



## Relatório da Acção A3 do Projecto Life/Priolo

### O Projecto LIFE Priolo – Avaliação socioeconómica de um sítio Natura 2000.



## Relatório da Acção A3 do Projecto Life/Priolo

### O Projecto LIFE Priolo – Avaliação socioeconómica de um sítio Natura 2000



O Projecto LIFE/Priolo é uma parceria da SPEA com a Câmara Municipal do Nordeste, o Centro de Conservação e Protecção do Ambiente da Universidade dos Açores (CCPA), a Direcção Regional dos Recursos Florestais (DRRF), a Secretaria Regional do Ambiente e do Mar (SRAM) e a *Royal Society for the Protection of Birds* (RSPB).





**Trabalhar para o estudo e conservação das aves e seus habitats, promovendo um desenvolvimento que garanta a viabilidade do património natural para usufruto das gerações futuras.**

**A SPEA – Sociedade Portuguesa para o Estudo das Aves** é uma organização não governamental de ambiente que trabalha para a conservação das aves e dos seus habitats em Portugal. Como associação sem fins lucrativos, depende do apoio dos sócios e de diversas entidades para concretizar as suas acções. Faz parte de uma rede mundial de organizações de ambiente, a *BirdLife International*, que actua em mais de 100 países e tem como objectivo a preservação da diversidade biológica através da conservação das aves, dos seus habitats e da promoção do uso sustentável dos recursos naturais.

---

## **Relatório da Acção A3 do Projecto LIFE- Priolo**

### **O Projecto LIFE Priolo – Avaliação socioeconómica de um sítio Natura 2000. Sociedade**

Sociedade Portuguesa para o Estudo das Aves, 2009

**Direcção Nacional:** Ricardo Azul Tomé, Maria Ana Peixe, Pedro Guerreiro; Ana Leal Martins; João Jara; Paulo Travassos; Pedro Coelho; Miguel Capelo; Paulo Simões Coelho; Teresa Catry

**Direcção Executiva:** Luís Costa

**Coordenação:** Joaquim Teodosio

**Agradecimentos:**

**Fotografia da capa:** Floresta Laurissilva, SPEA-LIFE Priolo

de la Cruz, A., J. Benedicto & A. Gil 2008. *O Projecto LIFE Priolo – Avaliação socioeconómica de um sítio Natura 2000*. Sociedade Portuguesa para o Estudo das Aves, Lisboa.

# TABLE OF CONTENTS

<b>EXECUTIVE SUMMARY</b>	<b>6</b>
<b>1. INTRODUCTION</b>	<b>8</b>
1.1 Description of SPA Pico da Vara / Ribeira do Guilherme	8
1.2 Why is the site of socio-economic importance?	9
<b>2. OVERVIEW OF SITE'S SOCIO-ECONOMIC BENEFITS</b>	<b>11</b>
<b>3. METHODOLOGY</b>	<b>13</b>
<b>4 DETAILED VALUATION OF DIFFERENT BENEFITS</b>	<b>16</b>
<b>5. FUTURE PROSPECTS FOR THESE BENEFITS</b>	<b>30</b>
<b>6. CONCLUSION</b>	<b>37</b>
<b>BIBLIOGRAPHY</b>	<b>39</b>

## EXECUTIVE SUMMARY

---

The Special Protection Area (SPA) Pico da Vara / Ribeira do Guilherme is a Natura 2000 protected area in São Miguel Island in the Azores archipelago, Portugal. This area was protected because of the existence of the Priolo (*Pyrrhula murina*) an endemic bird of the Island of São Miguel that can only be seen in this area.

The preservation of this area provides much more than the conservation of a bird. Laurel Forest vegetation only exists in the Macaronesian islands. Nearly 50 per cent of endemic plants and all endemic vertebrates of the Azores are present in this area. The preservation of this biodiversity and of the interactions in it, guarantee the maintenance of all other Ecosystem Services considered in this study.

The conservation of this area, and especially the preservation of this vegetation, provides many ecosystem services to the local, national and global community.

The most important services in the SPA are those related to water, its provision, quality and regulation. Ecosystems preserved in the SPA regulate the water cycle providing a reduction in the occurrence of floods and landslides, which are very habitual events in this area having caused 29 deaths and around €20,000,000 in damages, in 1997, in a village close to the SPA. This regulation of the water cycle also provides water for almost all the councils of Nordeste and Povoação whose total water demand is 1,408,273 m<sup>3</sup>/year. This water supply is worth more than €600,000, based on the prevailing price of water. The real value should be higher, since agricultural use was not considered in this calculation because there is no price established for this use. The SPA is a guarantor of water quality. Since the establishment of the SPS, water quality in the area now exceeds legal requirements for potable water. Previously many local people bought bottled water. Medium expense by a family in 2001 in bottled water was €46.5 per year (Regional Water Plan in the Azores). **The total benefits from water quality impacts of the SPA are estimated at over €110,000.**

Carbon storage in the SPA was quantified tentatively. The total amount of **carbon stored in the SPA was estimated at around 465,000 tC plus 223,667,84 tC/year sequestered in the peat area.** Further research is needed to obtain improved estimates of this potentially valuable service.

The SPA has also the potential for developing Ecotourism activities. At present, this potential has not been developed significantly. A value for tourism, calculated by the Travel-Cost method for visitors staying in rural houses in Nordeste council, was estimated at around **€60,000**. Expenses on active tourism by visitors of the SPA were calculated at **€16,500**. These values are conservative; since accommodation in the Nordeste region is not very developed and currently active tourism activities are limited to trekking activities.

Inspirational services of the area are also very important; the SPA received a mean of **10 school groups every year, as hosts 8 graduates, 0.25 PhD students and 1 MSc student every year.** Scientific research from the area is also reasonably important, since 1968, a total of 10 scientific papers have been written directly related to the area, and many others used this area as one of their study sites.

Landscape and amenity values and existence values of the site were valued by a willingness to pay enquiry for the protection of the SPA. This survey found that the Povoação community values the conservation of the SPA at between **€500 to 800 per person**. Taking the lower estimate, this gives a **benefit of over €3,000,000 for the Povoação region alone.**

Other potential ecosystem services, that for the moment remain unexploited include the use of Azorean Blueberries (*Vaccinium cylindraceum*) for cultivation as well as in manufacturing of jams and cakes, and ornamental use of endemic species for gardening. These two services should be encouraged in order to be put capture the value.

The SPA Pico da Vara / Ribeira do Guilherme was financed, between 2003 and 2008, mainly by a LIFE Priolo Project. The expenses of this project can be an example of total socioeconomic benefits derived by the management of the area and the tasks developed by this project should be continued in order to maintain the conservation of the area.

The LIFE Priolo Project created an average of **21.6 Full Time Jobs** every year directly, divided between a technical team, a group of national and international interns and a fieldwork team of local

people. Indirectly, this project also supported another 4 Full Time Jobs through expenditure of around €300,000 per year and expenses of workers and volunteers of the project of around €50,000 a year.

The LIFE Priolo Project as a manager of the site created infrastructure that will remain after the project. This infrastructure will assist the delivery of recreation related services and include an Environmental Centre, 14 km of trails in the SPA and the planting of 3 orchards with traditional and endemic fruits.

The Project also eradicated exotic species and cultivated endemic planting techniques, an average of 40 workers were trained on these techniques every year.

## 1. INTRODUCTION

### 1.1 Description of the SPA Pico da Vara / Ribeira do Guilherme

Pico da Vara / Ribeira do Guilherme was classified as Special Protected Area (SPA) in 1999 (Decreto-Lei n.º 140/99 de 24 de Abril). In 2005, its area was increased along with the publication of the SPA's Management Plan (Decreto Regulamentar Regional 9/2005/A, de 19 de Abril)

This SPA is located on São Miguel Island (Figure 1), the biggest island in the Azores archipelago. It comprises the council regions of Nordeste and Povoação. At present the SPA covers an area of 6,067.27 ha representing 28.3 per cent of the total area of the two councils.



