start as a consequence of: the expansion of the agricultural border; secondary forest burning; leftovers eliminations and scaring away wild animals. Other minor causes of fire are: hunting, festive activities -especially the use of fireworks-, negligence of tourists, and selective extraction of wood species, among others (Manta, 2007).

FAO in conjunction with associate countries developed the TCP/RLA/3010, a South America Wildland Fire Network project which has the aim of strengthening the capacity of Latin America and the Caribbean countries to control and fight forest fires. It works through a Regional Cooperation Strategy that sets up sub-regional networks of mutual aid and it was officially acknowledged by the Latin America and the Caribbean Forestry Commission (COFLAC). This Regional Strategy comprehends globally agreed implementation mechanisms, as well as work plans divided by sub-regions; in South America's case there is the Cooperation Strategy for South America to Manage Fire. This Cooperation Strategy is composed by: Argentina, Bolivia, Brazil, Colombia, Ecuador, Paraguay, Peru, Uruguay and Venezuela and it has been operating as a Work Team since 2004 under the name of South American Regional Forest Fire Network.

The concept underlying the Network's activity is that there is no effective environmental protection without a set of coherent national and international guidelines that regulate fire within different ecosystems and contribute to the correct development of a global life-support system. This network has links with Central America and the Caribbean Networks as well as with the Global Wildland Fire Network, which was set up within the United Nations International Strategy for Disaster Reduction (UNISDR-GWFN – http://www.fire.uni-freiburg.de).

In addition, Brazil is acknowledged for the development of relevant programmes, projects and activities connected with this topic, which may benefit other Latin American countries as well. One of the best regarded programmes is the Monitoramento de Queimadas carried out by the Instituto Nacional de Pesquisas Espacias in conjunction with CPTEC (Centro de Previsão de Tempo e Estudos Climáticos). This programme provides a map of South America depicting "*queimadas*" and other vegetation fires detected by a group of satellites. Data obtained from satellite imaging thermal bands are updated every three hours every day of the year. Figure 8 shows an annual summary of those detections. Pará (44 794), Mato Grosso (32 984) and Maranhao (30 066) were the states with the highest number of events in 2015.

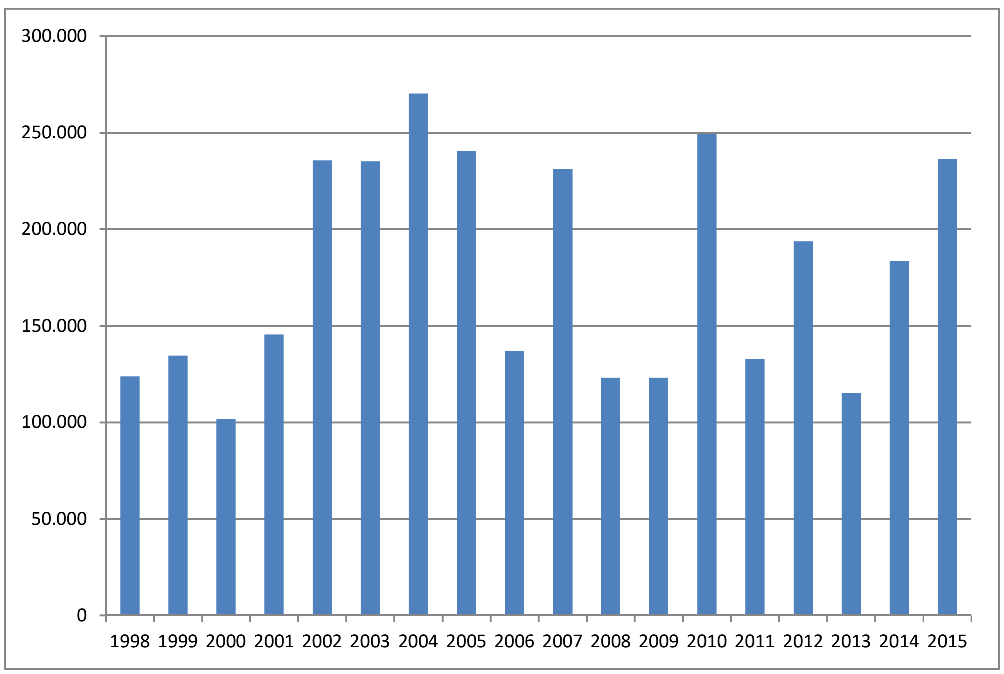


Figure 8: Number of fires in Brazil between 1998 and 2015. Source: http://www.inpe.br/.

At this stage, it is worth taking into consideration Arantes Pereira *et al*. (2012) research, carried out with the aim of validating heat focal points used when monitoring "*queimadas".* The study shows the operational limitations that the Instituto Nacional de Pesquisas Espaciais – INPE has when detecting small-sized fires. The authors conclude that minor size '*queimadas*' are less prone to satellite detection. A large number of small-sized burnt scars (below 100 hectares), imply a high omission index within the limits set by INPE's 'Queimadas' Monitoring System. The frequency of heat focal points showed that differences in spectrum, time and algorithm threshold interfere in the monitoring of burning vegetation, which in turn, leads to the need of a larger number of satellites so as to extend the information coverage. The most precise heat focal points came from MODIS-01D and AQUA products and provided guidance for the monitoring organisms' actions. Geo-technology tools showed efficiency to validate heat focal points. New research will be necessary to improve omission and commission cases (Pereira *et al*. 2012).

2.3.3. Forest fires in Uruguay.

The artificial forest in Uruguay (1 071 374 hectares) doubles the surface of the natural forest. 6.5% of the country's exploited surface is composed by artificial pine and eucalyptus forests, while 3.4% is covered by native forest (*monte indígena*) (Censo General Agropecuario, 2011). This situation is a direct consequence of the forestry policy encouraged by the 1987 Forestry Law. This law set forestry-priority areas, established protection measures for native forest and supplied forestry activities with benefits and subsidies. As a consequence, Uruguay's forested surface grew from 100 000 hectares to over one million. However, 64.3% of the country's exploited soil (10 million hectares) is covered in natural pastures. This means that in Uruguay field fires are taken into account as well as forest fires.

Even though the country does not have a specific forest fires data base, the National Emergency System in conjunction with DesInventar platform, have developed a disasters database based on press coverage of the last 30 years. Such database provides a starting point to a historical analysis of forest fires between January 1983 and May 2014.

An analysis of the information provided by this database shows that between 1983 and 2014 there were 1,260 fires in Uruguay. 889 of them were urban house fires, consequence of poor heating systems used in winter. 217 are forest fires, 60 are classified as field fires and 94 as interphase fires. This report will consider them indistinctively whether they are field, forest or interphase. (Figure 9)

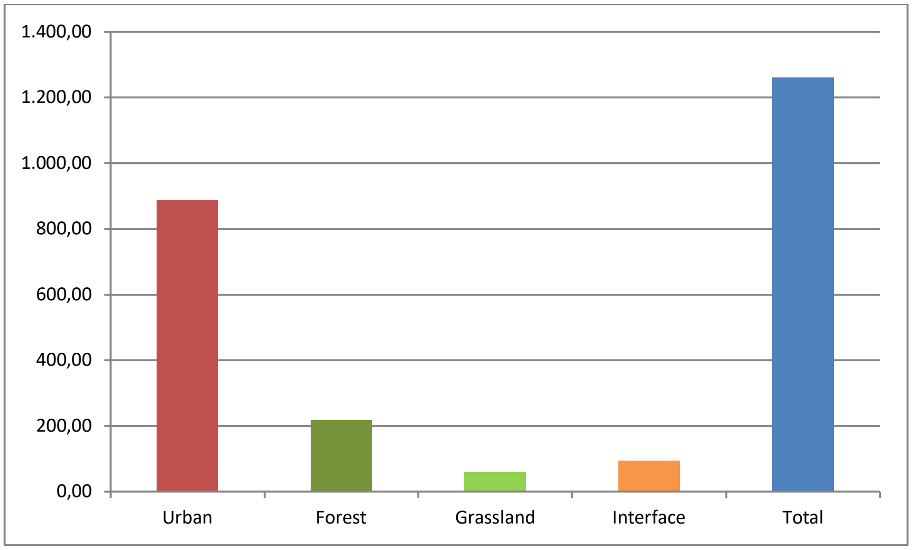


Figure 9: Number of fires recorded between 1983 and 2014. Source: SINAE

Figure 10 shows that Uruguay's amount of forest fires goes along with the tendencies found in the region and in the world. In spite of some peaks, there has been a steady increase in forest fires in the last years. Regarding surface, between 1983 and 2013 there were 74 000 burnt hectares. Figure 11 shows that the number of affected hectares has been growing together with the number of fire events.

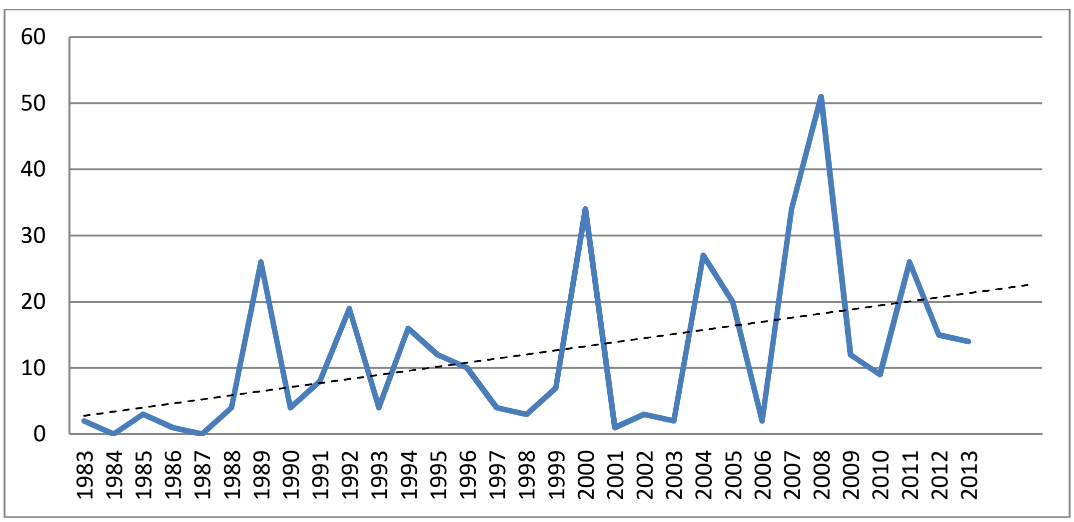


Figure 10: Yearly evolution in the number of forest fires. Source: SINAE

Regarding causes and according to the database, 51% of the fires break out as a consequence of socio-natural anthropic factors related to the interaction between nature and human beings, 32% a are consequence of anthropic-technological factors, only 9% have natural causes and 7% have other causes.

80% of the recorded fires required primary response according to the Coordination Protocol of the National Emergency System; such response was in charge of the National Fire Department, which is the proper institution in this case. All other fires demanded Departmental Response (20%) – except the Parque Nacional de Santa Teresa Fire in 1989 that required national-level response -. In these cases, the Departmental Emergency Committee (CDE) is in charge of leading the emergency through the Departmental Emergencies Coordination Centre (CECOED).

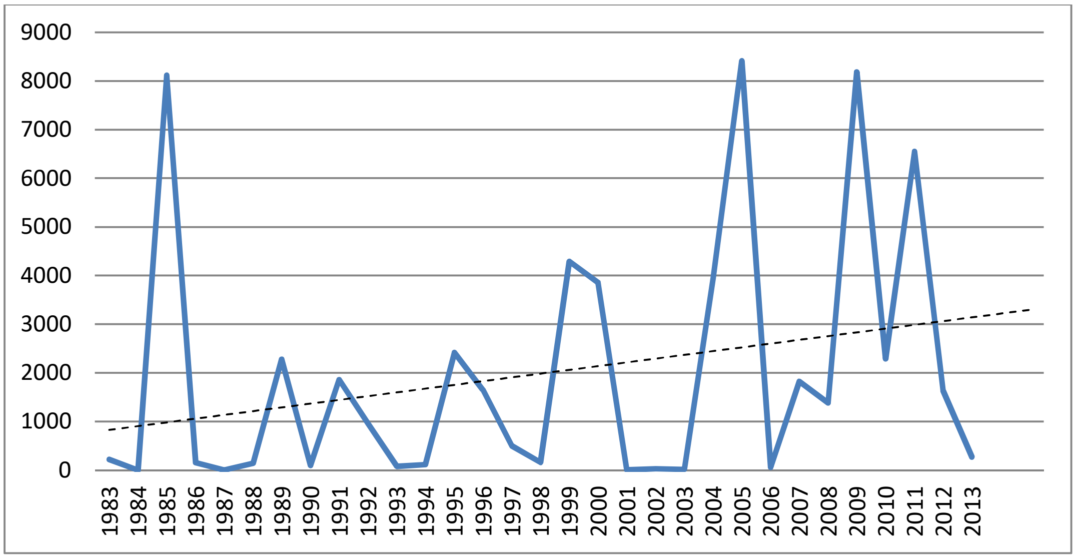


Figure 11: Evolution in the number of hectares burnt by forest fires in Uruguay. Source: SINAE

According to the database, there have been 13 deceased and 14 injured in forest fires in the last 30 years. 30 000 people were evacuated and 1 300 affected. The number of hectares burnt in forest fires (Figure 11) reached peaks in 1985, 1999, 2004, 2005, 2009 and 2011. Such peaks depict high-impact forest fires whose surface reached over 1000 hectares in all the cases. Some details that are worth mentioning:

On December 31st, 1985 there was a fire in Rocha Department, near La Esmeralda seaside resort. It was 27 km long and flames were up to 15mt high. Almost 8 000 hectares of artificial forest were lost, the whole seaside town was evacuated (around 200 people) and around 67 houses were affected.

There were several major fires in 1999:

- On December 6th there was a fire in Los Potrerillos Ecological Reserve in Palmares de la Coronilla, Rocha Department. It spread to 3 000 hectares and injured animals in the reserve.

- On December 16th there were fires in three forestry states in Paysandú, where 1 200 hectares got burnt.

On January 23rd, 2000 another major fire broke out in a Biosphere Reserve at the intersection of routes 14 and 16, near La Coronilla. It spread to around 5 000 hectares and was 8 km wide.

Around 30 fires were recorded in 2004, one of them took place in Rio Negro Department and it was a major event, reaching around 1 200 hectares.

17 fires were recorded in 2005. One of them took place in Parque Nacional de Santa Teresa and Punta del Diablo, where around 4 984 hectares were burnt, 15 houses destroyed and around 4580 people needed to be evacuated. That same year another major fire broke out in Amarillo, Rivera. There, 1 300 hectares were burnt and 250 of them were native forest.

Even though there were a lower number of fires in 2009, one of the largest pyrotechnics-caused fires in the country took place in that year. It happened 30 km away from Salto Department's capital city on January 1st. As a consequence, around 6000 hectares were burnt, and electricity wire lines and columns were damaged.

Finally, on December 22nd, 2011 there was a 4 200-hectare fire in Punta del Diablo and, on December 11th of the same year a field fire near Vichadero village, Rivera took up around 1,200 hectares of productive land. On the other hand, it can be observed that the fires' location in Uruguay bears no direct relation with the location of forested areas. Figure 12 shows that the highest number of these events for a 30-year period took place in the South-East region of the country, ranging from the Rio de la Plata coast to the Atlantic coast. 57% of the fires in that period happened in Canelones, Maldonado and Rocha, where only 13% of the forested surface in the country is located (2013 Censo Agropecuario, MGAP, 2016). However, 50% of the country's forested areas are in Departments in the North and on the West coast, where there are low rates of fire occurrence.

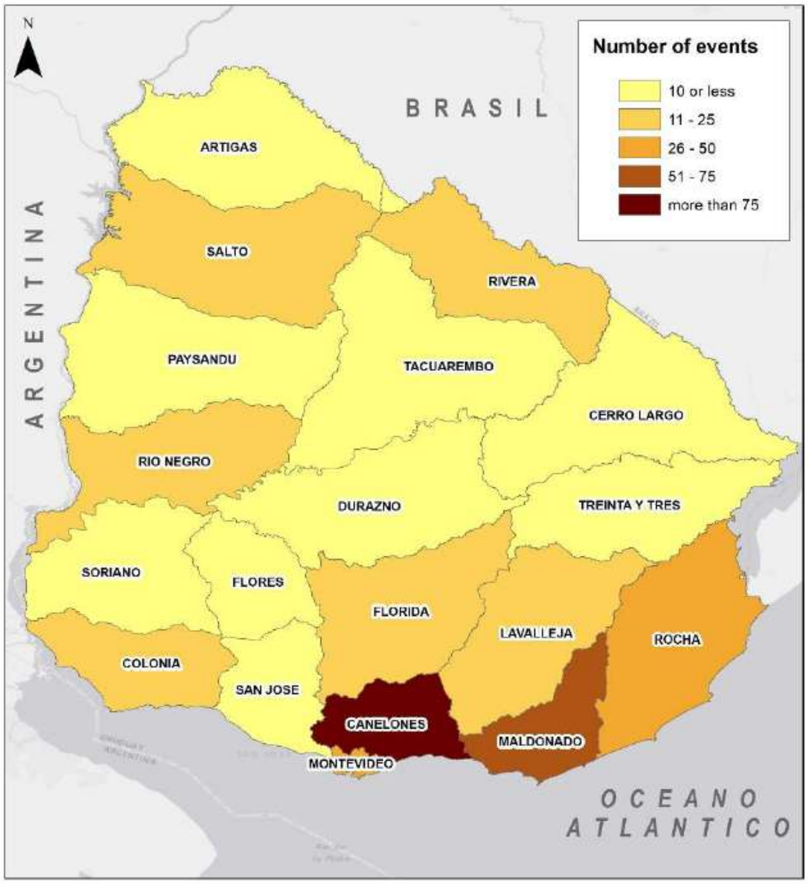


Figure 12: Amount of forest fires per department between 1983 and 2013

What is more, 80% of the fire events take place in the summer season, between December, January, February and March. This adds an extra matter of concern, as forest fires occur in the tourist season and in a region of crucial economic relevance for the country.

Regarding the amount of hectares affected by forest fires Figure 13, the distribution pattern does not seem as clear as the frequency's. It is worth mentioning that the number of hectares affected bears relation with a variety of elements that come together at the moment of the fire: its intensity (determined by the quantity of combustible material available), meteorological conditions, human control capabilities, among others. It is therefore hard to identify clear patterns due to such variety.

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Nevertheless, considering the location and attributes of the fires in Uruguay, it is possible to divide them into two large groups with specific characteristics and connotations, mainly because of their impact on economic activities: one group that impacts on productive activities and the other on tourism activities. As a consequence, the country's Centre and North regions are characterized by field fires related to agriculture and cattle breeding activities, while the South and East coasts, where seaside resorts and parks are located, concentrates fires in tourist and recreational forests.

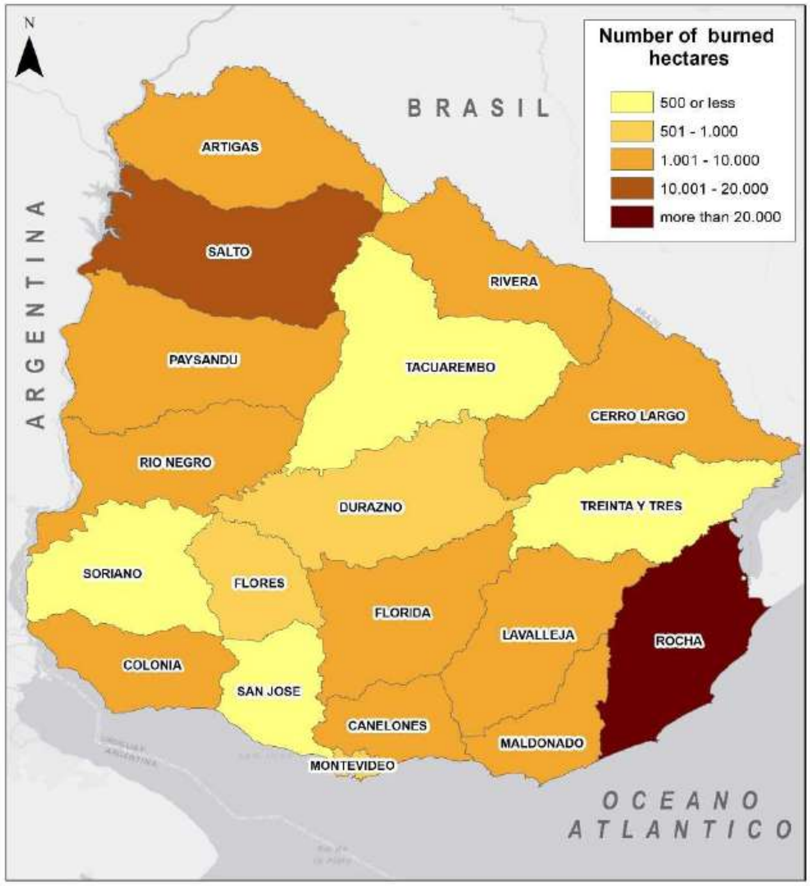

Figure 13: Number of hectares affected by forest fires per department between 1983 and 2013

2.4. Discussion and conclusion.

Uruguay is part of a local as well as regional growing tendency in forest fires that comes as a consequence of global change, climate change and cyclic-climatic circumstances –such as the South Oscillation (ENSO). These events' threats and vulnerabilities include changes in soil's use and coverage along with changes in ecosystems. In Uruguay, as both events come together –and especially the latter - they bring about forest fires that take place not in densely forested areas, but in regions that are not managed according to their high-pressure usage requirements and to the climate variables that promote forest fire risks.

A key element when analysing and assessing tendencies for these events, is having the possibility to access reliable, standardized and suitable information, in order to carry out a detailed analysis of the events at a planetary level. We are currently very far from having information to be shared across institutions and countries, due to a lack of common standards when reporting these events combined with a variety of methodologies used to prevent and support the topic. Latin America lacks shared and interoperable information systems, and countries use a variety of methods to approach and record these events. There are cases, such as Uruguay's, where the State does not have a forest fires database, which turns the national and local media into the main source to record them. Even though this information may be valuable in terms of dating the event, there is other crucial data, for instance: location, damage, burnt area and other specific characteristics, which may be questionable.

Integrating Geographic IT systems seems to be a thorough and efficient alternative to collect systematic information, analyse risk and develop more efficient control and prevention tools. However, not every country can access and use these tools because of poor skills for their management, or because they do not fit due to scale matters. It is also crucial to delve in the analysis of interphase fires, as they seem to be the most prejudicial to Uruguayan society and territory. This shows how necessary it is to keep strengthening forest fire control and prevention measures by developing technical means of analysis as well as by raising awareness in the population.

In connection to this topic and according to available information, the Sendai Framework for Disaster Risk Reduction 2015-2030 states that the extent up to which people and goods are exposed has been growing faster than their vulnerability has decreased. This has brought about risks as well as a constant increase in disaster-related losses. And, in turn, it has had considerable short, medium and long-term impact on the economic, social, health, cultural and environmental spheres at a local and community level. This document underlines the relevance of: adequate and reliable information; a larger number of early warning systems regarding multiple threats; accessibility of people to disaster risk assessments.

The document also reinforces the idea that to apprehend disaster risk it is necessary to collect, analyse, manage and use adequate data and practical information, making sure it reaches users according to their needs. In addition, it states how fundamental it is to access reliable data in real time, to use space and in situ information, including Geographic Information Systems, and to make use of technological innovation in information and communications to analyse and communicate data.

CHAPTER 3 FORESTRY IN URUGUAY

3.1. Introduction

Uruguay's economy has been historically based on agriculture and livestock production, and this has impacted on the country's natural resources, ecosystems and landscapes. The territory's main grassland ecosystem, with scarce presence of trees, mostly in the shape of gallery forests, hill forests, riverine forests and palm tree forests, has been deeply transformed by cattle growing first, and more recently by some intensive practices such as forestry.

There have been two stages in the introduction of exotic tree species in Uruguay: the first one, and closer in time, took place by the end of the last century and it was brought about by the development of a forestry model based on foreign design. The second one developed in the early XIX century, and had varied objectives, such as sand dune fixation, land subdivision and real estate speculation. The former process spread in most of the country's territory, while the latter, the oldest one, was concentrated on the Rio de la Plata and Atlantic coasts. These two different stages in implanting foreign tree species had different purposes and locations and, as a consequence, generated different kinds of transformations. There are areas where both processes developed, and their effects coexist. However, it is possible to appreciate a kind of foreign and mono-specific forestry of remarkable growth in the last years, and an older type of exotic forestry, which was introduced with the aim of fixing large dune extensions so as to develop urban areas.

This chapter will firstly focus on the forestry process that takes place at a national level and acts as a structuring phenomenon, and secondly it will center in the situation of forestry in the Atlantic coast.

3.2. Forestry as an activity to restructure the national territory.

In the last decades, forestry has been through an important process of growth in South America, especially in the most southern parts of the continent: Argentina, Chile and Uruguay. In Uruguay, specifically, the forested area has grown twice its size in 15 years (Figure 14). Such growth was encouraged and supported by the 1988 forestry policy. That policy has been subject to modifications and strong controversy has arisen regarding its environmental and economic effects. The forestry industry went through a restructure process in the 90's, which resulted from a series of corporate mergers and acquisitions. By the end of that decade, direct investment in the forestry industry was estimated in around 60,000 million dollars. Moreover, national investment prevailed over foreign direct investment and production was mainly oriented to developed countries industries (Alvarado, 2009).

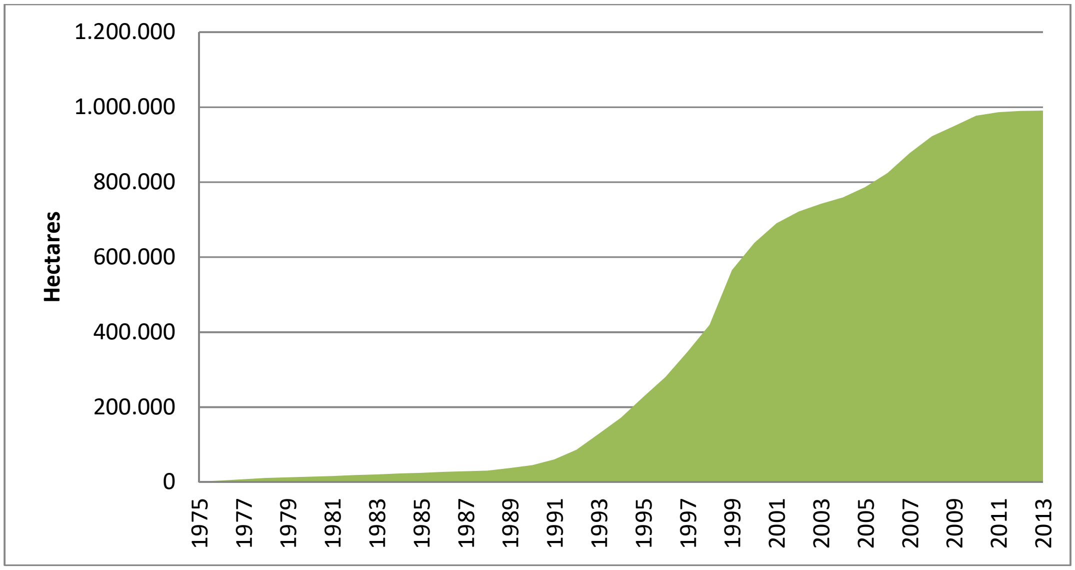

Figure 14: Accumulated forested hectare
Source: Dirección Nacional Forestal (National Forestry Office)

Some authors take this advance in forestry as a stage in the transnationalization of capitals known as 'forestry imperialism'. Such stage is seen as part of some kind of 'forestry geopolitics' outlined by the great pulp and paper companies in Northern countries that tried to impose a forestry development model to developing countries so as to satisfy their demand (Carrere y Lohmann, 1997). When facing such increase in demand, large corporations in the developed world needed to outline an international forestry strategy where a part of their productive activities were relocated. According to Alvarado (2009), even though some countries in the region already had local forestry development plans, those became fully successfully when their interests met the great international forestry corporations' strategies.

A growth in the use of cellulose come along with a rise in environmental awareness in European developed countries, giving birth and strengthening the green parties; this, in turn, resulted in regulations to protect natural forests against their depletion. The 80's environmental concerns meant that forestry production concentrated in implanted species rather than exploiting natural forests. In the beginning, productive countries tried to reforest, after that, they moved to other European countries, such as Spain and Portugal and finally they searched for better locations from an economic as well as from an ecologic point of view.

An increasing need of raw materials encouraged the development of the first pines and eucalyptus plantations that substituted native forests in Southeast Asia (Indonesia and Thailand), Central America (Costa Rica and Honduras) and Southern South America, especially in Uruguay.

There are some specific characteristics to the Uruguayan forestry development when comparing it with nearby countries. It is the only country where this activity had no previous relevance (there were less than 10 small companies that planted for the local market and two small pulp and paper plants) and where the foreign companies have been paramount to the country's recent development. The forestry policy produced a revolution in Uruguay's countryside, as it made it possible to build up a forestry development process from scratch. The plantation goals set for the first five years were easily exceeded and the forestation process kept growing until the end of the 90's. After that, it slowed down as a consequence of the crisis that took place in the region and later it recovered, to continue growing but more moderately. In 2012 there were 990 030 forested hectares, which means 31% of forestry-priority soils and 6% of the country's agricultural and cattle breeding surface.

3.2.1. Uruguay's forestry policy.

Alvarado (2005) states a number of characteristics regarding Uruguay's forestry policy:

- It was strongly supported by the State, that provided a legal framework as well as adequate material conditions for the investments;
- it generated strong debate in technical-academic spheres as well as in the society, regarding economic as well as environmental matters.
- it attracted strong private –and mostly foreign – investments along its primary stages, as well as in the transformation stages and forestry services.
- It brought about major territory transformations in forestry regions as well as in areas distant from them

Despite a decreasing tendency in the State's participation in productive activities, the design, implementation and funding of the forestry policy have not followed such path. What is more, the State has played a crucial role regarding this policy. The legal framework comprises: a framework law (Forestry Law Nº 15939), which was unanimously passed by the end of 1987; the article 45/Law N°16002 (Public Investments Plan) and a set of preceding decrees. This legal framework sets forestry priority areas and species, as well as the economic benefits that those fulfilling the legal requirements would be conferred. In addition, it states the need of the Forestry Office (Livestock, Agriculture and Fishery Ministry) to elaborate five-year forestry plans. The most relevant benefit to forestry is a subsidy to plantations: a 50% refund of the plantation's presumed costs to those planting in forestry-priority land (using a previously approved management plan) and able to demonstrate that 75% of their plants have rooted.

As the speed at which plantations grew was higher than expected, the State was not able to fulfil the payments in due time and this generated debt with the producers. The subsidy's amount began decreasing in 2003 until it completely disappeared in 2007. Besides the subsidy, producers had other benefits, such as, exemptions in supplies imports taxes, in rural property taxes and in rural income tax. In addition, the State bank (Banco de la República Oriental del Uruguay) approved those loans with beneficial conditions.

Even though forestry development plans are usually encouraged by the State, in Uruguay's case such encouragement was widely generous, making it easier for foreign companies to set up in the country. What is more, the State took responsibility for the transport infrastructure necessary for the forestry business. According to Alvarado (2005), the Uruguayan State not only funded but also guided forestry development by defining priority areas and species and by supplying training and technical update courses. However, there was not an explicit or implicit State policy with the aim of adding value to forestry production. Every initiative towards wood processing has been private and the State has only granted benefits to companies, without guiding them towards a specific industrial model.

3.2.2. The evolution of forestry.

During the 60's, and fostered by the Alliance for Progress Programme, Uruguay set out in an ambitious planning endeavour. With that objective, the government created the Technical Assistance Office for Investments Commission and Economic Development (CIDE), which worked in agreement with policies from the Economic Commission for Latin America and the Caribbean (CEPAL) (Garcé, 2011). The first forestry plans were then created based on assessments that defined priority regions to set up plantations. The Forestry Development Programme was drawn up in 1963. It had a series of objectives that resulted in two concrete actions: the creation of the Forestry Office within the Livestock and Agriculture Ministry (1964) and passing law N° 13.723 to encourage plantations (1968). Such law did not result as expected and was eventually repealed in the mid-80's (Alvarado, 2009).

Seven years later, with the passing of Law Nº15,939, the National Forestry Plan came about, setting a 50% refund of planting costs, tax exemptions and beneficial funding from Banco de la República Oriental del Uruguay. Many of the aforementioned benefits were cancelled in 2015, while silvopasture began to be fostered along with the production of quality woods.

The private sector has played a key role along since the beginning of this process and up to the current industrialization stage. Originally, there were three major foreign companies: "Empresa Nacional de

Celulosa de España" (ENCE) (Spain), "Forestal Oriental-Botnia" (Finland) and "Weyerhaeuser" (USA). These companies went through several stake restructures by internal transactions, mergers and third-party acquisitions. The 2007 international recession as well as conflict situations with Argentina had an impact on this process, and in May 2009 ENCE sold most of its Uruguayan operation in 340 million dollars to a joint venture made up by "Arauco" (Chilean) and "Stora Enso" (Swedish-Finnish).

"Montes del Plata" forestry company was set up in 2009. It run on equal stock from both head companies and its business objective was producing and exporting cellulose pulp to major markets worldwide. With strong investments in technology, research and plantation improvement, the company has achieved a sustainable forestry base so as to supply its state-of-the-art pulp mill located near Conchillas village, in Colonia Department. The company owns forested lots in 11 departments in Uruguay. The "Montes del Plata" Industrial Complex is located in Punta Pereira port (Colonia Department) and includes: a state-of-the-art pulp mill, a biomass energy-generation unit and a port terminal for exporting cellulose and receiving supplies.

On the other hand, the American-owned company "Weyerhaeuser" was set up in northern Uruguay in 1996. It planted 127 000 hectares of pine trees for mechanical transformation (sawing, board production, etc.) and built two industrial plants. This year the company sold their industrial operation and forested lots in US$ 402,5 million to Timberland Investment Group, that belongs to the Brazilian investments bank BTG Pactual. This was the second largest acquisition for a company located in Uruguay, after UPM took over Botnia in 2009, for US$ 2 400 million.

Finnish capitals also set up in Uruguay in 1990. First, Forestal Oriental (subsidiary of Shell) planted eucalyptus; after Shell's withdrawal from the market, and under the name of Botnia, the company launched an industrial investment plan. The group has forested around 100 000 hectares with eucalyptus and has built a pulp mill and a port terminal on Uruguay River shore, with a 1100 million-dollar investment. Two years after the pulp mill started working, one of company's business partners –the Finnish UPM – bought the company's complete stake within a world expansion strategy. By mid-2016 UPM communicated its interest in setting up a new and larger cellulose industrial project in the central region of the country. As a consequence, the investments in infrastructure that would be required and the potential environmental impact that the project would bring along, have raised political as well as social conflict in the country.

At this stage, it is worth mentioning the 'Uruguay-Finland agreement for investment promotion and protection' which was passed by the Legislative Power in 2004. This agreement was a requirement stated by Botnia in order to go ahead with the investment in a pulp mill. Based on the principles and guarantees of Investments Law, the agreement states mutual cooperation and protection to secure of each participant country's investments on the other one's territory for 20 years. A controversial issue is raised as the

Uruguayan State acts as guarantor regarding any losses the Finish companies may experience and also the fact that those companies may not be expropriated or nationalized. Another direct benefit has been conferring the locations of UPM and Montes del Plata pulp mills the quality of Free Trade Zones.

According to the Executive Power's resolutions, such decision is based on the Free Trade Zone Law (Nº 15921). The law states that 'the promotion and development of Free Trade Zones is declared of national interest with the aim of promoting investment, expanding exports, increasing the use of local work forces and fostering the international economic integration' and (…) 'the benefit of promoting, within an exports promotion policy, the set-up of high specialization and industrial technology economic hubs in the country's provinces'.

3.2.3. Impacts on the production and effects in the territory.

Milton Santos' (1998) classical conceptualization regarding the geographical space as the support of the fixed and the flowing, as well as the productive forces and movements they bring about in a material and immaterial flow, may be applied to the development and later exploitation of forests, as it deeply changes the geographical space's use and appropriation as well as the resulting space configurations (Alvarado, 2009). Forestry has fixed as well as geographically flowing space components, and they are both strongly related. Forest plantations mean a strong transformation in the territory. The presence of large monospecific forested areas has fragmented and changed the landscape, sometimes by substituting native forests and in other cases by covering up grasslands.

The arrival of large, global and hierarchical corporations brings about a transition in the use of the soil, going from family farming to forestry; this, in turn, means changing from a traditional extensive approach to a business-oriented and more technological one, integrating new and unknown rural practices. In addition, the fact that the strongest impulse to forestry came from foreign companies, gave rise to a process of increasingly foreign land ownership.

Those changes in land use also implied movements in the rural population and daily commuting from towns to plantations, as most forestry workers live in towns and are hired by companies that shift their activity from one forested area to another. Riella's research (2008) verified that from 1985 to 2004 forestry did not expel rural population. Rural population located in forestry-influence areas decreased less than rural population in non-forestry areas. However, forestry work is mainly outsourced and brings along high levels of informality and poor work conditions, regarding wages as well as risk.

On the other hand, forestry entails an important flow of heavy-load transportation that has several types of impacts on the territory. First of all, wood transportation is usually highly damaging for the rural road network as it concentrates a constant flow of heavy transportation in short periods of time. These loads also require large storage space, generally located in periurban areas or in ports. The industrial phase also has an impact on the territory, especially in the case of pulp mills, as they are larger and more complex than the plants that process wood mechanically. Along their building stage, the plants produce a constant flow of workers and loads, and they also require a series of infrastructure works to become accessible and to extend their services' network. Such works are sometimes carried out by the State and in other cases by the companies themselves. In 2016 the government began assessing positively a project to set up a third pulp mill in the central region of the country. It would mean an investment of around 5 000 million dollars and would create about 8 000 direct and indirect jobs to people and local companies. The territory is experiencing a new push.

It is in this context that the CPA Ferrere Consultant (2017) report is presented for the Ministry of Livestock, Agriculture and Fisheries; it confirms that forest production in Uruguay includes one million hectares planted and generates 25.000 jobs in 1.750 companies. According to this study, this activity contributes an annual average of 1.500 million dollars in exports and 280 million in taxes. In 2016, forestry sector exports included pulp, wood and wood products, and paper and cardboard. This figure represented 17.5% of the total exports of goods and placed it as the second most important productive chain behind meat. For this year, the forestry chain generated 3.6% of GDP, and two thirds of that value is directly associated with the added value produced by the pulp production chain. Estimations made by CPA Ferrere report show that the sector generates at least 25 thousand jobs, including direct, indirect and induced jobs, and at least 50% of these sources of employment are generated by outsourced and forestry companies' suppliers. According to information presented in the framework of this study, the forest chain involves 1750 companies, and 93% of them are micro and small companies. Thus, the study concludes that the forestry chain allows a better use of the land resource since employment, value added, and exports of the sector expressed per hectare are higher than the alternative uses of the land.

However, for others, forestation has proven to be a deficit activity in terms of generating jobs. Ricardo Carrere (2002) of the NGO Grupo Guayubira, states that the few jobs that were created in the sector were made at the expense of those that were lost in the activities which were replaced. According to official numbers, forestation generates fewer permanent jobs than extensive livestock farming, considered until now the most inefficient in terms of jobs generated per hectare. On the other hand, most of the jobs generated are equal or worse quality (both in terms of wages and working conditions) than the jobs it replaced. Illegal work, temporary, itinerant, semi-slave, dangerous, with terrible conditions of salary, accommodation, food and health, are the common characteristics in terms of employment in the forestry sector; defines this change as a total failure.

Alvarado (2009) also mentions that the change in land use implies the displacement of the rural population while generating inverse daily mobility, that is, from the villages towards the plantations, since most of forest workers go to live in the towns and they are hired by companies that rotate their activity from one plantation to another one. Outsourcing forestry work is high, which is associated with a high informality level, and consequently, poor working conditions, both in terms of wages and occupational risks. The author then adds that, on the other hand, the forestry sector generates important cargo flows that have a different impact on the territory. In the first place, the transfer of wood is usually highly damaging to rural roads, as it involves a very heavy and concentrated permanent traffic in short periods, which generates costs that are usually borne by the State. In the following tables you can see the employed labour force according to the intensity of the activity according to the 2011 Agricultural Census (Table 1; Table 2).

Table 1: Plantations with forestry as main source of income: number of holdings, area used, surface with artificial forests and employed labour force in 2011 (census year) according to intensity of forestry

Forestry activity intensity *	Number of plantations	Forestry planted area (ha)			Employed labor			
		Total	With planted forests		Permanent	Temporary (equivalent-man) ***	Total	For every 1.000 ha
			Hectares	(%) **				
Total	785	1.243.508	703.197	56,5				
Less than 45%	212	316.521	100.838	31,9	398	5	403	1,27
From 45% to 65%	261	490.148	274.550	56,0	813	159	972	1,98
More than 65%	312	436.839	327.809	75,0	676	118	794	1,82

* Expressed as a percentage of the used area.