Figure 1.1. SPA Pico da Vara / Ribeira do Guilherme location.

This area comprises the last big area of altitudinal Laurel Forest in São Miguel, which is being seriously compromised by invasive species that cover an important area of the SPA and threaten an even bigger area. The SPA also includes a small portion of a bigger peat area adjacent to it. This peat area is threatened by desiccation from conversion to pastures. We also include the peat area in this study.

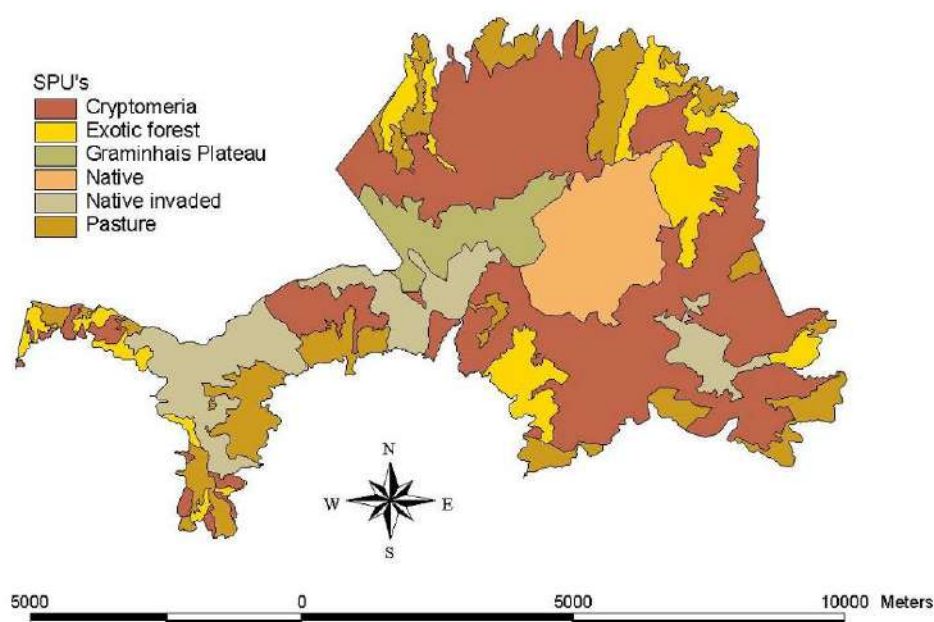


Figure 1.2. Habitats distribution of SPA Pico da Vara / Ribeira do Guilherme

The designation of this area as an SPA was due to the presence of Azores Bullfinch or Priolo, an endemic species in the Azores that is only present in this area. This bird is considered by Birdlife international to be one of the most threatened birds in Europe and classified as “Critically Endangered”, at the national level (Red Book of Vertebrates in Portugal), and at an international level by the IUCN (Red List of Threatened Animals).

The Laurel forest is also an important habitat for other birds such as the Azores Wood Pigeon (*Columba palumbus azorica*), a species with communitarian interest, the Canary (*Serinus canaria*), an endemic species of the Macaronesian Region, a few subspecies as the Azores Blackbird (*Turdus merula azorensis*), Goldcrest (*Regulus regulus azoricus*), Blackcaps (*Sylvia atricapilla atlantis*) and Grey Wagtail (*Motacilla cinerea patriciae*).

This habitat also includes also many endemic plants from the Azores such as Azorean Blueberry (*Vaccinium cylindraceum*), the Azorean Plum (*Prunus lusitanica azorica*), the Laurustinus (*Viburnum tinus subcordatum*), Azorean Holly (*Ilex perado azorica*), the *Picconia azorica*, the Buckthorn (*Frangula azorica*), the Azorean Heather (*Erica azorica*), the Azorean Cedar (*Juniperus brevifolia*) and the Laurel (*Laurus azorica*).

The main goals defined in the Management Plan for the SPA (Management Plan, 2005) are:

- To create a management structure that allows the implementation of this plan.
- To ensure the existence of necessary legislation for the protection of the SPA.
- To increase the area of suitable habitat for the Priolo in more than 300 hectares, whilst preserving the current area.
- To guarantee the support and collaboration of local population and visitors for the protection of the Priolo.
- Make compatible the economic activities developed in the area within the SPA with Priolo's conservation.
- Applied research into the factors that influence the structure of the natural vegetation, the distribution and abundance of exotic species and their influence on the Priolo.

## 1.2 Why is the site of socio-economic importance?

Natura 2000 areas are very often located in less developed areas. Their designation as protected areas is, at the same time, a conditioning factor and an opportunity for the development of ecosystem services they support. Natura 2000 areas however, also require management practices and conservation actions that require funding. The existence of well preserved natural habitats, associated with Natura 2000 areas, can guarantee the preservation of important ecosystem services, whose loss can result in high expenses for the public actor. Valuation of these services will help justify the costs of conservation.

Conservation spending does impact on the local population and can produce significant socio-economic benefits, but decision makers have limited funds and many other responsibilities, such as health and education to fund. Understanding the benefits of conservation can help make the case for public funding and create opportunities for additional financing.

The existence of a Natura 2000 site in a region can lead to restrictions on certain economic activities but it can also be an opportunity to develop alternative and more, sustainable activities that can support socio-economic development. For example, the existence of well preserved areas is also an opportunity for the development of ecotourism that can generate income to the local economy.

The SPA Pico da Vara / Ribeira do Guilherme is a good example of the socio-economic importance of Natura 2000 sites. It is located in the two less developed councils on the Island of São Miguel, it has benefitted by important EU financing for its conservation and it provides important Ecosystem Services (ES) to the local, regional and global communities.

Conservation of the SPA Pico da Vara /Ribeira do Guilherme is also expensive, since the biggest threat in the area, invasive species, is costly to address. This is the reason why it is so important to highlight the benefits generated by the existence and conservation of this SPA and also to find ways of increasing the potential range of funding sources.



With a total population of 12,017, the Nordeste and Povoação regions are the two least inhabited councils on the island. Together they represent only 9.1 per cent of the total of the population of the island within 28 per cent of its area, with a very low population density (56.7 inhabitants/km<sup>2</sup>). Population from Nordeste and Povoação councils has been decreasing since the 1950's as shown in figure 1.

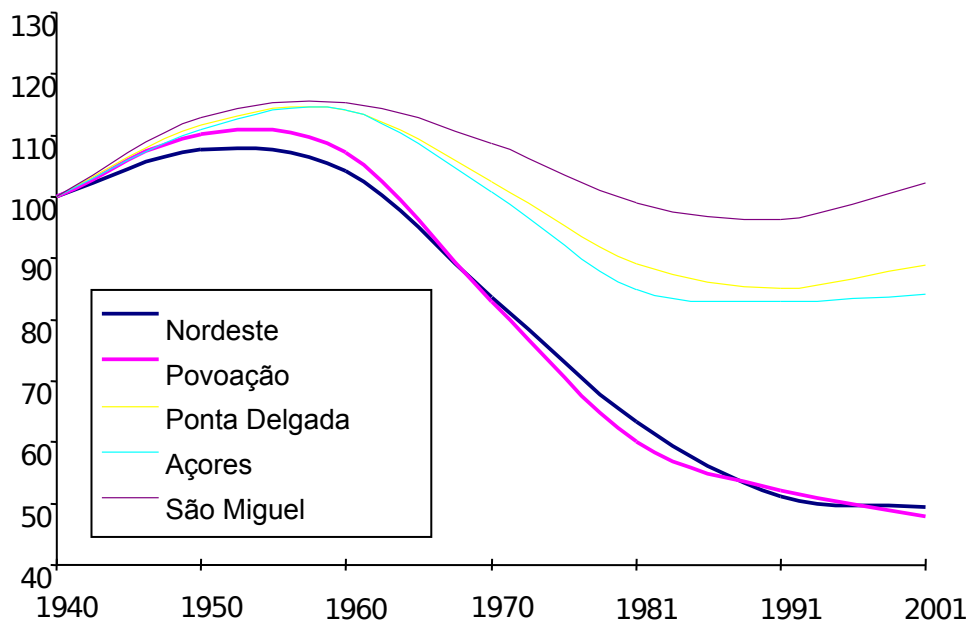


Figure 1.3. Evolution of Azorean population for every 100 people in 1940 (2001 Census).