** Percentage calculated respect to the total number of hectare in each section.

*** 200 hired wages of temporary workers are counted as 1 equivalent-man. Source: MGAP

Table 2: Commercial farms: number of farms, harvested area and employed labour force in 2011 (census year), as main source of income from the exploitation

Income source	Number of plantations	Forestry planted area (ha)	Employed labour force according to the census year							
			Workers				Wages			
							Total		Buy plantation plot	For every 1.000 ha
			Permanent	Temporary (equivalent-man) *	Buy plantation plot	For every 1.000 ha	Quantity **	(%)		
Total	41.356	16.308.971	110.048	9.685	2,9	7	23.946.678	100,0	579	1.468
Forestry	785	1.243.508	1.887	282	2,8	2	433.703	1,8	552	349
Citric agriculture	282	42.073	1.551	2.948	11,0	74	899.890	3,8	3.191	21.389
Other fruit trees	725	22.945	2.249	1.532	5,2	165	756.107	3,2	1.043	32.953
Vineyards	719	21.306	2.451	573	4,2	142	604.809	2,5	841	28.387
Horticulture	2.711	50.675	7.168	1.093	3,0	163	1.652.248	6,9	609	32.605
Cereals and oilseeds (rice not included)	2.457	1.740.620	8.266	1.301	3,9	5	1.913.395	8,0	779	1.099
Rice	353	420.624	2.625	288	8,3	7	582.640	2,4	1.651	1.385
Cereal seeds and industrial crops	56	23.422	249	15	4,7	11	52.728	0,2	942	2.251
Forage seeds	55	6.097	102	2	1,9	17	20.766	0,1	378	3.406
Seedlings	56	1.440	249	13	4,7	182	52.430	0,2	936	36.410
Cattle for meat	23.568	10.890.880	55.886	1.194	2,4	5	11.416.018	47,7	484	1.048
Dairy cattle	4.221	826.379	14.734	191	3,5	18	2.984.968	12,5	707	3.612
Sheep for meat and wool	2.912	840.299	6.013	140	2,1	7	1.230.698	5,1	423	1.465
Horses livestock	266	31.720	667	7	2,5	21	134.871	0,6	507	4.252
Pig livestock	633	11.825	1.400	9	2,2	119	281.827	1,2	445	23.833
Poultry	546	13.139	2.310	40	4,3	179	470.049	2,0	861	35.775
Other animals	224	16.115	441	11	2,0	28	90.308	0,4	403	5.604
Sale of agricultural services	439	79.092	1.069	38	2,5	14	221.380	0,9	504	2.799
Agrotourism	36	4.368	140	2	3,9	32	28.303	0,1	786	6.480
Others	312	22.444	591	7	1,9	27	119.540	0,5	383	5.326

* 200 hired wages of temporary workers are counted as 1 man-equivalent.

** It is the sum of the permanent and temporary workers columns multiplied by 200 (this value is a statistical coefficient).

3.3. Forestry in the coastal area

Vegetation is paramount to coastal areas, especially for the dynamics of sandy beaches. According to Panario and Gutierrez (2005) this is a positive interaction when considering the role of natural vegetation in building up primary dunes. However, it may turn negative if forestry or exotic species interrupts the natural flow of sediment between dunes and beaches or between dunes and river mouths. These authors state that there are wide coastal areas where native forests have been lost and others where exotic forestry has interrupted the sand's pass, resulting in a continuous retraction of the coastal line. This has led, in turn, to narrowing the coastline and damaging its associated structures.

Dunes located near large watercourses started being forested in Uruguay in the 40's. This decision may have played a critical role in the erosion process of beaches. Such forestry actions were usually associated to infrastructure development, such as building coastal boardwalks, streets, walls, etc. which ended up cutting the supply of sediments necessary in the sand cycle.

3.3.1. Forestry with exotic species.

The dynamics of the Uruguayan coastal area have been through meaningful change as a result of a series of actions. Gutierrez (2010) highlights the impact of sand extraction processes and forestry and urbanization on the beaches and coastal dune systems. The author relates these events with a high retention of circulating sand and with the erosion and retraction of the beaches coast line. Research in the conservation of riverine forests focuses on the negative impacts that exotic-species forestry–such as pines and acacias (*Pinus spp*. and *Acacia longifolia*) – has on the coast and its native vegetation. Mobile dunes get fixed and the coastal ecosystem becomes fragmented and reduced, limiting the original vegetation to relictual areas (Campo *et al*., 1999).

Along the decade of the 30's, forestry on the Atlantic coast had the objective of fixing mobile dunes so as to divide them into lots to be sold later. Real Estate operators offered beautiful beaches and plentiful fishery possibilities, as well as some tourist infrastructure that in some cases has not even been built, yet. This process intensified in the 40's when beach lots were sold, and new routes were built.

As the coast was taken up for recreational and permanent housing purposes, dunes were seen as an obstacle to progress. It was therefore decided to eliminate them by massive forestry. Such forestry was carried out using exotic species, such as acacia trees, walnut trees and cypresses. Dunes were also fought in the 70's, as they were considered sterile and unproductive. This made large sandy areas in Punta del

Este, José Ignacio and Santa Teresa a thing of the past, as it had already happened in Cabo Polonio in the 60's.

In those years, the building of route 10 brought along forestry and urbanization, shaping the image of what would eventually become the typical summer resort. Dune areas were changed into pines, acacias and eucalyptus forests. As a consequence, the fauna changed, and native forest areas received invading species that degraded their quality.

The Parque de la Reserva Forestal clearly reflects the frame of mind of that time. It was created by decree on 16th September 1942 and it is located on km 261 of National Route 10, 'Juan Díaz de Solís', around 30 kms from Castillos city, 64 kms from La Paloma city and very close to Cabo Polonio. It is a 3 600-hectare surface that between 1960 and the beginning of the 80's was forested with Pinus pinaster with the aim of stopping the dunes. However, the area was not taken care of after the initial forestation stage. Nowadays, it still controls the dunes and it also works as a vegetation curtain to protect nearby forested areas from oceanic winds.

Recent assessment in this area has shown that there are health issues as well as uneven diameters due to the high density and competition. It is mandatory to regulate growth, improve health and reduce the fire risk that results from high mortality together with waste falling from standing trees. This would supply relevant intake for the Reserve's fire protection system (Carro & Iglesias, 2014). This area has recently been stated as Protected Suburban Land by Rocha's City Hall Coastal Ordinance (Art. 14.5, Decree 12/03).

The land-occupation process described before has recently incorporated productive forestry with all the changes it brings along. The most important Forestry Development area in Uruguay's Eastern region is located near route 9 and belongs to Forestal Atlántico Sur (FAS). The company began operating in 2006 and it is a Uruguayan-Chilean partnership with international experience in trading and supplying woods to the cellulose industry. Its core business objective is managing forested areas to produce eucalyptus (Eucalyptus spp) and other secondary species to supply the wood industry. The company states that its forestry plantations integrate other uses of the soil and fulfil the FSC (Forest Stewardship Council) certification standards.

3.3.2. The presence of protected areas.

The study area stands out due to its biodiversity that makes it an extensive genetic reserve of reptiles, amphibians, mammals and birds. Its ecosystems comprise native fluvial forests, palm tree forests, wetlands, riverine forests and grasslands within a relatively small area and located among a chain of coastal lagoons, beaches and rocky headlands. It is the area with most environmental protection and conservation regulations in the country. The Reserva de Biosfera de Bañados del Este (Bañados del Este Biosphere Reserve) – approved by UNESCO in June 1976 - is also situated within in this area. The Bañados del Este lands along with the Altantic coastal strip were registered as a Ramsar area, being the first Uruguayan site to be included in the list of Wetlands of International Importance.

Law 17234 was passed in 2000 after a lengthy national debate. This law states that a National Protected Areas System (SNAP) configures a core tool for planning and managing protected areas. The Biological Diversity Agreement that frames the law was ratified in Uruguay in 1993 by Law Nº 16,408 and by the Environmental Protection General Law (Nº 17.283). SNAP currently consists of 14 areas (279 516 hectares) that include terrestrial and marine surface and cover 0.8% of the national territory. Even though it comprises a minor surface, over 70% of the country's landscapes are represented as well as over 30% of the ecosystems and priority endangered species.

It is worth mentioning that despite its small surface, the system includes a high number of relevant components. 5 of the 14 areas, are located within the study area (Cabo Polonio, San Miguel Fauna and Flora Reserve National Park, Laguna de Rocha Cerro Verde coastal-marine protected Area and Laguna Garzón Protected Area); and 3 others (Potrerillo de Santa Teresa, Laguna de Castillos y Laguna Negra) are in the process of joining the group. Simultaneously, many of them count on other types of departmental or international protection declarations. (Figure 15) (Table 3; Table 4).

These invaluable areas imply a new type of land usage, usually linked to ecosystem services because many wetlands and lentic environments help regulate processes that supply the necessary ecological conditions to enable human activity. This new land usage competes with forestry and with tourist activities that use both types of environments.

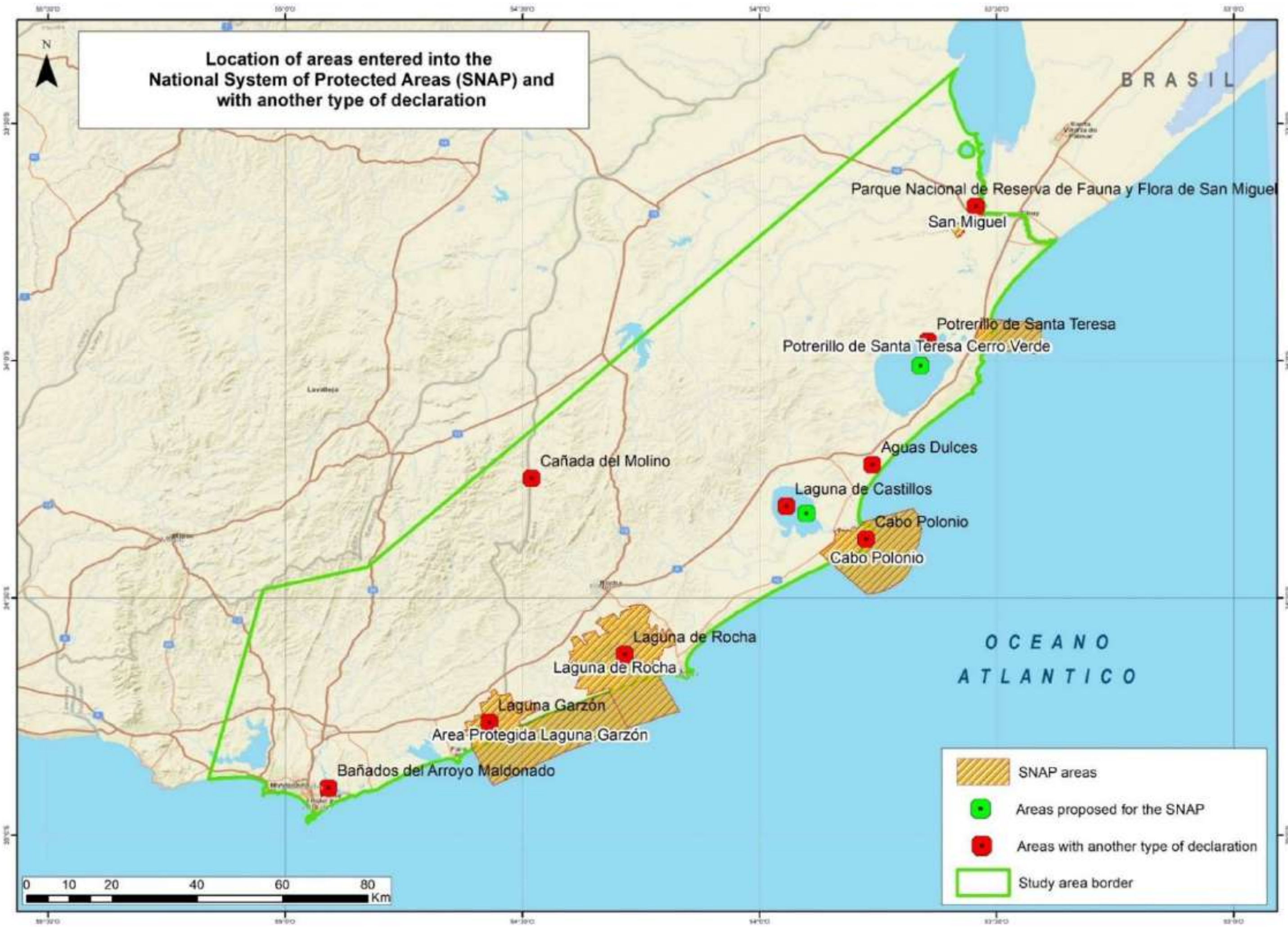

Figure 15: Protected Areas Locations
Own design. Source: SNAP

Table 3: List of Protected areas within the National Protected Areas System

Name	Status	Decree	Entry Date	Management Category	Surface (Hectares)	Marine Surface (Hectares)	Land Surface (Hectares)
Cabo Polonio	Entered	337/009	20/07/2009	II National Park	25.820	21.167	4.653
Parque Nacional de Reserva de Fauna y Flora de San Miguel	Entered	54/010	08/02/2010	II National Park	1.542	0	1.542
Laguna de Rocha	Entered	61/010	18/02/2010	V Protected landscape	34.295	10.273	24.022
Área protegida costero-marina Cerro Verde	Entered	285/011	10/08/2011	IV Habitats and/or Species Management Areas	8.968	7.284	1.684
Área Protegida Laguna Garzón	Entered	341/014 388/014	21/11/2014	IV Habitats and/or Species Management Areas	36.928	27.332	9.596
Potrerillo de Santa Teresa	In process to enter			Unknown	715	0	715
Laguna de Castillos	Entry proposal / research in progress			Unknown	30.850	0	30.850
Laguna Negra	Entry proposal / research in progress			Unknown	38.330	0	38.330

Table 4: Protected Areas within the study zone according to declaration

Site	Other national declaration	International designation	Sites mentioned in publications
Cabo Polonio	Dunas del Cabo Polonio Natural Monument Atlantic Coast Natural Monument (26Km), Cabo Polonio and Aguas Dulces Forestal Reserve, Islas Costeras National Park	Bañados del Este Bioshpere Reserve, Bañados del Este and Franja Costera RAMSAR Site	Dunas del Cabo Polonio Natural Monument, Costa Atlántica Natural Monument (26Km), Islas Costeras National Park, Cabo Polonio and Aguas Dulces Forestal Reserve, Atlantic Basin Complex - del Este National Park
Parque Nacional de Reserva de Fauna y Flora de San Miguel	Fuerte de San Miguel Historic Monument and National Park	Bañados del Este Biosphere Reserve, Bañados del Este and Franja Costera RAMSAR Site	Fuerte San Miguel Historic Monument and National Park, Atlantic Basin Complex - del Este National Park
Laguna de Rocha	Laguna de José Ignacio, Garzón and Rocha National Lacustrine Park and Multiple Use Area, Lag. de Rocha Protected Area	Bañados del Este Biosphere Reserve	Laguna de Rocha Protected Area, Laguna de José Ignacio, Garzón y Rocha Lacustrine Park and Multiple Use Area, Atlantic Basin Complex – del Este National Park
Área Protegida Laguna Garzón	Laguna de José Ignacio, Garzón and Rocha National Lacustrine Park and Multiple Use Area, Laguna Garzón Protected Area	Bañados del Este Biosphere Reserve	Laguna de Rocha Protected Area, Laguna de José Ignacio, Garzón y Rocha Lacustrine Park and Multiple Use Area, Atlantic Basin Complex – del Este National Park
Área protegida costero-marina Cerro Verde	Islas Costeras National Park	Bañados del Este Bioshpere Reserve, Bañados del Este and Franja Costera RAMSAR Site	Islas Costeras National Park, Cerro Verde, Atlantic basin Complex - del Este National Park
Estación Biol. Potrerillo de Santa Teresa	El Potrerillo de Santa Teresa National Park and Fauna and Flora Reserve Laguna Negra Protected Area	Bañados del Este Bioshpere Reserve	El Potrerillo de Santa Teresa National Park and Fauna and Flora Reserve, Atlantic Basin Complex - del Este National Park.
Laguna Negra	Laguna Negra Protected Area	Bañados del Este Bioshpere Reserve, Bañados del Este and Franja Costera RAMSAR Site	Laguna Negra Protected Area, Wetland de los Indios, Atlantic Basin Complex - del Este National Park, Palmar de Castillos
Laguna de Castillos	Laguna de Castillos Wildlife Refuge, Laguna de Castillos Protected Area, Cabo Polonio and Aguas Dulces	Bañados del Este Bioshpere Reserve, Bañados del Este Franja Costera/RAMSAR	Laguna de Castillos Protected Area, Laguna de Castillos Fauna Refuge, Cabo Polonio and Aguas Dulces Forestal Reserve, Atlantic Basin Complex - del Este National Park

3.4. Evolution of forested areas

Forested areas went through an important process of growth in Uruguay, which led to larger surfaces of pines and eucalyptus in the North and Central areas of the country. On the other hand, natural forest (native) has more presence in the Northern and Eastern Departments. Such forest has indigenous features and is protected by Forestry Law Nº 15939. This law bans its felling except if: will be used within the property where it is located or is part of a native forest management plan approved by the Forestry General Office.

Table 5: Total area of woods (in hectares) by species and department. Year 2013

Department	Pinus	Eucalyptus	Other Eucalyptus	Other	Registered Subtotal	Natural Forest	TOTAL (hectares)
TOTAL	**257.687**	**726.323**	**85.301**	**6.764**	**990.774**	**849.960**	**1.841.578**
Tacuarembó	70.065	40.880	7.056	552	111.497	120.603	**232.100**
Rivera	110.545	51.381	449	533	162.459	62.342	**224.801**
Lavalleja	2.560	108.377	8.427	184	111.121	95.129	**206.250**
Paysandú	31.131	99.866	9.527	3.039	134.036	58.762	**192.798**
Río Negro	8.266	113.842	19.917	1.052	123.160	37.687	**160.847**
Cerro Largo	8.141	51.109	3.141	2	59.252	65.987	**125.239**
Rocha	4.692	38.953	2.812	30	43.675	53.639	**97.314**
Maldonado	1.127	35.701	2.140	21	36.849	60.230	**97.079**
Treinta y Tres	3.641	20.628	1.209	4	24.273	62.291	**86.564**
Durazno	8.432	53.051	8.234	425	61.908	23.249	**85.157**
Florida	1.091	49.116	11.503	42	50.249	30.976	**81.225**
Soriano	727	35.161	8.064	297	36.185	26.357	**62.542**
Salto	0	838	0	0	838	45.702	**46.540**
Artigas	111	347	13	0	458	43.220	**43.678**
Canelones	1.813	16.201	427	189	18.203	22.282	**40.485**
San José	4.265	4.646	1.207	341	9.252	21.258	**30.510**
Colonia	561	1.951	941	40	2.552	14.737	**17.289**
Flores	440	3.834	72	0	4.274	4.737	**9.011**
Montevideo	79	1.285	1.006	13	1.377	772	**2.149**

Source: Forestry General Office – Assessment and Information. Natural Forest based on Cartography 2012 – DGF
Pinus, Eucalyptus and Others, based on Forest Registry

These measures have contributed to the expansion of the autochthonous vegetation surface from 667 000 hectares in 1990 to 850 000 in 2014, (data from the Livestock, Agriculture and Fishery Ministry) (Table 5).

Maps in Figure 16 depict an increase in productive forestry in Uruguay. The maps show the amount of forested areas for 2000 and 2013 in each administrative unit (department). Only two Northern departments had over 10,000 forested hectares (around 11 500 each) in the beginning of the century.

Ten years later, 6 out of 19 departments have located NE-W. Although there is an average annual growth of 3.89% for the period, in some departments it reaches 10%. Even though this is a fast-growing productive activity, it should be born in mind that there might be sub-records regarding information collection at initial stages.

The closer in time the data is from, the more reliable it gets due to the use of multiple collection methodologies. Rocha's annual growth rate is not within the highest (3.37%), climbing from 29 420 hectares in 2000 to 43 675 in 2013. On the other hand, Maldonado grows at an annual average of 7.59%, beginning in 18 544 hectares in 2000 and reaching 36 849 in 2013. The changes observed within the study area require a larger analysis taking into account geomorphological and usage differences.

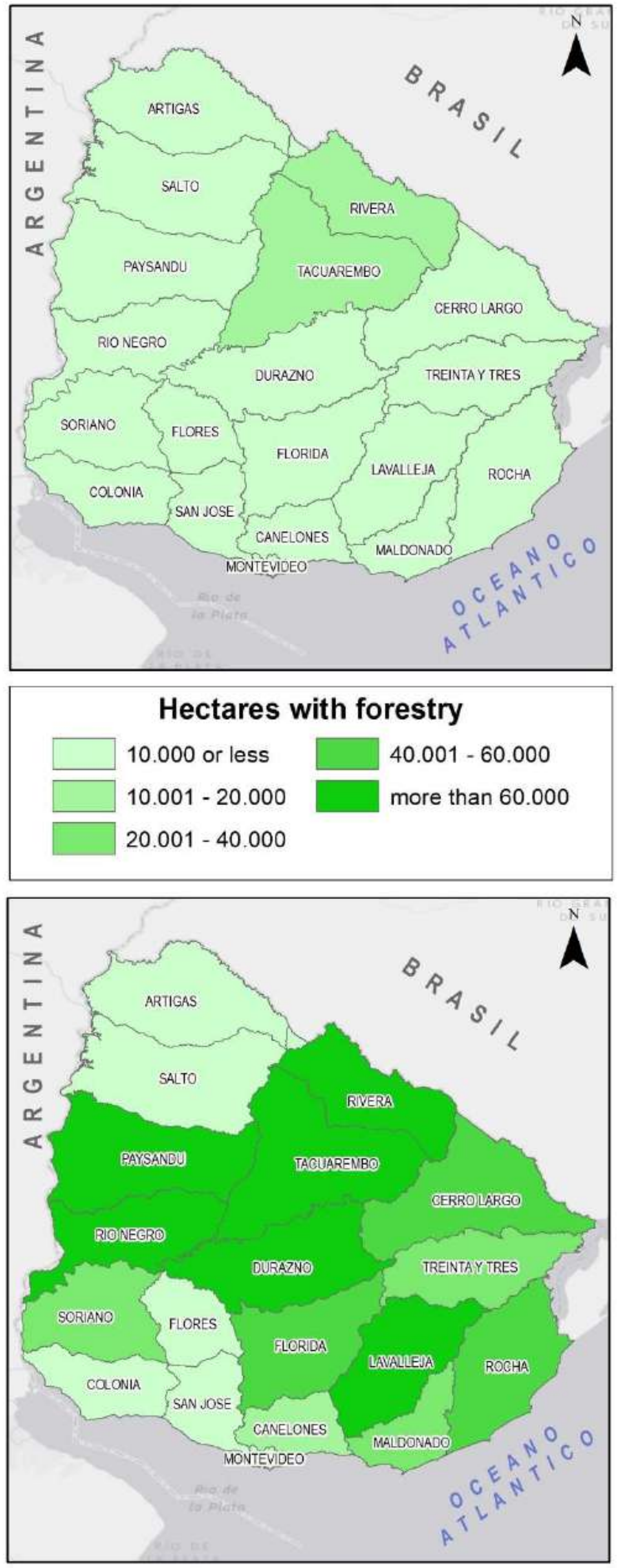

Figure 16: Forested area by department. Above map- Year 2000; Bottom map – Year 2013. Source: MGAP

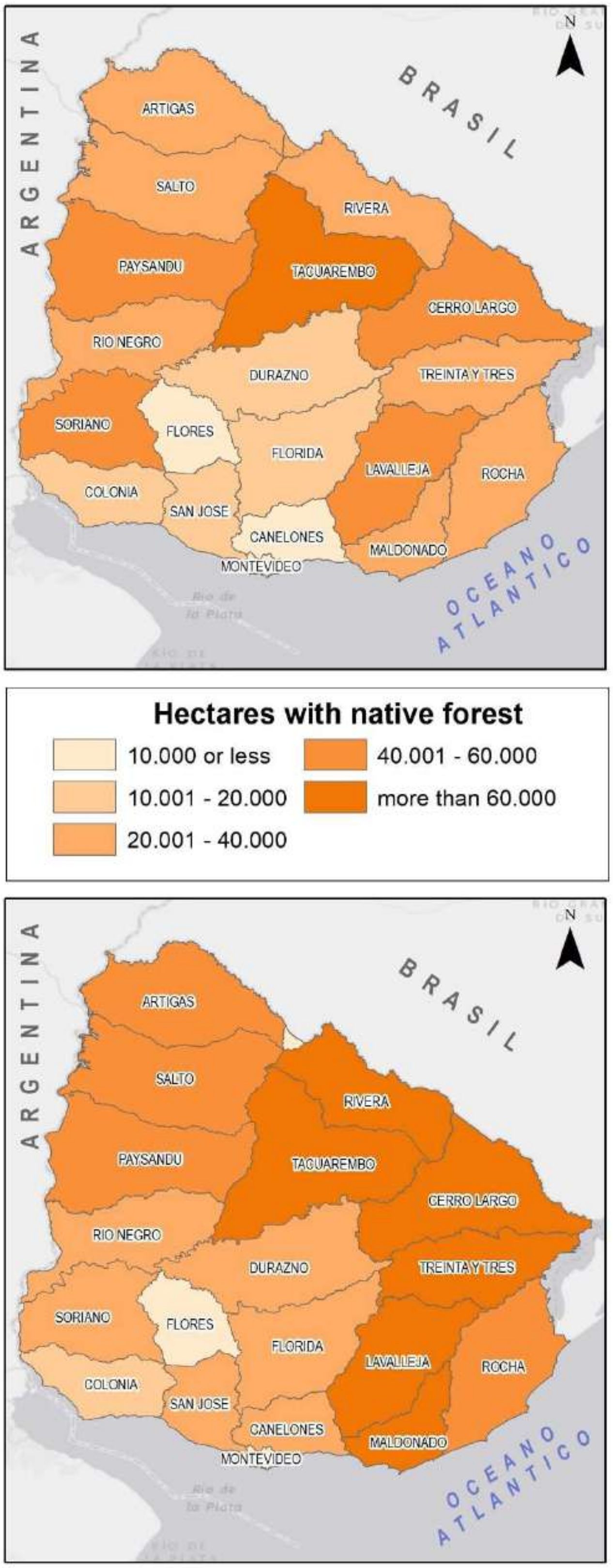

Figure 17: Area with native forest by department. Above map: year 2000; Bottom map: 2013

In addition, the native forest surface has also increased in these years. Such growth may be related to the protection supplied by Forestry Law Nº 15939 that bans native forest felling except if: will be used within the property where it is located or is part of a native forest management plan approved by the Forestry General Office.

In departments on the West coast, where agriculture and livestock farming activities are intensive, native forests were reduced. On the other hand, in departments located in the NE and E regions, where there is a remarkable development of forestry, figures have gone up. The average annual growth of native forests for the period is below the growth of artificial forests, 3.39%. The highest value is 12% and there are negative figures, close to -3% on the West coast. In Rocha, native forest has grown by 3.93% year, climbing from 36 254 hectares to 53 639. In Maldonado, on the other hand, the growth average is at 5.2%, that meant a rise from 35,947 to 60 230 hectares.

Nevertheless, even while the native forest surface is expanding, its quality is uncertain (Figure 17).

The agriculture and livestock breeding censuses provide more exhaustive data at this respect. The most detailed information comes from Enumeration Areas (sub-departmental units). The Enumeration Area is the smallest territory unit according to the 2011 Agriculture and Livestock breeding Census. Such area is the one assigned to each enumerator at the field stage of the investigation, based on the work load estimated based on information supplied by the year 2000 census. For information collection purposes the country was divided into 637 Enumeration Areas. The study area comprises 54 Enumeration Areas, 24 in Maldonado and 30 in Rocha. The use of these smaller territory units in the study area has provided a fresh perspective regarding the growth of both types of forests.

When analysing the study area, it can be observed that it concentrates high percentages of both types of forests within each department, mainly in year 2000. However, in 2011 there is a marked fall in natural forest (native) and a 78% rise in the artificial one. This situation contrasts with the observation at departmental level (Table 6).

Table 6: Natural and Artificial forest surfaces in the study area: per department and per enumeration areas according to 2000 and 2011 censuses. Source: MGAP

Area	Forest type	2000	2011	Percentage of growth
Departments: Maldonado y Rocha	Natural	72.201	113.869	58
	Artificial	47.964	80.524	68
	Total	120.165	194.393	62
Study Area	Natural	64.276	58.186	-9
	Artificial	43.948	78.027	78
	Total	108.224	136.213	26
Percentage representation	Natural	89	51	
	Artificial	92	97	
	Total	90	70	

The following cartography classifies the enumeration areas according to their amount of forested hectares and they are labelled with the percentage of hectares within the study area for both census years. In the North there is a reduction in forestry due to the growth of intensive rice crops. The Central area, on the other hand, experiments a substantial growth of artificial forest surfaces. Maldonado is the most heterogeneous area, and it does not show major changes. The coastal strip, in turn, shows a decrease in that kind of forest (Figure 18)

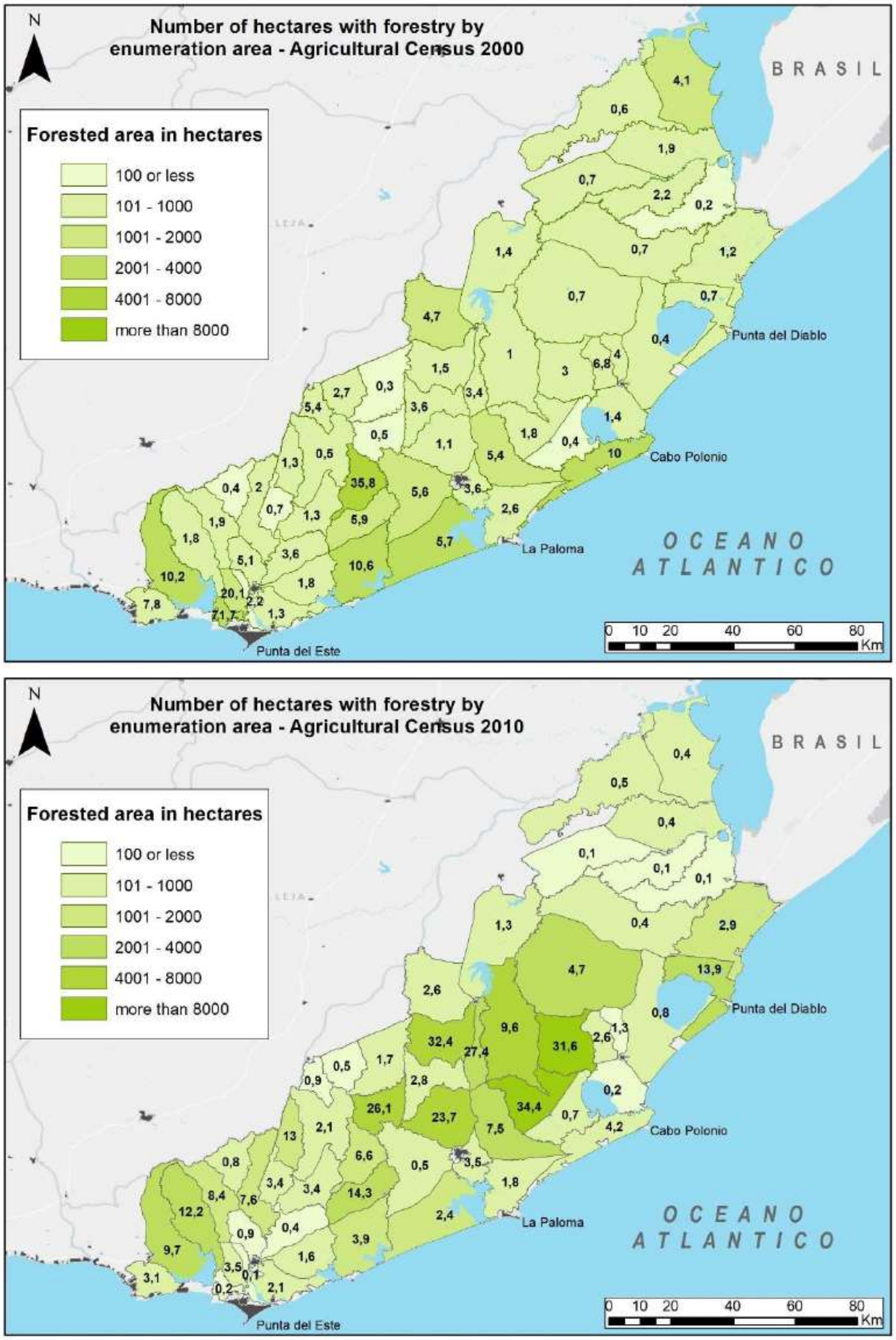

Figure 18: Artificial Forestry Maps by 2000 and 2010 enumeration areas
Own design. Source: Livestock Breeding and Agriculture Census, MGAP

The map below shows a series of lots related to the operations of the most developed forestry company in that area. A high percentage of artificial forestry is observed in the enumeration areas where those lots are located (Figure 19).

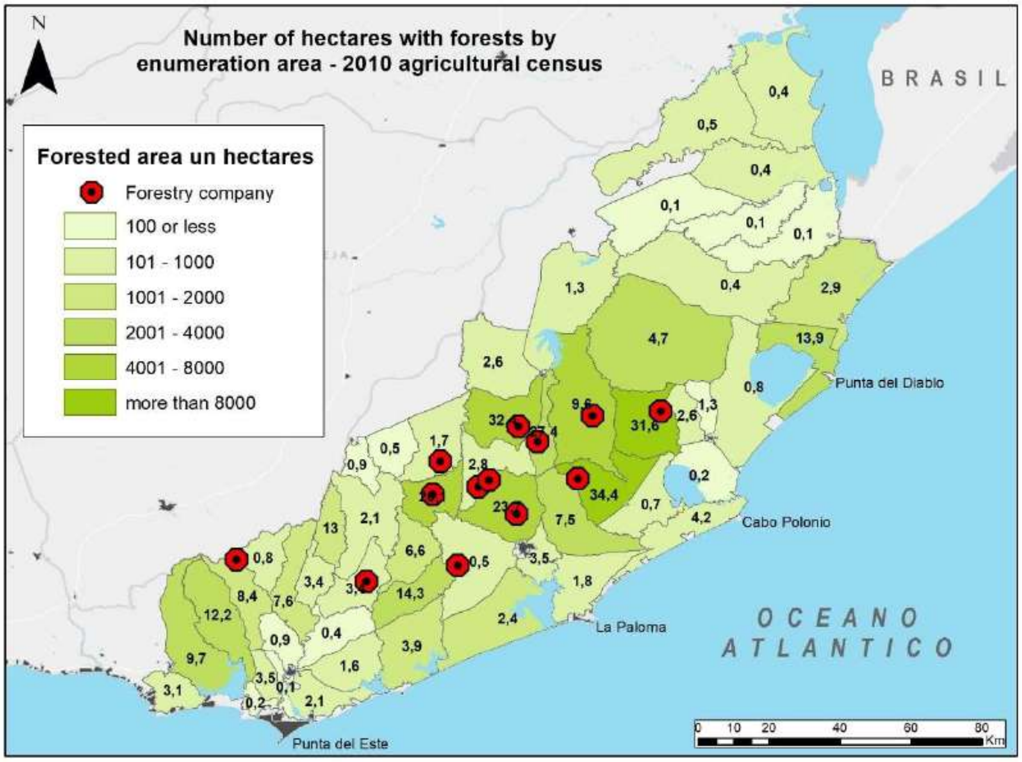

Figure 19: Location of Forested area and FAS forestry company sites. Own design.

Changes are more visible when analysing the evolution of the natural forest in the enumeration areas between 2000 and 2010. There is a clear fall in the surface of natural forest in the entire the study area. Such loss grows stronger in enumeration areas where the forestry business has developed the most. That decrease is also visible along the coastal area, except in the most western units. The concerns arisen by that reduction in native forests are not only regarding quantity but also the quality of the remaining forested surfaces.

Many forest areas have been invaded by exotic bushes and plants that are aggressive towards indigenous species. They are mostly highly-invasive plants that are not native so there are not any natural predators to control them. Even though some of them take up reduced areas and mingle with the ecosystem, others are extremely aggressive. Privet stands out in that group, as it has invaded several forests and is probably the most aggressive due to its perennial quality.

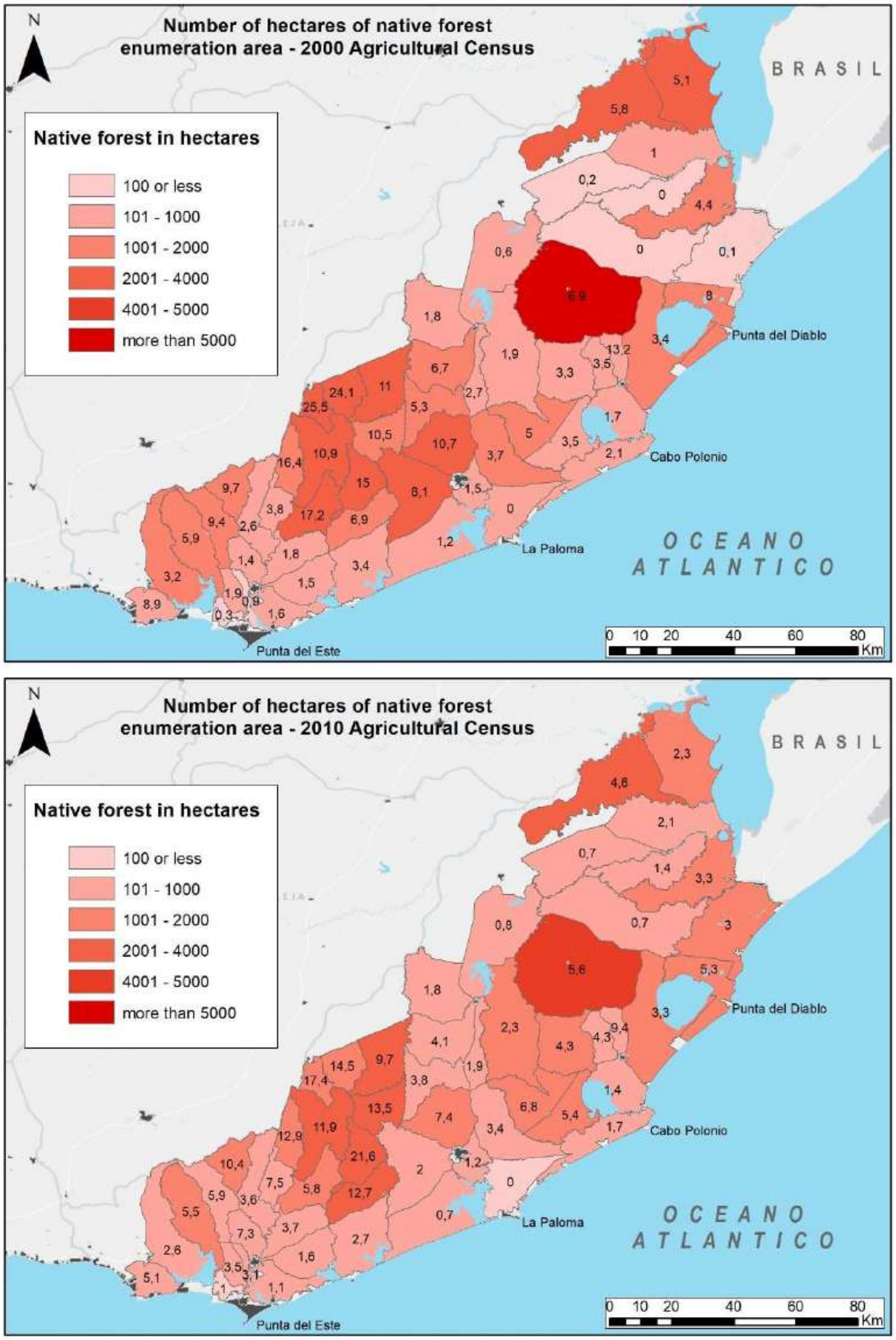

Figure 20: Native forest Maps by enumeration area – years 2000 and 2010
Own design. Source: Livestock breeding and agriculture Census, MGAP

On the coast, Australian acacia (*Acacia longifolia*) is highly frequent; it is frugal and has strong invasive features. It was originally introduced with the aim of fixing sandy soils and has spread along the Rio de la Plata coastal area; it is highly combustible and has an elevated biotic potential as it produces large amounts of fertile seeds that are naturally spread. The following cartography shows a classification of enumeration areas by native forest hectares. They are labelled with the percentage within the total study area for the two years analysed (Figure 20)

3.5. The impact of forestry on the coastal area

3.5.1. Ecosystems vs exotic forestry

The conceptual framework of the Directive Plan Bañados del Este Biosphere Reserve (1999) states that: "Biodiversity conservation proposals, constitute a link in the existing perception and awareness -in the context of a certain historical moment – between the ecosystems' status and their exploitation"; this highlights the area's ecological richness and the impact that previous and current anthropic activities have. That definition will be considered by several researchers who take the Atlantic coast as natural laboratory for their observations and research.

This way, there are several investigations confirming that along the Uruguayan coastal strip (450 km along Rio de la Plata and 220 km along the Atlantic Ocean) (Chebataroff, 1973), there is a group of vegetation formations that are tightly linked to the coastal geomorphologic and topographic characteristics (Fagúndez & Lezama, 2005; Delfino & Masciadri, 2005). Variations in their edaphic features - for example: nutrients, amount of water, topographic location, original material and evolution time – make up a mosaic of xerophilous, hydrophilic and mesophilic environments (Fagúndez & Lezama, 2005; Alonso-Paz & Bassagoda, 2006). Fagúndez & Lezama (2005) define woods, brushwoods and grasslands as coastal vegetation formations.

Woods and riverine forests are the classical wooden vegetation formations in the Rio de la Plata and Atlantic coasts. Those are unique formations within the region due to their specific mix of vegetation species and location (Alonso-Paz & Bassagoda, 1999). This xerophilous brushwood is linked to fixed dunes and can be classified into sand and prickly brushwood.

The coastal brushwood is flat and made up by bushes and bush-like trees that are mostly thorny and no more than 3 m tall (Alonso-Paz & Bassagoda, 1999). The main species are *Colletia paradoxa* "Espina de la

cruz", *Schinus engleri var uruguayensis* "Molle rastreo", *Celtis iguanaea* "Tala trepador", *Scutia buxifolia* "Coronilla". Besides, it is usual to find *Ephedra tweediana* which is the only native gymnosperm and also cactuses, for example *Cereus hildmannianus uruguayanus* and *Opuntia arechavaletai*. In addition, there are three exclusive species: *Senecio argentinus, Notocactus scopa var marchesii* and *Opuntia aurantiaca* (Alonso-Paz & Bassagoda, 1999). This brushwood stretches from San José to Rocha, but it is highly fragmented in reduced-sized patches (Fagúndez & Lezama, 2005). The coastal prickly brushwood is a pioneer species in dunes colonization that leads to natural fixation and soil formation in dune fields nearby the beaches (Alonso-Paz & Bassagoda, 1999). On the other hand, the riverine forest grew at a later stage and develops in areas protected from strong winds and saline dew (Alonso-Paz & Bassagoda, 1999).
These coastal formations are currently endangered as a result of human activities that include: forestry, tourism, urbanization and land division, fires, mining, agriculture and livestock breeding (Fagúndez & Lezama, 2005). Exotic-species forestry has a negative impact on the coast and its vegetation, as species reproduce spontaneously, invading almost all the coastal area. The most important changes were brought about by tourism activities that imply land divisions and building roads, boardwalks, streets and houses (Guayubira, 2008). The coastal landscape has been through successive changes that have restricted its original vegetation to relictual areas and have fixed mobile dunes (Carrere, 1990; Delfino *et al*., 2005).