Another characteristic of the region is the low level of education of its population. Nordeste and Povoação councils have high levels of illiteracy: 12.15 per cent and 11.91 per cent respectively (Census 2001). Both council regions also have a high rate of unemployment, 11.3 per cent for Nordeste and 13.8 per cent for Povoação, compared to the average unemployment of the island which is 10.3 per cent.

The Priolo and the native laurel forest of the SPA of Pico da Vara / Ribeira do Guilherme have been the focus of many scientific studies and three LIFE projects have taken place since the 1990's. The first was LIFE "Conservação do Priolo" (1994-1996) the second was LIFE "Estudo e Conservação do Património Natural dos Açores" (1997-2000) and LIFE Priolo Project (2003-2008). All these projects had a very important contribution to the economy of these two councils. Being the last one, LIFE Priolo Project, was the most ambitious. This Project, had an expected expense of €2,850,000 and implied important effects on local economy.

## 2. OVERVIEW OF SOCIO-ECONOMIC BENEFITS

---

### 2.1. Food

The Azorean Blueberry (*Vaccinium Cylindraceum*), found in the SPA *Pico da Vara / Ribeira do Guilherme*, was traditionally used for making jam and cakes. Although it is no longer used, this species continues to have potential value. Therefore, we will consider this service as a low importance service that could become more important if adequately promoted by regional institutions.

### 2.2 Ornamental resources

The Azorean Laurel Forest plants are increasingly used as ornamentals for gardens, although this has not developed due to the lack of available endemic plants to supply the demand. The LIFE Laurissilva Project is aimed at increasing the production of plants in order to allow this demand to be fulfilled. Therefore we will also consider this service as a low importance service that should be encouraged in order to increase potential service flows.

### 2.3 Water supply

Despite the high rainfall in the Azores, which ranges between 1000 to 2000 mm per year, the islands in the Azores face problems of water supply due to the hydrological regime and geological characteristics. Nordeste council, in 2008 had to transport water between villages.

Nordeste and Povoação's rivers are of torrential flow and there is no space to build big water reservoirs. The recharge of the aquifer is important to assure the availability of water in dry periods. The vegetation cover is an important factor for aquifer recharge. Preservation of forests, natural and planted, in the SPA guarantees this service.

The role of the SPA in assuring water supply for these two councils is of great importance, since almost all sources lie inside or very close to the limits of the SPA this area is the main reservoir of water for the two councils.

### 2.4 Ecotourism and recreation

Although Ecotourism is not very developed in the Azorean economy and especially in Nordeste and Povoação councils, it has been gaining importance in recent years. The Azores archipelago was awarded 2nd best sustainable island destiny by the National Geographic Traveller magazine (National Geographic Traveller Magazine, 2007).

A survey for passengers in flights from the Azores to England, Germany, Sweden and mainland Portugal highlighted the importance of Eco-tourism as the principal reason of their choice of destination (data from Regional Observatory on Tourism).

SPA Pico da Vara / Ribeira do Guilherme has unique characteristics suitable for ecotourism promotion. There is the Priolo, which can only be seen in this area; the *Pico da Vara*, the highest mountain in the island of São Miguel with four possible walking trails to reach to it. This area contains one of the few last remains of Laurel forest vegetation in São Miguel and the most important in terms of size and quality. The importance of this service will increase in future years.

There are many tourism activities that could be developed in the SPA *Pico da Vara / Ribeira do Guilherme*, such as bird-watching, walking trails, horse-riding, cycling, quads driving, paragliding, and botanical circuits. Some of them are currently available but others need development. For these reasons we will consider this service as a high importance service.

### 2.5 Cultural values & inspirational services

The SPA *Pico da Vara / Ribeira do Guilherme* has a remarkable scientific and educational value. As said before, is one of the last remains of native Laurel Forest in the Azores and is the only area in which rare Priolo can be found. But these are not the only reasons of its scientific importance, since even the principal threat of the area, invasive species; provide a very interesting research theme on habitat restoration and invasive species eradication.

The ecology of Laurel forest and conservation techniques used in LIFE Priolo Project, are some of the subjects that interest scientists and students not only from the Azores but even internationally. The SPA represents a living laboratory of a perturbed area and restoration practices.

For all these reasons we will consider this service as high importance service for the region since it is already developed.

## **2.6 Landscape & amenity values**

The SPA *Pico da Vara / Ribeira do Guilherme* also provides an attractive landscape, of a type almost lost in the rest of the island and provides many amenities for local people. Developing this service will depend on encouraging sustainable use of the area and promoting activities related to the SPA, therefore we will only consider it as mid importance value.

## **2.7 Climate / climate change regulation**

Protection of the SPA contributes in reducing the amount of carbon released into the atmosphere. To date there has been no attempt to quantify carbon sequestration in the SPA and to value it directly requires greater knowledge of the carbon functioning within the SPA ecosystems. Therefore, the conclusion reached by this study is only indicative.

Still, we considered this service as of high importance, because it is assumed the carbon content would be increased in the site by improving conservation practices especially those related to the peat area, and because the big area covered by *Cryptomeria japonica* plantations.

## **2.8 Water regulation**

São Miguel, as well as all volcanic islands is susceptible to many kinds of natural hazards. The area of Nordeste and Povoação, due to their rainfall regime and the unconsolidated nature of soils, is severely threatened by flood and landslide events. Therefore, water regulation by vegetation cover has a very important role in controlling these processes, being one of the most important services provided by the conservation of the SPA *Pico da Vara / Ribeira do Guilherme*.

## **2.9 Water purification & waste management**

The region covered by the SPA *Pico da Vara / Ribeira do Guilherme* has been classified as a low water quality area. Many people buy bottled water due to this low quality. Protection of the SPA and reduction of cattle pressure near sources of water is leading to a better quality of water reducing household costs in buying bottled water.

A reduction in cattle breeding is a happening but there are still some problems of water pollution that should be considered. Nonetheless, we considered this service as a high importance service.

## **2.10 Genetic / species diversity maintenance**

The SPA *Pico da Vara / Ribeira do Guilherme* comprises a high number of endemic species, some of which are quite rare. Although only one of them could be considered at the moment as having potential economic interest, others could become of interest in the future.

For this reason we considered this ecosystem service as of high importance, since despite not having a direct economical benefit, conservation of biodiversity could lead to important uses in the future.

## **2.11 Supporting services**

The Laurel forest has a high number of ecological interactions, especially those related to insect biodiversity, which although do not provide a service underpin many services now or in the future, such as pollination or plague control.

To avoid double counting benefits, we only discuss the 'insurance' value provided by maintaining the natural habitats of the SPA.

## **2.12 Wider socioeconomic benefits**

Management of the SPA *Pico da Vara / Ribeira do Guilherme*, was secured by LIFE Priolo Project as an experimental approach for future management of the area, therefore, we can consider that LIFE Priolo expenses should be management of the SPA expenses in the futur

### 3. METHODOLOGY

---

#### 3.1 Methodological framework.

Environmental and Ecological Economics are multidisciplinary sciences that try to set the best way of measuring the benefits that ecosystems provide to humans. These benefits are not easily quantified and, for this reason, it is more difficult to include them in decision-making. Although these estimates will always be lower than its real value, they are useful to justify and decide how to allocate public spending on conservation, preservation, or restoration initiatives, to consider the public's values, and encourage public participation and support for environmental initiatives, to compare the benefits of different projects or programs, to prioritize conservation or restoration projects and to maximize the environmental benefits per Euro spent. (Millennium Ecosystem Assessment, 2005)

Both disciplines differ on philosophical issues, while Environmental Economy, tries to quantify in monetary terms the benefits that ecosystems provide to humans in order to include them on cost – benefit analysis, Ecological Economy goes further and underlines the existence of services that can not be quantified in monetary terms, since their effect on human welfare is not direct, but that are supportive of the benefits that directly affect human welfare. In this study, we will try to underline both types of services, those with direct impact on human welfare and those that have not direct impact, but are basic for the maintenance of the first ones.

In order to evaluate ecosystem services, it is important to have a good definition of **ecosystem functions**, which are the physical, chemical, and biological processes or attributes that contribute to the self-maintenance of an ecosystem. Once these functions have been defined the **ecosystem services** are the beneficial outcomes, for the natural environment or people, which result from this ecosystem functions. (King & Mazzota,?) In some cases, this Ecosystem functions are not well known for Azorean Laurel Forest, which could imply an important handicap for our valuation. In these cases, we will try to obtain local data when possible or regard available bibliography that could be applied to our case without big error.

Environmental and Ecological Economics suggest different methodologies to try to value Ecosystem Services in monetary terms, each of them apply to different types of services (Nunes et al., 2001). In this study this methodologies will be applied to our local information, trying to get a monetary value for the service, expressed in Euro (€), using benefit transfer trying (whenever possible) to use function transfer or meta-analysis instead of direct unit transfer, which leads to a bigger error (Rosenberg & Stanley, 2006). Therefore, it will not be always possible to get to a monetary valuation, due to lack of data available, in this cases we will try to define a non-monetary quantification, expressing value in other units different than Euro, or a qualitative valuation, where we would underline value, but will not be able to translate it to a number in any units.

We will also apply to our methodology the concept of Services Providing Unit (SPU) (Luck et al., 2003), this concept allows to calculate different values for different areas. For example, as we have different habitats in the SPA, their contribution to carbon capturing or biodiversity, will be different and in this cases we will calculate a different value for each one of the habitats in our SPA.

Definition of SPUs and spatial referencing of valuation could be very useful not only for the representation of data but also to facilitate the information research and analysis using a GIS. This geographical approach can also help making spatial valuations which can be useful in planning (Troy & Wilson, 2006).

The methodology used in this study is based in that proposed by Troy & Wilson, 2006, that uses spatial explicit valuation in order to take advantage of the cartographic information already available from the SPA (fig X)

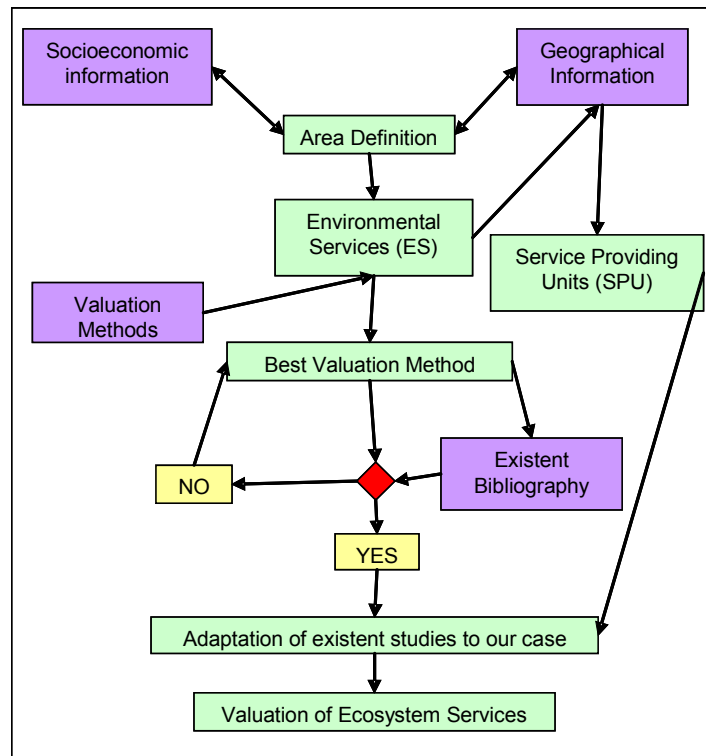


Figure 3.1 Methodology for our study.

## 3.2 Methodology steps

### 3.2.1 Definition of the study area.

As an introduction and justification of all the valuation we will define the area, its characteristics and the main processes taking place. This information will help justifying the selection of Ecosystem Services relevant to the area and also defining the area that will benefit from these services.

### 3.2.2 Definition of Ecosystem Services to be considered.

Since there is a big list of ecosystem goods and services, it is necessary to reduce our list to a few environmental services that have the biggest importance in our system. This way we can concentrate on those items that confer most of the value to the system and consider the others to be irrelevant, in order to save time.

### 3.2.3 Definition of SPUs in the SPA according to the service considered.

There should be identified different SPUs (Luck *et al.*, 2003) for each environmental service considered, since in some cases they will be different. This way we could select homogeneous characteristic areas for each service and refer geographically our valuations.

The geographic representation of data will also provide interesting information on relevant areas for each ecosystem service (Rosenberg & Stanley, 2006). In this step we will compile all the relevant information to value the ecosystem service.

### 3.2.4 Selection of a valuation method for each of the Services considered.

A valuation method will be selected in function of the characteristics of the environmental service considered (Nunes *et al.*, 2001) and regarding the geographic and environmental information available. This way we would have a first orientation on the characteristics of the studies that we should find in order to transfer the results and assure a more accurate result (Rosenberg & Stanley, 2006).

### **3.2.5 Research of bibliographic information adaptable to each case.**

A bibliographic research in ecosystem valuation databases available will be conducted (McComb et al., 2006); in order to find studies that suit our selected method or that could be extrapolated as a whole or partially. This will be an iterative process since depending on the results of this bibliographic research we may need to revise the valuation method or SPUs selected (Troy & Wilson, 2006).

### **3.2.6 Valuation of available information.**

We will compare the available bibliographic information and our original definition of the method in order to see if they match. If they don't, we will do the best adaptation of the method possible, regarding on the differences and considering this way the error we are having (Rosenbeg & Stanley, 2006).

### **3.2.7 Adaptation of available information to our situation.**

We will carry on an adaptation of the bibliographic information to our case by getting some environmental information when necessary in order to assure the accuracy of our data and results. This means that sometimes we will be directly adapting economical valuations (Monetary unit transfer), but in other cases we would just adapt functions or other kind of data, adding some local information (Wilson & Hoehn, 2006). This way we will obtain one value for each class of SPU considered.

### **3.2.8 Global valuation.**

Once each ecosystem service has been valued, the addition of all the services could be done geographically as well as quantitatively, this way we could also have some information of more valuable areas in terms of ecosystem services (Troy & Wilson, 2006). Finally it could be added the value of each area to obtain the complete ecosystems benefits of the SPA.

---



## 4. DETAILED VALUATION OF DIFFERENT BENEFITS

---

### 4.1 Food

Since the Azorean Blueberry (*Vaccinium cylindraceum*) is only a potential resource in the area, we can only establish a qualitative valuation highlighting the potential importance it can have if investment is carried on to develop its manufacture and commercialization.

This plant was traditionally used by the first island colonizers in making jams and cakes. Although more accurate studies must be carried out, this plant is thought to be similar in taste and productivity to the American Blueberry, which is usually sold. The Azorean variety is better adapted to the Azorean climate, being able to grow and produce even at high altitudes (empirical data from LIFE Priolo Project).

### 4.2 Ornamental resources

Laurel trees are of interest in ornamental use for gardens. Many other plants from the Laurel forest present interesting characteristics for ornamental use. Plants such as *Viburnum tinus*, *Vaccinium cylindraceum*, *Ilex azorica*, *Leontodon rigens* have colourful flowers or fruits that could be of interest for gardening.

Gardening in the Azores is a very common practice, and a main reason why many exotic species arrived to the island. Use of Endemic plants for gardening if promoted would be a way of reducing exotic plant importation, a way of mitigating impact of exotic plants control necessary for reducing the impact of invasive species on the island and could be a potential income for local people and for the management of the SPA. Again this is a potential resource, not one currently exploited significantly.