This brief description of the evolution in coastal vegetation for the last years can be verified when mapping the contrasting surfaces of productive vs. native forests by enumeration areas for the years 2000 and 2011. Such variations are a result of two competing types of forests – artificial and native – as well as the impact of other productive activities (rice crops, livestock breeding and tourism's intervention in land use).

When analysing the variations in natural and artificial forests for that decade the following is observed:

- In the NE zone, near Merín lagoon there is an area where artificial forests have been reduced while native forest has grown unevenly. It is a distinct rice crops area.
- In the central area the artificial forest is a main economic activity and has become predominant while the native forest has been drastically reduced. These two areas also have important fodder production and develop livestock breeding, as well. Native palm tree forests are affected by livestock grazing spreading along grasslands (a biome that has been left aside by conservation policies). Butia palm tree fields (characteristic in Uruguay's SE region) go through a lot of over-grazing along with dramatic changes in land usage (Rivas *et al*., 2014)
- In the SW part of the study area (mainly Maldonado Department), there is a slight increase in both types of forest. From a productive perspective, this is a hill-forested area that comprises tourist farms, some forested areas, some livestock breeding and also hills that discourage agriculture.

- Even though the coastal strip is a heterogeneous area, it shows a general fall (or is at a standstill) in the development of both types of forests. This is probably a result of the continuous progress of housing projects. Within this context, however, the area of Laguna Negra and Punta del Diablo, near the Brazilian border, show an unusual growth of artificial forests. (Figure 21)

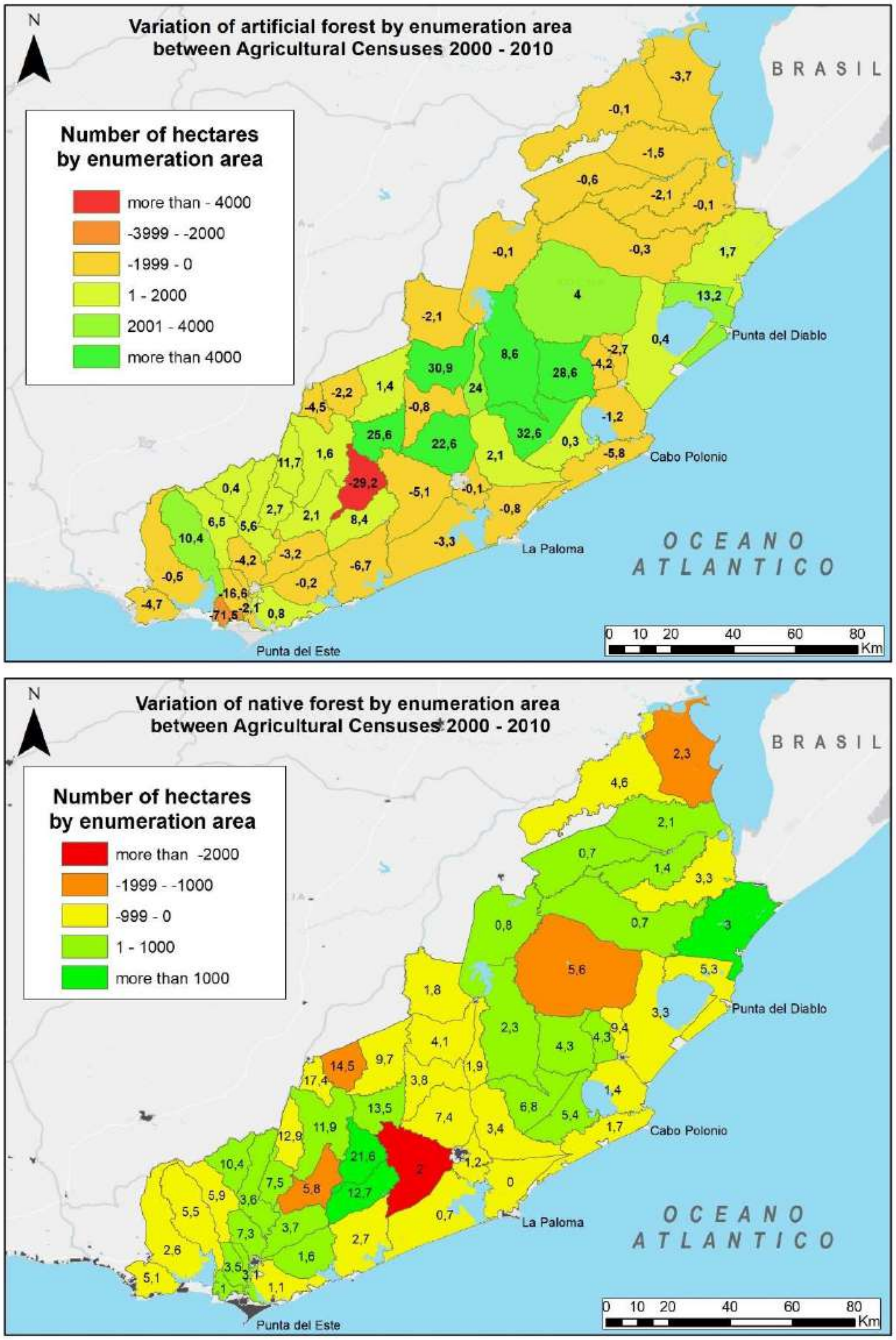

Figure 21: Absolute variations in artificial (above) and native (below) forests maps for the study area by enumeration areas, years 2000 -2010. Own design. Source: MGAP.

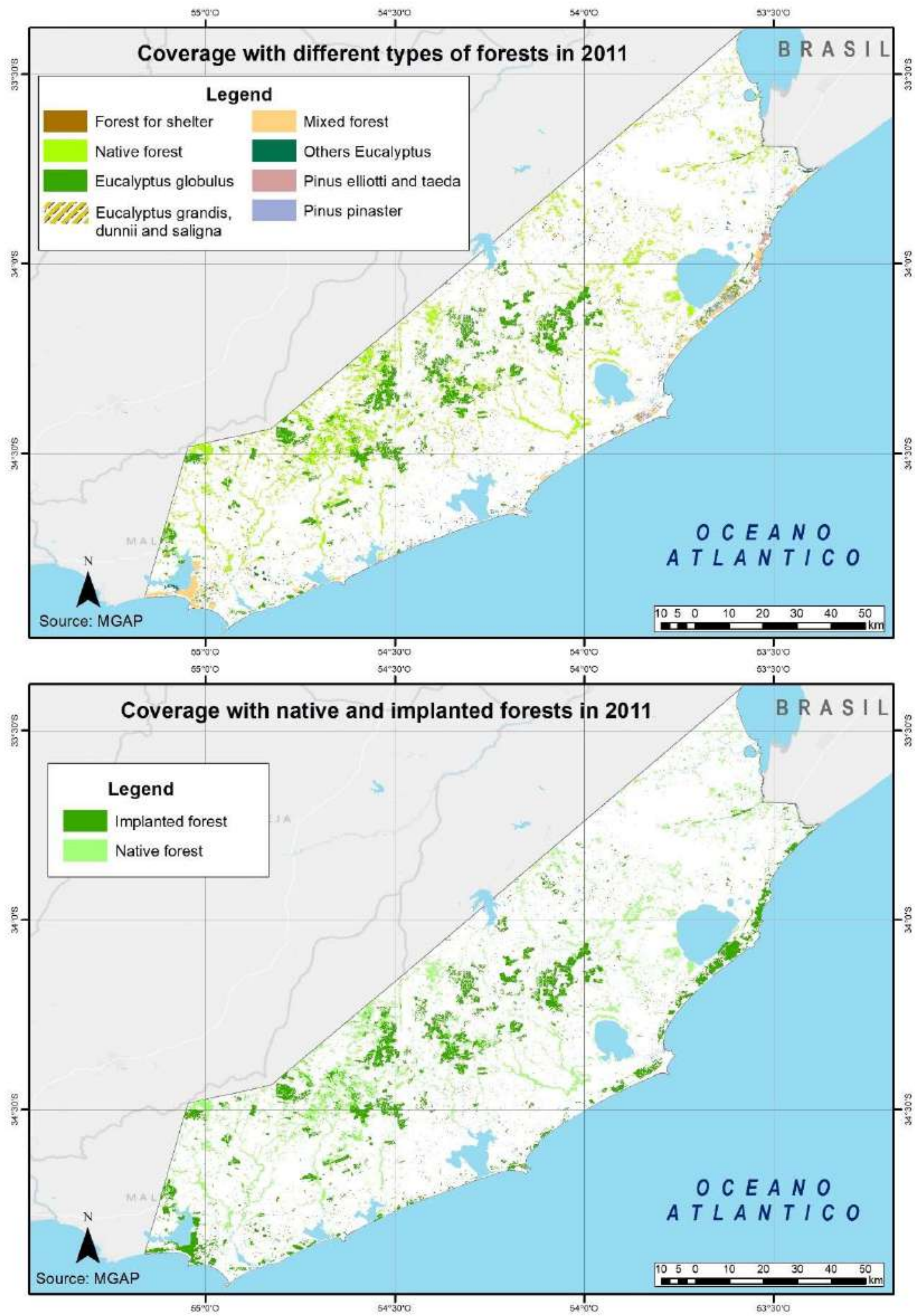

Figure 22: Vegetation coverage by forest types (above) and native and exotic forest (below), year 2011. Produced by the General Forestry Office using LANDSAT images.

Considering data collected by the National Forestry Office using a different data collection method. 1:50 000 digital cartography developed using Landsat (TM 2010 and 2011) digital processing and image interpretation, General Forestry Office information and field support. This product has PROBIO support and it is currently the most updated. The used resolution does not allow the identification of plantations less than two years-old or harvested surfaces that are still used in forestry.

The information collected was primarily subdivided in 8 types according to species and then assigned to the two pre-existing categories (artificial forest and native forest). The representation obtained using this methodology confirms the analysis from the agriculture and livestock breeding censuses regarding predominant presence and forest type in the study area (Figure 22)

3.6. Discussion

Forestry had not been a main industry for Uruguay and it was often linked to other productive activities. For instance, it was used as animal shelter in livestock breeding or as a wind barrier to protect crops. Later on, some exotic species –mainly pines and eucalyptus - were introduced along the coastal areas with the aim of fixing dunes and expanding and dividing lots so as to develop seaside resorts as well as camping and recreational areas. Until the first half of last century - or maybe a little longer - sandy areas, along with wetlands and native forests were seen as unproductive and worthless places and forestry was therefore considered beneficial in such regions.

By the end of the last century there was a dramatic change in the way that the forestry industry was regarded. This change brought about a new legal framework to promote forestry, and even though those regulations have become more cautious as years went by, they are still attractive for foreign capitals. This is how despite the protection supplied by the aforementioned forestry law, artificial forests have spread over some ecosystems as grasslands and native forests. Forestry has steadily grown as a relevant economic activity in Uruguay, resulting in territorial changes at landscape, infrastructure and social levels.

Laterra *et al*. (2011) state an increasing rise in scientific acknowledgement and also in general awareness regarding the various tangible and intangible benefits of ecosystems. As a result, the indiscriminate replacement of native forests, grasslands and wetlands for their agricultural, livestock, forestry, mining and real estate exploitation without a proper assessment of their collateral or external effects, has become an inadmissible practice. The study area concentrates a wide variety of ecosystems within a small territorial space. Such situation is acknowledged by the National Protected Areas System (SNAP) that has implemented a variety of sites with the objective of protecting the country's natural and cultural heritage. On the other hand, the fact that the beaches and lagoons located in the area are rich in biological species – especially migratory birds- turns them into an increasingly attractive tourist spot.

This chapter has two main focuses. Firstly, how the territory assimilated the new activity and how the different integration stages of that activity developed. Secondly, how the State keeps record that activity's uses of the territory and how it identifies the changes arising in land usage. There is reliable data regarding the registry and conditions of forested areas, as this configures information of interest for the production companies. On the other hand, inconveniences usually arise when plantations over 100 hectares that need to go through an environmental assessment process, do not start such process before planting –as the law states it – but they do it after. This action puts immediate pressure on the expected answer.
In addition, and in spite of the data available for the analysis, the use of diverse methodologies, measure units and measure periods, make it difficult to assess the real current conditions of the native forest.

Newer technologies, for example tele-detection, set limitations to the assessment of these ecosystems, as they are not able to identify certain types of ecosystems such as park forests and palm forests. With respect to riverine forests, even though they can be easily detected by remote sensing, it has not been possible to assess their quality. However, it is known that some exotic species have invaded these forests, replacing the native ones. A lack of knowledge and policies on the topic, can lead to important losses in the ecosystems' capacity to keep their soils productive, provide clean water, control of rivers' water levels and floods or to regulate the atmosphere and climate's composition.

There are two simultaneous territorial restructures. One is partially planned and developed through State regulations and by private companies, following their business interest. The other is an involuntary one, determined by the clash of native and exotic species. When indigenous forest and exotic plantations –mainly uncontrolled and not oriented to production- coexist, the natural ecosystem is eventually degraded by the invading species. Forest fires accelerate this process as they foster the expansion of species as pines and acacia. Even at present day, there is no clear awareness or integral reflection regarding those events and their effects on the landscape's quality and on the ecosystems' good and services.

3.7. Conclusion

There are one million forested hectares in Uruguay, mostly covered in eucalyptus and pines. They fit in a new productive model that required renewing and changing the territorial structure and brought about social, landscape and environmental changes. This development was fostered by foreign companies to supply an external demand and it was carried out taking advantage of beneficial regulations, including governmental incentives together with low production costs. It is possible to verify this expansion when analysing and comparing available data. This forestry model spread on sandy soils (defined as forestry-priority soils by Law) and later arrived to the study area, taking up prairie as well as rice crop lands.

Nevertheless, there was another kind of advance in forestry and land planning on the Atlantic coast that aimed at traditional sun and beach tourist activities. Developing without any planning and with low or inexistent controls, such forestry competes with high ecological value ecosystems, threatening healthy native forests and configuring a risk factor in forest fires. Information from varied sources agrees on stating a decrease in native forest areas and, as it has already been mentioned, it would be recommendable to analyse how degraded they have become so as to assess their recovery potential.

As a result of forestry developments with two different starting points and timings and with two different purposes, each territory has shaped differently. However, both have been through changes that are questioned as specific conflicts have arisen. On the Atlantic coast there is an active pro-conservation movement; there are protected areas awaiting a management plan (only the Laguna de Rocha currently has a management plan) and a shift in the way natural areas are valued that impacts on new land instruments (for example the Cabo Polonio Forestry Reserve Park, that has become Protected Suburban Soil by Coastal Regulations)

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CHAPTER 4 THE COASTAL AREA, A SPECIFIC AND DYNAMIC SPACE

4.1. Introduction

The sea-land interface shapes a specific type of territory whose location facilitates some exclusive uses of the littoral area. Their proximity to water led these coastal areas to become the land base where to set up equipment used in the exploration of marine resources in the biggest reserve in the planet. This is a location of high strategic value inside a reserve that has been increasingly controlled by international regulations. Moraes (2007) defines the littoral area as a specific location with its own specific natural and occupation features, monopolizing certain activities due to a coastal position that privileges all the activities related to circulation and has a leading position in the location of merchandise and maritime terminals for intercontinental transport. Such characteristics have made these areas preferred occupation points throughout History. Barragán & de Andrés (2015) state that coastal areas have shown a worldwide trend to demographic concentration where coastal cities and conurbations play a key role.

Uruguay has 486 km of coast on Rio de la Plata and 232 km along the Atlantic Ocean. According to the paper “Behind the 3 million Uruguayan population after the 2011 census” (Bengochea *et al*., 2013), almost 95% of the country’s population resides in urban areas, and it is densely concentrated in Montevideo and its metropolitan area as well as in Rio de la Plata and Atlantic Ocean coastal departments. Changes in population growth rates in each department can be explained mainly by internal migrations. Even though the coastal areas have a distinctively urban development tendency, it is possible to verify different situations regarding how the land is modified. While the Rio de la Plata coastal strip is highly modified, the Atlantic coast keeps some segments of high ecological value unchanged. According to data taken from the last National census (National Statistics Institute), a 17% of the national territory –corresponding to the coastal departments’ surface – holds a large percentage of the country’s population. Such percentage has climbed from 68% (1963) to 70% (2011). This tendency supports the existence of a peripheral land occupation model and confirms the relevance of the country’s capital city.

Although this increase does not impress as particularly large, it spreads along the coastal strip, taking up new parts of it and amplifying the pressure on that territory. When considering smaller measure units such as the census segments, it is possible to analyse the demographic concentration in more detail. This way, it is observed that 63% of the total population resides in 6% of the territory. This situation has become one of the main indirect origins of significant changes that the coastal-marine ecosystems have been through and that lessen the supply of ecosystem services oriented to human well-being (Barragán, J. M. & de Andrés, M., 2016).

The tendency to use coastal areas with leisure and tourism purposes has strengthened in the last years, resulting in the development of structures and urban interventions characteristic from major cities where those tourists usually come from. Uruguay's Tourist Office 2013 yearbook states that Rocha's Atlantic coast has been the fastest-growing tourist destination in the last 10 years (354% increase). In addition, and on the same line, Rocha's tourism GIP had a 47.07% annual average growth rate between 2007 and 2010. This chapter focuses on how the Atlantic coast has evolved regarding its use as a diversified and recreational location of high tourist interest and high ecological value. The area's wide range of uses – tourist, forestry, agriculture, livestock breeding and conservation – arise concerns when analysing its fire risk factors.

4.2. Integrated coastal zone management

The integrated coastal zone management can be regarded as a multidisciplinary process with the objective of integrating different governmental levels, the community, science and private and public interests, with the aim of creating and implementing protection and sustainable development programmes for environmental and coastal resources (Hildebrand, 2002). In this context, the coastal area is considered the research and management unit, a physical-biotic and social tangible reality that is trimmed by the researcher's analysis criteria. Therefore, it may be an ecosystem, a biota, a geo-environmental unit, a habitat, a municipality, a productive area, etc. According to Moraes (2007) it is the production and reproduction space of a human group and has a possibility for human use with some productive potential. This allows a vocational approach to such territory to acknowledge the advantages and disadvantages that tell it apart from others. Comprehending each and every of the aforementioned dimensions, the coastal area is a stretch of coast in the shape of a strip that comprises the sea-land interphase and has no clear delimitation (Kay & Alder 1999). There, each individual component requires an integrated analysis.

In "Base research on the Status of Integrated Coastal Management in Uruguay: practice, training and investigation" (Baliero, 2006), the main objective of integrated coastal management is regarded as improving life quality and developing communities that depend on coastal resources, keeping the ecosystem's biological diversity and productivity. This means that the planning and management of coastal environments and resources must be carried out bearing in mind the physical-biological, socioeconomic and administrative interconnections that take place within the coastal area. This management approach mixes participative processes and zone division, land planning, economic assessment, creation of protected areas and habitat management techniques. The main aim is to balance the uses given to the coast by legitimizing a set of objectives shared among the actors involved and moving towards an improvement of life-quality in communities and protection of the coastal ecosystems (Baliero, 2006).

Experts agree that the greatest threat for the coast is the development of urbanizations and artificial surfaces that turn wet areas, marshes, dunes, beaches, etc. into urban areas (Prieto y Ruiz, 2013). In the last four decades the Uruguayan Atlantic coast has undergone advances in urbanization in a lineal and extensive shape, in the development of infrastructure and equipment as well as in an expansion of crops and forestry. This has resulted in an increasingly artificial coastal shore that strengthens the intensity and impacts of severe climate events. Recent research states that Uruguay will probably be affected by Climate Change, as its coastal resources and population are highly vulnerable to modifications in rainfall, flow from Rio de la Plata tributaries and changes in the South-West Atlantic subtropical anticyclone location and its associated wind patterns.

These conditions would intensify the impact of existing threats on coastal areas and marine biodiversity by strengthening current dangers or by directly destructing habitats and species (Nagy *et al*., 2007). In addition, there is indirect contamination from an increasingly intensive agricultural production and direct contamination from urban and industrial untreated effluents that lead to an excess in nutrients arising along the summer season. The resulting eutrophication impacts negatively on the biodiversity and the fishery as well as on human health and leisure. All the aforementioned add to the incidence of harmful invasive species and the intensive exploitation of aquatic ecosystems.

Some of these problems are included in the short and mid-term Plan of Studies and Assessment and Perspectives regarding the biotic characterization process carried out at the location chosen to build the deep waters port (Soutullo, 2015). This is a 2012 project aimed at defining a location along Rocha's coast for a port terminal to cater for the mining and forestry industries. Great controversy was arisen around this project regarding its potential impact on ecosystems as well as its compatibility with the tourist development of this region. Even though the project has not been executed, yet, it is an initiative that requires an integrated management and planning approach so as to assess the vulnerability of systems and areas facing current impacts, climate change and changes in sea level. In this context, inappropriate policies may lead to developing some areas that may end up being damaged (Nagy *et al*., 2007).

4.2.1. Actors involved in coastal management

The coastal area is subject to multiple and complex national and departmental regulations. Such regulations may not always be directly addressed at the coastal zone, but they may be applicable to the area and its resources. In these regulations a sectorial approach to coastal resources management prevails over a more integrated one. There are laws and regulations regarding: land planning, environment and environmental assessment, creation of protected areas, protection of live resources (specifically some sorts of fish, shellfish and sea wolves as well as the Atlantic coast fauna and flora), artisanal and sports fishery, water hunting, aquaculture, tourism and forestry.

This range of topics involves several managing actors, stakeholders and jurisdictions. The state's actors that are most involved include some presidency offices as well as some ministerial offices: Defense; Education and Culture; Foreign Relations; Livestock, Agriculture and Fishery; Transport and Public Works and Tourism. Regarding the Housing, Land Planning and Environment Ministry, it is worth mentioning that the Environment Office (DINAMA) and the Land Planning Office (DINOT) are the ones that have tried harder to approach the coastal processes and problems from a comprehensive perspective. These institutions have developed innovative strategies by the coordination of assessments and activities that set off using international funding and were eventually included in the national budget with the aim of giving them continuity.

The Humedales del Este Biodiversity Conservation and Sustainable Development Programme (PROBIDES) started working in Rocha in 1993, having the biodiversity conservation and sustainable development of Uruguay's East region within its main aims. Other two useful examples of the work done on the coastal area are the ECOPLATA (1997) and FREPLATA (2001) projects, which have significantly contributed to building a governance system suited to the coast. Both programmes succeeded in consolidating coordination spaces where a multiplicity of actors took part: local, national and regional institutions, the society, professional institutions, and international partners (such as the International Development Research Centre from Canada and the Global Environment Facility).

As a result of invaluable integrated work, the Coastal and Marine Development Management Department was created in April 2015. This office works within the scope of the National Environment Office, in the Housing, Land Planning and Environment Ministry (DINAMA / MVOTMA). Professional institutions have contributed all along this process; university researchers from the Universidad de la República in a variety of disciplines have focused on the analysis of the coastal area due to its ecological value, biodiversity, geomorphology, wetlands landscape, coastal lagoons, as well as the development of traditional activities and the impact of tourism and new crops.

On the other hand, there is a new actor which has become increasingly relevant in coastal management: the National Emergencies System (SINAE), which was created in 2009 (Law Nº 18621). It is a specific and permanent coordination space for public institutions in disasters risk management. Its core objective is protecting the people, relevant goods and the environment from adverse phenomenon that may arise in emergency or disaster situations as well as creating the conditions for sustainable development. Its scope reaches every stage of the State's actions taken to manage risk in emergencies and disasters: prevention, mitigation, preparation, response, rehabilitation and recovery. The Presidency is in charge of the ultimate decision-making and the system comprises departmental coordinated groups called Departmental Emergencies Coordinated Centres (CECOED).

A third government level was created closer in time (2014): the Decentralization and Citizenship participation Law (Nº 19272) brings about the creation of municipalities, which have among their objectives to "adopt the necessary urgent measures to coordinate and collaborate with the national authorities in case of accidents, fires, floods and other natural disasters, communicating the mayor about them and being at his or her disposal". In connection with the municipal divisions, the Departments located on the Atlantic coast have different shapes: while Maldonado has divided its whole territory (3 out of 8 municipalities are located on the Atlantic coast: Punta del Este, San Carlos and Garzón), Rocha has only been partially divided and has 4 municipalities (3 of them on the coast: La Paloma, Castillos and Chuy).

4.2.2. Changes in the use and coverage of the land on Uruguay's Atlantic coast.

In contrast with the Rio de la Plata coast where the most densely populated urban areas are located, the Atlantic coast was the last to have its territory and environments modified. By the end of the XIX century this area had almost no organized human activity and the cities of San Carlos, Castillos, Rocha and La Paloma were just new-born towns. Just a few rural inhabitants ventured to those inhospitable coasts and made a living out of activities such as shark fishing. Even fewer people saw any kind of tourist appeal in those lands. This area remained untouched also due to the inaccessibility of several places, which resulted in population growing at a very slow rate.

Only halfway through the XIX century permanent communication between the East region and Montevideo was set up and later a stagecoach began taking journeys from Rocha to La Paloma's port. Trains appeared in 1917. Martinez Díaz (1977) states that the railway's development heyday in Uruguay takes place between 1889 and 1893. During those years almost one thousand kilometres of railways are built; that figure had doubled by the beginning of the XX century. The State encouraged the railway development by granting licenses to private companies and in 1884 a Law for the General Routes design of Railways was passed with the aim of organizing each train line at a land planning level. One of the six lines that the Law approved belonged to Ferrocarril Uruguayo del Este and linked Montevideo with Laguna Merín, via Pando, Maldonado, San Carlos and Rocha, with a branch going to Minas, between Pando and Maldonado.

AFE (the Trains and Tramways State Office) was created in 1920 to follow a nationalization process that had begun in 1915. Therefore, it took responsibility of the railways Uruguayo del Este and Rocha – La

Paloma. Now with a state-owned company status, Ferrocarril Uruguayo del Este keep expanding towards Rocha city and in 1928 a line linking San Carlos and Rocha was opened. This line was connected to the pre-existing one between Rocha and La Paloma's port. This transport option made it easier to access the Atlantic coast, where the small fishermen towns turned into leisure and resting places, even though they had not turned into major seaside resorts yet (Figure 23).

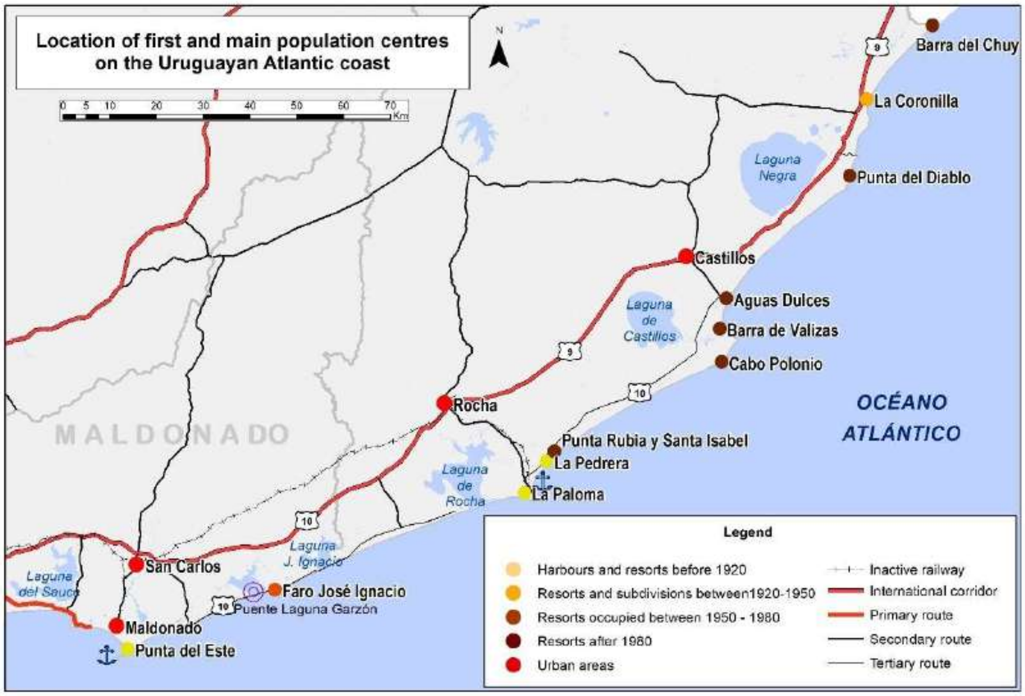


Figure 23: Main land communication routes and populated centres on Uruguay's Atlantic coast

The construction of the East railway at the end of the XIX century provided a quick and comfortable way to reach the main seaside resorts located on the Rio de la Plata and Atlantic coasts. The origins of this railway line show how this transport method was linked to the conditions of those social groups that fostered and used it, generating different construction, appropriation and resignification processes on the coastal territory. According to Adinolfi (2012), the development and, later, the disappearance of the railway shaped part of the Atlantic territory.

This new means of transport to reach the emerging East coast summer resorts meant an intensified flow of tourists, as the journey became shorter and, at the same time, it did not depend any longer on the weather or geographic conditions. This new concept of the coastal region, that gained strength by the end of the XIX century and the beginning of the XX, intensified the leisure and well-being qualities associated to the coast. Those perceptions added to the fact the sea is regarded as a healthy place and as a leisure natural environment, which is healthy, clean and far-away from the contamination of the cities. Such processes, alongside the real estate speculation, fostered the development of the first seaside resorts on the East coast of Uruguay.

On the other hand, route 10 – which runs parallel to the coast and is only interrupted by the lagoons - was built well into the XX century by unifying several minor roads in the stretch between Punta del Este and the Castillos-Aguas Dulces motorway. Passenger railways lines stop running completely in 1998. This meant that several towns that had grown alongside the railway lost their main income sources and were gradually isolated, as motorway transport kept growing.
However, the intensive use of the coastal strip for real estate developments, and the sun and beach tourism paradigm mean an important territorial segmentation along Maldonado and Rocha's Atlantic coast. In addition, Piriápolis and Punta del Este consolidate as development centres as they concentrate new services fostered by the strong trend in real estate investments.

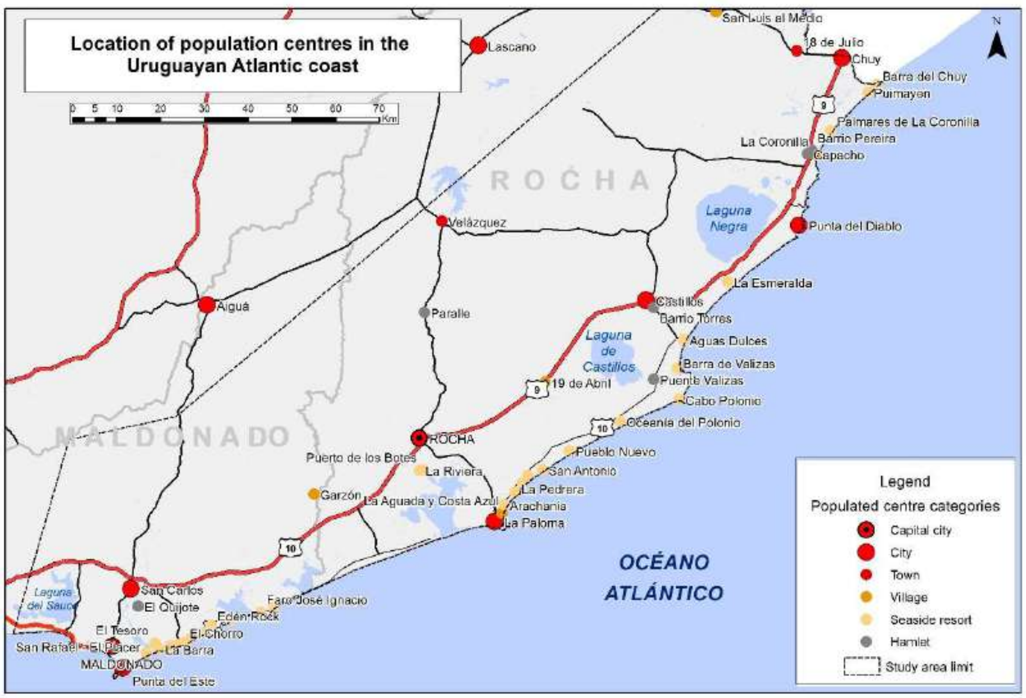


Figure 24: Location of population centres (villages/towns/cities) along the Atlantic coast

The seaside resorts that had been planned by the end of the 30's were mainly sold among middle class families from Montevideo and from other departments, too. There were real estate societies that in 1940 offered the incredible seaside resorts on the Atlantic coast, beautiful and safe beaches and plenty of fishing as well as some tourist-oriented infrastructure that was actually never built. As the beach lots were promoted for sale and new routes were opened, the territory was progressively occupied with recreational as well as permanent housing purposes. In this context, the dunes were considered an obstacle to progress and were therefore massively forested. This exotic species-based forestry development had already begun in the 30's and it used acacia trees, walnut trees and cypresses. Nevertheless, its most important push took place in the decade of the 70's when pine trees were massively planted. In that occasion teams of young people came from different parts of the country to join the fight against the sterile and unproductive dunes. This was how the sandy areas of Punta del Este, José Ignacio and Santa Teresa became a thing of the past, as it had already happened in Cabo Polonio. According to experts on this subject matter, as a result of the ecologically mistaken forestry process that ends up acting as a barrier to winds, there are currently only four or five dunes able to recycle their own sand. There are other serious consequences of forestry, such as the progressive depletion of the beach, because it is deprived of the necessary sediment that is carried by the wind. This has a contradictory impact, as it goes against the tourism that the area is meant to attract: the place becomes not so appealing without the beaches. In addition, those thousands of pine trees one next to the other reduce the phreatic zone and modify the landscape, turning it into something foreign and monotonous. A large number of native species lost their natural habitats and ended up leaving. As a consequence, small wetlands and waterholes progressively dried up leading to the disappearance of birds, mammals and other biological richness that used to live there. In those years, route 10 brought along progress in the shape of forestry and urbanization. A series of real estate investments were developed along the Atlantic coast: Maldonado-Punta del Este and Rocha (La Paloma, La Pedrera, Punta del Diablo, Cabo Polonio) and they mean a remarkable increase of vacation homes as well as a growing tendency to permanent settlement in the area.(Figure 24)

The coastal lagoons, which were initially seen as an obstacle to progress, were later linked to a social and environmental movement that arose against the dominant model of an environmentally aggressive tourism model. This was specially the case of Garzón and Rocha lagoons. Both of them have sandbars that periodically join the Atlantic Ocean and they are located in Punta del Este y La Paloma, the main tourist attraction points of the East coast. In 1950 the Transport Ministry encouraged building works for a bridge in Garzón Lagoon and thus began roadworks so as to join Rocha and Maldonado via route 10. It was a controversial project and was consequently not finished; all of its framework was removed in 2014. Between 1994 and December 2015 the lagoon could be crossed by a raft run by the National Hydrography Office. Discussion regarding building this bridge was resumed several times as it was seen as driving force for the region's – and mainly for Rocha's - tourist development.

Finally, in December 2015 architect Rafael Viñoly was head of a project that built a circular bridge that avoids high-speed circulation. It took a U$S10 million private and State investment. Advocates find its functionality in the slow motor vehicles circulation; a height that lets vessels pass below; and a pedestrian crossing that allows fishing as well as enjoying the landscape. In some near future it will be possible to assess how this project impacts on the coastal territorial structure and on the conflict arising from the fact that Garzón Lagoon has been part of the Bañados del Este Biosphere Reserve since 1976 and part of the Laguna de José

Ignacio, Garzón y Rocha National Lacustrine Park and Multiple Uses Protected Area. Also, it has been in the National Protected Areas System (SNAP) since 2014.

Such transformation process brought along a series of building works and changes: dunes forestry, docks, port, breakwaters and other building sites along the coast. All these have significantly changed the coast's appearance and affected the coastal dynamics, as well. In Alvez's (2011) characterization of the Atlantic coast it is stated that in the last 40 years the mobile dunes fields that feed the beaches on the Atlantic coast have been reduced by 50%. Most of such decrease is a consequence of dunes being fixed by forestry. While the mobile dune surface in 1966 was 89 km^2, by 2005 it only took up 43.7 km^2.

These changes that take place in the area nearby the shore are different from those happening in areas further from the coast. These have traditionally been livestock production zones, where rice crops were introduced in 1930. This type of production remains stable, only with a steady increase in productivity. Maldonado and Rocha had a 47% increase in the amount of bovine and ovine cattle in 12 years, reaching almost one and a half million animals in 2015; fodder crops increased by 25% in the same period.

On the other hand, the rice crops region made up by Cerro Largo, Treinta y Tres, Rocha and Lavalleja grew by 20%, reaching 130 000 hectares. Crops have become more intensive and this has meant that production climbed from 600 000 tons in 2007 to almost 1 000 000 in 2104. In addition, a new and totally productive approach to forestry started. Between 2000 and 2010 exotic species forestry went up by 68% in the aforementioned departments, but this increased reached 78% (DIEA, 2015) in the study area. At this stage exotic species were introduced with the aim of supplying the cellulose industry and strengthening the forestry model introduced by the General Forestry Office (Livestock, Agriculture and Fishery Ministry).

4.3. The Uruguayan Atlantic Coast's characteristics, the study area.

The study area comprises a surface 50 km wide in the terrestrial part of the Uruguayan Atlantic coastal strip. It is a softly hilled area with some steeper slopes in places where crystalline basement is present. The geological substrate has a varied composition, including ancient rocks that become visible in the rocky headland that usually defend the beaches, as well as sedimentary rocks and sediments that have become newly exposed as a result of the sea's subsidence and oscillations. Near the coast there is a strip of active dunes that then become semi-fixed and fixed. Inwards the continent, the extensive Lomas de Narvaez dunes system continues below some scarce soil.

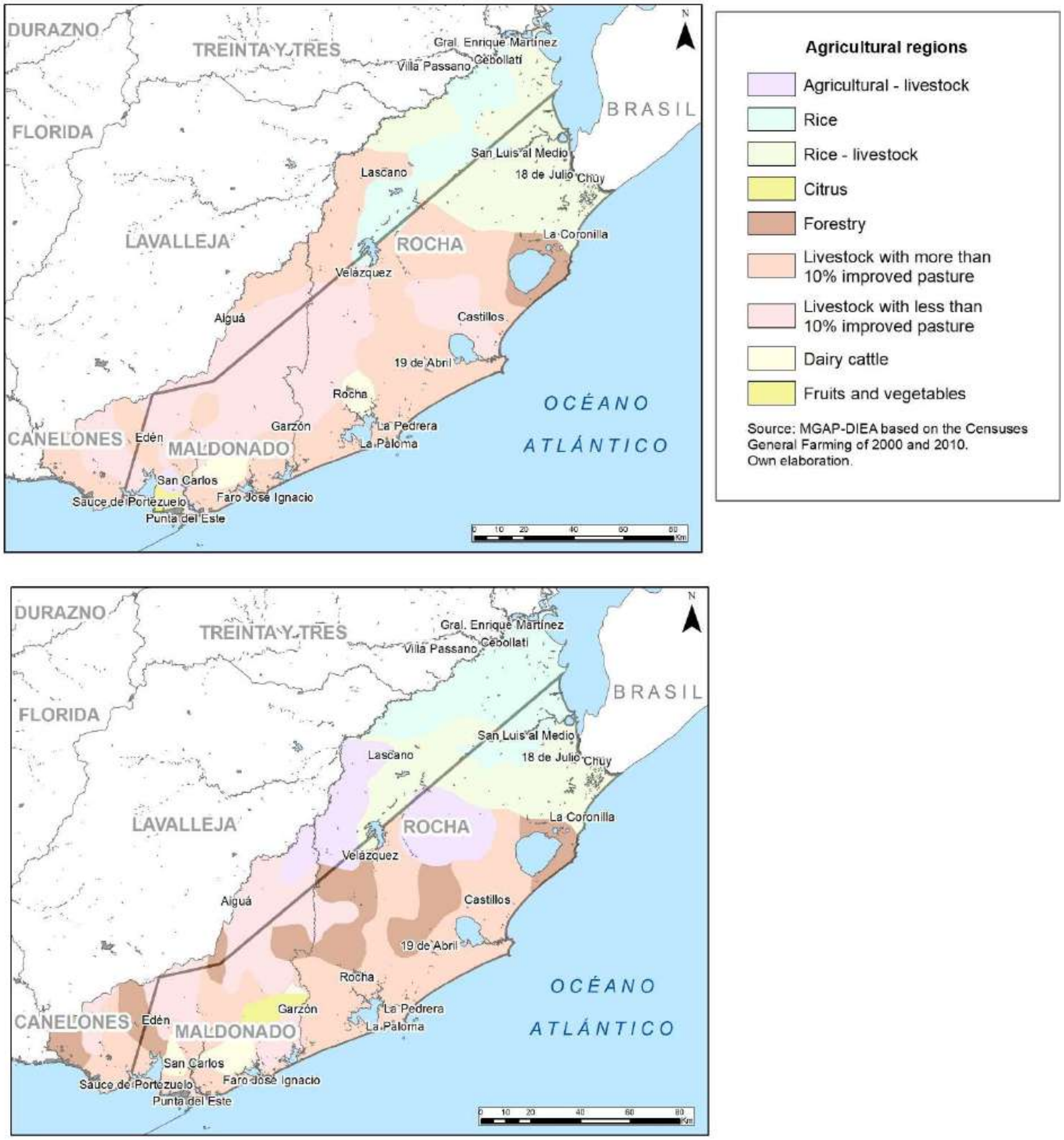


Figure 25: Map of agriculture and livestock farming regions according to the agriculture and livestock farming censuses 2000 and 2010

As a result of important erosion processes, some stretches of coast also depict deep gullies. Even more inwards there is predominance of low and intermediate plains with more productive soils. The hydric network consists of Maldonado and Valizas streams and other lentic environments, including coastal lagoons (José Ignacio, Garzón, de Rocha, de Castillos, Negra and Merín), some of them occasionally reaching the ocean.

Regarding the climate, there is an average temperature of 16.5ºC, the lowest within the country. In the summer season it reaches 23.1°C, in autumn 17.7°C, in winter 12.0° C and in spring de16.9°C. Average rainfall is below 1100mm/year. In “Climate of change, new adaptation challenges for Uruguay” it is stated that the area has the highest accumulated rainfall trend both in the spring-summer season and in the summer-autumn one.

In such context, economic activities have a specific distribution: tourism is predominant on the coast, mostly in the summer season; in areas further from the coast livestock breeding and forestry prevail, and rice crops lead on the East. It is worth remembering that those activities are developed in areas of high-ecological value, sometimes trying to make them compatible, sometimes competing with them and other times just depleting them. The activity that raises most controversy is tourism. The concentration of coastal tourism has a strong impact on the coastline continuity. Public organizations as well as private ones have shown very poor understanding of coastal ecosystems. This has resulted in low-scope tourism investments that do not take into account the limitations of the natural resources available in the area.

According to Ahmed & Nadasen (2013), this type tourist development causes a loss in ecosystem services that gravely affects the western South African coast, making it vulnerable to natural and climate risks. Such concepts could be applied to the Uruguayan case, where a series of problems converge: depletion and disappearance of dune fields and riverine forests as a result of forestry and, more recently, the illegal circulation of all-terrain vehicles; substitution of native forests with crops, forestry and new urban developments; changes in the vegetation’s shape and structure because of forest fires, that also have an impact on isolated houses; rigid structures built on the coastline, increasing coastal erosion; eutrophication and contamination of water bodies, resulting from excessive amounts of different types of waste; introduction of exotic species, moving away the autochthonous ones.

4.3.1. Tourist development

The coast is currently perceived mainly as a high-value leisure space and, consequently, tourism has turned into a very dynamic activity. Tourism is one the fastest-growing economic activities in South America; according to the World Tourism Organization the increase of international tourists duplicated between 2000 and 2015, which has had great impact on income as well as on the associated employment rate. Latin America has been the second fastest growing region in the world for international arrivals between 2010 and 2015, only beaten by Asia and the Pacific. Latin America grew from 50 million tourists in 2010 to 65 million in 2015, which means an annual average growth rate of 5%. In this context, 2015 had the best performance, growing 6.5% compared to 2014 (Figure 26).

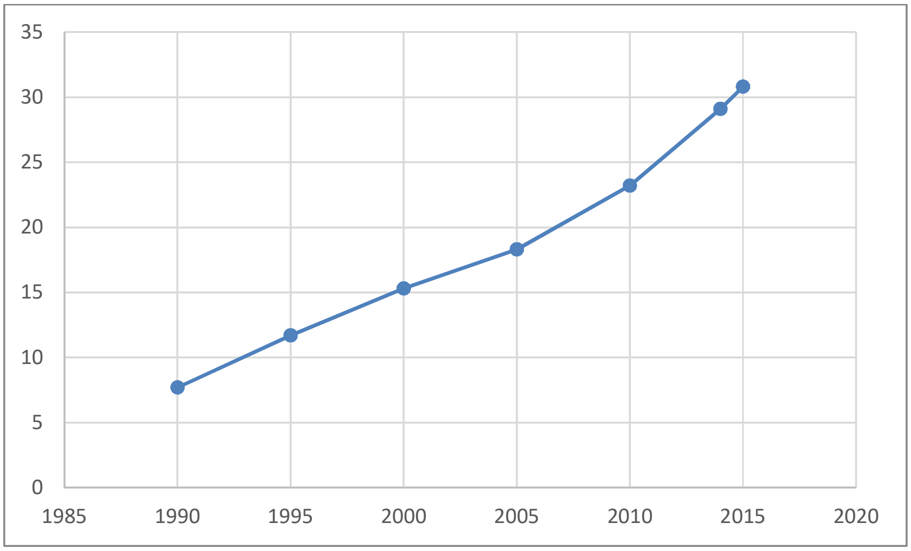


Figure 26: Number of international tourists visiting South America (millions). Source: World Tourism Organization

The Tourism section in the Uruguay XXI Investment Opportunities report states that Uruguay is the country in Latin America that receives most tourists in relation with its population. In the last decade, the amount of international arrivals climbed from 53% of the total population to almost 100%. Tourism configures the economic activity that brings along most income (over U$S 1 800 million/year), beating the country's traditional exports industries. Therefore, tourism has gained greater share in the country's GDP, reaching 7.1% in 2015 and supplying around 110 000 jobs.

The aforementioned report, based on data from the World Tourism Organization (UNWTO) and the International Monetary Fund (IMF), states that tourism has had a dynamic behaviour within the GDP, becoming the activity generating most income, when compared individually with other export activities. In 2016 income from tourists' expenditure was above U$S1 800 million and tourism provided jobs to 110 000 people. This growth is not only a consequence of international arrivals, but also of Uruguayans that living in a better economic climate choose different destinations within their country to spend their holidays.

Internal tourism makes a more diversified and extensive use of the existing offers. According to Dominguez Perez (2016) Montevideo is the main source of internal tourism and the South-East region the main receptor. In addition, there is an important intra-regional flow of tourists that usually travel to neighbouring departments. In 2015 the Central-South region was the source of two out of three local tourists and only received 33% of them. On the other hand, the East area was the source of 8% and received 34%, being the major beneficiary of internal tourism. The destinations chosen by local tourists were: South (Montevideo and Canelones), East (Punta del Este and Rocha) and the hot spring waters on the West coast. Most of the expenditure is also concentrated in those areas, especially in the East.

Alsonsoperez & Risso (2010) had already shown that around 80% of the tourism GDP concentrates in five departments: Montevideo, Maldonado, Canelones, Colonia and Rocha, and in the stated order. An analysis of the accumulated growth rate indicates that in those departments the concentration of tourism GDP increased from 79.88% in 2008 to 80.91% in 2010. That would be a remarkable growth rate considering the fact that between 2002 and 2006 the average increase was 0.25%, while between 2007 and 2010 it reached 10.28%. Rocha, Maldonado and Colonia's rates have been higher than the national average. Rocha and Maldonado's situations were extraordinary, as their average growths between 2007 and 2010 were 42.29% and 28.76% respectively. Results show that 80% of the tourism GDP converges on Southern departments located on the Rio de la Plata and Atlantic coasts.

This tendency is confirmed by information from the Tourism and Sports Ministry (2011). 2.352.000 visitors arrived in Uruguay in 2010 and they spent around US$ 1 496 000 000. When comparing these figures with 2009 data, it is possible to observe a 14.7% increase in the amount of visitors and 13.9% growth in expenditure (World Tourism Organization, 2011). In 2010 tourism was around 6% or Uruguay's GDP. 40% of the tourists who arrived in the country in 2010 came from Argentina and Brazil and chose the East coast as their destination. 25% of them visited Punta del Este, 6% Rocha's coast, 5% Costa de Oro and 4% Piriápolis.

Despite its economic and social benefits, tourism may also be the origin of a variety of negative environmental and social impacts, for instance, the pressure on natural resources or a loss of local traditions (Eagles *et al*., 2002). A rise in the amount of tourists may affect the landscape, local activities, leisure centres and services. A badly-planned tourist development means more congestion, more garbage and more vandalism. In addition, governments can make this situation even worse by placing short-term economic benefits before planning: building inadequate infrastructure, not considering the local population's needs and not applying the necessary conservation criteria so as to protect the natural and landscape value of the tourist attractions. Planning should be seen as a process that implies choosing a desirable future and picking the necessary strategies and actions in order to reach it.

Since the decade of the 60's Uruguay has concentrated its tourism on the coastal and marine zone, promoting "Sun and Beach" and generating a highly seasonal kind of tourism. The country's image as a tourist destination is strongly linked to the coastal offer - in particular to Punta del Este- and there are no other structured alternatives to integrate the existing natural and cultural heritage so as to spread the benefits of tourism to more economically depressed regions. It was only in the 90's when Uruguay began promoting its natural landscapes through the Uruguay Natural brand (Tourism and Sports Ministry). The National Protected Areas System was created in February 2000 by Law 17234. Such law "declares of public interest the creation and management of a Protected Areas National System, as an instrument to apply national environmental protection policies and plans".

Currently, there are 18 areas within - or about to be admitted into- the system. Nonetheless, Uruguay still does not have enough tourist alternatives that allow the country to take profit of these protected areas. Additionally, the growth in tourism in Maldonado, and specifically the urban development that it has brought about, has affected in different ways the coastal ecosystems. This, in turn, has made it difficult to add value to tourism in natural and cultural areas.

The fact that the tourism industry is constantly expanding fosters the creation of new destinations and ways. The Atlantic coast of Uruguay has added ecotourism and sustainable tourist activities to the traditional sun and beach tourism that have boosted the economic as well as social and political development in the area. According to Karez (2012) ecotourism starts in de 80's, linked to the conservationist movement. It is a sustainable option that promotes the conservation of protected areas and the respect to local communities. Even though there is an interest in protecting the Atlantic coast - taking care of its environmental and landscape quality and fostering active recreation and low-impact tourism options- the regulations regarding lot divisions, property options, land occupation, building developments as well as strict measures to regulate effluents use and treatment are still at a too early stage in order to reach such objective.

That sort of tourism minimizes the negative impacts on the natural and socio-cultural environments. Also, it may contribute to maintaining protected areas by using them as eco-tourist points, and generating economic benefits to local communities, organizations and authorities that manage them. They may also provide jobs and profit opportunities to local communities and raise awareness in tourists and local populations regarding the conservation of natural and cultural resources. However, if eco-tourism becomes massive, it may bring about environmental and social damage because of a disorganized land occupation, a loss of local traditions and habits and the eviction of local communities as a consequence of an overvaluation of the land and real state as well as job-seeking migrations (UNESCO, 2006; Karez, 2012).

4.3.2. Evolution of Uruguay's Atlantic coast.

Tourism on coastal areas is one of the alternatives that has developed most in the last decades (UNEP, 2009; Karez, 2012). It strongly depends on natural resources such as the weather, landscapes and ecosystems, and also on cultural resources, for example historic and cultural heritage, handcrafts and traditions. The most relevant problem regarding this type of tourism is how it impacts on the environment in terms of lineal urbanization, pressure on sensitive areas, waste production, habitats fragmentation and social impacts, for instance, loss of identity in addition to social and cultural values. Its development is primarily based on an unplanned process driven by economic objectives. In the long term, and as a consequence of their damages to the environment, the biodiversity and the depletion of ecosystem services, those impacts end up affecting the same tourist activities they were fostered by.

Table 7 and Figure 27 depict the population growth between 1963 and 2011 censuses. The most densely populated centres are the departmental capitals of Maldonado and Rocha, together with San Carlos. Those three cities were founded by the end of the XVIII century. Maldonado, San Carlos and Punta del Este currently make up the Maldonado – Punta del Este conurbation. They are very close to each other and also well-connected by their roads network; the three together reach a population of almost 100,000 inhabitants. Although Punta del Este is the only coastal city of the three, the other two strongly depend on its tourism development. Maldonado experienced a remarkable population growth between 1963 and 2011, mainly because of a high migration rate. According to Labat (2011) such growth can be explained by a steady migration process towards that area that could be compared to the one that shaped Montevideo's (capital of Uruguay) metropolitan area. San Carlos also shows a high growth rate while Punta del Este has a positive though slower one. Due to its functional and economic characteristics, Punta del Este is prone to a wealthy but also seasonal type of population. However, a 76% growth is still remarkable, as it works as an attraction pole for international migration.

In Rocha, the fastest growing urbanizations are linked to well-differentiated situations. On the one hand, La Paloma and its expansion to La Aguada – Costa Azul make up some sort of coastal continuum, integrating a seaside resort, oceanic port and city from the late XIX century, with a couple of other seaside resorts, all of them with high growth rates. On the other hand, Chuy and its Brazilian twin city Chui are defined by their population which has been made up by heterogeneously composed migration flows and by being a "supplies" city for tourists because of its hectic commercial activity on both sides (Navarrete, 2006) (Figure 27).

Table 7: Percentage of growth - 1963 -2011 censuses – Urban population centres

Department	City/Town/Village	2011	Category	Growth 1963 - 2011
Maldonado	Maldonado	62.592	City	317,1
Maldonado	San Carlos	27.471	City	100,6
Rocha	Rocha	25.422	City	30,5
Rocha	Chuy	9.675	City	236,4
Maldonado	Punta del Este	9.277	City	76,0
Rocha	Castillos	7.541	City	26,6
Rocha	La Paloma	3.495	City	327,3
Rocha	La Aguada y Costa Azul	1.090	Town	419,0
Rocha	Velázquez	1.022	Village	0,8
Rocha	18 de Julio	977	Village	30,4
Rocha	San Luis al Medio	598	Town	54,5
Rocha	La Coronilla	510	Town	4,5
Rocha	19 de Abril	205	Town	-33,4
Maldonado	Garzón	198	Town	-42,6

Source: National Statistics Institute

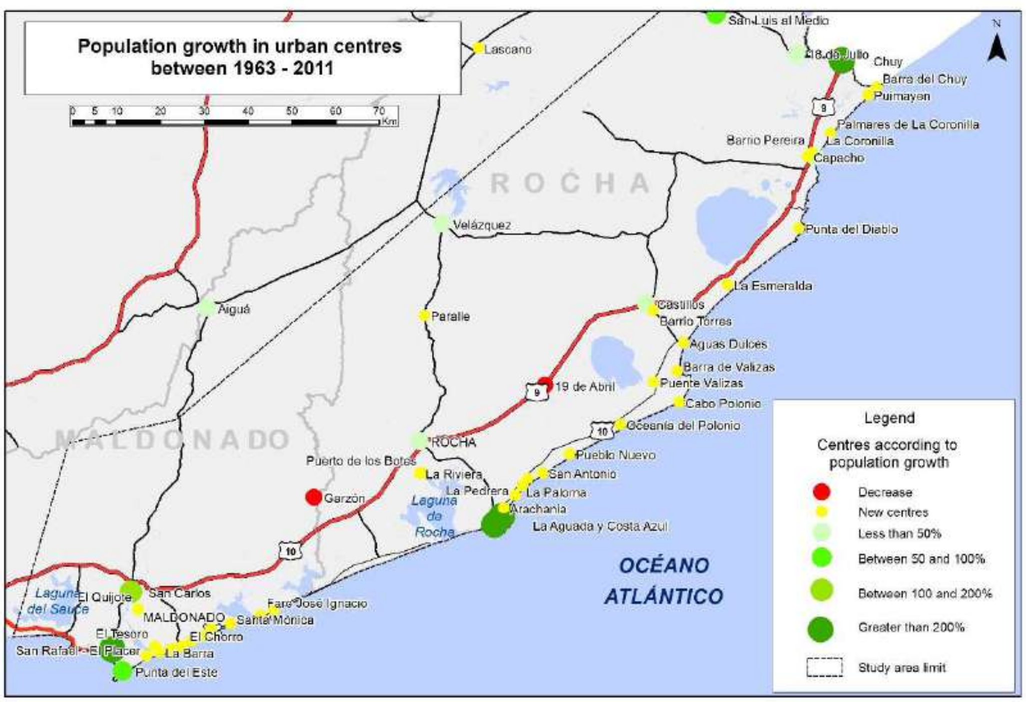


Figure 27: Population growth in cities/villages/towns between1963 and 2011 Source: National Statistics Institute.

The remaining group of populated centres is composed by settlements of different types, with an intermediate, low or even negative growth rate that have all shown a decreasing trend between the two last censuses (2004 and 2011). These are all cities away from the coast, except La Coronilla, whose contaminated beach has put off tourist arrivals (Leicht, 2012).

As a result of new public policies to foster tourism, a new chain of summer resorts has emerged to join the older real estate developments along the coast. With a comb-shaped distribution and accessible mainly via route 9 and later by route 10, they grew slowly and scattered, due to a hard, costly and conflictive building process. (Table 8)

Table 8: Smaller seaside resorts on the Atlantic coast. Source: National Statistics Institute

Department	Town / village	Population	Department	Town / Village	Population
Maldonado	San Rafael - El Placer	3.146	Rocha	Cabo Polonio	95
Maldonado	Balneario Buenos Aires	1.551	Rocha	Pta. Rubia / Sta. Isabel de La Pedrera	94
Maldonado	El Tesoro	1.396	Rocha	Barrio Torres	83
Rocha	Punta del Diablo	823	Rocha	La Esmeralda	57
Rocha	Puimayen	505	Maldonado	Arenas de Jose Ignacio	38
Rocha	Capacho	457	Rocha	Puente Valizas	32
Rocha	Aguas Dulces	417	Rocha	La Riviera	30
Maldonado	El Chorro	392	Rocha	Puerto de Los Botes	21
Rocha	Arachania	377	Rocha	Paralle	16
Rocha	Barra del Chuy	370	Rocha	Palmares de la Coronilla	10
Maldonado	La Barra	339	Rocha	Pueblo Nuevo	10
Rocha	Barra de Valizas	330	Maldonado	Edén Rock	8
Maldonado	Faro José Ignacio	292	Rocha	Oceanía del Polonio	7
Rocha	La Pedrera	225	Rocha	San Antonio	6
Rocha	Barrio Pereira	186	Maldonado	San Vicente	4
Maldonado	Manantiales	149	Maldonado	Laguna Blanca	4
Maldonado	Santa Mónica	111	Rocha	Tajamares de la Pedrera	2

Regarding their population, those nearby Punta del Este clearly stand out and they are part of that city's peri-urban area. The other ones, despite having really reduced permanent populations, they are overcrowded with tourists during the summer season. In 2017 newspapers made reference the area's loss of peace and quiet referring to Punta del Diablo, which has a permanent population of 823 inhabitants and received 15,000 tourists in one weekend (El Observador, 21/01/2017). Manatiales, La Pedrera, Cabo Polonio, Valizas and Aguas Dulces are all highly seasonal seaside towns and all go through situations similar to the one described for Punta del Diablo in the summer season. The contradiction lies on the fact that the natural resources that make these places tourist attraction spots, are at the same time depleted by that massive tourism activity (Arnaiz & Virgen, 2011; Leicht, 2012).

Data from the 2011 Population and Housing Census contribute to having better knowledge of the land's occupation characteristics regarding the types of populated centres and their permanence / seasonality features. There is high rate of empty houses, in special those classified as seasonal, denoting the area's tourist features. Country-wise there is an average 15% private empty houses and 10% seasonal private houses. In Maldonado and Rocha, on the other hand, the percentage of empty houses climbs to 44% and the seasonal ones to 14%. The highest figures are in Punta del Diablo (98%), mostly in the area that stretches South-West. Punta Rubia, Santa Isabel and Oceanía del Polonio have similar figures. Moving away from the coast, high rates of empty houses are linked to rural migrations. (Figure 28)

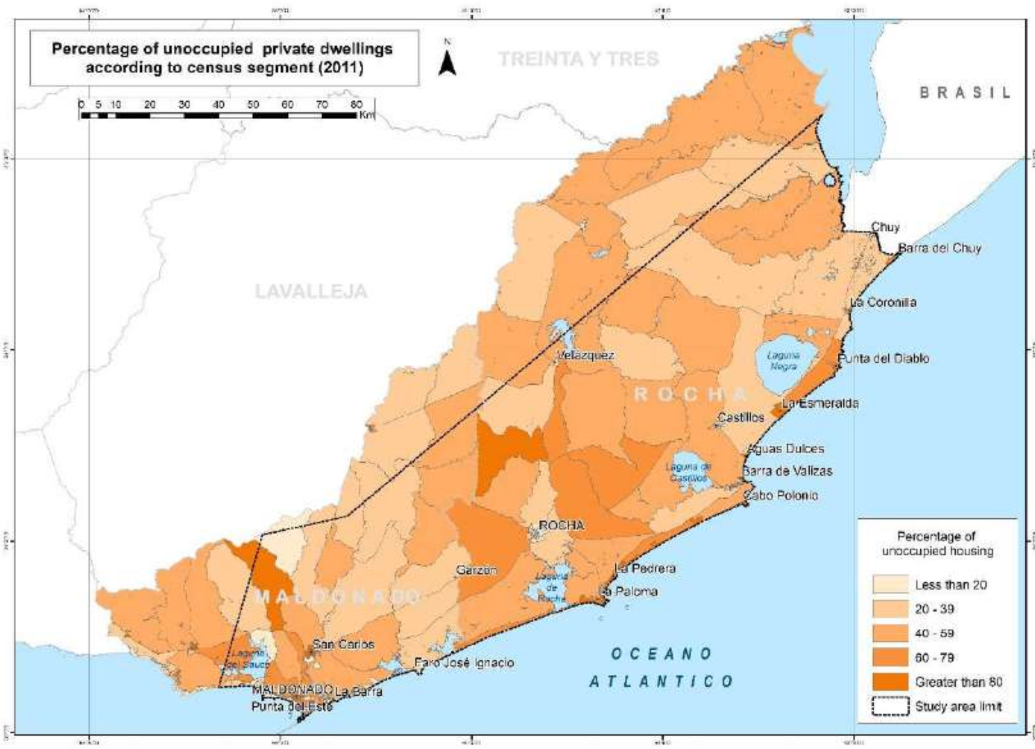


Figure 28: Percentage of empty private houses by census segments – Maldonado and Rocha – 2011 census. Source: National Statistics Institute. Own design.

The house-home ratio may configure another valid perspective to analyse the situation explained before. A 1 ratio means an equivalent number of houses and homes. Considering values disaggregated by populated centre, all the figures are positive in the study area for the 2011 census. The highest values mean a high number of houses in relation to the homes; this may be interpreted as a large number of houses that are not permanently inhabited. Most of these cases can be found in small and newer seaside resorts: Balneario Buenos Aires near Punta del Este, San Antonio and Tajamares de la Pedrera near La Paloma and, a little further away, Oceanía del Polonio. There is a third spot near La Coronilla. As it has already been mentioned, this town has gone through a decline process which results in a low tourist turnout, and therefore, a high rate of available houses (Figure 29).

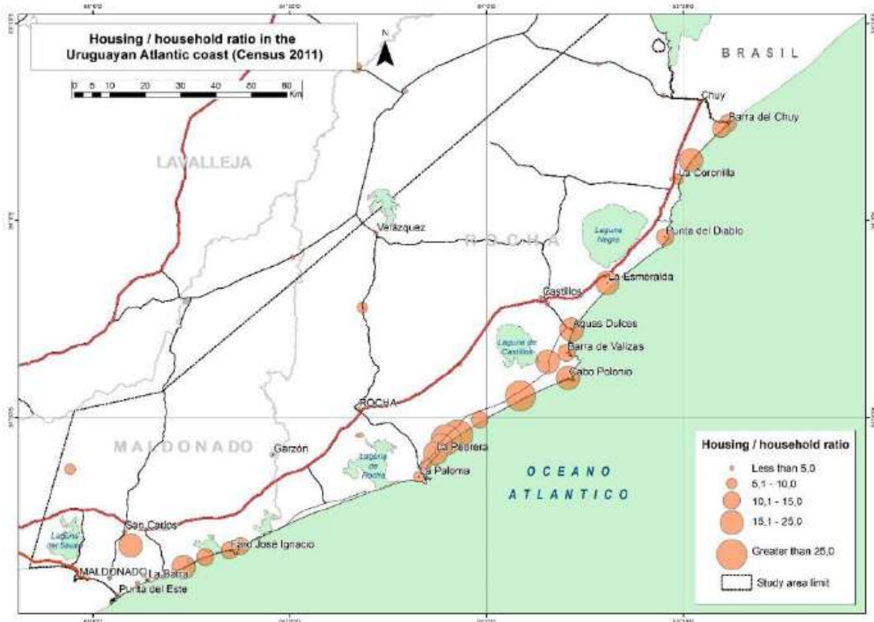


Figure 29: Housing/household ratio by village/town/city on Uruguay's Atlantic coast. Source: National Statistics Institute. Own design.

4.3.3. Land's occupation regarding fire ecology.

Fire is currently regarded as an essential and natural element for the proper running of several forest ecosystems. It has influenced vegetation communities along the time and it has played the role of keeping some ecosystems naturally healthy. In such context, fires are part of the ecosystems' dynamics and they are an ecological management tool (Jardel *et al*., 2009). There are a number of factors that impact on their behaviour, for instance, the combustible vegetation available, humidity, temperature, wind and topography; all of these define the fire's intensity and propagation. On the other hand, human beings have been using fire as a land management tool for thousands of years. However, according to FAO (2011), since the end of the XX century there has been a change in the way that fire and human activity interact. Such change together with an increase in El Niño phenomenon frequency, it has turned fires into a threat for many forests and the diversity within them.

Fires are infrequent in tropical, rain and cloud forests. Nevertheless, they were devastated by uncontrolled fire during the 80's and 90's. According to Huffman (2014), the interaction between fires and climate change has been changing ecosystems and leading to losses in biodiversity. In spite of that, this author believes that fires along with their consequences should not be regarded as repeated, unexpected events, but as regular and permanent components in most terrestrial ecosystems.

At a worldwide level, the frequency of some undesirable and destructive fire events has diverted the focus from the main issue: a lack of useful and desirable fires. More intense fire prevention policies and governmental prohibitions regarding controlled burnings are not a long-term solution for the fires' worldwide issue.

Forest fires constitute regular abiotic elements in several ecosystems around the world. However, it is important to bear in mind that when native species do not count on the necessary strategies to use fire, those events turn into direct threats to wild life and also change their life conditions, for instance, food resources, habitat and nesting places (Adamic, 2001). Terrestrial species that use up a small range of biota as well as those living in the underbrush and on the soil's surface are the most exposed to the impacts of forest fires. Thus, they are the most frequently killed by those fires. On top of that, those species that are able to get away from the fire and manage to get back to their habitats after it is over, do not stand much of a chance to survive. Conditions to develop wildlife in areas affected by fire only get restored in the years following the event.

Additionally, the consequences that forest fires have on the biological diversity and on the biomass volume have an impact on the hydrologic cycle that, in turn, affects the coastal-marine systems, disturbing the vegetation and marine species' behaviour. Photosynthetic activity can be greatly affected by smoke from fires (Davies & Unam, 1999), damaging human and animal health. One of the greatest ecologic effects of forest fires is an increase on the chances of having further events of the same type in the subsequent years. A lack of canopy increases light penetration, leads to drying vegetation and accumulates more combustible materials.

The study area does not comprehend ecosystems adapted to fire and able to go through or take advantage of such events. On the contrary, fire constitutes a damaging factor that interacts with large areas of exotic species that benefit from it, as it helps to keep the species alive. Additionally, there are agriculture exploitation areas that use controlled fires in productive fields. This range of relations between fire and species is not frequently taken into account by environmentalists or by planners. Such heterogeneity must be born in mind regarding the fires' frequency, extent and extension as well as the changes they bring about in the vegetation's composition, structure and distribution in patches around the landscape (Costafreda-Aumedes, S., Garcia-Martin, A., & Vega-García, C., 2013; Saura, 2010). Saura (2010), among other authors, have stated the need to frame forestry within an approach that comprises landscape ecology and land planning. The pressure derived from a heavy flow of tourists in the summer season makes ecosystems conservation, vegetation structure maintenance and better fire management more complex as long as there are no clear rules regarding how to use this territory.

4.4. Discussion

The Atlantic coast has specific features, high ecological value and one of the best –and improved - locations regarding the transport system that make it easy to reach. Such development has encouraged the use of the coastal area with tourism purposes, fostering permanent population settlements and the expansion of urban structures that are aggressive towards the space and the subjacent ecosystems. The expansion of urbanization regardless of its characteristics –permanent or temporary, concentrated or isolated – alongside the implantation of exotic species have increased risk factors in the area. This is how impacts and threats to the coast spread, as current stress sources increase and habitats and species are destroyed.

Dune forestry using exotic species (pine trees, eucalyptus and acacias) that had begun in 1940 to keep dunes away from grazing lands, kept expanding as a condition necessary for urban development (Panario & Gutierrez, 2006). On top of this, there is an increase in the demographic pressure along the summer season that excessively overloads the beaches. Risks derived from urbanization and industrialization began to settle alongside the pre-existing impacts of rural activities'. In addition, the line that divides rural and urban becomes increasingly blurred.

There is a multiplicity of topics and issues affecting a reduced area, reached by specific as well general regulations that need to be integrated with each other so as to improve the response capacity. The development of an integrated management system for the coastal area run by different organisms in conjunction with the State University has been in Uruguay's agenda since the 90's. For them, it has been a priority to reach integrative and participative public polices in order to deal with stress sources that accumulatively affect ecosystems; besides, they agree on the need to have a strategic management perspective.

Even though there has been progress in that direction as political, academic and local citizenship definitions aim at sustainable development and nature conservation - as they are regarded as holding those goods and services that have added so much value to the area-, when decision-making time arrives, those agreements seem to become fragile. Specifically, when assessing fire as a damaging factor, despite partially acknowledging its danger potential, it never gets to configure a regulation priority.

The National Protected Areas System may be regarded as a strong presence in the area, created in response to ecologic disturbances and landscape modifications in terrestrial ecosystems. The effective management of Uruguay's protected areas has been assessed using the Management Effectiveness Tracking Tool (METT), although not as usually as it would be necessary. Such tool allows to outline strategic lines in order to draw up a plan that picks up current stress sources and direct threats as a result of their present impact or of how they are regarded by local inhabitants. There are a few areas that currently have a management plan. Nevertheless, in nearby protected areas unintentional fire, invading tree species and massive tourism are regarded as stress sources.

The Management Plan's strategic lines (designed according to their impact on the conservation objects) include: fire prevention and control, natural prairie's research and management, exotic species planning and tourism development planning. In addition, ecologists and conservationists are highlighting the relevance of "altered fire regimes", that is, too much, too little or the wrong kind of fire, as threats to biodiversity conservation (UICN, 2004).

4.5. Conclusion

The population evolution and shape, changes in soil usage according to agriculture and livestock farming national policies and the growth of tourism activities, have made the coastal area join a certain development model, where an excessive concentration takes place on a narrow strip of land. Moving on with such trend and disregarding variables as longshore drift, sands mobility and ecosystems preservation would imply negative impacts on the coastal system normal development process. Even though there have already been some negative changes in parts of the study area, those are still isolated cases. An integrated management system within the area may be able to alter that trend, focusing on sustainable development instead.

Tourism development is regarded as one of the most important variables to be taken into account, for a series of reasons: it has grown remarkably in this area; it takes up a significant share of the country's GDP, matching that of the traditional activities; and, last but not least, it has predatory characteristics regarding the landscape. Although some tourism options foster sustainability, preservation and an appreciation of the natural and cultural environments, they represent a minor share within the general offer. Previous experiences in integrated management, as well as new organisms specializing in coastal-marine management and protected areas that comprise a wide variety of native species make it possible to think of an adequate response to anticipate further damage on the coastal area.

So as to avoid having a partial perspective on the subject, protected areas management plans and land planning tools must include the fire issue as well as its links to tourism-forest fires and ecosystems-forest fires. Prevention, control and a beneficial management of fires should be part of those regulation systems as they always impact on the natural resources present in any given ecosystem.

CHAPTER 5 FOREST FIRE AND LAND TRANSFORMATION

5.1. Introduction

The use of geographic information technologies enabled important improvements in research about forest fires behaviour and management in the decade of the 70's. In 1984 Rothermel and Burgan developed a modelling system to analyse the evolution of fires called BEHAVE. This model, which is currently updated and in use, employs combustible, slope, relative humidity and wind speed as variables. Development in this field increased hand in hand with multiple advances in satellite imaging and simulation software.

By using Geographic Information Systems (GIS) it becomes possible to create, combine and transform georeferencial variables (Teodoro & Duarte, 2013). Considering that fire prevention, detection and fighting imply bringing together information from different data models and sources, this kind of software is highly suitable to carry out space and time analyses aiming at a predetermined objective. Mixing information regarding combustible vegetables, land digital models, meteorological data, ecosystems cartography, satellite images and anthropic elements – such as the roads network and housing areas – is key in these kinds of analysis. These models are also highly useful when modelling and calculating forest fire risk indexes. Moreover, such usefulness increases as they allow using multiple- scale techniques, inter-operability, real-time data analysis and Augmented Reality.

The possibility of observing the Earth from space is core to this progress; obtaining optical, infrared and thermal information allows not only learning about the terrestrial coverage response regarding its colour, but also provides adequate ranges to detect fires and recognize burnt areas. Radiometric and space resolutions both contribute to improving knowledge about threats and vulnerabilities, even though they have different analysis requirements.

In this chapter those tools are used to identify burnt areas and to analyse how they relate to the land's coverage and the population's distribution. A forest fire risk index is applied to that data; there, threat and vulnerability dimensions are integrated so as to approach the damage on people, goods and the environment from a geographical perspective.

5.2. Research design

It is an ex post-facto investigation that applied GIS and remote sensing technologies with the aim of getting to know the forest fires risk level in a forestry-urban interface area. Firstly, a retrospective exploratory analysis was carried out; its main objective was to spot burnt areas on the Uruguayan Atlantic coast for a

10-year period. The sources used were: Landsat satellite images (TM/ETM/OLI), data from the Desinventar database (https://online.desinventar.org/) and newspaper's information. The two largest events with available satellite images were chosen for analysis, although images had to be frequently discarded due to cloudiness. After digitally processing this information, a risk index was applied. This index is based on the geometrical characteristics of housing distribution in the forest. This investigation, which was carried out in a test area that had been through major fire events, had the aim of understanding the residence/forest space structure and its relation with forest fire events.

The research also comprises data collection regarding fire risk perception from several stakeholders as well as an analysis of public policies on the subject. The objectives are getting to know the risks, the awareness levels and the reactions to current regulations. The component parts of this investigation are analysed in this chapter as well as in chapters 6 and 7.

5.2.1. Selecting the case study.

The selected area is a narrow coastal strip (30km long by 5 km wide) with a SW-NE orientation located between the Atlantic Ocean and Laguna Negra. It is a densely forested sandy strip with scattered population. Punta del Diablo seaside resort, which is located on the northern end of this strip, has 823 inhabitants and 2 110 houses; 344 of them are inhabited according to 2011 census. This town is visited by a large number of tourists in the summer season. Located far southern is La Esmeralda. It is a less developed area – 57 inhabitants and 240 houses, 24 of them inhabited according to 2011 census -. It was in this strip of land where the two largest non-programmed and unmanaged forest fires took place.

5.3. Methodology

Geographic information technologies work with real-world geometric representations and associated data. The integration of raster and vector spatial data models strengthens analysis and modelling capacities. Achieving geoprocessing in a methodology expands the spectrum of data processing, allows the inclusion of satellite image processing and generates new information resulting from modelling. The methodology used in this chapter includes a set of procedures that allow to identify threat as the result of forest fires, basically burned area, and vulnerability measure through dwelling exposure within the forest. It is applied in a pilot area of the Atlantic coastal area.

5.3.1. Remote sensing and the identification of burnt areas.

There has been a great expansion in the use of data from earth observation satellites in fire prevention and assessment in the last decades (Chuvieco, 2009; Chuvieco, 2003). There is a wide range of techniques and sensors used in this kind of events. According to Performance test parameters of remote sensing for burned area identification using Landsat-8. (2014), burnt areas cartography through remote sensing includes: AVHRR (Advanced Very High-Resolution Radiometer), SPOT-Vegetation (*Satellite Probatoire d'Observation de la Terre*), MODIS (Moderate Resolution Imaging Spectroradiometer) and Landsat TM/ETM+ (Thematic Mapper / Enhanced Thematic Mapper plus). Also, NDVI (Normalized Difference Vegetation Index) is among the methodologies used for area recognition, as well as supervised classification and main components (Martín & Chuvieco, 1995; Cahoon *et al*., 1999; Siljestrom & Moreno, 1995; Chuvieco *et al*., 2005). On the other hand, and according to Manzo Delgado, L. & López García, J. (2013), the Normalized Burn Ratio indexes for burnt areas (NBR; López-García & Caselles, 1991) and the Burned Area Index (BAI; Martín *et al*., 2005), have proven to have the best results because their use of near infrared bands and short-wave infrared makes them both more sensitive to carbon and ashes present in the soil. (Bastarrika *et al*., 2011).

The first test of these methodologies was carried out in the area where Punta del Diablo's March 30th, 2015 fire had taken place. There, around 70 hectares had been burnt. The images to be processed had been taken from Landsat 8 and OLI and they corresponded to the burnt area on cloudless days at nearby previous and later dates. They were: LC82220842015079 from March 20th, 2015 and LC82220842015095 from April 5th, 2015.

5.3.2. Processing

Top-of-the atmosphere reflectance transformation (TOA) with DOS1 correction was applied to both images, using Semi-Automatic Classification (SCP) QGIS Plugin. The SCP complement is in charge of calculating automatically the TOA reflectance, which is defined as the reflected energy ratio over the total incident energy (NASA 2011). The necessary information for such process is supplied by each image's metadata.

The applied formula is as follows: $\rho p=(\pi * L\lambda * d2) / (ESUN\lambda * \cos\theta s)$

where:

$L\lambda$ = Spectral radiance in the sensor

d = Earth-Sun distance in Astronomical Units

$ESUN\lambda$ = Average Solar exo-atmospheric Irradiance

θs = Solar zenith angle in degrees, which is equivalent to: $\theta s = 90° - \theta e$ where θe is the solar elevation

Radiance is defined as the "energy flux (mainly irradiant or incident energy) by solid angle that leaves a surface's aerial unit in a given direction". "Radiance is what the sensor measures and depends, up to a certain extent, on the reflectance" (NASA, 2011).

Re-scaling factors are provided for each band of Landsat 8 OLI images. This allows a direct conversion from digital DN values to Reflectance, calculated using the following formula:

$$L\lambda = M_L * Qcal + A_L$$

where:

ML = Band-specific re-scaling multiplication factor, taken from the metadata (RADIANCE_MULT_BAND_x, where x is the band number)

AL = Band-specific re-scaling additive factor, taken from the metadata (RADIANCE_MULT_BAND_x, where x is the band number)

Qcal = Pixel values discretized and Calibrated from the standard product (DN digital values)

Such values are taken from the metadata file that NASA supplies attached to the image. The DOS1 atmospheric correction (Dark Object Subtraction) or SPO (Pixels Subtraction Method) is also known as the Chavez Method. This method is based on the assumption that in the absence of atmospheric effects, the minimum ND value for the image –corresponding to its dark areas - should be zero. On the grounds of such assumption, any differences between zero and the histograms minimum values are a result of an increased radiance that is absorbed by the sensor as a consequence of the atmosphere's diffuse radiation. The procedure implies extracting each band's minimum ND from its total ND.

In addition, assuming that only a few elements on the surface of Earth are absolute black, a 1% reflectance –instead of 0- is adopted. The fog effect given by Sobrino *et al*. (2004):

$Lp = Lmin - LDO1\%$

Specially for Landsat images:

$Lmin = ML * DNmin + AL$

Assumptions:

Lp=path radiance

Lmin = "radiance that corresponds to a digital count value for which the sum of all the pixels with digital counts lower or equal to this value is equal to the 0.01% of all the pixels from the image considered" (Sobrino et al., 2004 p 407)

- LDO1% = radiance of Dark Object, assumed to have a reflectance value of 0.01

There is a variety of DOS techniques (for instance: DOS1, DOS2, DOS3, DOS4), based on different Tv assumptions (atmospheric transmittance in the viewing direction), Tz (atmospheric transmittance in the illumination direction), and Edown (downwelling diffuse irradiance). The simplest technique is DOS1 and it makes the following suppositions (Moran *et al*., 1992):

$$Tz = 1$$

$$Edown = 0$$

Therefore, the fog effect is: $Lp = ML * DNmin + AL - 0.01 * ESUN\lambda * \cos\theta s / (\pi * d2)$ and the resulting reflectance on Earth's Surface given by: $\rho = [\pi * (L\lambda - Lp) * d2] / (ESUN\lambda * \cos\theta s)$

5.3.3. Burnt areas spectral response

When comparing the healthy vegetation's spectral signature with that of the burnt areas, it is possible to observe that the SWIR2 (1200 nm) y NIR (850 nm) bands are the ones supplying most information as it is where both signatures seem to be more contrasting. Those wave lengths correspond to Landsat 8 waves 7 and 5, respectively (Figure 30). Several investigations assessing the results from the vegetation's spectral bands before and after the fire show that the aforementioned bands are the ones showing the most significant variation. (Figure 31). This mechanism allows using a 754 bands combination (Landsat 8) to carry out the visual analysis. This would enable to tell burnt (identified in red) from not burnt areas (identified in green). With the aim of improving the contrast, the red band is set in the blue channel. (Figure 32; Figure 33)

This is how burnt areas are easily spotted visually, but it is hard to classify them automatically, as there is a wide range of space and spectral diversity resulting from the fire's magnitude (Chuvieco *et al*. 2008, Soverel *et al*. 2010). Later, Fuentes (2015) states satisfactory results to the application of burnt areas automatized discrimination using indexes such as NBR (Normalized Burn Ratio) to Landsat images.