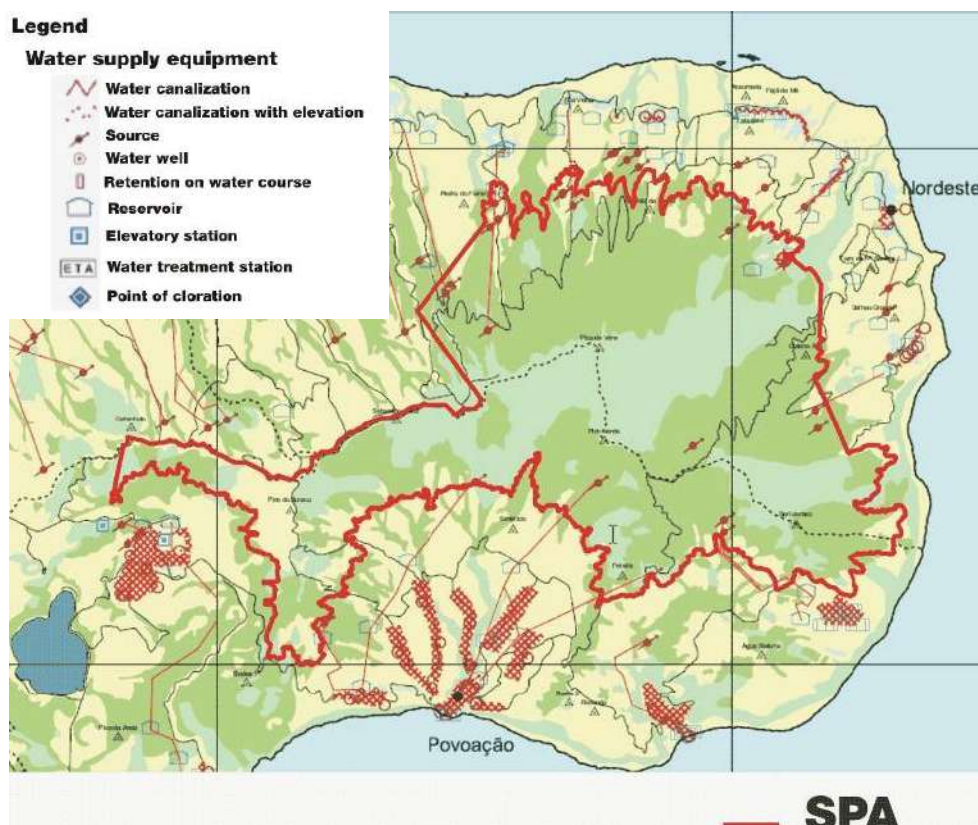
### 4.3 Water supply

Despite high rainfall in the Azores and especially in the area of the SPA *Pico da Vara /Ribeira do Guilherme*, during the summer of 2008, it was necessary to transport water between some villages to guarantee water availability. This scarcity of water is due to lack of a big reservoir and the flow characteristics of rivers in the area.

The villages not affected by the dry period were those that were supplied by water retention by peat in the *Planalto dos Graminhais*, therefore we can say that water supply in the councils of Nordeste and Povoação depend on the conservation of this peat and natural vegetation by the SPA.

Looking on the water supply system for the two councils (Figure 2.2) we can see that almost all sources of water are inside or very close to the SPA, therefore the provisioning of water depends on the infiltration rate by the vegetation existent in the SPA. If we look to the river basin, we will also notice that almost all the basins have their source and important reaches into the SPA. Only the ones that serve the villages of Salga, Achadinha e Achada in Nordeste and Furnas and Ribeira Quente in Povoação do not originate in the SPA. In the case of the Nordeste village, they are served by a part of the peat in Graminhais Planalto that was not included in the SPA, in the case of Povoação council they are served by sources of water in Furnas Village.





**Figure 4.1** Map of water supply system in São Miguel island (Nordeste and Povoação councils) (Source: Regional Plan for Water in the Azores)

We can get an estimation of water value from the market price for water. In order to calculate this value we will use the following equation

$$Y_a = \sum P_a \cdot Q_{ia}$$

in which:  $Y_a$  = Value of water supply for the area,  $P_a$  = Price of water per sector and  $Q_{ia}$  = Water consumption in each sector.

Since the SPA is present in two councils, with different prices for water, we considered two different service providing units, one for the area serving Povoação and other for Nordeste. Water supply calculations are shown in figures 2.2 to 2.5.

**Table 4.1** Water consumption (m<sup>3</sup>/year). Source: Plano Regional da Água dos Açores.

	Urban	Industrial	Agriculture	Tourism	Total
<b>Povoação</b>	458,936	96,720	185,322	47,472	788,450
<b>Nordeste</b>	331,865	69,940	218,018	0	619,823
<b>Total water demand</b>					<b>1,408,273 m<sup>3</sup>/year</b>

**Table 4.2** Price of water (€/m<sup>3</sup>) Source: Plano Regional da Água dos Açores.

	Urban	Industrial	Agriculture	Tourism
<b>Povoação</b>	0.51	1.3	Not available	0.51
<b>Nordeste</b>	0.55	0.55	Not available	0.55

**Table 4.3** Total value of water supply for each council (€).

	Urban	Industrial	Agriculture	Tourism	Total
<b>Povoação</b>	234,057.36	125,736	0	24,210.72	384,004.08
<b>Nordeste</b>	182,525.75	38,467	0	0	220,992.75

**Table 4.4** Calculation for the total value of water supply in the SPA.

	Value of water supply (€)	Percentage of the council	Value (€)
Povoação (SPA served)	384,004	60 per cent	230,402
Povoação (Furnas and Ribeira Quente)		40 per cent	153,602
Nordeste (SPA)	220,992	80 per cent	176,794
Nordeste (Peat area)		20 per cent	44,197
SPA's total value			604,997

Total estimated value for water supply results in a value of €604,997. This result is a conservative estimate of the water supply value for the area because of two reasons. Firstly, there is no price for the agricultural use of water, and this use is the most important one in both councils. Secondly the price of water is subsidized and doesn't represent the real resource cost of water which should include extraction and treatment costs.

## 4.4 Ecotourism and recreation

### 4.4.1 Ecotourism

Ecotourism is not a very developed sector in the SPA area, but it has big potential. We will consider two different items in this service, the value of the area for tourism, using a travel-cost approach and the recreation value of the area, using incomes from an active tourism enterprise that develops many activities in the area.

The travel-cost method was established by a survey of usage and price on three rural hostels in Nordeste council: *Casas da Madrinha* (Vila do Nordeste), *Residencial S. Jorge* (Vila do Nordeste) and *Casas do Frade* (Lomba da Fazenda). In the survey, all managers of these hostels considered pedestrian trails, most of which are in the SPA, as an important reason why tourists come to the area. All establishments considered in this study are located in Nordeste council, since at the moment of the study (2006) it was the only council with good access to the SPA, and because the SPA can be considered one of the biggest touristic resources in the council. In the case of Povoação council, SPA has to compete with Furnas, which is a very important touristic spot. In table 2.6 we show the number of visits in each hostel during 2006.

In order to apply this method we will consider as the travel cost, the price of plane tickets, car rental, and length of stay (hostel price) considering the mean stay for each type of tourist from survey data (Table 2.7). All prices were considered as the minimum possible price at the present in the market, in order to assure a conservative approach.

With information about number of visitors from each origin and travel costs in the areas, we designed the demand curve for the SPA as a touristic attraction and calculated its value considering that there is no price for entrance (Figure 2.3).