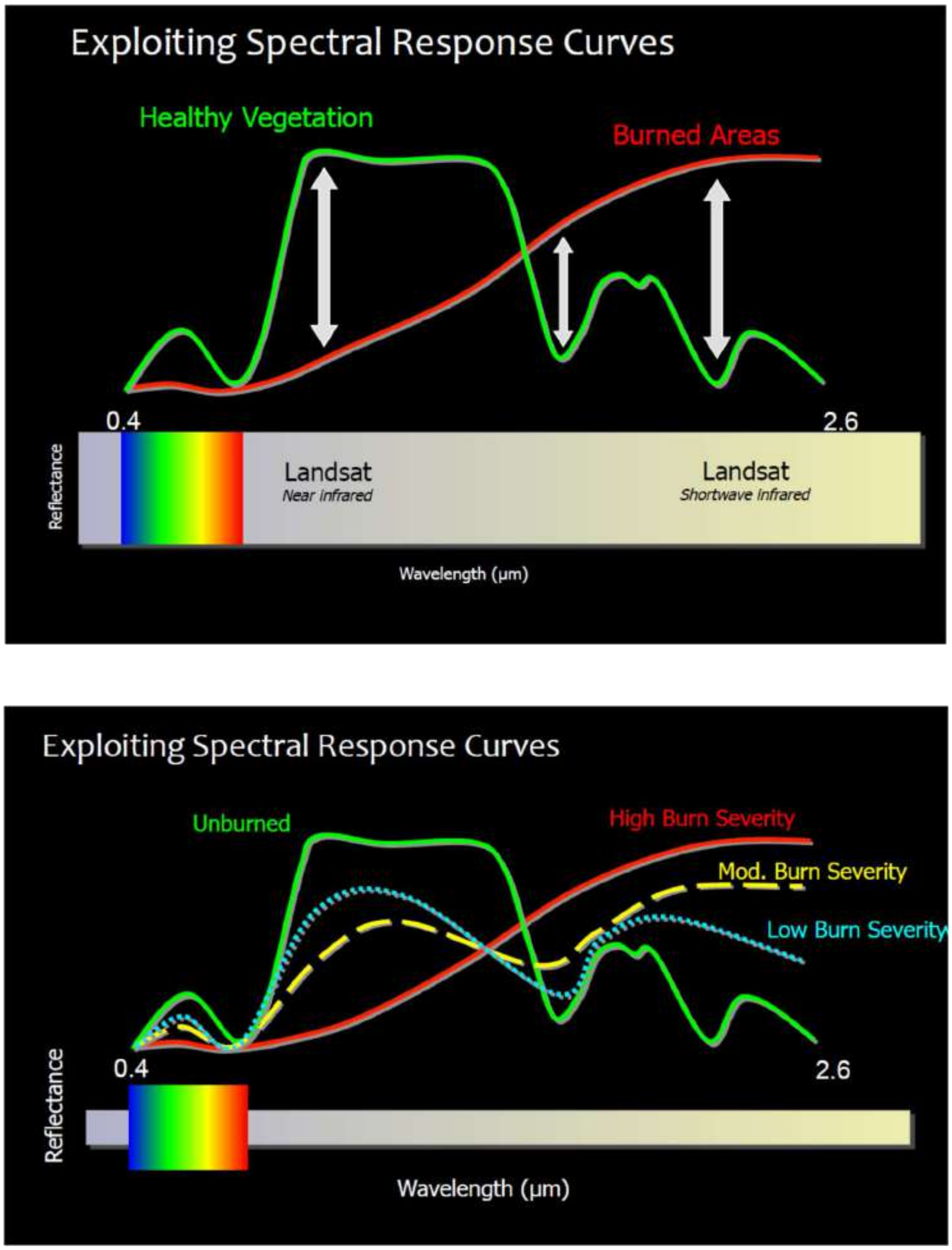


Figure 30: Spectral signatures in vegetation and burnt areas.

Source: Introduction to remote sensing for wildfire applications - NASA

AoI	LANDSAT-8 SPECTRAL BAND					
	Band 1	Band 2	Band 3	Band 4	Band 5	Band 7
	0.43 - 0.45 µm	0.45 - 0.52 µm	0.53 -0.60 µm	0.63 -0.68 µm	0.85 - 0.89 µm	2.10 – 2.30 µm
Vegetation before fire	0,134	0,111	0,092	0,066	0,308	0,052
Vegetation after fire	0,125	0,104	0,078	0,071	0,128	0,12

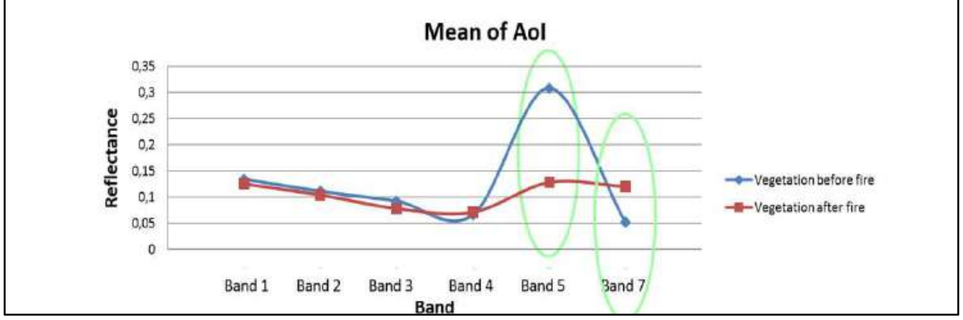


Figure 31: Burnt area statistical description

Source: Indonesian National Institute of Aeronautics and Space (LAPAN)

The test area used was the entrance to Punta del Diablo, where a fire on March 30th 2015 burnt 70 hectares. The processing of Landsat 8 images comprised atmospheric correction and image calculation to reflectance in QGIS with DOS1 atmospheric correction SCP.

Afterwards, the burnt area was outlined, in a procedure that used tools from Semi-Automatic Classification Plugin en QGIS. The image used was Landsat LC82220842015095 from April 5th 2015, after the fire and piled from band 2 to 7.

The burnt area was outlined by defining a training polygon (ROI), using the automatic region growing Algorithm. This Algorithm marks a seed pixel on the image and then, using a pre-defined distance (0.05 in this case), automatically defines a polygon that comprises the surrounding spectrally homogeneous pixels. (Figure 34; Figure 35)

The same procedure was used to outline training polygons for the rest of the assessed coverages: water, sand, naked soil or urban areas, forestry and crops or herbaceous. The spectral signature was also calculated for each category. (Table 9)

Figure 32: Pre-fire: LC82220842015079 Punta del Diablo (20/03/2015) Band composition: 754

Figure 33: Post fire: LC82220842015095 Punta del Diablo (05/04/2015) Band composition: 754

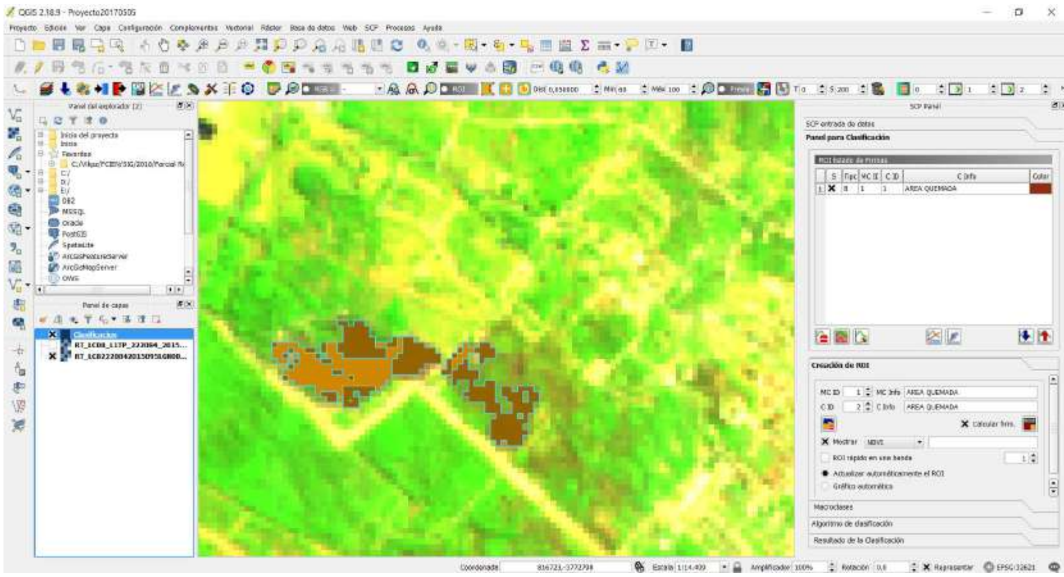


Figure 34: Burnt area outline in Punta del Diablo using QGIS

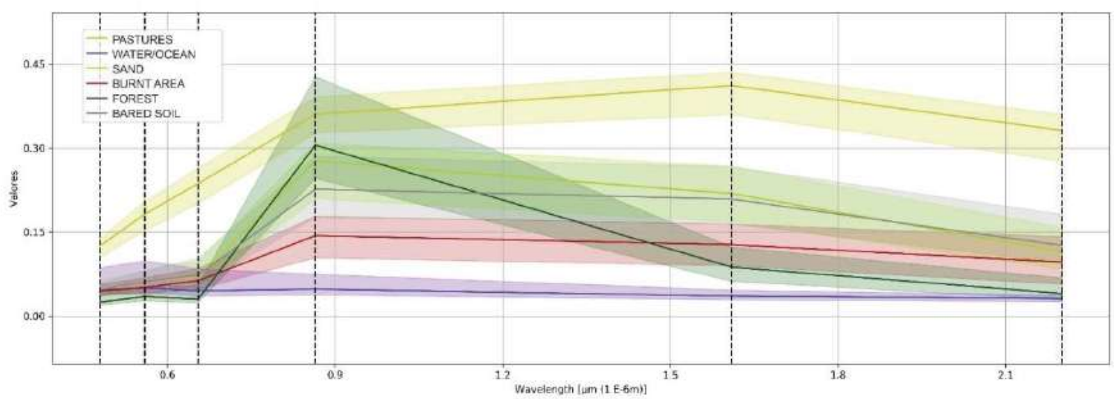


Figure 35: Spectral signatures coverage from Punta del Diablo area

Table 9: Spectral signatures data from the image's coverages

	MC_ID = 3 MC_info = HERBACEO C_ID = 3 C_info = HERBACEO ROI_size = 2576 pixels					
Wavelength [E-6m]	0.48	0.56	0.655	0.865	1.61	2.2
Values	0.0437	0.06294	0.06928	0.27701	0.2185	0.11544
Standard deviation	0.00379	0.00482	0.00679	0.02008	0.02478	0.01339
	MC_ID = 5 MC_info = AGUA C_ID = 5 C_info = OCEANO ROI_size = 6944 pixels					
Wavelength [E-6m]	0.48	0.56	0.655	0.865	1.61	2.2
Values	0.04644	0.05029	0.04482	0.048	0.03548	0.03118
Standard deviation	0.00398	0.00492	0.00441	0.00468	0.0027	0.00221
	MC_ID = 6 MC_info = ARENA C_ID = 6 C_info = ARENA ROI_size = 10 pixels					
Wavelength [E-6m]	0.48	0.56	0.655	0.865	1.61	2.2
Values	0.12551	0.18215	0.23635	0.36056	0.41156	0.33154
Standard deviation	0.01472	0.02133	0.02588	0.02361	0.02448	0.02836
	MC_ID = 1 MC_info = AREA QUEMADA C_ID = 1 C_info = AREA QUEMADA ROI_size = 252 pixels					
Wavelength [E-6m]	0.48	0.56	0.655	0.865	1.61	2.2
Values	0.04426	0.05091	0.06288	0.14348	0.12729	0.09631
Standard deviation	0.00328	0.00402	0.0056	0.01643	0.01882	0.02118
	MC_ID = 2 MC_info = FORESTACION C_ID = 2 C_info = FORESTACION ROI_size = 1903 pixels					
Wavelength [E-6m]	0.48	0.56	0.655	0.865	1.61	2.2
Values	0.02468	0.03472	0.02991	0.30508	0.08725	0.04013
Standard deviation	0.00209	0.00366	0.00351	0.03972	0.01129	0.00649
	MC_ID = 4 MC_info = SUELO DESNUDO C_ID = 4 C_info = SUELO DESNUDO ROI_size = 1987 pixels					
Wavelength [E-6m]	0.48	0.56	0.655	0.865	1.61	2.2
Values	0.04679	0.06182	0.07301	0.2265	0.2088	0.12586
Standard deviation	0.0043	0.00565	0.00914	0.01523	0.02306	0.01823

REFERENCE		
HERBACEO		PASTURES
AGUA/OCEANO		WATER/OCEAN
ARENA		SAND
AREA QUEMADA		BURNT AREA
FORESTACION		FOREST
SUELO DESNUDO		BARE SOIL

5.3.4. Land damage assessment

Evaluating the effects that fire has on society and ecosystems should entail taking into account all those changes that the territory goes through as result of fire. Such effects are tightly linked to the fire's intensity and severity as well as its length in time, which is - in turn - connected to the amount of existing combustible material, how humid that material is, the topography, the winds and the extinguishing methods of choice. The role of remote sensing in defining risk conditions may have two focal points: generating critical variables to forecast possible ignition and propagation and assessing resources that could be potentially damageable in case of fire.

Remote sensing has been used to assess the impacts of fire at a global as well as a regional scale.
The most commonly used study methods have been based on medium space resolution sensors (like Landsat-TM/ETM+, SPOT-HRV, IRS-WIFS/AWIFS), with pixels between 30 x 30 m and 100 x 100 m. (García, 2003; Koutsias *et al*., 1999; Salvador *et al*., 2000; Siljeström & Moreno, 1995). The main objective of these assessments has been to develop a cartography of burnt areas, which gets fairly precise when the fires as medium-sized (over 25 hectares).

More recent research has tried use images so as to determine how severe post-fire conditions get. This is a really interesting method to reach a more precise assessment of damage and potential regeneration conditions (Lentile *et al*., 2006). The USA's USGS is currently developing an operative programme with the aim of mapping those areas that have been affected by large fires all around the country. It uses a semi-empirical method based on Landsat images (Key & Benson, 2006). Despite being successful in a diversity of ecosystems (Brewer *et al*., 2005; Cocke *et al*., 2005), this system has had issues in others (Kasischke *et al*., 2007); this has led to considering the use of simulation models so as to improve the diagnosis of intermediate severity levels (De Santis & Chuvieco, 2007; De Santis & Chuvieco, 2009; De Santis *et al*., 2009).

On a global scale, satellite images from SPOT Vegetation, Terra-MODIS and ERS-ATSR sensors are being used to develop a worldwide assessment of burnt areas. The objective is to spot the carbon signal, or at least a post-fire loss of vegetation coverage. This signal has better stability than that from active fires but, on the other hand, it has a lower spectral contrast. This makes it harder to tell it apart from other changes in vegetation, such as: tree felling, harvesting, floods or cloud shades. There are two products that stand out among the global series: The Globalcarbon series carried out by ESA (Piccolini & Arino, 2000; Tansey *et al*., 2004), and the one based on MODIS images (Roy et al., 2005; Roy et al., 2002). They both have been covering the whole planet with daily resolution (as long as the clouds allow it) since 2000 (Chuvieco, 2009).

5.3.5. Applying burnt areas detection indexes

According to Heredia *et al*. (2003), in the last years NDVI has been one of the most used burnt areas spectral indexes, as it offers a variety of alternatives depending on the available sensors (Chuvieco *et al*.,2002; Trigg & Flasse, 2001). These authors have proved, however, that the traditional vegetation index NDVI (Normalized Difference Vegetation Index) does not discriminate burnt areas properly. Instead, it gives satisfactory results in time comparisons. Millano, J. & Paredes, F. (2016), who carried out a newspapers and periodicals research for Latin America, state that the vegetation's dynamic evaluation done from NDVI time series has become increasingly relevant to model climate and monitor the vegetation's response to global climate change as well as the annual rainfall cycle applied with agricultural and livestock breeding purposes.

In addition, its application has become paramount when assessing the impact of ENSO in base line statistics, to calculate meteorological drought, and even the vegetation's relative greenness, emphasizing those areas used for dryland farming as well as for pastures. Moreover, as forest fires encourage deforestation and global warming, and ENSO has been held responsible for long periods of drought and an increase in temperature, the NDVI has become a useful tool to analyse the burnt areas space and time distribution pattern and to identify primary attention areas. When applying this index to the test burnt area, it is possible to spot that area as well as other coverages that get mixed with it. (Figure 36; Figure 37).

$$NDVI = \frac{(\rho_{NIR} - \rho_{RED})}{(\rho_{NIR} + \rho_{RED})}$$

For the Landsat 8 image the construction goes as follows: NDVI(L8) = (b5-b4) / (b5+b4)

$$NDVI = \frac{(\rho_{NIR} - \rho_{RED})}{(\rho_{NIR} + \rho_{RED})}$$

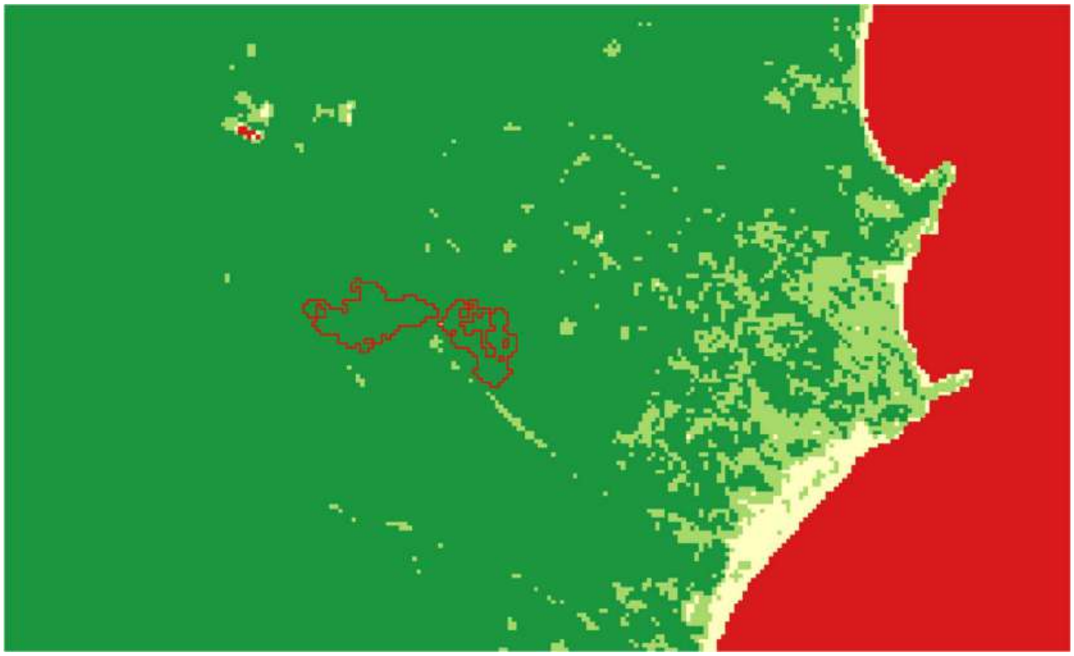


Figure 36: NDVI Pre fire: LC82220842015079 Punta del Diablo (20/03/2015)

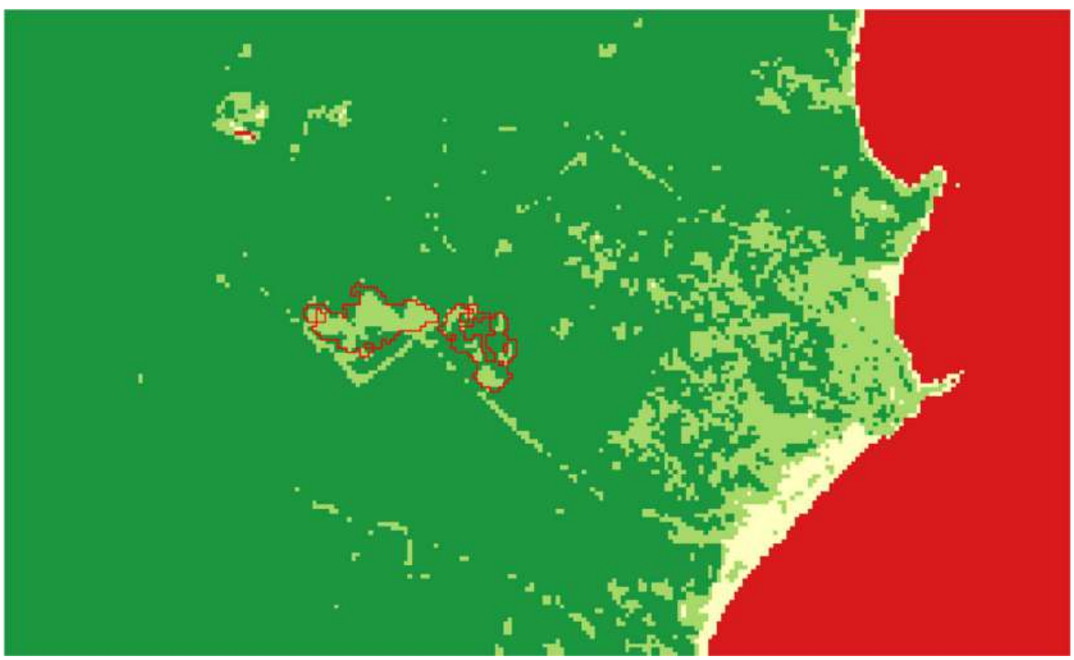


Figure 37: NDVI Post fire: LC82220842015095 Punta del Diablo (05/04/2015)

There is a variety of methods that can be used to calculate the area affected by fire. The most frequent are the ones based on comparing by subtracting from the fire's previous and following images. This image subtraction method was applied to NDVI images previous to and following the fire's date. The resulting image shows a sudden NDVI decrease (due to the vegetation disappearance) and a variation in the images' contrast, making it possible to tell areas with sudden changes from others without any visible changes. The most stable area values tend to zero, while those areas that have been through changes show positive – and even negative – values, depending on the study area and the time when the images where taken (Quintano, *et al*., 2003). (Figure 38)

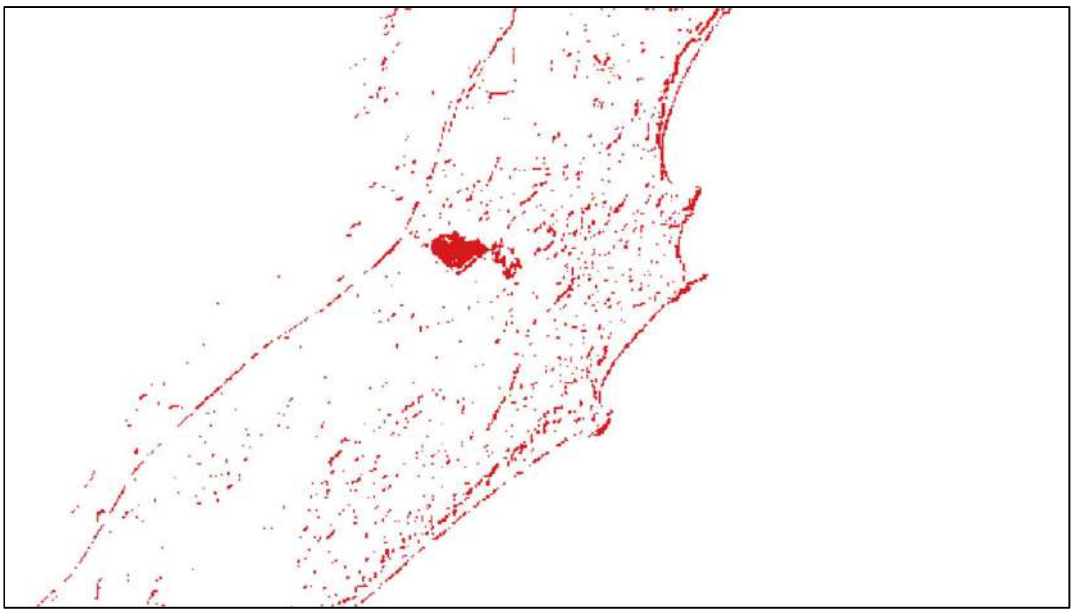


Figure 38: ΔNDVI < -0.2 cartography for the test area - Punta del Diablo

Another way of calculating burnt areas is by developing spectral indexes adapted to the carbon signal. This prevents confusing them with areas behaving likewise and makes it easier to spot them. The AQL 2004 project has been crucial regarding this matter. The Latin American Network for Forest Fires Tele-detection (RedLatif) was set up by the end of 2004. It had the support of the GOFC-GOLD International Programme (Global Observation of Forest and Land Cover Dynamics), and its main objective is mapping large burnt surfaces. It was developed based on 32-day surface reflectance MODIS composites and was able to build the AQL2004 (Latin American Burnt Areas) algorithm, which supplies relevant regional and national data (Chuvieco *et al*., 2008).

In the present case study, two of the most frequently used indexes of the last years - the BAI (Burned Area Index) and NBR (Normalized Burn Ratio) - were applied. Independently from the used index, it is worth considering that the spectral response from the burnt area will vary according to a series of variables, such as the time lapse between the fire and the image capture, the land humidity, the time of year and the existing ecosystem or plantation. As a consequence, values taken from previously burnt areas were used so as to define the threshold between what is burnt and what is not. (Opazo & Rodríguez, 2007).

The BAI that Martin defined (1998) was developed for NOAA – AVHRR images and modified in 2002. It adds information from SWIR in the red channel, which improves discrimination (Figure 39; Figure 40). It is constructed as follows:

$$\text{BAI} = \frac{1}{(\text{PcSWIR} - \rho\text{SWIR})^2 + (\text{PcNIR} - \rho\text{NIR})^2}$$

For Landsat 8 it is:

$$\text{BAI (L8)} = \frac{1}{(0.2 - b7)^2 + (0.08 - b5)^2}$$

This methodology needs convergence points, that is, the reflectivities of a convergence point for the burnt areas in SWIR and nearby infrared, because it is based on calculating the spectral distance from each pixel to a converging value that burnt areas usually have; that highlights carbonized areas over other coverages (Chuvieco *et al*., 2002; Gajardo *et al.*, 2010). In this case, the ones calculated by the AQL 2004 project were applied.

Convergence points:

$PcSWIR = 0.2$

$PcNIR = 0.08$

SWIR L8 = b7

NIR L8 = b5

The NBR index, also known and the burnt area normalized coefficient, is based on the spectral contrast between the nearby infrared (NIR: 0.78 - 0.90 μm) and the short-wave infrared (SWIR: 2.09 - 2.35 μm). Within a post-fire environment, burnt surfaces are not reflective in NIR because of the structural changes in the vegetation. On the other hand, they are highly reflective in SWIR due to the loss of water and vegetation. Key and Benson (1999) defined NBR; this index identifies surfaces affected by fire whose variation interval, when normalized, stays between -1 and +1 by means of the following expression: NBR = ρ NIR – ρ SWIR / ρ NIR + ρ SWIR. For Landsat 8 images it is: (b7-b5) / (b7 + b5). (Figure 41; Figure 42)

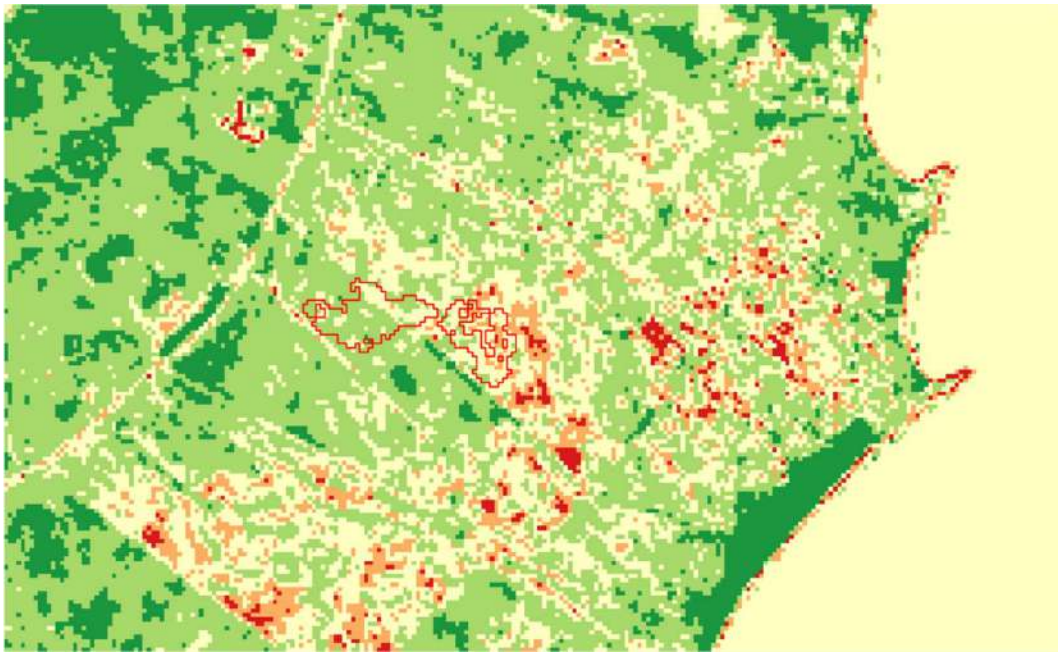


Figure 39: BAI Pre fire: LC82220842015079 Punta del Diablo (20/03/2015)

Figure 40: BAI Post fire: LC82220842015095 Punta del Diablo (05/04/2015)

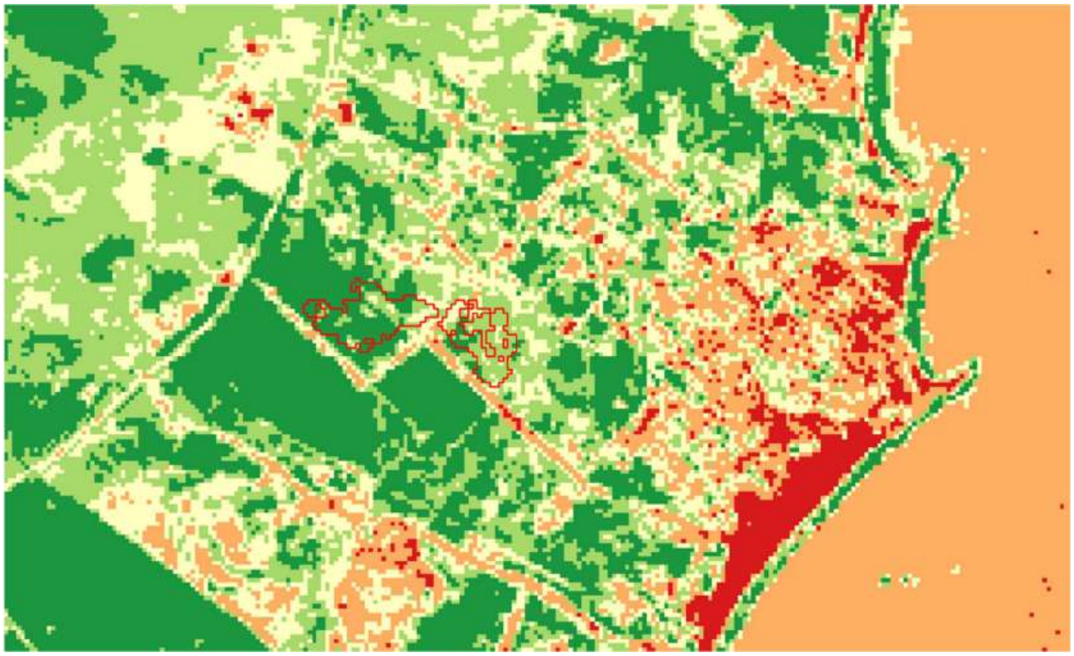


Figure 41: NBR Pre fire: LC82220842015079 Punta del Diablo (20/03/2015)

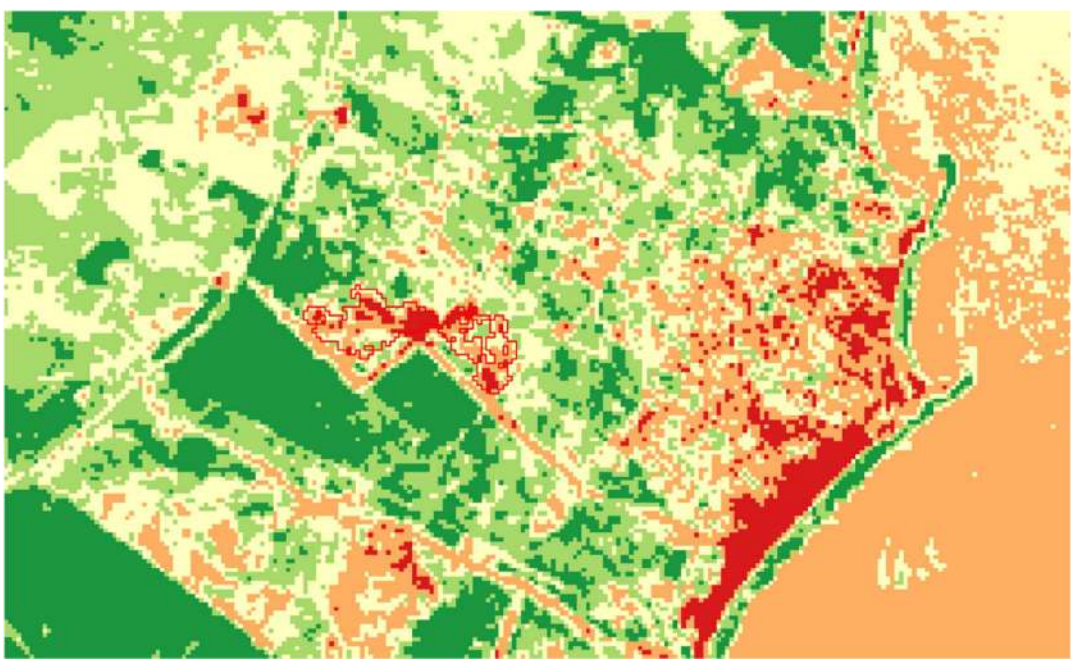


Figure 42: NBR Post fire: LC82220842015095 Punta del Diablo (05/04/2015)

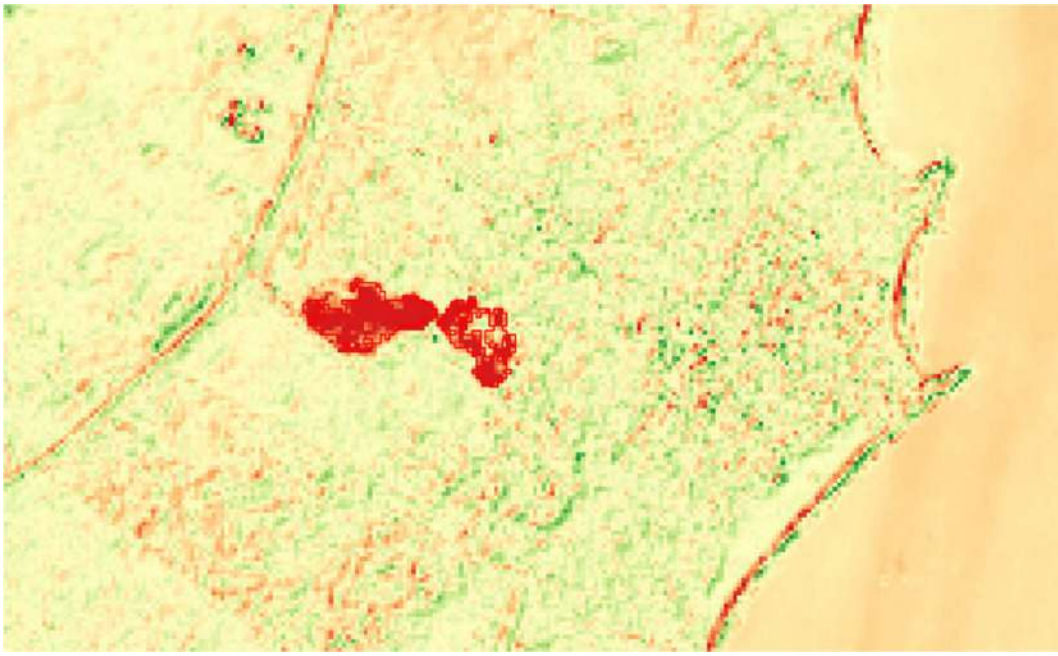


Figure 43: 1.74 < ΔBAI Cartography for the test area - Punta del Diablo

Figure 44: 0.35 <ΔNBR Cartography con for the test area - Punta del Diablo

The variations resulting from these indexes were processed later. (

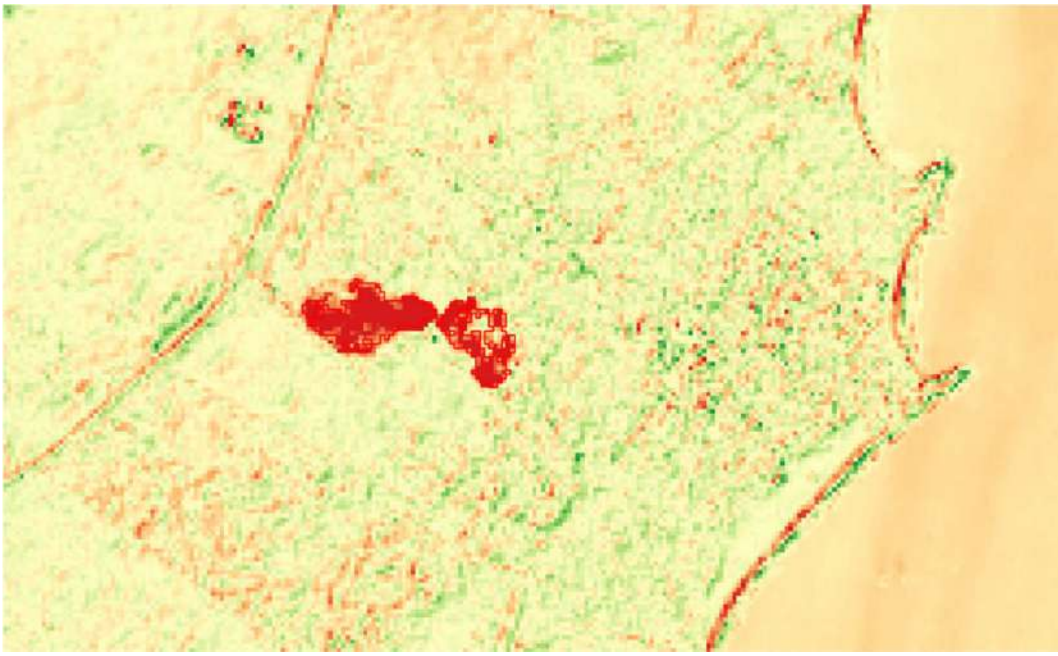
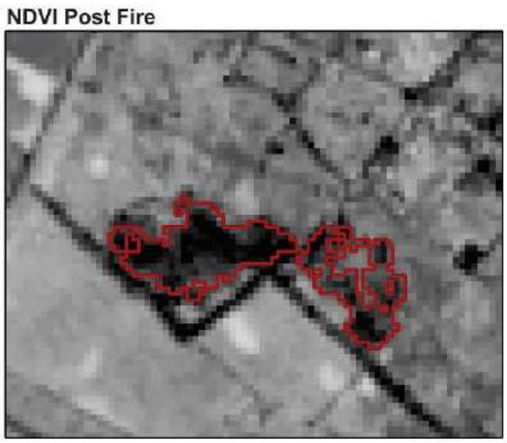


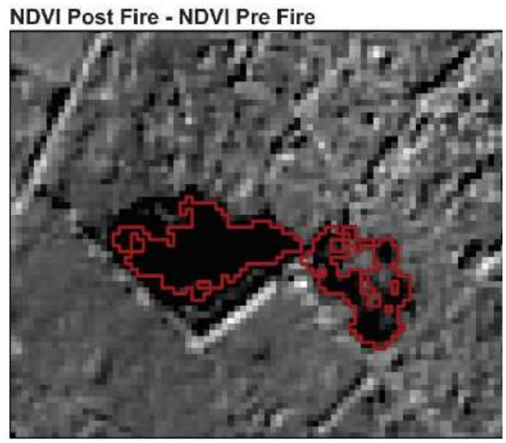
Figure 43; Figure 44).

A summary of statistical values for the three indexes can be found in Figure 45.