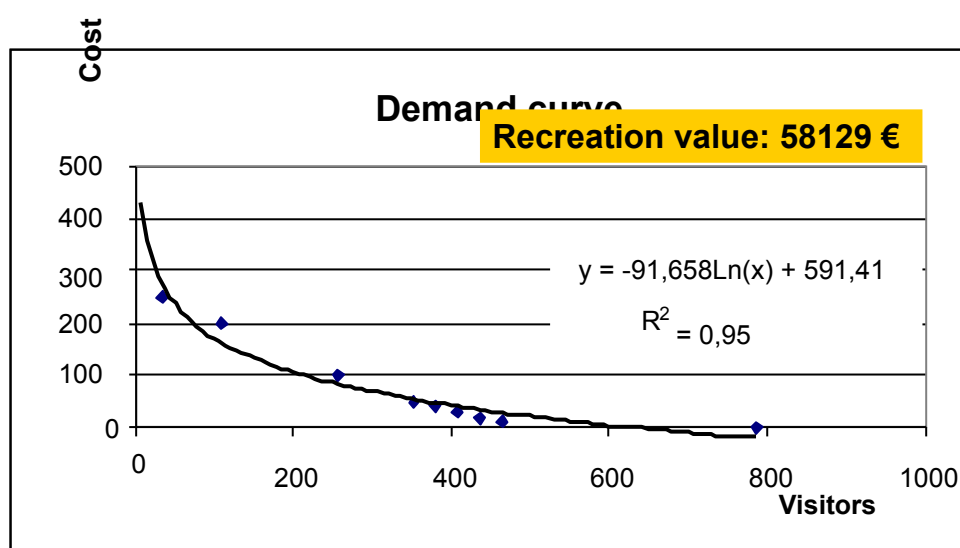
As a result, the total estimated value for recreation value of the area for tourists is around **€58,000**.

**Table 4.5** Number of visits for each origin in rural accommodations in Nordeste council

	São Miguel	Azores and Madeira	Mainland Portugal	Scandinavian countries	Western Europe	North America
Madrinhã	296	0	178	59	59	0
S.Jorge	106	80	93	66	53	79
Frade	11	0	36	288	25	0
TOTAL	413	80	306	414	137	79

**Table 4.6** Travel-cost, for each origin of tourists, to arrive to Nordeste council.

	São Miguel	Azores and Madeira	Mainland Portugal	Scandinavian countries	Western Europe	North America
<b>Flight</b>		150	250	500	300	400
<b>Car rental</b>	7	24	24	24	24	24
<b>Lodgement</b>	18	30	30	20	23	22
Travel-cost	50	258	358	588	394	492



**Figure 4.2:** Demand curve and recreation value estimation for the SPA.

#### 4.4.2 Outdoor activity tourism.

Many activities are or could be developed in the SPA. It is important to highlight that potential value would include many other activities, such as bird-watching, botanical tours, canyoning, paragliding as well as specific tours to see the Priolo.

To calculate the actual value of these activities we will consider annual earnings of an enterprise that currently works in the area with pedestrian walks, riding and quad circuits. In 2006 this enterprises received a **total income of €16,500**.

We cannot consider all this benefit as being provided by the SPA, since the enterprise has costs in guides and vehicles of which we couldn't have the information. However, since there are other enterprises that do this circuit, and we do not have available information about them, we can consider that total earning of this enterprise as a good indicator of total income from tourism activities in the SPA.

#### 4.5 Cultural values & inspirational services

##### 4.5.1 Educational value

The SPA is an important area for educational and scientific purposes, since it preserves the last remains of natural forest in the island of São Miguel, and is the biggest area in which this vegetation can be found. It also provides an interesting "live" laboratory on many restoration and conservation practices.

School groups visit the area from all over the island and we use these trips to estimate the educational value of the area by the travel-cost method. In order to calculate this value, we will use the schools that visited the SPA in the last 3 years. In figure 2.4 we can see the number of visits received from each council.

We consider travel-costs as a function of time and length of the travel to reach the SPA, in table 2.8 we show the travel cost estimated for each council (Cost per km and time are mean costs of bus rental). With this data we established a demand curve (figure 2.5) for the SPA, from which we calculated the marginal value, considering that there, is no price to entry the area. Overall, this gives a value of €2,958 for the services related to education.

**Table 4.7** School visits in the SPA and estimated travel cost.

Council	Participants	Travel-cost
Nordeste	336	1,00 €
Povoação	250	7,10 €
Ponta Delgada	26	15,40 €
Vila Franca do Campo	23	11,30 €
Lagoa	30	13,40 €
Ribeira Grande	70	11,75 €

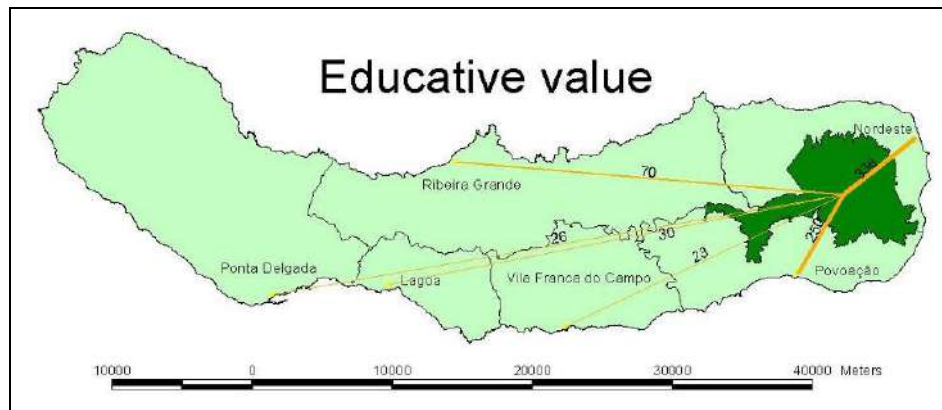


Figure 4.3 Number of school visits to the SPA between 2004 and 2006.

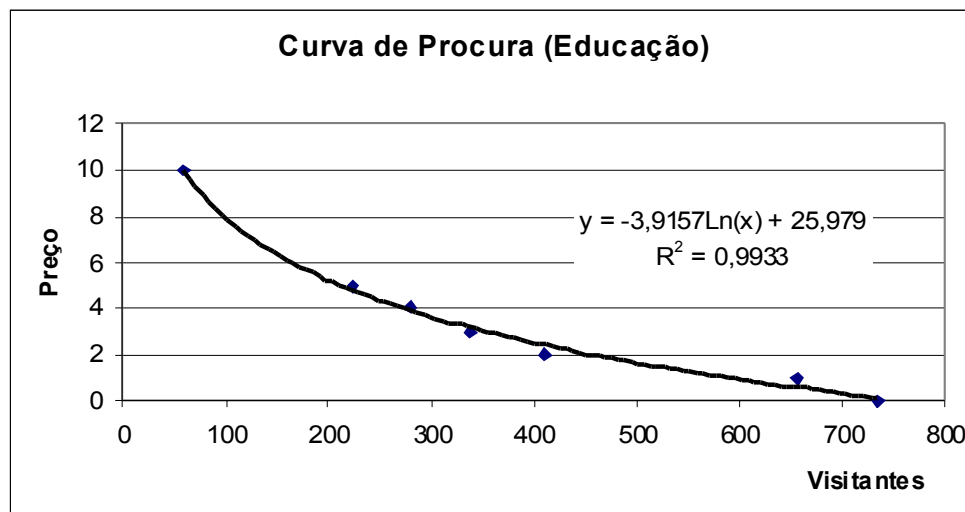


Figure 4.4 Demand curve and Educative value estimation for the SPA.

#### 4.6.2 Scientific value

Because of the existence of an endemic bird, which can only be found in this area and as a “live” laboratory on restoration and conservation practice, the SPA has been the study area of many scientific works. Table 2.9, lists papers related to the SPA.

Table 4.8 Published papers directly related to the SPA “Pico da Vara/Ribeira do Guilherme”.