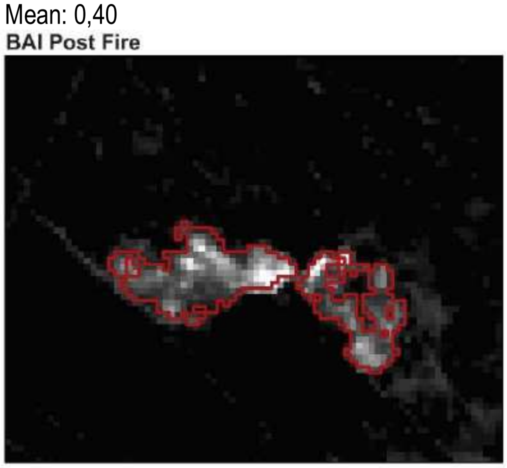
Figure 45



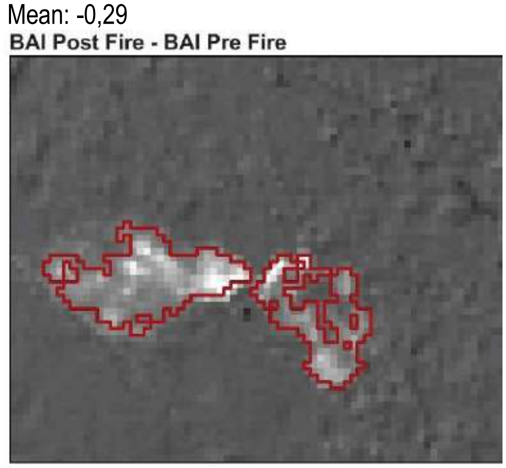
Min: 0,27
Max: 0,55
Mean: 0,40



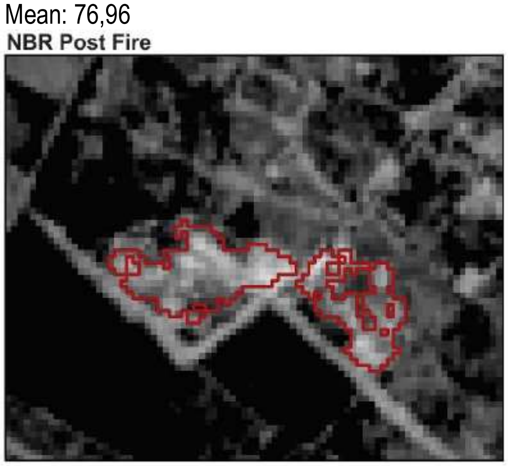
Min: -0,49
Max: 0,06
Mean: -0,29



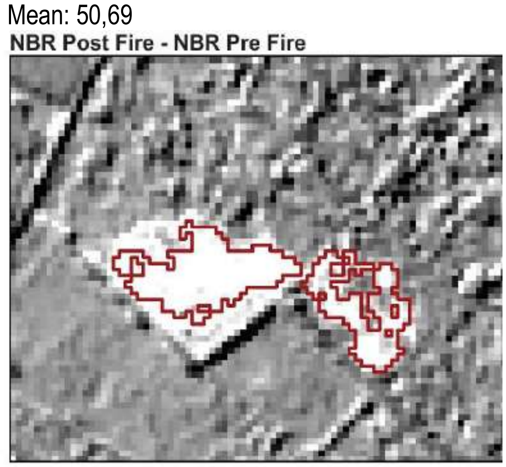
Min: 35,45
Max: 258,31
Mean: 76,96



Min: -0,73
Max: 229,95
Mean: 50,69



Min: -0,49
Max: 0,13
Mean: -0,19



Min: -0,85
Max: 0,72
Mean: -0,001

Figure 45: Values for different indexes in the outlined burnt area

Figure 46: Comparison of the burned area according to NDVI, NBR and BAI indexes
Punta del Diablo - 03/30/2015; 70 ha

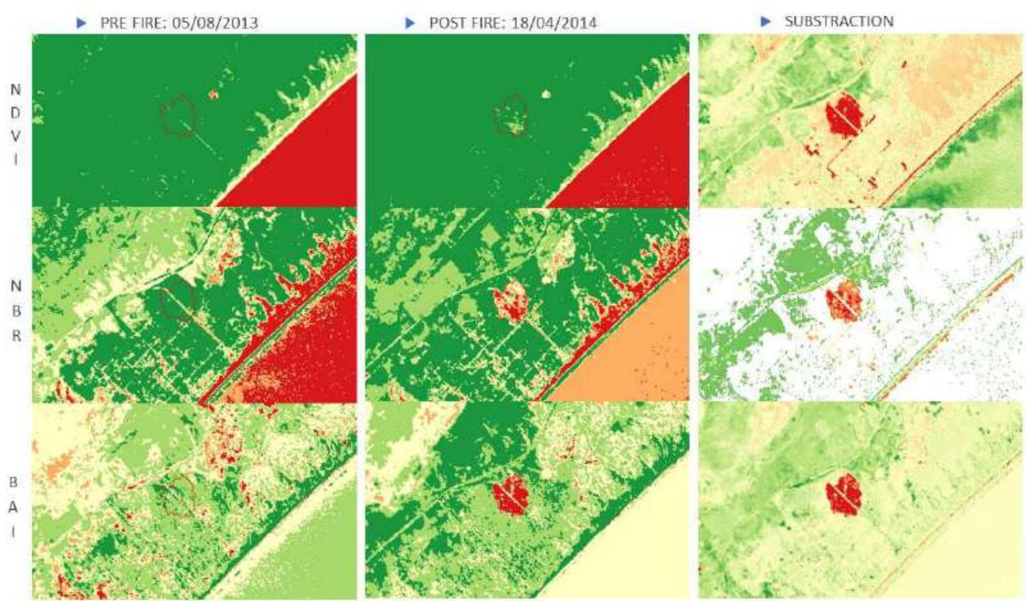


Figure 47: Comparison of the burned area according to NDVI, NBR and BAI indexes
La Esmeralda - 26/15/2013; 50 ha

5.3.6. Analysis of results

The UN-SPIDER (United Nations Platform for Disaster Management and Emergency Response) Knowledge Portal mentions that the difference between the NBR index pre and post fire (∆NBR), allows the calculation of burn severity. A high ∆NBR value would mean greater damage, while negative values may mean a post fire new outbreak. Such difference may vary according to the case. However, the USGS (United States Geological Survey) has proposed a classification of severity levels. The chance of mapping the resulting data using a pre-defined classification may aid the development of emergency post-fire rehabilitation and restoring plans. (Figure 48;Table 10)

Table 10: Burn severity levels obtained calculating ∆NBR, proposed by USGS.

Severity Level	dNBR range (scaled by 10^3)	dNBR range (not scaled)
Enhanced Regrowth, high (post-fire)	-500 to -251	-0.500 to -0.251
Enhanced Regrowth, low (post-fire)	-250 to -101	-0.250 to -0.101
Unburned	-100 to +99	-0.100 to +0.099
Low Severity	+100 to +269	+0.100 to +0.269
Moderate-low Severity	+270 to +439	+0.270 to +0.439
Moderate-high Severity	+440 to +659	+0.440 to +0.659
High Severity	+660 to +1300	+0.660 to +1.300

Figure 48: USGS Burn Severity classification for the test area - Punta del Diablo

Mapping was developed in two steps and using AQL 2004 methodology. In the first step the most severely burnt pixels were chosen, while in the second one, the mapping of each burnt area was improved by including neighbouring pixels that had been previously identified. This is how commission and omission mistakes were reduced; mistakes of the first type originated in classifying pixels as burnt when they were not, and the second type was caused by those burnt areas that might have been left outside. (Chuvieco *et al.*, 2002; Chuvieco *et al.*, 2008). The choice of pixels was based on the post-fire's image NBR and BAI values, as well as on multi-temporal comparisons of those indexes with previous images (Figure 49).

Post-fire image:	BAI>99		NBR	>0
Multi-temporal change	BAI t – BAI t–1	>1.74	NBRt – NBR t–1	>0.35

Figure 49: Punta del Diablo's burnt area outlining wiht AQL2004 index

By applying the compound indexes Burn Severity and AQL2004 to Landsat 8 images, it was possible to discrimitate and calculate the area affected by the two forest fires analysed. These models have recognized limitations as a consequence of the burnt area's spectral heterogeneity as well as the different vegetation types and structures present, making it difficult to reach precise and generalized algorhitms. However, considering that the aforementioned processes have reached the best possible result for the present investigation, the outlined areas will be used to pursue the analysis of forest fire risk in the area. It is noticeable that the AQl2004 index is much more restrictuve than the Burn Severity one (Figure 50: Burnt area comparative according to Burn Severity and AQL indexes - Punta del Diablo 30/03/2015; 70 ha

Figure 51).

Figure 50: Burnt area comparative according to Burn Severity and AQL indexes - Punta del Diablo 30/03/2015; 70 ha

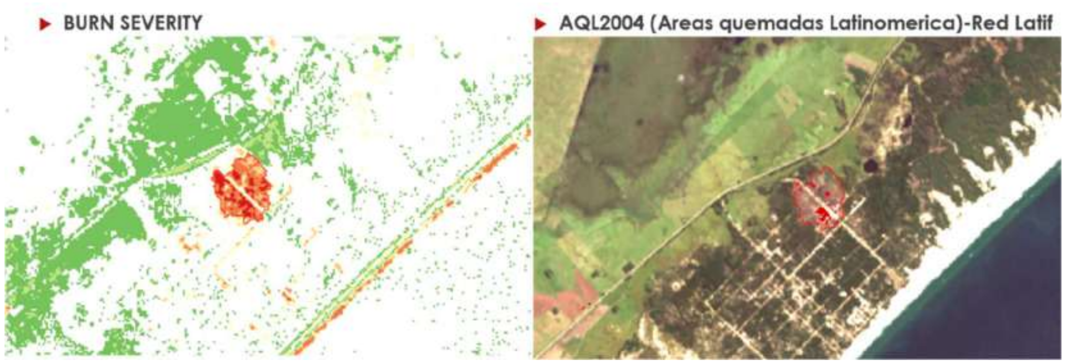
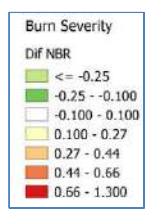


Figure 51: Burnt area comparative according to Burn Severity and AQL indexes La Esmeralda - 26/12/2013; 50 ha



Finally, an analysis of the affected coverages was carried out using burnt area indexes for both analysed fires. With this aim, a supervised classification of images previous to the La Esmeralda and Punta del Diablo fires was carried out. That classification helped to define diverse kinds of coverages, such as forested, crops, sand, bared soil and water. (Figure 52;Figure 53)

Figure 52: Supervised classification Landsat 8 image LC82220842013217 (05/08/2013)

Table 11: Area for each category according to the supervised classification, Landsat 8 image LC82220842013217 (05/08/2013)

Coverage	Area (ha)	Total Area (ha)	Percentage
Forestry	7068	23400	30,21
Water	1695	23400	7,24
Sand	677	23400	2,89
Crops	8000	23400	34,19
Bared soil	5961	23400	25,47

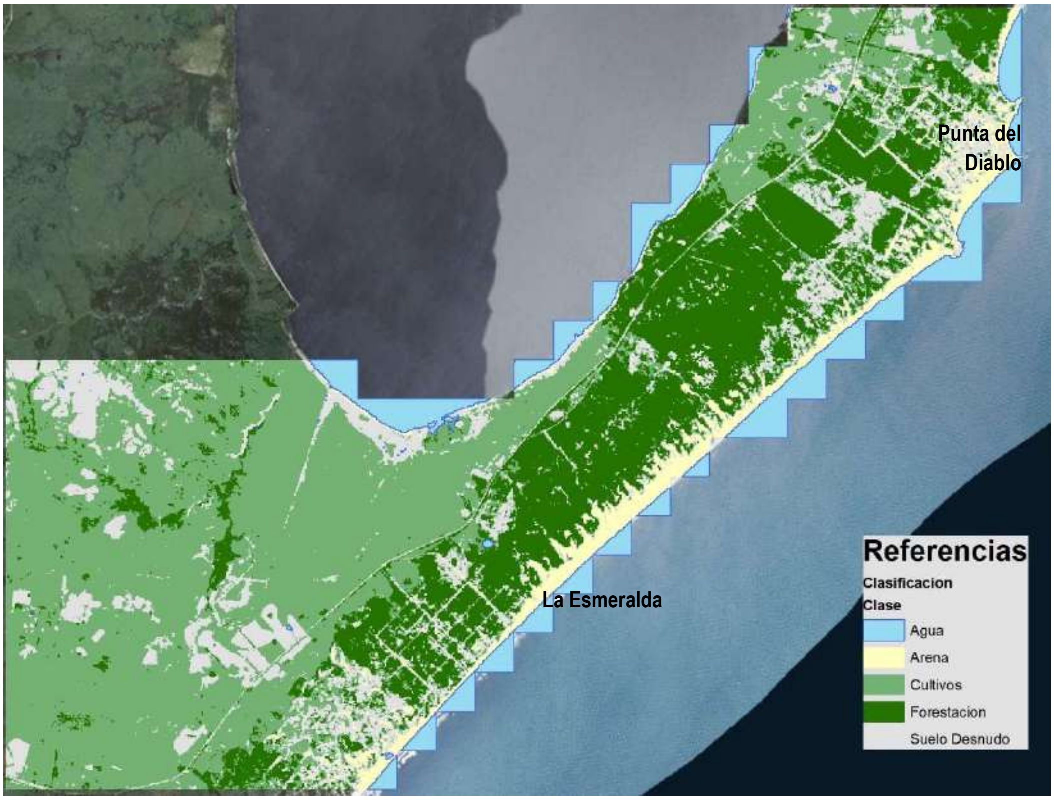


Figure 53: Supervised classification Landsat 8 image LC82220842015079 (20/03/2015)

Table 12: Area for each category according to the supervised classification,

Landsat 8 image LC82220842015079 (20/03/2015)

Coverage	Area (ha)	Total Area (ha)	Percentage
Forestry	5872	23400	25,09
Water	1742	23400	7,44
Sand	1075	23400	4,59
Crops	10994	23400	46,98
Naked soil	3716	23400	15,88

The identified coverages have had slight variations in these two years; the crops surface –including pastures -has had the greatest growth, while the forested area has decreased by 5%. The changes in naked soil are mainly a consequence of seasonal changes, as one of the images was taken in the winter while the other was taken by the end of the summer. There is no modification – or they are really minor - in the sand and water surfaces (Table 11; Table 12). These images mark as naked soil the following areas: Punta del Diablo - inhabited area and rocks promontory; the NE coast; and the emerging outline of La Esmeralda's forested area on the SW coast. It is worth bearing in mind that there are some scattered houses between both seaside resorts which could not be identified because of the woodlands and the image resolution.

By intersecting burnt areas and coverages and applying the burnt areas indexes, it is possible to recognize coverages affected by the two analysed fires. The area resulting from the intersection of outcomes of AQL 2004 and Burn Severity (High Severity and Moderate to High Severity) indexes for both fire events, and based on the previous soil classification for both dates in the study area:

Table 13: Type of burnt coverage by Burn Severity and AQL 2004 indexes in the analysed fire events

Image	LC82220842013217 La Esmeralda			LC82220842015079 Punta del Diablo		
Index	Burn Severity (ha)		AQL2004 (ha)	Burn Severity (ha)		AQL2004 (ha)
Date	26/12/013			30/03/2015		
	High	Moderate -High		High	Moderate -High	
Forestry	14,4	39,87	4,59	0,27	0,90	0,99
Water	-	53,53	-	0,23	-	-
Sand	-	-	-	-	-	-
Crops	3,42	115,94	0,49	0,99	2,52	3,06
Bared soil	-	1,42	-	-	0,27	1,35

Forestry and crops are the most affected coverages in both indexes. Bared soil, which includes buildings on rock promontories, roads and fallow lands – is less affected. It is worth bearing in mind that the water-class pixels that the indexes identify as burnt areas, are coastal zones where there are foamy waves. (Table 13)

5.4. Land occupation

5.4.1. How the Uruguayan Atlantic coastal zone is occupied

The magazine “Los Departamentos: Rocha” from 1970 mentions ‘many kilometres of Atlantic coast’, stretching up to the mouth of Chuy stream in the border with Brazil. These are suitable to set up seaside resorts and are becoming increasingly popular with national and foreign tourists, as communications grow wider and modern. The article mentions Santa Teresa National Park and La Coronilla as the main spots at that time. The latter had an important flow of tourists that almost vanished after a channel used for the drainage of wetlands was modified, deteriorating its beach’s water quality. The tourism offer also included La Paloma city and its nearby seaside resorts, while locals found coastal recreational areas mainly in the precariously built infrastructure supplied by fishermen towns such as Valizas, Cabo Polonio and Punta del Diablo. Until 1965 these towns were separated from the route by a sandy strip of 5 to 6 km.

Today, there is a set of consolidated seaside resorts: La Paloma, La Pedrera, Aguas Dulces, Valizas and Punta del Diablo, as well as a chain of smaller towns heading towards a similar growth path. Such evolution results in a disorganized urban development, where problems such as illegal occupation, inappropriate use of public spaces and the unavoidable impacts of not having basic services, especially sewage systems (Gadino, 2011). This author quotes the Coastal Ordinance Presentation document (2004) regarding how by mid-20th century Rocha’s coast was indiscriminately divided into lots making an abusive interpretation of the Populated Centers Law. In 10 years 140 000 lots of an average 500 square meters were defined. Such division, without any planned public services or any real demand, encouraged a process of informal land occupation of the coastal area.

The project to integrate the marine-coastal Cabo Polonio protected area into the National Protected Areas System (2009), states that since the mid-seventies this region went through an unplanned building process where houses were built on private as well as state-owned land. Houses of this sort kept spreading in the 80’s as a consequence of changes in tourism that resulted from new demands in recreation and leisure options. There was a search for getting away from the conventional model and finding more “spontaneous” activities, more contact with nature, more rusticity and stronger relationships with local inhabitants. This model expanded all along the coast, in places where the local government could not collect real estate taxes as most owners did not pay them.

The aforementioned situation has resulted into large areas of the Atlantic coast where natural and urban spaces overlap. It is a scattered urban area driven by the rules of a modified natural environment and the lack of urban planning. An important amount of exotic forestation species in the area adds up to the issues mentioned before, resulting in a forest-urban interface area with high degrees of contact. The dense and unmanaged forests bring about concerns regarding fire intensity as well as vulnerability of their nearby human settlements.

5.4.2. Interactions between environmental conditions and society

Society and nature have a dynamic and complex relationship; this bond has been Geography's subject of study, approaching it through profuse concepts and research methods. Regarding risk, and from society's perspective, this relationship brings about transformations, conflicts and negative externalities, especially when processes are driven by a purely economic rationale; in addition, risk grows as a result of poor planning.

The objective for the present case study was to know what damage the analysed forest fire events caused, and on which coverage, that is to say, how an anthropic event impacts on an area that has been increasingly transformed by society, recreating its own risk.

5.4.3. Forest fire risk indexes

Forest fires have been widely studied as they are seen as a threat to society. A variety of authors, using a wide range of methodologies and techniques, have approached the analysis of their causes, reasons to propagate, as well as related meteorological, topographic and biological variables. However, the vulnerability dimension has not been looked into in the same way. On the other hand, the fire events that have taken place in peri-urban areas surrounding important USA and European cities, have attracted the researchers' attention regarding the protection of the wildland-urban interface (WUI). Analysing fire risk and danger in such areas, implies, for example: focusing on the dangers existing around the urban area; analysing housing vulnerabilities; assessing social and institutional vulnerabilities in these complex and highly damaging situations. In summary, going beyond the physical vulnerability.

According to Collins, T. W. (2005), wildland-urban interface (WUI) fire risk has become increasingly violent all along the West of the USA as a result of amplified biological and physical risks, the rapid growth of population and deficient political mechanisms. This author's approach takes the perception of risk, the conflict of interests and values, the economic restrictions and the institutional incentive structures as determinant variables for vulnerability. He questions the current management as well as the unidimensional representation of residents. Gaither *et al*. (2017) walks a similar path when analysing the USA's South-west; he describes the situation of an area that is one of the most forest-fire prone and, at the same time, comprises some of the poorest or socially most vulnerable rural communities. The capacity to assess social vulnerability is an increasingly core factor when aiming at risk reduction and the promotion of a resilience culture (Birkmann, 2006; Langridge *et al*., 2006; Mendes. *et al*. 2011).

5.4.4. Exposure to danger and sensitivity in different territorial components

The study area has scarce permanent population. However, the population grows a lot in the summer season, with people sometimes staying for just a few days or weeks. The analysis focuses on the vulnerability of houses. When facing a threat, the exposure level and the predisposition to loss in an element or group of elements contributes to the knowledge of such risk by means of the interaction of those elements with the dangerous environment in question.

A PATFOR (Land and forestry planning participative instrument from la Generalitat Valenciana) guide was adapted as reference. There are three variables involved: occupation, adjacency and dispersion. So as to apply and calculate, the 23 400-ha area was fragmented in a 1 x 1 km grid that comprises both analysed fire areas in La Esmeralda and Punta del Diablo. (Figure 54)

Figure 54: 1 km^2 grid applied on the study zone for index calculation

Housing occupation in forested areas was calculated based on a 25 meters buffer on a layer of housing spots. This resulted in lots of approximately 275 m^2, each containing a house. Afterwards, houses with intersecting buffers were grouped together. Forestry, on the other hand, was defined by a Landsat 8 LC82220842015079 (20/03/2015) image supervised classification (Figure 55)

Occupation= ΣArea of buildings on forested area.

After that, the grid's cells were classified as follows: Low occupation, Medium occupation, High occupation. For this classification the range was divided in tertiles, not including zero.(Figure 56; Table 14)

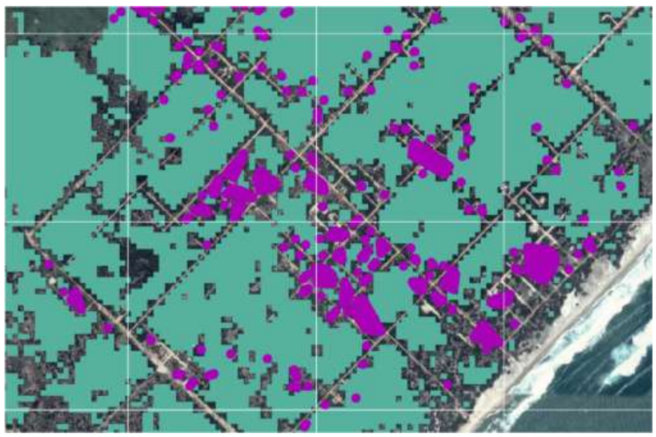


Figure 55: Houses grouping in the forested area

Table 14: Weighing of the occupation variable

OCCUPATION	VALUE (m^2)	INDEX
Low	0 - 1000	1
Medium	1001 - 4000	2
High	4001 - 30200	3

Figure 56: Mapping of occupation in Punta del Diablo - La Esmeralda

The contact perimeter between forested areas and each group of houses or isolated house within each cell was taken into account to analyse adjacency. Each cell is characterized considering the worst case it contains. (Figure 57)

Figure 57: Adjacency mapping for a cell Punta del Diablo - La Esmeralda

Table 15: Weighing of the adjacency variable

ADJANCENCY	ADJANCENCY %	INDEX
Low	< 50	1
Medium	>50	2
High	100%	3

Within the grid, there is a 53.2 km total perimeter of areas containing grouped or isolated houses and there is an adjacency perimeter of 16.13 km between those houses and the forested areas (31% of the total). That may seem a low percentage, but it is worth considering that adjacency was assumed only if the two areas strictly intersected. Therefore, there might be areas with nearby forests that were not included. However, such situation seems to be counteracted adequately by the 25-meter buffer assigned to each house.

The urban surface perimeter that is 100% surrounded by forest was classified as High Adjacency. 1.47 km (9.11%) in the grid's area are classified that way. In addition, there are 6.20 km (30%) of the urban surface perimeter that is between 50% and 100% surrounded by forested area (Medium Adjacency). Finally, if the urban surface perimeter is surrounded by forested area in less than 50%, it was classified as Low Adjacency. This category represents 53% of the total grid's surface (8.46%). (Table 15; Figure 58)

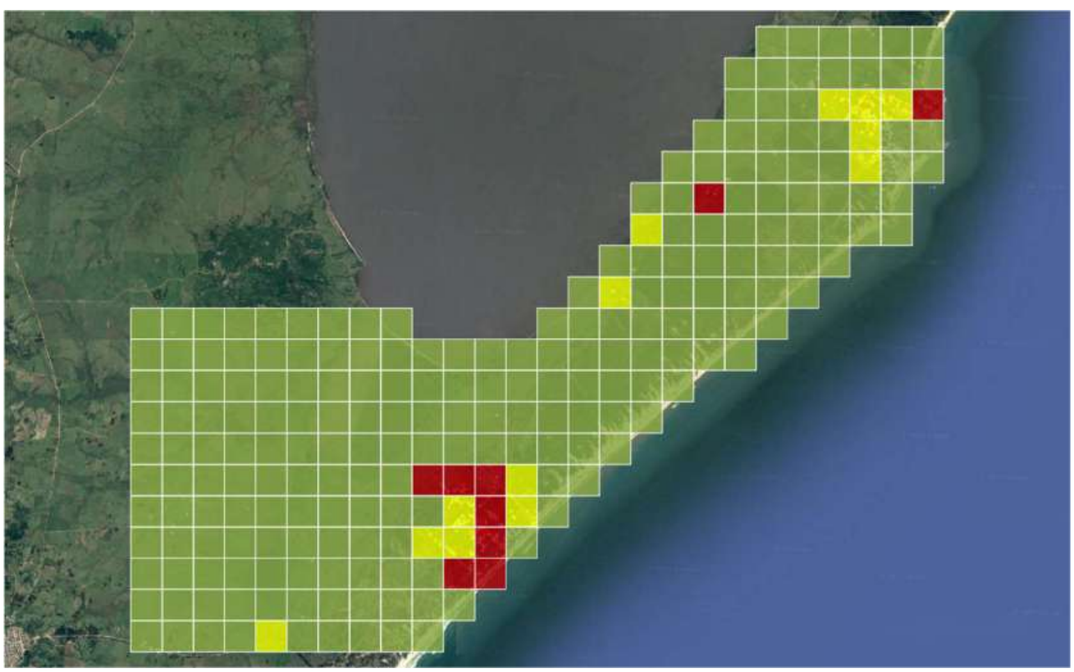


Figure 58: Adjacency mapping - Punta del Diablo - La Esmeralda

Dispersion was calculated by adding the distances between centroids of isolated houses or house groups in each grid's cell and then dividing that value by the number of centroids by cell.

Dispersion = Σ distance between gravity centers in the forested surface /Number of polygons

The resulting range of results was classified in High Dispersion, Medium Dispersion and Low Dispersion. The longer the distance, the higher the dispersion and the greater the vulnerability. (Table 16; Figure 59)

Table 16: Weighing of the Dispersion variable

DISPERSION	VALUE (km/number of polygons)	INDEX
Low dispersion	0 – 0,42	1
Medium dispersion	0,421 – 2,75	2
High dispersion	2,751 – 8,36	3

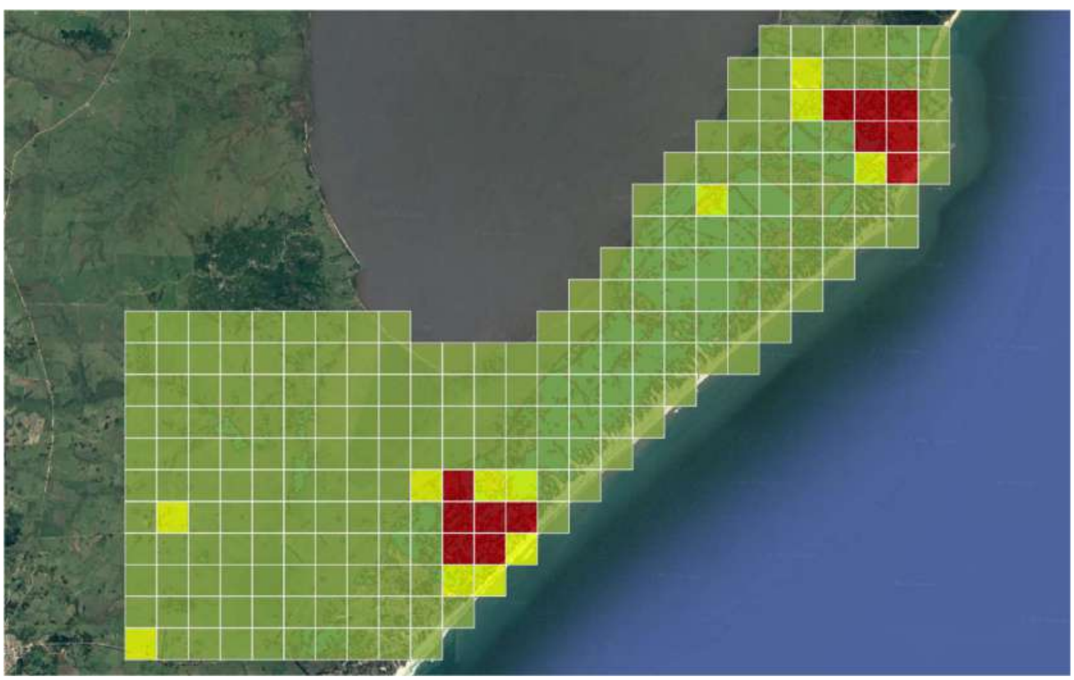


Figure 59: Dispersion mapping - Punta del Diablo - La Esmeralda

5.4.5. Exposure to forest fire risk assessment

Houses and people's vulnerabilities are alike during the summer season. The three variables were analysed and houses were then re-classified weighing the situations with higher risk. The highest risk is assigned to those cells depicting high occupation, high adjacency with forestry and dispersedly located houses. A housing vulnerability matrix was outlined based on the previous categorization. The applied criterion was as follows (Table 17)

Table 17: Housing vulnerability categories

Occupation	Adjacency	Dispersion	Vulnerability of the house
High occupation	High adjacency	High dispersion	HIGH
High occupation	High adjacency	Medium dispersion	HIGH
High occupation	Medium adjacency	High dispersion	HIGH
High occupation	Medium adjacency	Medium dispersion	HIGH
Medium occupation	High adjacency	Medium dispersion	HIGH
Medium occupation	Medium adjacency	Medium dispersion	MEDIUM
Low occupation	Medium adjacency	Medium dispersion	MEDIUM
Low occupation	Medium adjacency	Low dispersion	MEDIUM
Low occupation	Low adjacency	Medium dispersion	LOW
Low occupation	Low adjacency	Low dispersion	LOW

Housing vulnerability graphic results are depicted in the following figures. The most vulnerable cells are located in the peripheral area of Punta del Diablo's center as well as in La Esmeralda. There are some other isolated cells near route 9 depicting high and medium vulnerability. (Figure 60; Figure 61)

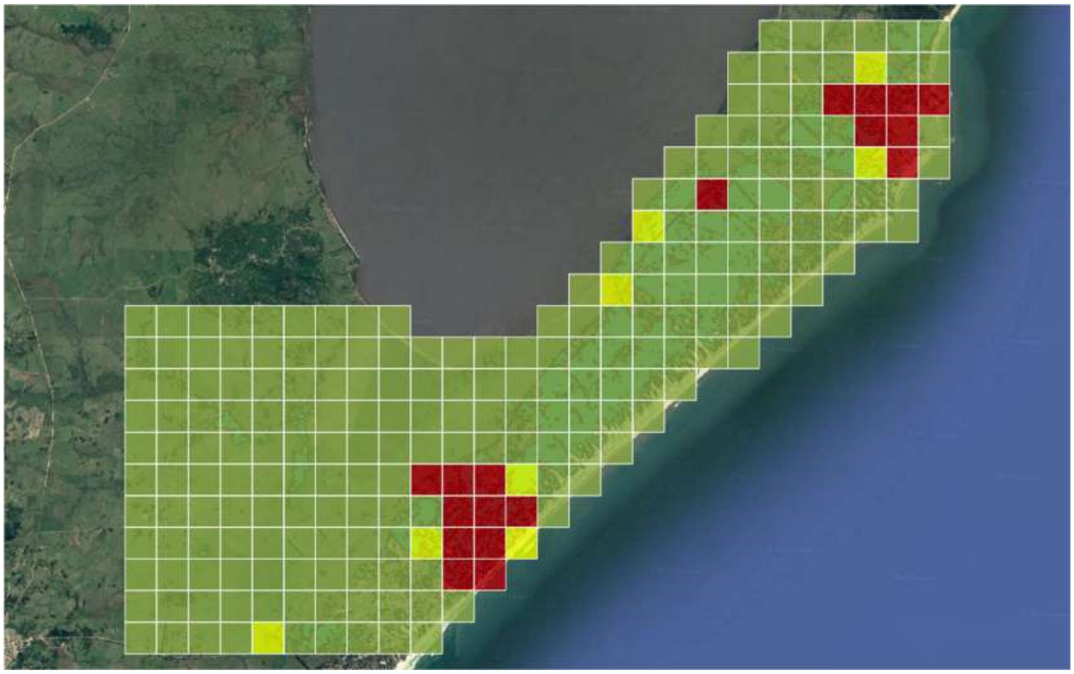


Figure 60: Housing vulnerability index mapping - Punta del Diablo - La Esmeralda

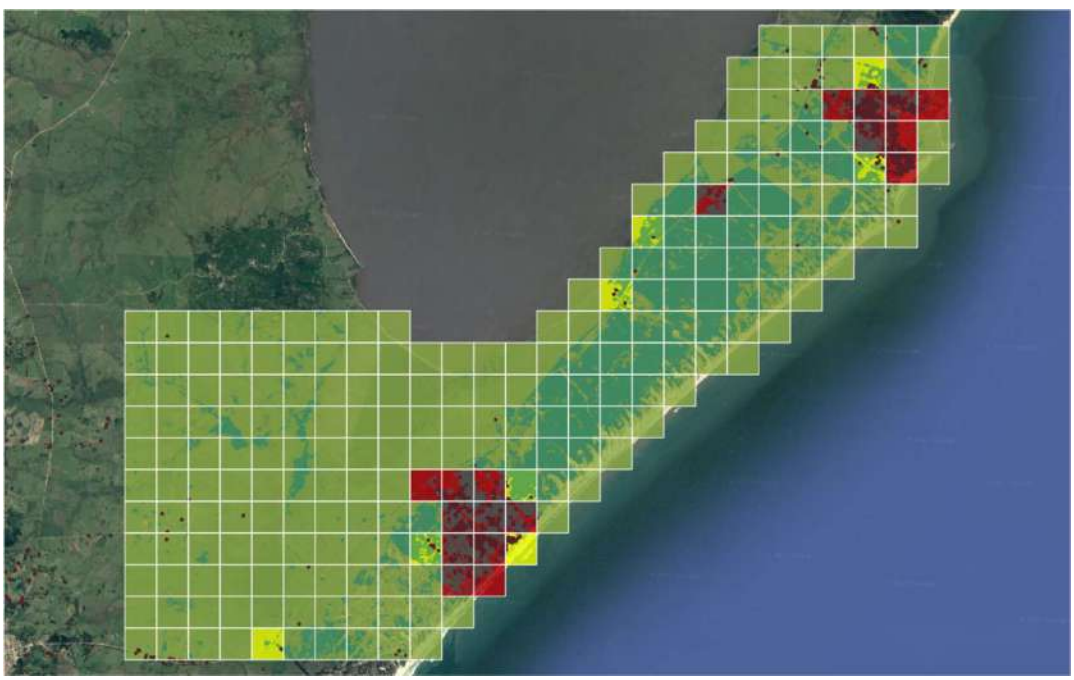


Figure 61: Overlap of Houses and forests location with the housing vulnerability index grid
Punta del Diablo - La Esmeralda

5.5. The urban-forest interface.

The urban-forest interface is defined as that area where forested surfaces contact areas with building development. The term was first used in the mid-seventies in California regarding an increasingly common type of fire (the urban/ wildland fire interface) (Butler, 1976).

The urban-forest interface is growing worldwide; houses are increasingly located within forested areas for economic reasons or, also, with the aim of living in a more natural environment. These changes tend to bring about important problems as governments are usually not able to reach those areas with the necessary services. In addition, such locations usually increase forest fire risk as well as damage risk in buildings, urban areas and, eventually, human life. When fire breaks out in those areas where buildings are in direct contact with the forest, it may not only reach the buildings but also spread into the built areas.

Forest fire management in urban-forest interface areas is complex as it involves protecting property as well as human life. It is a complicated type of fire, with characteristics that are hardly ever taken into account in land planning or building regulations.

There is usually insufficient protection against forest fires in houses or other structures, which also generally lack the necessary self-protection means to slow down or prevent fire from moving forward; also, the need to maintain a gap dividing urban areas and forests is not usually fulfilled. The territory's characteristics add up to these vulnerabilities, as these are hard to access areas that may turn into trap when assistance is required.

On the other hand, and usually as a result of those accessibility issues, these forests are usually not adequately managed. This is how biomass tends to get accumulated and forest fire risk vulnerability grows. Involving the local population is crucial in order to achieve a satisfactory risk management process. In this context, raising awareness has two main aims: firstly, to supply the necessary information so as to impact on people's behaviour and make them respond actively to risks; secondly, to supply the necessary knowledge to react adequately to danger (Fleischauer *et al*., 2007).

This scattered settlements model is regarded as unsustainable in terms of energetic inefficiency, social segregation, land waste, habitat fragmentation, landscape deterioration, etc., nevertheless, the way it contributes to increasing forest fire-related risk is not taken into account and preventive actions towards such impact have been quite limited so far (Gaiana, 2012).

5.6. Discussion

Geographic information technologies provide relevant support to spot and weigh forest fires and the resulting damage in terms of burnt areas and structure losses. These tools develop on a daily basis, bringing along new information and increasingly powerful applications to be used in the assessment of these events. However, some inconveniences arise when applying these tools to medium-sized fires. Within the country's dimensions, the study area holds the most relevant events affecting an urban-forest interface area with a vast tourist flow.

The high levels of cloudiness in the Landsat satellite images –that were chosen because of their space resolution – complicated the availability of appropriate optical images on the dates of the analysed forest fires. This meant that data for two fires was processed. It is worth emphasizing that those were major fire events and they were remarkable because of their location, near new seaside resorts.

There are several indexes to allow identifying burnt areas; choosing and applying the most effective to discriminate the mark left by the fire means a remarkable approach to having detailed knowledge of the specific area and its surroundings. After some trials, Burn Severity and AQL2004 were chosen as the ones that best discriminated burnt areas, without mistaking them with sandy, scattered grass or naked soil areas. The application of indexes and pre and post-fire variations calculations are also influenced by the availability of images that, as they were not taken immediately after the event, are affected by new outbreaks.

Each forest fire is a complex phenomenon affected by a range of factors (meteorological, topographic, ecosystem types, structures). This makes it difficult to elaborate generally and systematically applicable indexes to detect burnt areas. Such complexity, in turn, stimulates the development of research so as to define new indexes to best apprehend the real situation. In urban-forest interface areas that grow disorderly and unplanned, the challenges are larger and the need to develop bigger-scale investigations becomes mandatory. In this sense, facing a forest fire risk local analysis involves a vulnerability assessment, which is another complex dimension that requires a multiple-angle approach. In the current case study a simple approach to vulnerability was chosen, analysing the exposure of houses to forest fire.

Applying vulnerability indexes as well as indexes to identify burnt areas, are practices that - when carried out frequently and integrating continuous technological advances and local adaptations - turn into valuable fire management tools. Uruguay uses the Nesterov forest fire risk index, which has an estimated and purely meteorological approach. It uses data from 22 stations and generates information for large areas in the country; it is the only available measure regarding this topic. Even though there have been initiatives to put other indexes into practice, (for example the Fire Potential Index; Fernández et al, 2010a; Fernández et al, 2010b) and to include optical satellite images information, adding variables like vegetable combustible and improving space resolution, these proposals have not become operative.

According to Fleischhauer *et al*., (2007), natural disasters are typical examples of conflict between people and the environment. This author states that the vulnerability of inhabited areas to natural disasters is a result of decades of developing land planning policies that have ignored dangers and risks of such land planning and development decisions. He also presents the idea, which would be applicable to the Uruguayan reality, of bringing together knowledge and technology with risk and land planning managers so as to achieve prevention and mitigation of natural disasters.

5.7. Conclusions

We close this chapter reflecting about the limitations and potentialities that geographical information technologies – especially remote sensing and geographical information systems - have when analysing and assessing forest fire risk. The methodologies applied previously have some clear advantages, as they supply a systematic flow of information with a set frequency and allow an analysis the whole work area. Remote sensing has been used to analyse the impact of risk at regional and global levels. Moreover, it allows spotting the location of active events, identifying areas which are more fire prone and verifying the extension of burnt areas.

The present work analysed 50 and 70-hectare fires using a variety of indexes. Burn Severity and AQL2004 were eventually chosen as they were the most convenient because they supply a sharper discrimination. According to Chuvieco (2009), cartography depicting medium-sized burnt areas (25 hectares and above) has a good degree of precision. However, as the population in forested peripheries is growing steadily, more precise and suitable tools are becoming necessary. The urban-forest interface brings together two major issues: the risk of houses being located well into the forest and accessibility issues. This, in turn, increases vulnerability in the population, as their houses and more exposed due to their legal vulnerability, as well.

Approaching forest fire risk requires a multi-scale perspective. At a medium scale, its threats and dangers are analysed through remote sensing. But vulnerability also requires a local-scale perspective. The topic of forest fire vulnerability has not been deeply explored. The most frequent research looks into demographic density and socioeconomic level as variables that can explain the resulting damage. However, these new ways of land settling require including new cultural aspects that bring along other vulnerabilities. Occupation can be assessed through its geometric distribution.

The space distribution of infrastructures – or the lack of them – can be modelled using geographic information systems. These systems are also natural tools to merge data from several sources. This chapter used geo-processing to analyse vector and topographic information and mix it in an index that brings together adjacency, occupation and dispersion. Elements that can also be useful when trying to learn about risk factors and geographical characteristics include: raster and vector data models, remote sensing digital and field data, census and samples data, models and simulations.

CHAPTER 6 PUBLIC PARTICIPATION AND RISK PERCEPTION

6.1. Introduction

Participative processes allow stakeholders, and especially those that are taking risks of some kind, to learn about risk-reduction alternatives, give their opinion and state their righteous points of view. They require two-way communication channels that let the participating actors build understanding, find agreements, point out disagreements as well as set priorities with the objective of reducing risks in the community.
An exhaustive study on methodologies that involve the stakeholder analysis made by Valente in her doctoral thesis (2013) meant a significant contribution to develop this chapter. The discussion raised in the model proposed by Freeman in 1984 on the theory of the stakeholders as interested parts, distinguished between those that concern or meet affected by a decision or action, including a wide range between these two situations; this is a point of relevance in matters as forest fires which involve use of public and private spaces, investments and externalities, direct damages at the individual and the social level (Reed *et to.*, 2009).

Although it is a concept made up at the management organization level, it was quickly incorporated into the studies that require knowing the points of view of civil society groups. Stakeholder research is used to work more effectively to achieve transparent implementation of decisions or objectives, understand the policy context and assess the possibility of future policy options in political science, but also it is useful in understanding power dynamics and enhancing the transparency and equity of decision-making in development projects (Reed *et al.*, 2009). Besides, stakeholder analysis has been enriched by the development of participatory methods for project design and planning, like rapid and participatory appraisal, action research, social forestry, and land-use planning (MacArthur, 1997) and is too much appreciated to understand the diverse variety of potentially conflicting stakeholder interests (Reed *et al.*, 2009).

Between these methods, interactions that take place face-to-face and also those that take place through the social networks help information circulate among actors, building trust bonds based on finding common interchange practices. Sharing some point of view is paramount to achieve strategic objectives. That shared perspective provides a common set of values and it may become a strategy itself, as it helps to avoid possible conflict as well as to solve the existing ones (Natenzon & Ríos, 2015). It is crucial that every stakeholder in some problem or conflict, for example forest fires, is able to express their interests and points of view, requirements and commitments, searching for common solutions that benefit the majority of the group.

Also, communal participation starts when the members of a local society get actively involved and take responsibility at each stage of the programmes and public polices they are influenced by. Such social participation will depend mainly on what the convening organism is. The social recognition held by actors and institutions involved, as well as the transparency of their actions and messages when trying to democratically integrate citizens, is what eventually legitimates the whole process (Murgida, Gasparotto & Natenzon, 2004).

Even though well-planned participative processes are critical in democratic contexts, their application must be carefully prepared, and their rules and objectives must be transparent and well-known by every actor involved so as to prevent them from becoming opinion-catching processes used by privileged or minority sectors of community. In the present study, public participation was analysed using two different techniques: first, taking advantage of the opportunities provided by the National Emergencies System to organize workshops, and later, collecting complementary information using an on-line questionnaire administered to other intervening actors. The possibility to organize workshops with the aim of outlining a forest fire risk management Plan for La Paloma-La Pedrera municipality (Rocha), allowed to reach local actors that have a say at different levels of development programmes and public policies. A group of researchers in conjunction with the NGO Cultura Ambiental were in charge of organizing the participative workshops. Inspired in the FLACSO methodology (Facultad Latinoamericana de Ciencias Sociales) (Poggiese, 1994), a variety of disciplines and areas involved in forest fire risk planning and management worked together. This activity was endorsed by the AECID (Spanish International Cooperation Agency for Development) and took place within the “Project to strengthen national capabilities to face forest fires and to promote a risk management and environmental protection culture”. This demand is following the current approach identified in the international and national organizations who are seeking for a major integration relating forest development, global challenges with needs and local interests. These new agendas are focussed in bringing new stakeholders to the scene, as well as a taking in account the complete set of multiple perceptions, values, opinions and interests regarding the forests and the forestry sector. In this scenario, the progress towards the Forest Sustainable Managing (MFS) is recognized as a need to work together with the interested parties of the forest and to take perceptions, preferences and behaviours (Valente *et al*., 2015).

This experience tried to bring together governmental, academic and community actors with the objective of interchanging ideas and working together towards some common ground. The AVC (Vulnerabilities and Capabilities Analysis) methodology from the International Red Cross and Red Crescent Societies was used within the activity. Its aim was to define attitudes towards risk and transformation actions that contribute to the development of communities. This, in turn, allowed an interchange process which can strengthen those interinstitutional relations that are fundamental to outline risk maps and to further develop joint early alert systems

In addition, and due to the tourist-oriented characteristics of the area, the opinions of local tourist operators were collected through an online survey. This chapter comprises a description of the research together with the results obtained at the workshops’ interchange activities as well as in the surveys.

6.2. Methodology and approach

The concept of participation has several connotations. Within today's democratic societies, public participation is regarded as a positive civic, political and social expression (Natenzon & Ríos, 2015). Participative methodologies (understood as a scientific-technical process) bring together social actors who are dealing with some problem so as to outline a diagnosis and some action strategies. The methodology and techniques applied for the present case attempt to define more integral options for social construction that can remain longer and supply feedback to each other.

6.2.1. Methodology

Multiple participative planning methodologies have been developed and applied in Latin American countries in the last decades. The FLACSO methodology being one of those, approaches complex management issues crossing multi-sectorial, interdisciplinary and participative aspects. In addition, it has an initial condition: there should be political willingness and a decision to implement the experience based on an agreed and feasible methodological framework. Such concepts are expressed through two methodological tools: the methodological cycle and the logical sequence for case treatment. The methodological cycle involves the actors and enables the construction of the necessary settings for the planning stage. Meanwhile, the logical sequence works on a diagnosis for the problematic situation and on the design of a strategic model for decision-making, actions development and its permanent adjustments (Poggiese, 1994).

The development process proposed for the current task was as follows:

- A first group stage with the aim of defining the plan, data collection and tools preparation.
- A second interactive stage that took place in the field. It allowed the collection of new information through the active participation of La Paloma-La Pedrera inhabitants.
- Another group stage to systematize and analyse the information gathered in the workshop and in the field.
- A new stage of interaction with the community to reach agreements and validate the perceptions and assessments.

The feedback sessions with the local community allowed the participants to validate or adjust the information shared. Eventually, a document was drawn up and revised by the inhabitants and the process facilitators.

Along this process, social actors are regarded as users, not only in their informant role but also through interchange relationships that let them make proposals regarding the topics at discussion as well as state their own needs and interpretations. Therefore, they gain an active role that impacts on the action proposals and work plans, as those are permeable to the results from those interchanges (Natenzon & Ríos, 2015)

Agreements were reached in the workshops concerning the concepts and information to be used when outlining the plan's grounds: a conceptual framework about threats; vulnerabilities and risks; familiarizing with the area (affected and potentially risky areas); identification of local actors and their roles; forest fires precedents analysis; risk perceptions analysis and resources & capabilities analysis. Involving the local communities is a vital pre-requisite when seeking Sustainable Disaster Risk Reduction (RRD) (Haworth et al., 2016). According to Gaillard and Maceda (2009), an RRD based on the community fosters participation by involving communities in identifying risk (including dangers, vulnerabilities and capabilities) and the ways to reduce it. Even though official information is vital for definitions and decision-making, the aforementioned collaborative participation may supply more updated information as well as risk-related information with relevance at a local level. Forest fire risk cartography plays a fundamental role in fire prevention and fighting since it provides significant data about vegetation types and conditions, combustible elements, firebreaks, location of detection and extinguishing elements, etc. Being familiar with the surroundings is paramount at a fire's early stages. Moreover, it helps to elaborate an early alert and response system and an evacuation plan. The main objective is reaching reliable and updated data that is missing in the official cartography development process due to time or space scales.

6.2.2. Data collection techniques

Participative techniques encourage the participation of every member in a specific group. There are varied ways to apply them, depending on the objectives and they have a limited reach in terms of time as well as the product they supply. Perception studies, emotional maps, discussion groups, debate meetings, problem tree analysis, SWOT analysis, future workshops, socioenvironmental animation and NIPs – Participative Intervention Nucleus, are among the techniques that may be applied in participative processes regarding environmental conflicts, at different stages and with a variety of objectives (Bustos, 2005).

Workshop with stakeholders at La Paloma city in September of 2015

The tools applied in these workshops included: social cartography and participative mapping, the development of a historical records calendar, visual observation, field trips, indoors simulation activities, identifying response vulnerabilities and capabilities in a multidirectional communication so as to agree on protocols and solutions to add to the plan. Local representatives from the Emergencies Coordination Centre institutions, from the society, the private sector, education and the community were invited to participate.

Those workshops made it possible to gather information about forest fire precedents and the existing resources to approach them (human, material, infrastructure, etc.) and also to spot threats, vulnerabilities and capabilities. Such information worked as input to assess the existing needs and outline a prevention plan. After the workshops, interchanges continued electronically, seeking to validate the information collected in the face-to-face stage. At that stage other actions took place: the field trip to assess risk, the simulation game, checking the measures taken and identifying other needs.

Observations during the field trip: firebreaks, exotic vegetation characteristic of the area and land with accumulated fuel.

6.2.3. Choosing the area and the participants

Rocha is Uruguay's most Eastern department. The municipality of La Paloma is located in Rocha and it comprises La Paloma and La Pedrera as well as some neighbouring seaside resorts: Santa María de Rocha, La Aguada, Atlántico, Costa Azul, Antoniópolis, Arachania and Punta Rubia. All of them are classical urban-forest interface areas, including urban settlements surrounded by forested areas where the newest seaside resorts are located and including extensive camping areas. It is one of the areas with more tourism dynamic and infrastructure and it counts on a roads network led by routes 10 and 15 as well as a series of minor roads. La Paloma municipality is really close to Rocha, departmental capital city, which gives it a commercial, tourism and services edge and turns it into the department's most important tourist spot.

The aforementioned characteristics helped to reach an agreement and set the activity in that municipality. Even though the largest uncontrolled forest fires in that area date back to 2007, it still has great vulnerability because of: the tourists' flow, its disorganized housing development, a large forest mass without organized cleaning standards and some areas that are difficult to access (Punta Rubia, Santa Isabel de La Pedrera, Pueblo Barrancas). The workshops were attended by representatives of: La Paloma municipality, the

Emergencies Coordination Centre, National Navy Prefecture, Internal Affairs Ministry (Fire Department, National Road Police Office, Police stations in the area, National Sanitary Works Office, National Public Education Administration, Transport and Public Works Ministry as well as health professionals and neighbours (some of them volunteer fire-fighters).

6.3. Perceptions of the actors involved.

Information comes from the real world and it is perceived in the context a sociocultural process. Such process is affected by each individual’s values, personality, experiences, risk exposure level, and socioeconomic and cultural level (Chardon, 1997). The aim of the workshops was to get better knowledge concerning degrees of risk knowledge and perception, viable behaviour in the event of a forest fire and the area’s communal organization. Afterwards, a diagnosis was attempted regarding the relations between the population and its fire-prone surroundings.

6.3.1. How National authorities perceive forest fire risk and its resulting damages.

There is the generalized perception that forest fire risk awareness has grown in the last years. As a consequence - and with the objective of protecting the population as well as its significant material possessions and surroundings - there is a series of public service initiatives planned by a variety of organizations that range from forestry associations to companies and their Corporate Social Responsibility programmes. Such initiatives are usually endorsed by State’s institutions, for example: the National Forestry Office, the Uruguayan Air Force, as well as decentralized ones (City Halls and Municipalities).

In the summer of 2016 the National Fire Department Director took part in a press conference organized by Presidency. In that occasion, he stated the importance of the human factor in forest fire prevention and he highlighted the population growth in the seaside resorts. In addition, he relied on the response capacity where coordination among the Fire Department, the Army, the Air Force, the departmental emergency centres and City Halls is key; besides, and for the first time, he referred to the National Police Force as a relevant actor in this context, stating the importance of reporting people who are not fulfilling fire prevention recommendations. He emphasized the relevance of avoiding open fires and he also recommended having fire extinguishing elements at hand. Moreover, he discouraged the traditional use of fireworks in places like forests or fields during religious festivities or music shows.

According to information from the National Fire Brigade (DNB), the number of interventions in forest and field fires has been reduced by 75% in the last five years. However, these figures must be taken cautiously and keep vigilant. As an example: in the summer 2011 there were 5,010 interventions while in the last season there were 1 222. In the summer 2011 10,281 hectares got burnt while the same happened to 111 hectares in 2014. National Fire Department Director explains that such decrease may be a result of multiple factors, for instance: prevention, mitigation and response actions that have been developed coordinately by public and private organizations as well as the people's commitment to a more responsible behaviour.

On the other hand, the National Emergencies Systems Director, also states the relevance of prevention and awareness regarding fire risk. He remarked the fact that 98% of the fires are caused by human beings, and that is linked to having a responsible personal attitude towards our surroundings, the people, the environment and the material goods when the time of enjoying the summer comes. The National Emergencies System is the strategic leader of every public policy regarding forest fire risk management and, in such role, promotes the coordination of all the actors involved and the most effective use of the existing resources so as to supply the highest standard in security and well-being to the population. He explained that the 2016 National Plan for Forest Fire Prevention and Fighting is the tangible result - in concrete actions for prevention, fighting and response - of the aforementioned aims. The plan comprised: building and maintaining firebreaks and cleaning lots all around the country; daily IRIF issue (Forest Fire Risk Index, based on the Nesterov index issued by the National Meteorology Institute); regular surveillance and fire detection flights; strengthening the Fire Brigade and the Emergency Attention Areas in the Army; carrying out fire-fight exercises, training and drills; local and national communication campaigns run by private actors as well as by the State.

There are some remarkable future lines of work that reflect an integrative perspective regarding forest fire risk:

- Implementing a VGI-type tool (Volunteered geographic information) based on volunteers' feed and using the OpenStreetsMap platform. This is framed by the "Pre-Post Disasters Volunteer Geographic Information Project for humanitarian response and risk prevention" and has the participation of the Military Geographic Service.

- Consolidating a system of coordination and planning to work on disaster risk reduction using social networks such as Facebook, Instagram and Twitter - among others- with the aim of collecting relevant data in cases of emergency and improving decision-making as well as response.

- Recruiting volunteers through the National Volunteering plan from the Social Development Ministry. National Emergencies System Director stated that he trusts this innovative work opportunity to become appealing in the next summer season for a large number of volunteers who would carry out prevention tasks during the season.

6.3.2. How local authorities perceive forest fire risk and its resulting damages.

At a local level, forest fires are seen as one of the most important threats for Rocha, especially in La Paloma and La Pedrera. Some large-scale fires, for example the one that took place in Santa Teresa National Park in 1996 and in La Esmeralda and Punta del Diablo six years later how violent such events can become in the area. Factors that promote the recurrence of fires include: high forest density on the coastal strip (mainly maritime pines, acacias and eucalyptus), the characteristic high temperatures of the summer season, scarce rainfall and winds of changing intensity and direction. Risk increases due to irresponsible human actions and the accumulation of combustible materials in the area.

In the work area there are some highly dangerous vegetable combustibles, for example very inflammable brushwood species (acacias), pine forests with dense underbrush and thick conifers with a spongy and loose-knit layer of long needles with lots of air in between. In addition, there are wood leftovers that get naturally accumulated as a consequence of storms or excessive aging of the forested mass along with herbaceous vegetation and underbrush growing among the wood.

There is an acknowledged increased vulnerability as a consequence of the summer seasonal population, as a growing number of tourists –mainly young people - spend their holidays alternating destinations within this region. The 2011-2012 Strategic Plan from Rocha's Strategic Tourism Board (Horizonte 2015) states that the Atlantic coast concentrates a vast majority of the tourism offer, with La Paloma as the leading city. This report also presents crowding as one of the area's weaknesses, resulting in saturated services and infrastructures; all the aforesaid factors come together to boost risk.

By means of interchanging and analysing information arising from the workshops, it was possible to approach this municipality's problems from the perspective of coastal forestry, the existing population and the main forest fire events that had taken place in the last years, reaching the following results:

1. Coastal area with high forest density: a 35-km coastal strip from Rocha Lagoon to el Palenque where there are 5,000 hectares forested with different purposes. This forested surface generates a high

volume of forest mass waste whose management and collection bring about a major problem for the area.

2. Local population and tourism-related activities: There are over five thousand permanent and deeply rooted inhabitants in La Paloma and La Pedrera. In addition, and due to tourism, there is a temporary population that can reach fifty thousand people who are not familiar with the territory and do not use the local media (such as radios and press) to keep informed. This makes them more vulnerable in case of emergencies, such as forest fires. However, local key actors state that most fires are a result of local inhabitants' careless actions or accidents.
3. Waste management: pruning is regarded as one of the main problems of the seaside resorts' area. On one hand, forest waste should be retrieved quickly in order to reduce forest fire risk. That activity means long hours as well as human resources and machinery expenses to carry pruning waste. In the summer 2013 it was necessary to take 1094 journeys carrying street pruning waste; this could have been reduced just by having the adequate equipment. On the other hand, it is difficult for the local and tourist populations to acquire and apply good practices regarding a responsible management of pruning waste. Critical risk areas mentioned by key local actors:

- La Serena: high risk resulting from houses –in many cases built using wood - being surrounded by trees and not having the recommended setback or protective clean areas.

- Santa Isabel: high risk resulting from houses –in many cases built using wood - being surrounded by trees and not having the recommended setback or protective clean areas.

- La Pedrera: high risk area due to its topography. There is a wide area of gullies that hinder the accessibility of Fire Brigades or tank trucks. There are also dead-end streets. In the neighbouring Punta Rubia, even though there is good access to the camping zone, some private recreational clubs are located in high-risk areas: within the forest mass and predominantly built in wood.

6.3.3. Workshops' results.

The activity's main objective was to come up with a proposal for a Forest Fire Risk Management Plan for La Paloma-La Pedrera municipality. This process was fostered by the National Emergencies System (SINAE) and carried out by the NGO Cultura Ambiental (member of the Civil Society Global Network for Disaster Risk Reduction and Uruguayan Network of Environmental NGOs), in conjunction with researchers from the Territorial Analysis Applied Techniques Laboratory (Geography Department, Science School, Uruguay State University). It involved activities developed with the objective of identifying and analysing threats, vulnerabilities and capabilities; drawing communal forest fire risk maps and finally designing early warning and evacuation plans. Information records regarding forest fires in the area were considered; these included: fire maps, response and warning as well as communal prevention and early warning strategies (i.e.: citizens' networks).

When approaching risk management, emphasis was placed on integrated knowledge from the community, the professional groups and the State's organisms so as to build up communities resilient to a variety of socio-natural threats. Every step of the plan's elaboration was supported – locally as well as departmentally - by SINAE's Direction and Technical Coordination Office. Additionally, the participation of several actors was encouraged: local and departmental SINAE's representatives, National Response System to Climate Change associated institutions and local organizations from La Paloma and La Pedrera.

The forest fire risk vulnerability analysis was developed with input from the participative workshops in conjunction with information supplied by the professional team. It was possible to identify the following critical factors: the summer season weather conditions; high forest density on the coastal area; lack of maintenance in empty lots; the accumulation of combustible materials as a result of cleaning tasks developed privately. Vulnerability was categorized taking into account physical or topographic, social, organizational, institutional and material aspects. A summary of the vulnerabilities spotted would be as follows:

- Phyisical level: La Pedrera's geomorphology, which is characterized by deep gullies, makes it difficult to evacuate the area's population in case of an emergency.

- Social level: visitors in the summer season are not well-informed regarding a fire event: they do not know who to warn and lack precise knowledge of the territory so as to supply emergency authorities with the coordinates of their location. On the other hand, some local population's bad practices risk the seaside resort: accumulation of pruning waste in empty lots or lack of maintenance of empty lots where dead leaves accumulate. Overconfidence in the local population is also regarded as a risk factor, as people do not take the necessary prevention and self-protection measures.

- Structural level: there are some critical spots where the houses are located well into de forest and their main building material is wood. Thus, fire fighters or other emergency institutions have limited access to the area in emergency situations.

- Organizational level: even though there are some local organizations, there are no tight networks of neighbours working jointly and participating actively to approach risk; social networks are still weak at a local level.

- Institutional level: there are scarce human resources with a high turnover rate, which results in basic training levels. The Fire Brigade additional human resources available in the summer season are not familiar with the area, which makes them less efficient.

- Communicational level: there is no defined and available signalling for evacuation routes and risky areas. There are scarce evacuation exits in La Paloma and almost no connection between La Pedrera and Punta Rubia.

6.3.4. Local tourist agents survey results

The Uruguay's Atlantic coast forest fire risk evaluation survey was administered to hotels, camping sites, real estate agents and tourist farms as they were not represented in the participative activities even though they are strong and invigorating actors in the area. The questionnaire was divided in four sections: respondent's general characteristics; forestry characterization, spotting benefits and drawbacks; questions about forest fires and, finally, a section about forestry management agents. A total of 30 questionnaires have been processed and analysed.

The first set of questions had the aim of finding and defining opinions at area and town levels. The answers collected cover almost all the municipalities, except Chuy. It is worth remembering that Rocha's territory is not fully divided into municipalities so there are extensive rural areas that depend directly on the City Hall. Questionnaires answered in Maldonado were twice as many as the ones answered in Rocha, probably as a result of a larger amount of tourism agents located in that department. Moreover, almost all the responses come from tourism business located on the coast, with the exception of the real estate agents whose offices are usually located in the capital cities. 50% of the answers were from hotels while the remaining 50% were equally divided (8,3%) among camping sites, agricultural and livestock breeding activities, real estate rental and sale and tourism services.

The second set of questions had the aim of outlining the benefits and drawbacks that tourism agents see in forestry on the Atlantic coastal area. There is a general positive opinion (Figure 62) regarding forestry, even though answers cover a wide range of positions and when going deeper in the subject differences arise.

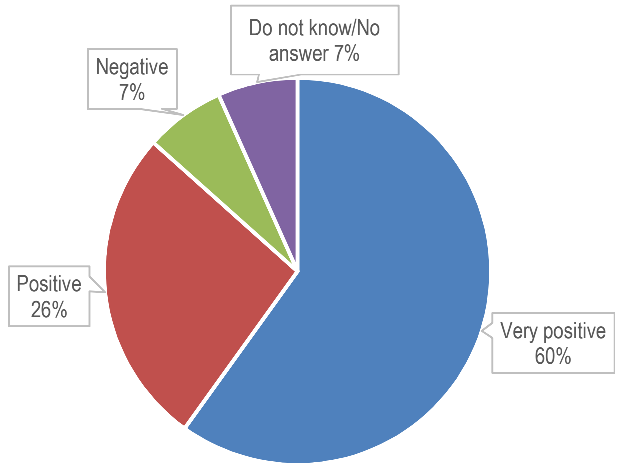


Figure 62: Opinion about benefits of forestry one the Atlantic coastal area

Some of the reasons underlying the positive answers are: the variety of landscapes shaped by forestry that contrast with those of large cities where most tourists come from; the fact that forests embellish the area; from a more functional perspective, forests provide shade, shelter and wood. Some respondents link forestry to natural tourism as it encourages investors to spot potentially interesting areas, as they see it as a way of caring for the environment.

On the other hand, other responses state that despite the fact forestry is fundamental for tourism on Rocha's coastal area, there is currently a lack of proper care and management of the forest. Forested areas are seen as fundamental for animal and human lives, but they also need to be controlled.

On the other hand, there were negative responses associated to plantations developed in the 70's in Cabo Polonio's entrance. Respondents state that those plantations had the aim of benefiting some summer resorts over others; also, that forest blocks North-West winds that are essential for the sand to get in and out the sea, going through the land and shaping a chain of dunes. Such blockage encouraged the development of grazing lands that fix sandy soils even more. All these processes resulted in the dunes height falling by 50% in 30 years. Respondents forecast a change in the area, shifting from a sandy area to cattle grazing fields. Nevertheless, the native forests present in the area together with the *ombú* tree forest are positively valued.

Regarding the current amount forested area, 78.6% think it is adequate. When asked about which types of forest should be privileged, five types were mentioned. Among those, the ones most frequently mentioned were the ones with aesthetic value, the recreational ones and where biodiversity is conserved. (Figure 63)

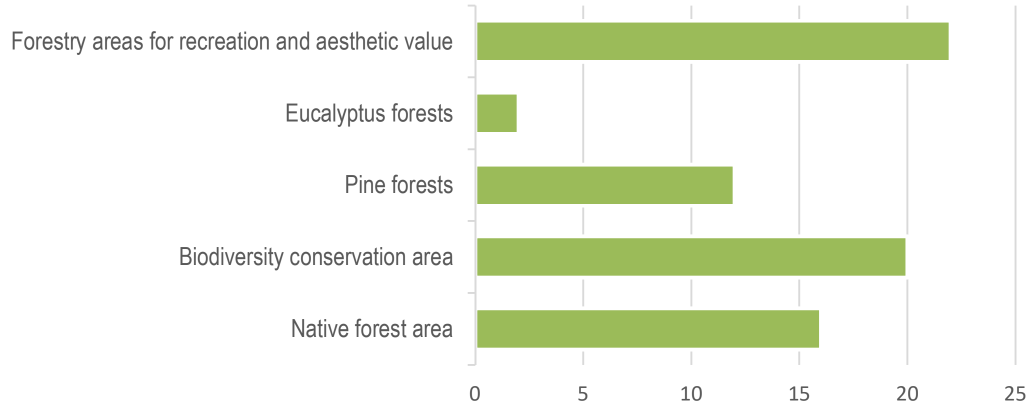


Figure 63: Types of forest that should be present on the Atlantic coastal area

There was a wide variety of replies when respondents were asked to mention the most important functions of forests (up to 3). The most frequent choices were linked to environmental quality, recreation and landscape. (Figure 64)

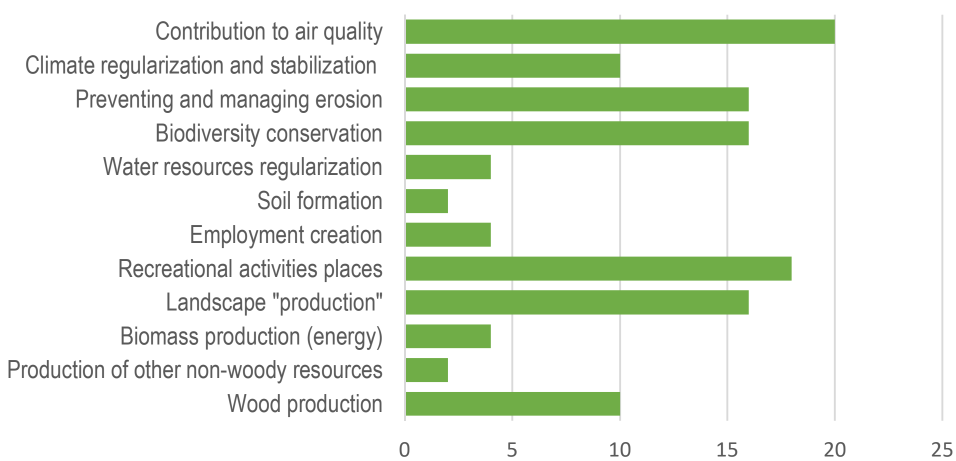


Figure 64: The most important functions acknowledged for forests on the Atlantic coast

Regarding the most important problems affecting forests within the study area, they could mention up to 4. The two most relevant were forest fires and difficulties in forests' management (Figure 65).

Among the measures suggested to deal with the aforementioned problems respondents mentioned, for example, increasing means to fight forest fires, specifically setting up cameras on high lands to allow park rangers to identify fires at an early stage. Some other proposals have a wider perspective and suggest implementing efficient forestry policies and regulations to maintain and manage forests. That would mean having a detailed record, identification and delimitation of areas forested or to be forested so as to allow authorities to control them properly.

In addition, those not carrying out adequate practices could be subject to fines. There is some lack of awareness as ideas are expressed in conditional: ‘there should be laws or regulations to make owners keep their areas clean under penalty of fine. This would bring along peace and safety for themselves as well as their neighbours, who may be affected in case of fires’. In addition, it is believed that the current legislation should be more widely communicated. Finally, the possibility of creating jobs related to maintenance of forested areas is also mentioned.

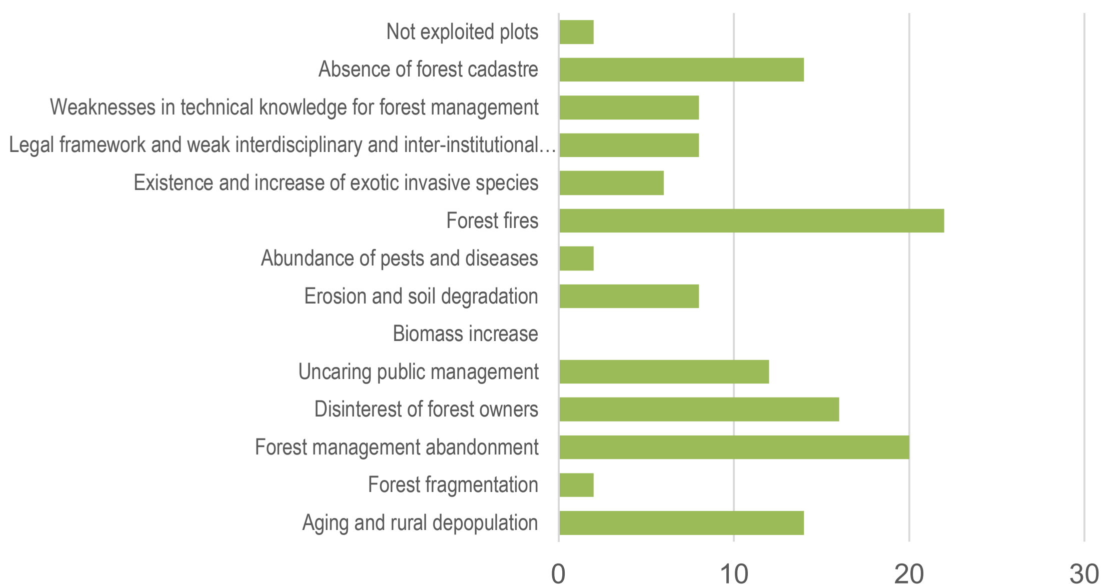


Figure 65: Main problems affecting forested areas on the Atlantic coast

There is also a more conservationist point of view, with proposals for better care and protection of the autochthonous flora. In this context, de-forestation is requested, substituting pines with native forest species. Other actions are suggested for these areas, for example, more research so as to determine which species would better suit them, as well as the creation of public and private institutes to develop activities related with forested areas, bird watching, arboretums and to promote a better knowledge of native species.

There is also a search for land planning solutions, specifically when green areas are divided into lots with building purposes. On the urban areas, meanwhile, lots with abandoned materials, junk, wood and accumulated pruning waste should be taken care of. Many replies emphasize the need to raise awareness regarding the active role the community should play in improving its immediate surroundings, stressing the need to encourage the love for nature and the acknowledgement of society's dependence on it. The community and also the authorities should commit to caring for the environment and respondents refer to a State-neighbours cooperation so as to raise awareness of dangers and get ready for risk.

About the following question: Are you familiar the national policy for forestry management (objectives and measures)? 60% of respondents know it, 20% know it badly and 20% know it reasonably.

The third set of questions starts asking about memories of forest fires in the area in the last 10 years. 65% of the people surveyed remembered events, being 2014 and 2015 the most recalled years, followed by 2010 and 2012. Besides, 2006, 2008 and 2013 were also mentioned while the fires that took place in 2007, 2009 and 2011 were not recalled. It is worth mentioning that fire events taking place closer in time are usually the most recalled ones. The most frequent causes of fire events are: fires started to clean property and accidental fires (camping bonfires, cigarettes, etc.); intentionally started fires come in third. The lack of City Hall cleaning services for dead leaves and weeds are also pointed out as a potential fire-starter, together with people's carelessness.

In addition, the most frequently factors mentioned as causes of fires spreading are: lack of waste and bushes cleaning; lack of firebreaks and strong winds.

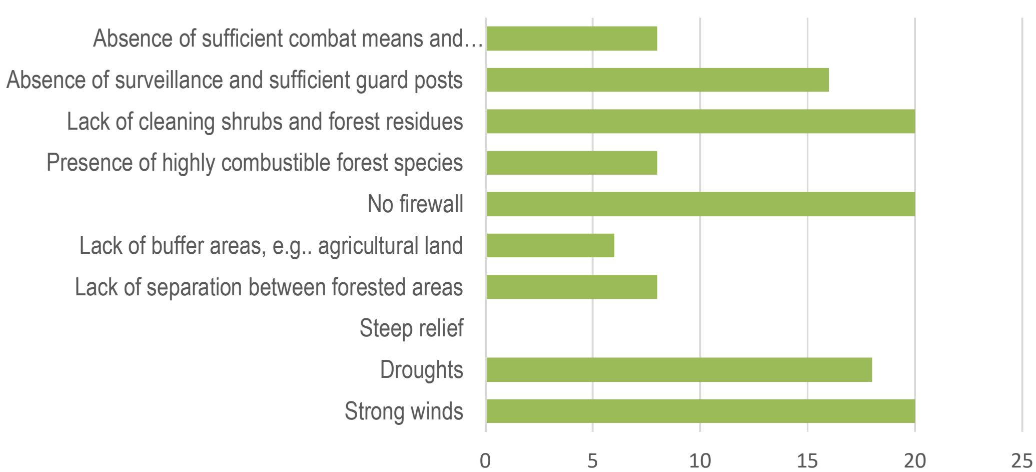


Figure 66: Main causes for forest fires spreading

The most acknowledged impact of fire is its effect on biodiversity; the destruction of houses and goods comes afterwards (

Figure 67).

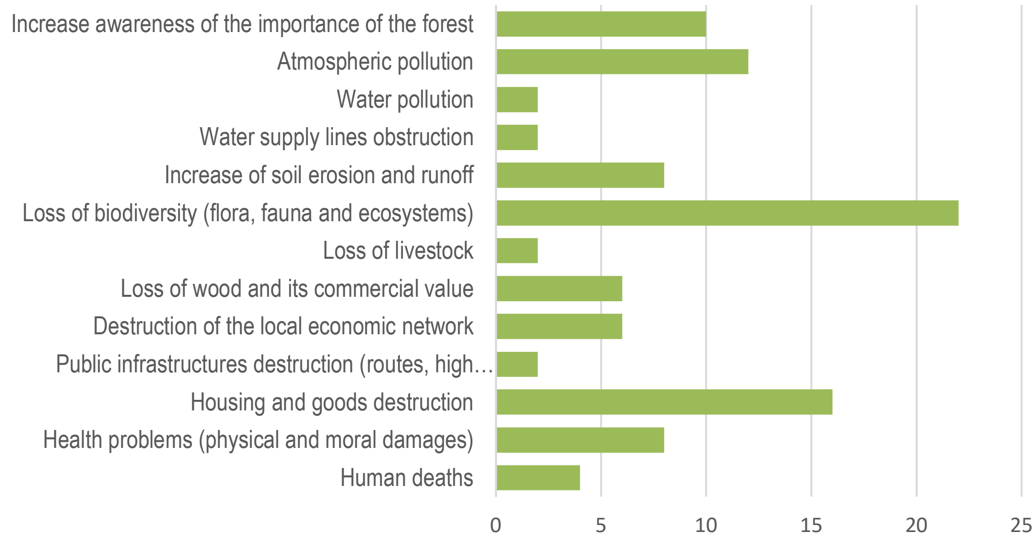


Figure 67: Most visible impacts of forest fires on the Uruguayan Atlantic coast

When asked about necessary investments for forest fires prevention, three answers were the most frequent: awareness and information campaigns, cleaning of bushes and control and fines to debtors. There were also mentions to: land planning, owners' organization and training and increasing fire-fighting resources. Finally, less frequent opinions were: subsidies to owners so as to integrate forestry management in their property; rehabilitation of burnt forested areas; and developing combustible vegetable management strips.

The last set of questions focused on agents responsible for forestry management. In this case City Hall authorities as well as land owners were widely and directly mentioned. Municipalities and national offices came second– specifically the Livestock, Agriculture and Fishery Ministry and the Housing, Land Planning and Environment Ministry. Meanwhile, organized owners and private companies are the least frequent mentions. On the other hand, when asked about who should define the interventions in the forest, National and City Hall authorities are the most recurrent answers, but organized land owners are also important.

6.3.5. A prospective look

This last set included a question aimed at getting to know the respondents' opinions regarding the near future. The specific question was: what do you think will happen in the study area and in the near future regarding the following topics? The objective is to get acquainted with perceptions about the evolution of some relevant aspects and some activities in the area.

There is a pessimistic view regarding the native forest's future as it is the type of terrestrial coverage that decreases the most; it is also thought that the conservation areas will go through a falling tendency, too. On the other hand, the agricultural area is expected to grow as well as the number forest fires (even though an important proportion of respondents think the latter will remain the same). Recreational areas are predicted to remain stable in the near future. (Figure 68)

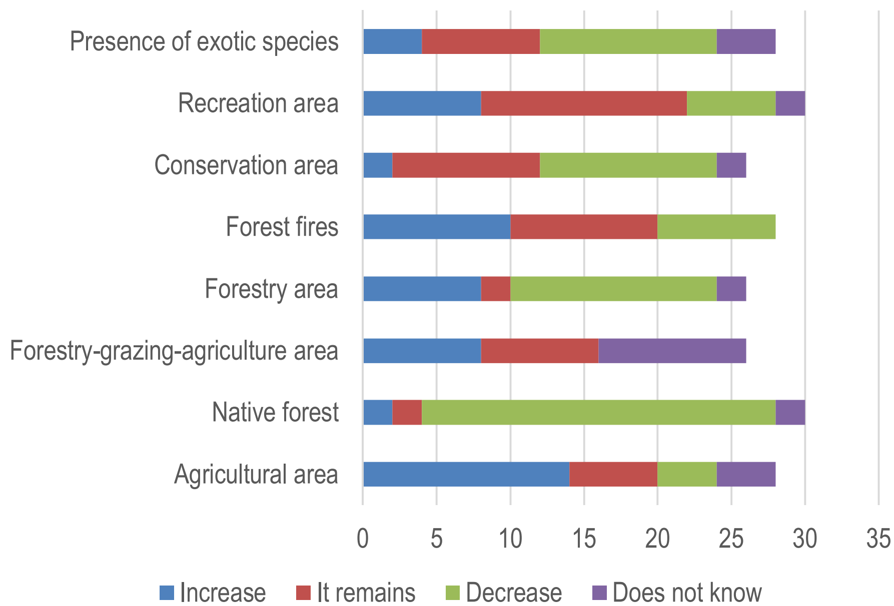


Figure 68: Near future perception for relevant aspects of the Atlantic coast area.

Within the topic of forestry types and the production of wood, there is a widely spread opinion that foresees an increase in wood production for the next years while other forested areas with alternative purposes (tourism, recreation, landscape) are expected to decrease (Figure 69).

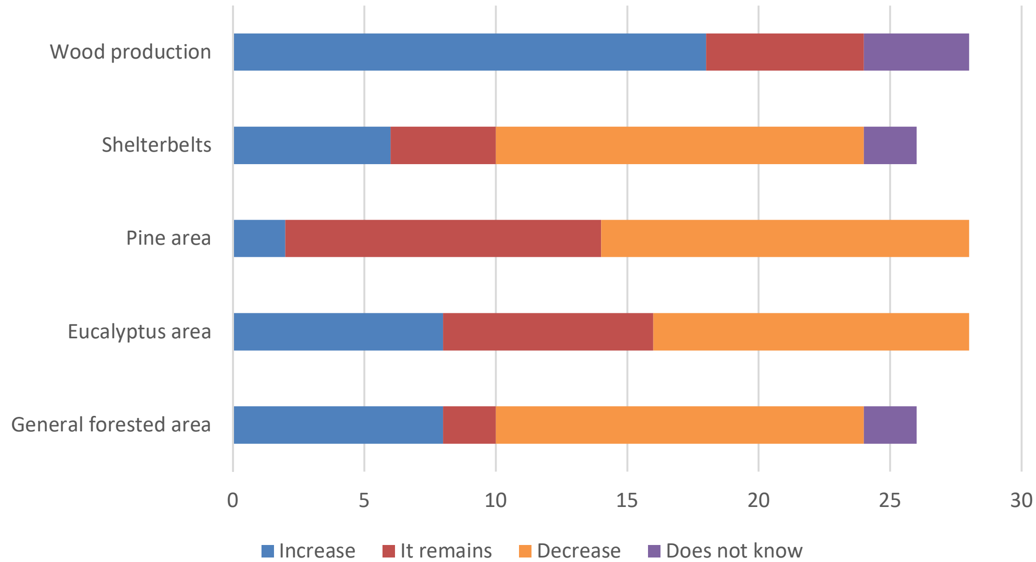


Figure 69: Perception about the future of forestry in the Atlantic coastal area

How do respondents think society will respond to this issue? They were asked about two relevant aspects of social behaviour: cultural valorization and economic valorization. For both questions there is an optimistic expectation of improving the current situation that is expressed through more concern or more interest. (Figure 70)

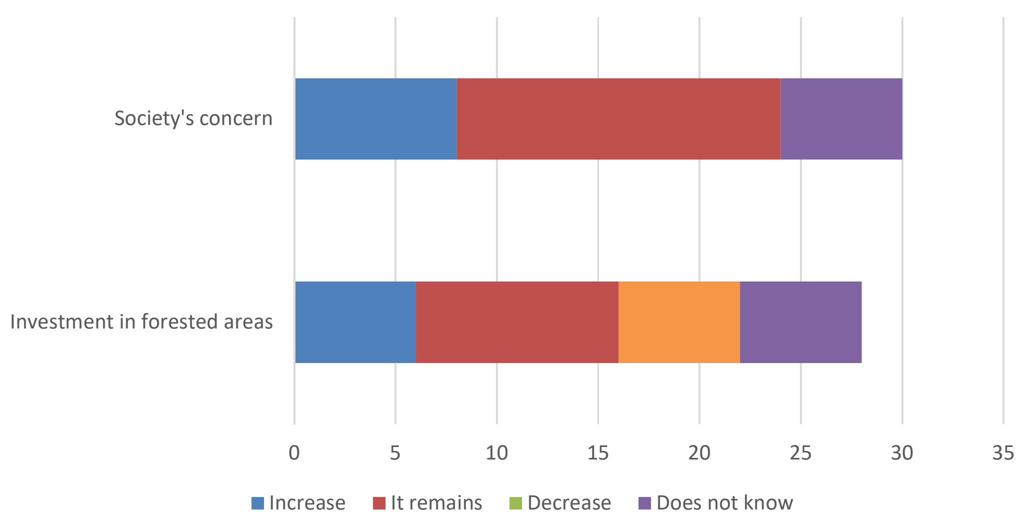


Figure 70: Perceptions about the community's behaviour in the near future.

Finally, respondents were asked to choose the most possible future scenario for the study area from three possible options. 60% believe that forested areas will be covered with eucalyptus. This is a fast-growing species and it is also probable that underlying this opinion is the fact at present, forested areas in Uruguay are 70% eucalyptus and 30% pine trees.

Moreover, 27% think that fires will be more frequent, and acacias will end up being the predominant species. Even though pine trees, eucalyptus and acacias are all highly combustible, the latter is the most combustible of all. It is an aggressive, hard to control species and spreads plague-like, pushing away native flora and fauna. Acacias are an invading species on the coast and have colonized the dunes. As it is an exotic species it has no natural enemies to prevent it from spreading and as it also is a highly effective bush, it grows quickly an inhibiting any possible competition from autochthonous vegetation. Such efficiency is reflected in the plant's germinal tissue (even if it is cut, it sprouts back from its roots located one meter deep), to its seeds (10 thousand per tree) that keep their germination potential for up to five years on the ground and it is fostered by fire.