1968	VAN VEGTEN, J. A. The Azores bullfinch not extinct. <i>Ardea</i> 56: 194.
1982	LE GRAND, G. Priolo, a ave mais interessante de S. Miguel. <i>Açoreana</i> 6: 195 – 211
1991	BIBBY, C. J. E CHARLTON, T. D. Observations on the São Miguel bullfinch. <i>Açoreana</i> 7: 297 - 304.
1992	BIBBY, C. J., CHARLTON, T. D. E RAMOS, J. Studies of West Palearctic birds – Azores bullfinch. <i>British Birds</i> 85: 677 - 680.
1994	RAMOS J. A. ;Fern frond feeding by the Azores Bullfinch. <i>Journal of avian biology</i>

	1994, vol. 25, no4, pp. 344-347
1995	RAMOS, J. A. The diet of the Azores bullfinch <i>Pyrrhula murina</i> and floristic variation within its range <i>Biological Conservation</i> , Volume 71, Issue 3, 1995, Pages 237-249
1996	RAMOS, J. A. Introduction of Exotic Tree Species as a Threat to the Azores Bullfinch Population <i>The Journal of Applied Ecology</i> , Vol. 33, No. 4 (Aug., 1996), pp. 710-722
1998	RAMOS, J. A. Biometrics, weights, breeding and moulting seasons of passerines in an Azores cloud forest. <i>Ringling &amp; Migration</i> , Vol. 19, no. 1, pp. 17-22. <i>May 1998</i> .
2006	CEIA, R.; HELENO, R. and RAMOS, J. "Abundance and distribution of passerines in native and exotic forests in São Miguel, Azores" <i>Bird Study</i> , submitted December 2006
2009	RÚBEN H. HELENO, RICARDO S. CEIA, JAIME A. RAMOS, JANE MEMMOTT Effects of Alien Plants on Insect Abundance and Biomass: a Food-Web Approach. <i>Conservation Biology</i> , 23, 2, 410-419.

This makes a total of **10 scientific papers**, plus, at least **6 scientific papers in preparation** within LIFE Priolo Project and MSc and PhD students that stayed in the Project. **This area supported an average of 8 recent graduates in practices every year**, one PhD student during the four years of the project (which means **0,25 PhDs per year**) and **1 MSc student** every year.

#### 4.6 Landscape & amenity values

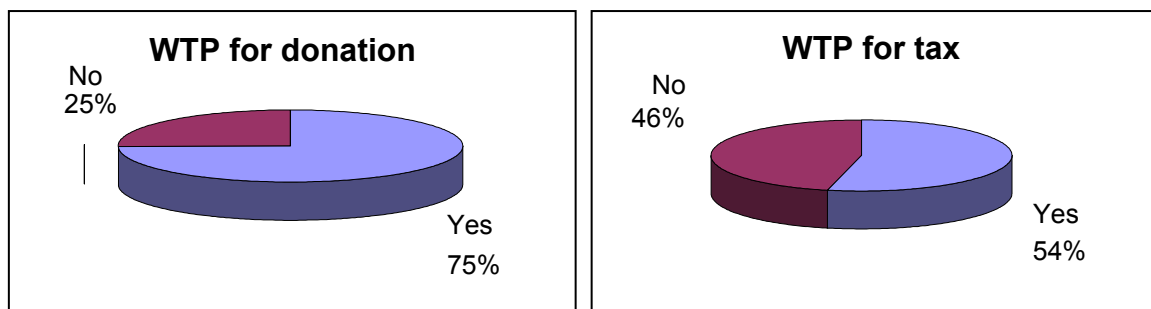
Landscape and amenity values in the SPA were considered in a **Willingness to pay** (WTP) survey carried out with the population in the island. 67 surveys were done within the Povoação council region, which represents about a 1 per cent of this council's population (6300 regarding census in 2001).

People were asked whether they would be willing to pay for the SPA's conservation. The payment vehicles explored were a tax, a free donation or an entry fee. Answers to this question are shown in figure 2.6.

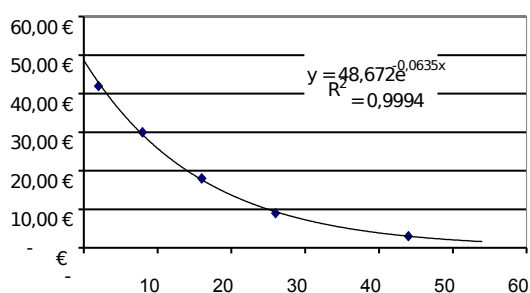
Afterwards people were asked about the money they would pay in any of these cases and with the answers a demand curve were constructed, calculating from them the marginal value of the SPA considering that at the present SPA has no entry charge for the local population. Demand curves are shown in figures 2.7 to 2.8 and results of this marginal value are shown in table 2.10

Therefore, we will consider that marginal value attributed to the SPA ranges between €500 and €800 for the population of Povoação council.

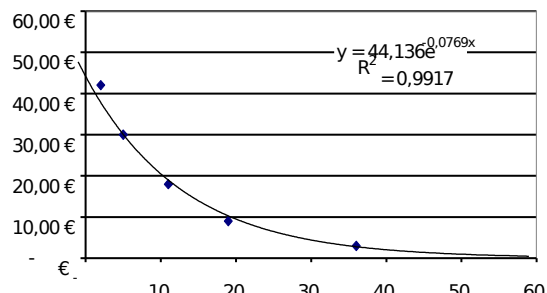
No survey was carried out within the population of Nordeste council or the rest of the island; therefore, we can consider that a global value will be clearly higher than this one. Even based on Povoação council alone, the value is in excess of €3,000,000. However, this value cannot only be considered as amenities value since it also represents the existence value of Priolo and Laurel forest. Unfortunately, due to the characteristics of the survey, we cannot separate the landscape amenity values from other potential benefits. It is possible that some benefits would be double counted if we, for example, add this value to the educational value.



**Figure 4.5.** Willingness to pay for conservation of the SPA Pico da Vara /Ribeira do Guilherme as a donation and a tax respectively.



**Figure 4.6** Demand curve of WTP for donation



**Figure 4.7** Demand curve of WTP for a tax.

**Table 4.9** Mean WTP and marginal value of the SPA.

	Mean WTP	Marginal value of SPA
Tax	5,15 €	<b>568,25 €</b>
Free donation	10,41 €	<b>749,51 €</b>

#### 4.7 Climate / climate change regulation

While global values for greenhouse gases exist, measuring carbon storage and sequestration remain challenging.

The existence of the SPA will lead to a preservation of natural and plantation forests in the area, thereby stopping the pressure to convert to pastures. We can assume that conservation and protection in the SPA will increase its potential as a carbon sink. On the other hand, eradicating exotic plants will create a net release of carbon into the atmosphere, at least in short term, although there could be an improvement of the characteristics of the SPA as sink for carbon. We tentatively estimated carbon stored, considering the distribution of the principal habitats existent in the SPA (figure 2.9).



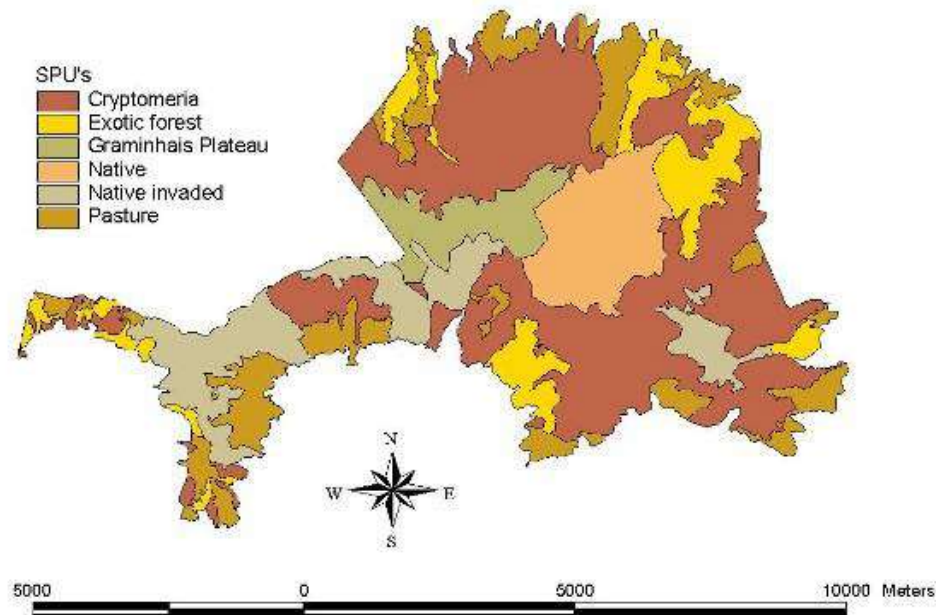


Figure 4.8 Main vegetal areas in the SPA Pico da Vara / Ribeira do Guilherme.