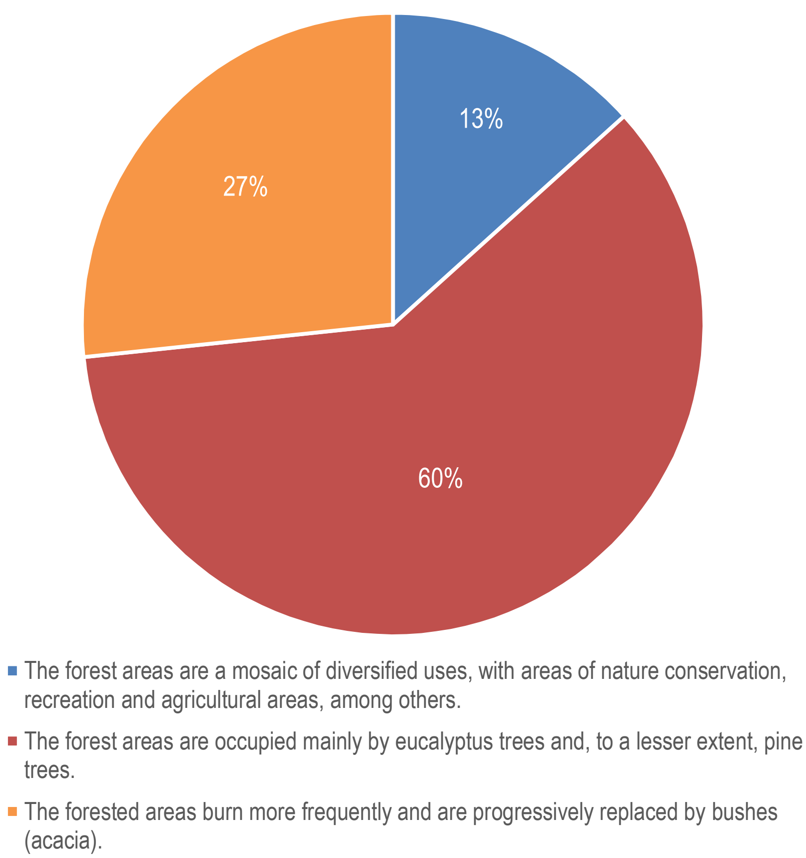


Figure 71: Choice of future scenarios

Only 13% picture a more diversified future that suits the multiple interests present in the region, with conservation areas, recreation areas and agricultural areas, among others. Some of those interests may be linked to economic benefits while others relate to ecosystem services and biodiversity conservation, which are paramount for a more respectful development of tourism, with better management of social, environmental and economic variables. (Figure 71)

Considering Valente et al. (2015) a succinct evaluation can be made. The authors cited the academic literature which summarizes the profile of the owners of small forests global level in four types: the classic owner who worries principally for the financial yield of the forests; the one that also values the environmental and recreative aspects of the forests; the owner who considers the forest as a hobby or ecologist valuing the environmental and aesthetic role of forests, and finally the indifferent or passive owner, who does not have others aims beside the forest property supports inside the family. It thinks that the changes in the rural – urban migration, as well as the generational transfer of the land and the new land uses promote a potential increase of the indifference of the forests owners in the future replacing to the traditional type. Valente et to. (2015) holds that Portugal follows the mentioned trend with increase of indifferent owners, mentioning Baptist and Santos (2005); Radich and Baptist (2005), who asset that recreative and environmental functions still are underestimated by the owners of this kind of forests. However, seeing European level surveys, forests are increasingly perceived as green and natural environments and less as an economic activity or service provider.

6.4. Discussion

If participative processes are not able to fulfil the requirements necessary to build trust among their participants, they may end up bringing about results that are harmful for the resolution of the problem or conflict they are dealing with. In addition, they may lead those affected by that problem or conflict to reject the participative proposals as a result of the frustrating experience they have been through. This is why this sort of activities must be carefully and transparently carried out, in total fulfillment of the given word.

The relation between the State and the society should be taken into account in these situations as it powerfully influences the decision-making process as well the plans' implementation. This is a constant premise in participative practices, whether they are carried out face-to-face or online. It is worth remembering that the Uruguayan State has a strong presence with still some paternalistic qualities. However, it is interesting to observe how some co-operation and co-responsibility concepts arise from local actors. This is a less passive approach resulting from the interchanges between stakeholders and it may be seized so as to reduce uncertainty about which decisions to make.

Using a more systematic approach to that wider range of options may lead the dialogue to new solutions. This interchange of perspectives about a topic – the risk of the Atlantic coast facing the forest fire problem added to diverse soil uses and interests within a small territory – that is analysed by actors with different backgrounds, from different professions and experiences results in a unique type of knowledge (Rist *et al.,* 2006). Valente (2013) summarizes what several authors have said about the potential benefits of stakeholders' participation in different processes. Among such benefits, stand out those situations when actors with different track records and from a variety of disciplines and experiences are encouraged to take part in an interchange of perspectives about a certain topic, generating new knowledge.

This experience enables a reflection about Robirosa's (1990) definition of participation that implies integrating three aspects: taking part in the sense of belonging, being a member; taking part in the development of adaptive actions; taking part, in the sense of influencing through actions. At the opinions collection stage –whether online or face-to-face – participants positioned themselves as actors capable of seeking and developing adequate solutions at a local level and adapted to their own communities. The face-to-face workshops supplied an opportunity to see how capabilities to make decisions effective are built and they were also a great chance to hear minor or less powerful groups.

Moreover, the surveys were responsibly replied. Even though it is not a representative sample, the 30 questionnaires that were filled-in represent a variety of regions, actors and opinions committed to the problem. This result reflects the need of deeper involvement at supra-local levels; it is worth mentioning that regarding budget, local authorities (municipalities) depend economically on City Halls (second level of government) and this brings about difficulties in executing proposals.

Therefore, participation may constitute a way to build new knowledge and to produce public spaces. Participation merges different social actors to interchange discourses, popular as well as expert knowledge regarding local concerns. Scientists and technicians belonging to the local population in question and also external took part in the participation exercise. However, they were all involved with the local logic and able to suit to it when actions plans needed to become operative.

Finally, it may be stated that when social actors make an autonomous commitment with the complex problem in question, weaving together multiple interrelations and interests, they bring along association networks where to build knowledge and make decisions grounded on participative planning methodologies based on a strategic approach (Natenzon 2003; Natenzon & Funtowicz 2003). It is an achievement rooted in a multi-directional communication process.

6.5. Conclusion

The present investigation used two different channels to communicate with the local community. The participative situations aimed at designing a proposal for a forest fire management plan, encouraged an interaction situation and enabled participants to assess higher risk situations and spaces, reach agreements regarding forest fire response and prioritize vulnerabilities to be reduced and capabilities to be strengthened. Participants from different organisms and actors from the local community with different educational profiles and levels came together in order to supply solutions to risk situations.

On the other hand, an online questionnaire was administered to tourism agents who are relevant to the area's population and economic dynamics. 20 open, closed and mixed questions with single and multiple-choice options were included with the aim of collecting information regarding forest fire risk and forestry management. The answers supplied show different perceptions regarding forests; there is a positive point of view regarding forestry in Maldonado department, where woods are a valuable asset within the seaside resorts' landscape. In Rocha, however, opinions are more negative when referring to the trilogy exotic species-forest fires – biodiversity and natural landscape losses. Regarding opinions about forest management and its connection with forest fires, there is general demand to the departmental as well as national authorities for more specific regulations, more fines and improved public services so as to reduce risk.

Participation in the three workshops increased trust regarding this conflict-solving search. As workshops were organized by central organisms and had a concrete objective, they encouraged expectations of a transparent process where interest conflicts are reduced and trust in institutional structures and in local actors increases. Even though they do not regard these activities as legitimizing, they do understand that participative and integrative decisions may bring along social acceptance and support for their implementation.

These activities are, therefore, part of a specific communication process where those holding expert knowledge as well as those holding popular knowledge are both senders and receivers and adjust their discourse in each work meeting, giving feedback to each other's knowledge and experiences. These practices result in development, prevention, safety and emergency programmes that have an impact and shape the social activities (Murgida et al., 2004). In addition, they boost the group's self-esteem and trust in collective as well as individual capacities.

It is also encouraging that all along the process and interesting reflection from Wilches-Chaux (1997) was present: “Between the individual and the environment there is something that we could call a transition zone, a force field whose thickness changes every minute according to the circumstances. There is no final answer to the question: where do I finish and my environment begins?” Beyond the philosophical questioning, it can be considered that the core of participation lays in the population’s involvement through their citizenship rights, which means that every institution that makes up the society respects the environment.

CHAPTER 7 PUBLIC POLICIES

7.1. Introduction

In modern society the definition and institutionalization of customized policies to manage risks and disasters is critical. There is an explicit acknowledgement of the need to count on civil protection and defense in extreme situations. Even though risk has been present since the dawn of humanity, its concept, nature and how it is perceived are always changing. It was only in the XVIII century when the difference between natural threats and disasters became explicit; the earthquake followed by a tsunami that almost wiped Lisbon out on November 1st, 1755 arose an important social debate at that time; the event also brought about an interesting confrontation of opinions between Voltaire and Russeau, as the first one held the divine providence responsible for the event, while the latter questioned human decisions. In his notes, he stated: 'Most of our physical evils are a result of our own deeds and we could have avoided almost everything by keeping the simple, uniform and lonely way of life that nature prescribes'. (Rousseau, II Discurso, OC, III, p.138). That was how the concept of social vulnerability starts arising (Acosta, 2005; Olimpio & Zanella, 2017), by expressing the people's unsafe living conditions (Blaikie *et al*., 1996).

The concept of natural risks went through different stages, beginning with a religious or supernatural conception to explain disasters, changing into a modern science axiomatic explanation based on measures and shifting then to a manifest engineering point of view. Currently, there is a holistic perspective of disasters that focuses on understanding the relation between danger and vulnerability. Cardona (2004) defines risk as a complex concept related to possibilities and, therefore, with a decision; its complexity derives from the simultaneous occurrence of the situation, the consequences and the context. All these factors should be taken into account when trying to calculate or qualify risk. Lately, governments have been integrating all these concepts and, as a result, risk management is more focused on disaster reduction; prevention and mitigation actions are put into practice before the events happen; and actions are taken towards minimizing vulnerability factors.

Andean countries in Latin America have been through major negative events because of their physical geography. As a result, they have higher awareness levels regarding disasters and have strong institutions that have shifted from attention and response paradigms to a more holistic management when facing risk situations. Uruguay has recently joined such tendency; this has meant decentralizing the organization and building closer bonds with local governments. This risk management style, in turn, led to acknowledging how relevant it is to develop a close link with the community.

7.1.1. Planning and risk reduction

The 1987 United Nations General Assembly proclaimed the 90s as the International Decade for the Reduction of Natural Disasters (Bulletin nº108 OPS). This proclamation had the objective of requesting special attention from nations to programmes and projects oriented to a reduction of material, economic and human losses as a result of natural disasters. The Sendai Framework for Disaster Risk Reduction 2015-2030 currently states the urgency of anticipating disaster risk. This implies strengthening people's resilience by planning measures and also efficiently protecting them, their means of life, health, cultural heritage, socioeconomic assets and ecosystems. Risk management comprises a series of measures and tools applied to intervene the threat or vulnerability in a way that current risks are reduced or mitigated. This is a preventive approach to risk that links it directly to planning from its early stages. As Matus said: "Planning means thinking before acting" (Huertas, 2016: Interview with Matus).

7.1.2. The institutionalization of risk management at a national level

The initiative to create a national emergencies system in Uruguay was born in the 90s. It was fostered by concerns triggered by large economic losses to the State, when a country whose economy is based on agricultural and livestock production exports began to be shaken by droughts and floods. This does not mean that there had not been any disasters before. Records for the highest number of evacuated people in Uruguay date back to 1959. At that time, a huge flood moved almost 45 000 inhabitants away, when they were faced with the daunting possibility of the Rincón del Bonete dam (located on Río Negro, in the central region of the country) collapsing. Later, in 1993, an unpreceded fire event took place at the Palacio de la Luz (building where the National Power and Electrical Transmissions Administration offices are located) and it resulted in the death of five people. The need to have a specific institution within the Uruguayan State to deal with emergencies stemmed from these situations.

The National Emergencies Systems was created by Decree 103/1995 on February 24th. It has the "mission of planning, coordinating, executing, leading, assessing and participating in prevention as well as in the execution of the necessary actions within every emergency, crisis and disaster situation" in all the country. A month later, Decree 371/1995 endorses such mission and makes important modifications to the organization (Art 2 Modification). It is composed by the National Emergencies Committee, The National Emergencies Council, The Permanent Technical and Operative Office (DTOP) and Departmental Committees.

Ten years after, the National Emergencies System was still partially implemented and lacked clear strategies and policies, such as the internal regulations necessary for its consolidation. On the other hand, years of floods alternated with years of drought brought about major losses in a country where an intensive model of agricultural and livestock production grew steadily. There were, also, other damaging events, such as frequent tornados and the 2005 storm, with winds up to 180 km/h, 10 victims and important damages along the country's coast.

Those were events that showed very poor preparation and response levels. In the following decades, the national government, aided by some international cooperation, worked on the development of some operative spaces called Departmental Emergencies Coordinating Centers (CECOED). In 2006 their institutional capacities were strengthened through projects formulated in conjunction with the United Nations Development Programme. In this sense, their greatest joint effort resulted in passing the bill that created the National Emergencies System. At the same time, a series of events taking place during those years – the 2005 extra-tropical cyclone, the 2007 and 2009 floods and the 2008/09 drought – reinforced the topic within the State's agenda.

Law Nº 18,621, which created the National Emergencies System, was passed in 2009. It was created as a permanently working public system and had a multi-institutional and decentralized profile. According to the law, its main aim is '…protecting people, their meaningful goods as well as the environment from possible or real disaster situations through a State's joint coordination, adequately using the available public and private funding so as to foster the conditions for a sustainable national development.' Its stated mission comprises: articulating, taking in consideration social actors' resources and responsibilities; bringing together private and public efforts as well as their needs regarding each situation; and ensuring the best management of the available resources.

The Top Management of the National Emergencies System (SINAE) is set up at the highest government level: The Executive Power; the National Management is the liaison between different SINAE agents, it is in charge of promoting and coordinating policies, strategies and activities, and of proposing tools and plans to reduce risks. In addition, the National Assessor Commission for Reduction of Risk and Attention to Disasters is created as a technical and assessing body. On the other hand, Ministries, State's autonomous bodies and decentralized services are responsible for a decentralized fulfilment of other risk management activities.

The Departmental Emergency Committees (CDE) are responsible for the decentralized coordination and execution of risk management; they are in charge of adapting SINAE's global policies to their local environments. They are composed by: the city Mayor (or a representative) who is the CDE's president, the local Police and Fire Department Chiefs, and representatives from several Ministries: National Défense, Social Development and Public Health. Other actors may be convened, as well. The Law also gives a formal framework to the Departmental Emergency Coordinating Centres (CECOED), where each Mayor appoints a representative. These representatives are in direct contact with risk at a local level.

In 2014 the Executive Power approved the System's protocol. It defines a general framework for the National Emergencies System governability so as to regulate the organization and sequenced responsibilities, actions and procedures to be carried out by the Uruguayan State in case of sudden emergency or disaster and according to the real or expected impact level.

7.1.3. The coordination centres within the local government

There are 19 Departmental Emergencies Committees (CDE) and Departmental Emergencies Coordinating Centres (CECOED) set up and working at different development stages. These local centres are focused in response rather than risk management. However, there are some attempts to change the old work paradigm into newer prevention, education and mitigation models. Rocha's CECOED is carrying out some actions as the one explained in chapter 6 or others aimed at managing forest fire risk. It is worth mentioning a meeting that took place in La Paloma (summer 2016-2017) with people responsible for fire prevention actions. The Director of the National Rehabilitation Institute took part in that meeting and referred to how persons deprived of liberty are in charge of carrying out forest cleaning tasks.

When facing an undesirable event, departmental joint actions include the effective participation of sectorial counterparts at that specific territorial level. The greatest local weakness lays in the technical support, usually resulting from municipal and sectorial limitations regarding human and financial resources. The problem's complexity and the uneven development of the actors, bring along difficulties in coordination that get worse due to technical and economic limitations. All this, prevents them from being in a real role of development promoters. Mansilla *et al*. (2005) describes a political vulnerability scenario for the inter-institutional structures. So as to strengthen them, this author suggests fostering not only the work on real tasks decentralization, but also on the generation of a self-sufficient local base that takes initiatives and facilitates or ensures the continuity of the actions. In that sense, the Interinstitutional Management Group aims at increasing participation; it was initially composed by the government, the University and some civil organizations. However, it still needs to involve unions, private agents and the community in general.

Forest fire risk management plans at a local level

According to Lavell (2000), vulnerability - and therefore risk - reduction or construction as well as the future damages resulting from a variety of natural or anthropogenic physical phenomena, are fundamental elements in a society's development style. This conceptualization brings about a new point of view regarding disasters, which is necessary to turn into the permanent action and focus of each management plan.

It is also necessary to be alert regarding the evolution of risks generation and types, as they are dynamic social constructions. New threats arise as a result of the trend to move residential areas away from city centres as well as to build summer houses in forested and hard to access areas. The development of buildings and infrastructures within areas of combustible vegetation is today a regular situation on the Uruguayan coastal zone. Interface fires spread on vegetable combustibles as well as on structures, increasing the threat and the vulnerability at the same time. Risk management plans need to take into account this particular situation, which is the result of a type of development and urbanization.

7.1.4. Conceptual and methodological framework

As it has been already mentioned, in the 90s the United Nations proclaimed International Decade for the reduction of Natural Disasters. This action had the objective of raising awareness about the importance of the reduction of natural disasters (CRID, 2010). The experience gained along those 10 years encouraged a conceptual change, shifting from simply responding to disasters to reducing them, and emphasizing on the key role of human activity (CRID, 2010). This way, the concept of risk reduction by means of local interventions taking place before the physical event and its impact, gained strength. The concept of "risk" became paramount as the best way to understand how their constituting aspects (threat and vulnerability) behave, and also, to be able to act on them, using public policies to achieve their reduction (UNIDDR, 2001).

Risk is therefore composed by factors related to threat and vulnerability. Threat refers to an event's possibility of causing some sort of damage to society. On the other hand, vulnerability refers to a series of characteristics present in a society – or in parts of it – that make it more prone to damage and to find it difficult to recover afterwards. Currently, the main objective is finding risk determinants and finding intervention options, doing it just from the planning stages and not as a reaction to compensate an ongoing crisis. Within this perspective, risk results from a series of processes, decisions and actions that depend on economic expansion models as well as development and social transformation styles (Lavell, 2001).

For SINAE, risk management is a complex social process whose final objective is permanently reducing, preventing and controlling disaster risk within a society. This should happen in agreement with a series of sustainable human, economic, environmental and territorial aims. Therefore, its main objective is not only responding to emergencies and disasters adequately and in time, but also controlling risk factors so as to prevent them from turning into actual disasters. Within this perspective, risk management comprises prevention, preparation, attention and recovery stages.

At a local level, a risk management plan developed for municipalities or smaller towns requires the direct involvement of local institutions, the community, educational institutions and social and environmental organizations. This is fundamental when implementing prevention strategies that are based on communication with the population, as well as in stages of response and restoring, when local organizations are required to work together.

On the other hand, if the plan is developed collaboratively, it will add value to its own and to new information as well as to the existing local networks that contribute to exchanging such information in due time. Developing a local forest fire risk management plan entails coordinated work between local institutions and the community so as to build trust and interchange knowledge. Building good rapport contributes to: successfully communicating prevention measures; defining the local vulnerabilities, needs and capabilities for fire risk reduction; and encouraging the information flow and an evacuation plan when facing an alert.

Developing a local forest fire risk management plan also involves: analysing the regulations applied at different territorial and sectorial levels; identifying threats and vulnerabilities for that area in particular; and developing measures and actions for risk reduction and disaster management. All of the aforementioned have the objective of contributing to the people's safety, welfare, life quality and sustainable development. When intervention takes place at such a specific territorial level, the particular principles of the intervention are the result of a highly participative process comprising every local social actor. It is also relevant to know how to deal with external and technical support actors, what agreement levels are reached and what type of coordination there is.

It was the participative workshops' goal to propose a forest fire risk management plan for La Paloma and La Pedrera local communities. The workshops allowed interacting and sharing information and knowledge about forest fire threats, identifying local vulnerabilities and resources to approach the problem in those communities. All of these, in turn, enabled an interchange as well as a strengthening process of the fundamental interinstitutional relations to build risk maps and then develop joint early alert systems.

The activities comprised: local actors survey; forest fires records analysis; risk perception analysis; discussion of the conceptual framework for threats, vulnerabilities and risks; region survey (affected areas and potential risk areas); and an analysis of the community's and local institutions' resources and capabilities.

7.1.5. Legal and institutional framework

Getting to know the legal framework that comprises the risk and the territory of interest is an unavoidable starting point. Regarding forest fires, Uruguay has a legal framework that regulates different aspects of such events at a national level: Forestry Law Nº15939, February 1988; Decree Nº452/988 that enables that Forestry Law; Law Nº15896 (1987) regarding competencies, prevention and fire-fighting; the decrees enabling the permits issued by the National Fire Brigade; Decree Nº436, November 2007 regarding forest fires prevention, alert and response.

The Forestry Law N°15939 encourages forestry developments on Uruguayan territory. According to this law, the Forestry office has the objective of coordinating fire prevention in conjunction with the Fire Brigade. It also refers to the obligations to be fulfilled regarding fire prevention and forest's protection against fire. As a consequence, every forest management, forest planning or forestry project should design an anti-fire roads network that should be kept free of vegetation at all times. Also, the owners of forested surfaces adjacent to railways or public roads must keep some strips clean and vegetation-free, with sizes as prescribed by the regulations. The Transport and Public Works Ministry, the Departmental Governments and the State's Railway Administration will keep roads or railways nearby forested areas clean and free of brushwood and will also build firebreaks.

Forested areas of any kind, whether public or private, will be located 12mt or more from the dividing line. However, on the Southern side, the minimum distance will be 25 meters. In case a neighbour considers that a certain plantation – even if it is developed within the regulatory framework – may damage their property, the National Forestry Office will be in charge of analysing the situation, deciding if there is (or not) damage and eventually setting a new minimum distance for the plantation. In case plantations are divided by public roads, they must be located at least 5 meters away from the dividing line.

The permits issued by the Fire Brigade are regulated by Law 15896 (1987) and its regulatory decrees. The Fire Brigade is a fire police body that acts at prevention and executive levels; it is in charge of fire-fighting or defence in situations that endanger human life as well as material resources. The permit the Fire Brigade issues is required to any kind of buildings and their surrounding risk areas. It is necessary for new or existing buildings aimed at housing, as well as with any other non-residential purposes.

The 'General Action Plan for forest fire prevention, alert and response' is another legal tool that resulted from an agreement between the National Emergencies System and the National Fire Brigade (Interior Ministry). It has the objective of preventing fire outbreaks, and in case they happen, achieving early alert and efficient response.

The ‘General Action Plan for forest fire prevention, alert and response’ was approved by Decree N°436/007 from November 2007. It bans any type of outdoors fires within the country’s territory every year between December 1st and the second fortnight of April. Fires lit for barbecuing are exceptions within the regulation, as long as they use spark arrestors. Also, fires to cook within camping sites, vacation camps and clubs are allowed but they must be lit in specific areas. In the case of camping site bonfires, they must be inside a 5-meter circle, free of weeds or other combustible materials, surrounded by stones, sand or earth and they must be put out very carefully.

The last exception are fires started by the National Fire Brigade with the aim of training staff in forest fire fighting. When planning any kind of activity that may imply direct or indirect fire risk, public authorities as well as the general public must take into account the Forest Fire Risk index issued daily by the National Meteorology Institute.

There is another prevention measure stating that anyone responsible for any kind of forested area must keep it clean and surveilled and the firebreak streets must always be free of vegetation, pruning waste and dead leaves. The National Emergencies Systems will inform the population about those areas where it is totally forbidden to light fireworks due to current fire risk.

Law Nº 18308 regarding Land Planning and Sustainable Development (2008) is the first regulation to mention risk. Its Article 4 states that land planning and sustainable development comprise: identifying areas of risk that are a result of natural phenomena or infrastructures that are dangerous for human life; it later excludes the urbanization processes of lands containing natural risks or affected by major technological accident risks for goods or persons. Then, its Article 49 (regarding Environmental Sustainability within Land Planning) refers to risk prevention; it states that at the time of assigning land uses, the authorities must take into account the prevention objectives as well as the territorial limitations set by competent institutions referring to human health risks.

This law also states that Departmental Governments have the power to develop Land Planning tools. It was within those powers that Rio Negro Department – which has a large forested surface – developed and passed its Departmental Guidelines (Decree 293/014). They are the only preventive regulation system regarding the effects of forest fires on urban areas or isolated houses. Its Article 32 refers to Minimum Distance to set up forestry developments and it states that ‘any new or reforested plantation should be located at a minimum distance of 500 meters (in a straight line) from: any urban area; the expected city growth limit; any land category within the consolidated or non-consolidated urban space definition; any sub-urban land considered of residential priority. In addition, the plantation must be set at least 100-meters away from any isolated house, school, agro-industry (feed-lost, wind farms), among others. Regarding firebreaks, they must be 12mt wide when dividing from neighbouring properties, plus 8 clean meters within the plantation. It they are located on the Southern limit; the width must be at least 25mt.

The Land Planning and Sustainable Development Regulations for Rocha (2012) do not include specific measures regarding this topic. However, there is clear concern about forest fires and their control on the coastal zone. It even refers to the special care that must be put in the prevention and fire-fighting strategy within the department's large coastal forested surfaces. Dangers placed on human life and the resulting psychological consequences add up to the environmental and economic after-effects of fires. Coordination with the National Emergencies System is regarded as paramount to a departmental strategy for fire prevention and fighting. Within the future objectives, there is the development of fire prevention and contingency plans and the preparation of evacuation plans for the people in all Rocha's seaside resorts.

There is another national decree (N° 238/009) that creates the National System for Climate Change Response within the Housing, Land Planning and Environment Ministry. It has the aim of coordinating and planning public and private actions required for risk prevention, mitigation and adaptation to climate change.

Finally, it is worth mentioning how Law N° 19272 (Decentralization and Citizenship Participation, 2014) relates to risk management. Its Article 13 states the mission of Municipalities, and within it, refers to taking urgent measures in order to coordinate and collaborate with national authorities in case of accidents, fires, floods and other natural catastrophes, communicating them immediately to the Mayor and staying at his/her disposal.

7.2. Discussion

The concept of risk management is relatively new and it implies a strategy to deal with uncertainty. Even though risk never goes away completely, having the capacity to know what its components are and the possibility of reducing uncertainty has brought about a new attitude towards some events that used to be seen as inevitable disasters. On the other hand, it is frequently observed that a more cautious attitude only arises after going through a major adversity.

Currently, governments tend to institutionalize those articulations aimed at managing risk, and they also decentralize tasks as a way of suiting mitigation, response and restoring actions to the local context. Risk management tries to bring central and local government levels closer to the community; such interchange of technical and field knowledge, academic and everyday facts, helps to improve planning and response capacities. In this process, the social perception of risk gains value as it is a cognitive process taking place within a concrete geographic space and under specific circumstances.

On the other hand, it is interesting to think about the role that international organisms play in this context. They have been the largest promoters of risk reduction strategies. Examples of this are: the International Decade for the Reduction of Natural Disasters (1989); the Yokohama Strategy for a Safer World: guidelines to prevent natural disasters, preparation for disaster situations and mitigation of their effects (1994), the Action Plan and International Strategy for Disasters Reduction (1999), and more recently, the Hyogo Action Framework (2005-2015). The latter has fostered national and local efforts to reduce disaster risk and it has strengthened international cooperation through regional strategies, plans and policies and by creating global and regional platforms to reduce disaster risk. Finally, there is the current Sendai Framework (2015-2030) that focuses in resilience.

The Hyogo Action Framework states the need to strengthen local communities, recognizing their history, culture and identity. According to this Framework, those communities have good knowledge of the environments where they are inserted. On the other hand, the Sendai Framework fosters the communication flow from national to local areas, reinforcing national and international participation at a local level with the aim of increasing resilience.

Uruguay depicts a regular behaviour, where institutions are born and grow driven by demands that arise unexpectedly. In 2011 the UN requested several international agencies to carry out a diagnostic assessment that has been a valuable input to foster and strengthen the National Emergencies System. Such assessment has been useful in order to implement the Hyogo Action Framework in the country; it has also set a starting point in the consolidation of an integral risk management system, helping to supply the institutional background necessary to go deeper in prevention tasks as well as in the development of permanent coordination areas. There is a more updated perspective where disaster risk management has become a critical component of development.

According to that perspective and taking into account that disasters and emergencies usually impact more aggressively on the most vulnerable sectors, it becomes impossible to reach sustainable development without taking into account the safety variables. Acting on safety is, therefore, seen as a component of sustainability and it implies the challenge of developing a joint, decentralized and coordinated work. The challenge involved is that of bringing concrete actions to the field; developing coordinated public policies within this given institutional density. The decision-making process as well as the roles and definitions that each actor is entitled must be crystal clear, as this is the time when risk-related laws are passed.

Nevertheless, changes in the legal framework or the interinstitutional structure do not necessarily mean efficiency. Mansilla et al (2005) analyse seven Latin American countries that have walked a long way in this subject matter, referring to the budget allotted to emergency attention and to the work of related organisms.

These authors state, for example, that probable losses are not usually considered a component of that budget. In addition, there is a lack of budget independence at different government levels. In Uruguay, for example, local development –at a municipal level – depends on the departmental government (a second government level).

Municipalities need to get technical and financial resources from departmental governments in order to: successfully take up new responsibilities regarding the promotion of economic development; and reach sustainable development levels that entail an integral risk management approach. There must be a quite autonomous distribution of resources so as to strengthen the municipal capabilities to design and carry out territorial-based initiatives that require interinstitutional coordination and citizenship participation. It is still uncertain how much awareness there is regarding topics such as the need of planning and also encouraging real public participation in risk prevention matters, or if it still true that disaster becomes relevant only when it strikes, demanding a major governmental response. (Mansilla *et al*., 2005)

7.3. Conclusion

The concept of risk changes alongside the different development stages; we are living now within the holistic perspective of the sustainable development paradigm and risk should, therefore, become part of such concept. International, national and local perspectives are increasingly showing their agreement with the trend towards risk reduction. Institutions make such tendency more or less explicit through a variety of laws.

Uruguay has joined that tendency a bit late, probably because its inhabitants do not feel exposed to 'natural disasters'. However, some threats – droughts and floods, for example - have brought about great economic losses. Even though those are usually seen as isolated events, the perspective changes when they are grouped to shape repeated patterns. When these sorts of events take place in the country, institutions aimed at integral risk management are created, usually with the financial and technical support of varied international organisms.

Regulations regarding forestry have changed according to the productive matrix of choice. There is little reference to fire risk, except for regulations aimed at taking care of the production itself. When looking at the forestry development on Uruguay's Atlantic coast, new weaknesses arise. There are no mandatory free spaces or alert systems; coastal forestry has been integrated to an urban-forested region where a lack of land planning regulations has multiplied the ecological disaster that was set off when, a century ago, the region was forested with land division purposes. Land Planning and Sustainable Development Law Nº 18308 (2008) lightly mentions the need to include the idea of risk within that of development; departmental guidelines also refer to forest fire threats but there is no mention about how to solve this new risk that is the result of carelessness.

Interinstitutional plans that mix all governance levels require a major synergy among the actors involved, with the aim of solving regulatory, institutional and economic issues. *'Political change, economic reforms and public policies with the aim of protecting people and resources are key in disaster reduction. It is possible and necessary to take advantage of the opportunities to change social behaviour that arise after a disaster…'* (EIROD, 2014). The SINAE stems from the idea that we all are the system and it still has a long way to go in terms of strategies, interactions and lessons learnt regarding risk management.

CHAPTER 8 CONCLUSIONS AND RECOMMENDATIONS

8.1. Introduction

This investigation focuses on a particular place. Uruguay is a country of grasslands instead of a naturally forested one. Natural forests are only located by the rivers or in the shape of scattered species, such as park forests or palm tree forests. However, forestry was introduced in the country at two different moments and with two different economic purposes; firstly, it was aimed at fixing sandy areas in order to divide coastal lands; later it was intended to produce cellulose to be exported as raw material. These two situations and their specific objectives were analysed in Chapters 3 and 4. The research area is located on the Uruguayan Atlantic coast, where this situation has been taking place since the beginning of the last century. There, the beaches bring along a tourism development that has become one of the major contributors to Uruguay's GDP. The number of tourists doubles the number of residents within a landscape containing a forest that has developed chaotically and with scarce or uncertain regulations.

As it has been explained in Chapter 1, the objective of this investigation is to learn about forest fire risk in Uruguay's Atlantic coastal area so as to outline proposals for forest fire risk reduction. Two lines of investigation were developed with such aim; the first one was technological, and it used tele-detection tools (to identify risk in areas that had been affected by forest fires) and geo-processing (to identify areas where houses are most exposed) (Chapter 5). The second line was based on workshops and a survey. The workshops convened the public participation of local representatives from risk management organisms and local inhabitants who took an interest in the subject; the survey, on the other hand, was applied to local tourism agents. The most relevant results regarding vulnerabilities and capabilities arising in both stages are presented in Chapter 6.

The approach of this research brings together scientific knowledge and public participation. It relies on the importance of interactions between participating actors such as administrators, local inhabitants and academics, which supply relevant input for decision-making processes regarding some complex phenomena. In addition, it seeks to grade the proposals aimed at preventing these negative events that resulted from participative processes so as to include them in the debate regarding land planning regulations.

The main conclusions of this investigation are presented in this chapter. The conceptual background that could improve fire risk management in section 8.2; the need to include forest fire risk and to acknowledge the specific characteristics of the region where they take place within the land planning regulations in section 8.2.1; the risk-reduction proposals that resulted from public participation and from the application of geographic information technologies in section 8.2.2. Section 8.3 contains recommendations arising from the investigation; 8.4 presents challenges and limitations found along the investigation and, last but not least, 8.5 includes reflections for improvement and future investigation lines

8.2. Proposals for management improvement

Climate change in addition to modifications in the uses of land alter the fire regime, making the events more frequent and severe (Fernandes, 2013; Bovio *et al*., 2017). The urban-forest interface keeps growing along the Uruguayan coastal area, which also has a high number of seasonal-use houses. A series of variables foster the development of a fire-prone scenario: poorly kept forests, hard-to-access areas, exotic forestry species that are highly inflammable, native vegetation that is increasingly being substituted by more aggressive exotic species that are better adapted to fire and summer seasons characterized by heat and drought waves.

The current forest fire management approach privileges fires extinguishment rather than addressing land management issues. This just speeds up a process that moves towards expanding a problem in a more fire-prone future. This results in a costly emergency response of limited efficiency. Firebreaks are the most popular measure although they are unevenly effective, because of some pyrophyte species that use fire to spread and regenerate and the area's characteristic strong and variable winds. Despite some campaigns aimed at raising awareness regarding fire prevention based on warning about careless attitudes, there is scarce knowledge concerning forest fires causes and consequences and limited understanding of their characteristics.

If forest fires' features are changing, the forest fire risk management strategy and regulations should be changing alike. In addition, having a single strategy does not seem recommendable. A strategy only based on fire extinguishment leaves aside the fact that some vegetation species benefit from fire to spread, thus increasing fire risk. On the other hand, a strategy that combines extinguishment with forest management preventive actions, becomes the most efficient in order to mitigate risk (Fernandes, 2013). Hirsch et al (2001) refers to a sustainable forest management style that comprises two simultaneous aims: minimizing fire's socioeconomic impacts and maximizing its ecological benefits. These apparently contradicting objectives can be reached by means of an intelligent forest management approach against fire. This implies planning and implementing integrated forest and fire management actions at plant as well as at landscape level. An intelligent management approach against fires has the aim of controlling the fire regime by intervening the combustible vegetation to foster more fire-resistant (less inflammable) environments.

8.2.1. Integrating forest fire risk in land planning

Interface fires bring about particularly complicated situations, where people and assets are put at risk while evacuations and a variety of other emergencies take place, breeding an increasing feeling of concern inside fire-fighting systems (Galiana, 2012). This kind of fire breaks out when inflammable vegetation and urban development mingle; it has a high ignition rate in areas where human life and property are at stake (Moreira et al., 2011). Within this context, emergency planning implies increasing the efficiency of the extinguishing tools and, more importantly, raising awareness in the area's inhabitants. As this is a relatively new type of event, regulations are scarce, and the social perception of risk is still weak. The Uruguayan Atlantic coast comprises a range of realities that were mostly apprehended along this investigation.

There are areas registered in cadastre, which means that those lots' conditions can be followed-up. These are usually clean lots where the forests, even when they are exotic, seem to be part of the summer resort's characteristic features; on the other hand, there are areas that resulted from abusive land divisions and went through a disorganized – and sometimes even illegal - settlement process. As a consequence, it is not always possible to find out who their owners are only using the cadastral registry. These are high fire-risk areas where exotic forestry confronts native forest areas.

Hirsch et al (2001) refers to information technology developments as useful tools to find out how forestry management policies and practices affect the fire regime and vice-versa. They also help to outline risk areas related to land planning, creating a specific category that comprises urbanizations that do not have immediate continuity regarding the major urban areas and are located in forested lands or are isolated houses within forested areas. Such categories place a collective risk and should therefore be included in land planning tools and regulations. The budget allotted to fire prevention and fighting is completely public; this implies that the legal regulations should have the capacity to modify the existing situation where costs end up fostering the location of people and infrastructures in the riskiest environments (Napoleone, C., & Jappiot, M., 2006).

8.2.2. Vulnerability reduction and land planning.

A forest fire management strategy should take into account new environmental variables, for instance, climate change, urban expansion in interface areas, a decrease in small-sized rural lots, invading exotic species, etc. Reducing vulnerability means making decisions at very different contexts. Land planning, environmental education and prevention related to forest care have become fundamental to turn danger into an asset that encourages well-being and improves life quality.

Vulnerability assessment needs to take into account the capacity of environmental and social systems to take in exogenous as well and endogenous change. That, in turn, means suiting and adapting land planning policies and tools.

As most of the Uruguayan regulations regarding land planning and risk management appeared together, while decentralization and public participation are subsequent, it is necessary to analyse their connections so as to include public contributions within the vulnerability reduction objectives. The social perception observed in the participative stages of the investigation suggests the existence of confusing communications among the three governmental stages. Requirements are usually formulated in the wrong place and in the wrong way. That means that there is not adequate understanding and the results reached usually mean disbelief regarding the advances towards an improvement in forest fire risk management. An example of this can be how a local government needed to demand the cleaning of pruning waste from a lot that had been deforested so as to build houses for State's employees. In spite of this kind of situations, local inhabitants acknowledge a shared responsibility and demand a more cooperative attitude between State and citizens.

8.3. Recommendations

The investigation's main argument states that the information interchange between the academy and the stakeholders brings along enriched answers that contribute to a more successful management of the issue. Regarding the present case study, there is a very poor prospective view regarding an urban-forest interface of high ecological, cultural and economic value, while management remains reduced to some preventive communication campaigns, the opening of firebreaks and fire-fighting itself.

The recommendations arising from the present investigation concern an improvement in forest fire management with the aim of reducing damage and oriented to:

Developing forest fire risk management plans in conjunction with local inhabitants: their knowledge becomes critical when there is limited property registry and scarce knowledge about the forests' conditions and activities developed within and among them (specially the building of isolated houses inside forested areas). In this sense, it is necessary to keep the jobs of those people whose responsibilities directly relate to fire management (forest management, parks and protected areas care, fire-fighting).

Updating the coastal forests management plan: even though cleaning forests periodically is mandatory, it is difficult to control such tasks and, even more, to communicate with the land's owners. It is suggested to turn to more intelligent management alternatives in order to modify the current situation where highly inflammable exotic species reproduce the threats. Even though substituting species is a long-term solution, it is still frequently suggested by a variety of authors.

Adapting land planning regulations: there are two main concepts to be integrated. On one hand, the urban-forest interface land occupation approach. This type of settlements is currently growing around cities worldwide and in Uruguay it is spreading all along the coast. Even though Land planning usually categorizes Wild-urban interfaces as tourism development areas, it is noticeable that, in fact, they currently tend to gather different kinds of urban developments. On the other hand, there is the concept of vulnerability and high-risk areas. According to Land Planning and Sustainable Development Law Nº18,308, risk zones are defined by the presence of natural phenomena or dangerous infrastructures for human settlement. Therefore, it seems advisable to specifically define perimeter measures, unauthorized situations and critical areas where the vegetation implies high forest fire risk. Having a cartography of vulnerability

Improving communications with permanent as well as seasonal inhabitants: local actors are concerned about their expected behaviour when facing forest fires and also about the types of events that they are supposed to report. Suitable and permanent communication tools are necessary in order to communicate with natives as well as with foreigners about evacuation routes, information spots and health care centres in case of forest fire.

Turning information technologies into an ally: the aim of this recommendation is to encourage the use of this kind of tools at every risk management stage. Prevention of these events is improved when previous fires are known. There is a wide range of available tools that can help to develop a reliable and thorough forest fire database.

8.4. Investigation’s challenges and limitations.

Forest fires imply high complexity as well as high uncertainty. If we reduce the analysis to just the event (understood as the ignition and its result, the burnt area), the available bibliography and indexes show how limited the systematization models are when trying to bring together a series of elements bearing variable behaviours. Each forest fire is unique; the different vegetation types and structures, the meteorological conditions and the topography impact in the spectral heterogeneity of the burnt area and make it difficult to simplify the analysis. These conditions become more critical in interface fires. Nevertheless, the continuous technological developments, a wider range of available data, and an academic community increasingly involved in the use of those technologies, allow foreseeing improvements in their scope and reach.

As forest fires involve the whole society from their very beginning, the main challenge when analysing them lies precisely in not only approaching the physical event itself, but all its dimensions. The public perception regarding the use of fire as well as fires, regarding the benefits of forest management, regarding collective and individual aspects and regarding how reliable risk reduction administrators seem to be, are all paramount to understand this problem. Working with such complexity levels is an important challenge that demands integrating a variety of perspectives through an interdisciplinary and multidimensional approach.

When participative methodologies are applied so as to reach the commitment of all the actors involved, there are some points that need to be made clear: the investigation scope; the fact that solutions will be long-term; the difficulty that integrating all points of view entails and the need to agree on desirable achievements. It is critical not to set impossible expectations to highly-involved actors, such as local inhabitants who experiment the consequences like mangers with political anxiety. The workshops that were carried out had representative participation of all stakeholders' groups, except tourism agents who were sent the survey to be completed online.

Participation in workshops was active and committed and it included field trips proposed by attendees. On the other hand, only thirty questionnaires of the online survey were completed but they came from towns where forest fires are lived very differently.

Finally, it is worth mentioning some difficulties placed by the used data. This is an area of high cloudiness; this meant that even though ten summer seasons were analysed, images from only two of the largest fires could be processed. Another disadvantage was not having a registry from the National Fire Brigade that could have helped to discriminate with a higher degree of certainty the fires from other controlled burnings. This information deficiency led to resorting to the database from NGO DesInventar, built using newspapers information.

8.5. Improvements and future research areas.

Regarding technological tools, it is the objective to move forward in remote sensing but incorporating Sentinel images (as they have better space and radiometric resolution), and also algorithms related to Open Data Cube. It is expected that these new products will allow a better discrimination of land coverages in burnt areas.

Upcoming steps imply presenting this investigation's results to competent organisms so as to confront opinions with the aim of adjusting and consolidating contributions that may be taken into account in future regulations.

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