Since we had no available local data on biomass or carbon content in vegetation, values for carbon stored were obtained by data transfer from studies carried on the same vegetation. In the case of Japanese red cedar (*Cryptomeria japonica*) trees for example, the carbon content was estimated at **76.81 Mg C/ ha** of forest by a study carried on Japan (Fukuda et al., 2003).

Where we could not find data on the same species, we considered the closest vegetation type possible. In the case of Azorean Laurel Forest, we calculated the carbon content from data of biomass established by Fernandez-Palacios, 1991 for canary laurel forest and applied a 0,5 correction factor for the ratio of carbon in biomass (Research Agency of the forestry commission, UK). The carbon content on Laurel Forest was estimated to be of 127,55 tC/ha.

For invaded Laurel forest, due to the lack of empirical data we assumed a similar value of carbon content to intact Laurel Forest, since we can consider than the process of invasion, generally means an alteration on the quality of biomass, but not necessarily an alteration on total biomass on the ecosystem.

For *Pittosporum* forests there is no existent data, even in Australia, where this plant is natural. Due to its characteristics we consider it similar to Laurel Forest, since although *Pittosporum* trees are higher than Laurel Forest's, *Pittosporum*'s allelopathic effect does not allow the growth of underlying vegetation that contributes highly to Laurel Forests' Biomass.

Pasture is not considered relevant for carbon storage, since values of carbon storage in these areas are very low.

Finally we consider peat in the SPA. We use a carbon capture estimation by Worrall et al., 2003 in a British peat study which concluded that "their study catchment represented a net carbon sink of 12.9 gC/m<sup>2</sup>/yr with a range between 6.4 and 27.9 gC/m<sup>2</sup>/yr," (Worrall et al., 2003). Since our peat area has suffered disturbance we will consider the smaller value as the most plausible.

Results of carbon content for each of the types of vegetation existent in the SPA are given in table 2.11.

Table 4.10. Carbon storage and captured by SPA vegetation

	Carbon storage (tCO <sub>2</sub> /ha.)	Carbon storage (tC/ha.)	Carbon capture (tC/ha.year)	References



Laurel Forest	468,11	127,55	--	Fernandez–Palacios,1991
<i>Pittosporum undulatum</i>	432	120	--	Olson et al., 1985
<i>Cryptomeria japonica</i>	281,89	76,81	--	Fukuda et al., 2003
Peat	--	--	640	Worrall et al., 2003
Pastures	Non-relevant	Non-relevant	Non-relevant	

If we compare this data with the Olson et al., 1985 map of major world ecosystems ranked by Carbon content on Live vegetation we see results are consistent. Olson calculated a revised medium carbon density for “Southern taiga” of 80 tC/ha, which matches with results obtained for *Cryptomeria* trees, and of 120 tC/ha. for Tropical and Subtropical Broad-leaved Humid forest, that could correspond with Laurel and *Pittosporum* Forests. In total we have 465,364 tC stored in vegetation, plus 223,667 tC/year in the peat.

For a monetary valuation of the site, we would need to know the annual balance of carbon of each of the habitats. Since this information is not available, we would need to carry out a survey on vegetation for a few years in order to estimate this, which was not possible to do within this work. We could use three prices for monetary valuation:

- **The market price.** This is relevant if we want to sell the carbon as a voluntary offset, which is not the case of this study since at the same time we are releasing carbon by eradication of exotics work.
- **The damage cost price.** This is the estimate of economic damage done by a ton of CO<sub>2</sub> released today. The Stern Review estimates this as \$85 (for CO<sub>2</sub>e per ton) or \$238 (for C per ton).
- **The shadow price, or official price.** This is an estimate of the price of 1 ton emitted today assuming we still reach our Kyoto limits. Official price in the UK is about €25.

In order to apply these methods accurately we should have a forecast on the situation of vegetation without the SPA, which is quite difficult to assess. We could consider that native forest vegetation would remain since there are other laws for its protection, but it would be more invaded by exotic species. Unfortunately, the carbon implication of exotic species invasions has not been studied and it could result both in an increase of stored carbon or a release of it.

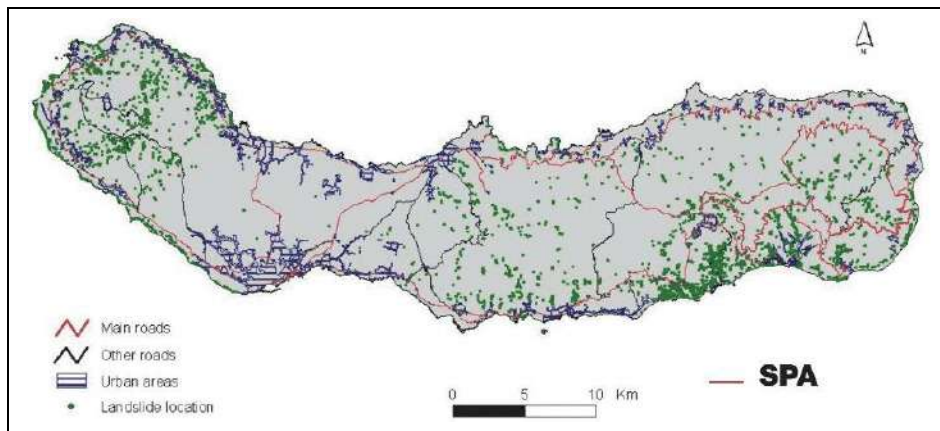
We could also consider loss of peat in the area, since it is very common in the Azores to drain peat in order to increase pastures area. We could consider that without the SPA a part of the peat would be drained, resulting in a net release of carbon. Unfortunately, since we do not have the total carbon stored in the peat, we cannot apply this estimate. Despite this uncertainty, carbon storage could be a significant service delivered by the SPA.

## 4.8 Water regulation

S. Miguel Island can experience very high and continuous rainfall, river regimens are torrential and soils are not well consolidated. These three facts lead to a very high risk of landslides and flooding that usually happen concurrently.

### 4.8.1 Landslides risk

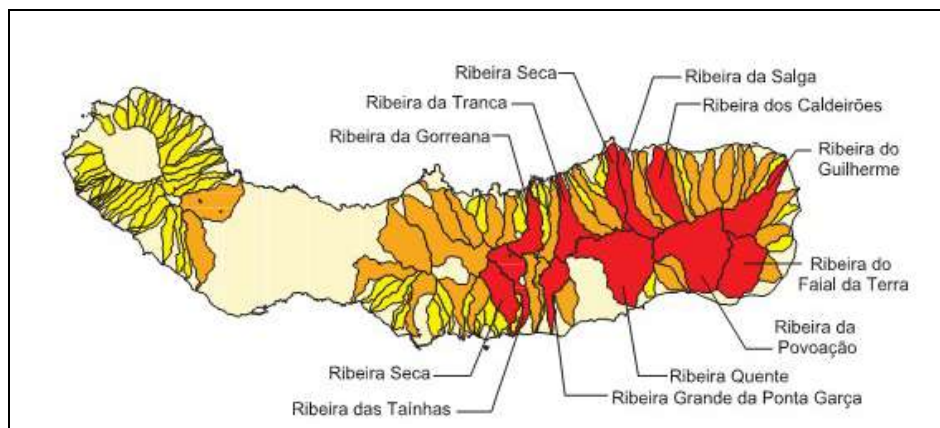
P. Valadão (2002), created a map, from historical information, aerial photography and field surveys, of landslides that occurred in S. Miguel Island (Figure 2.10). He concluded that the most hazardous areas in relation to these processes were related to the young central volcanoes and sea cliffs in their vicinity and to the old basaltic volcanic complex of Nordeste which is the area covered by the SPA.



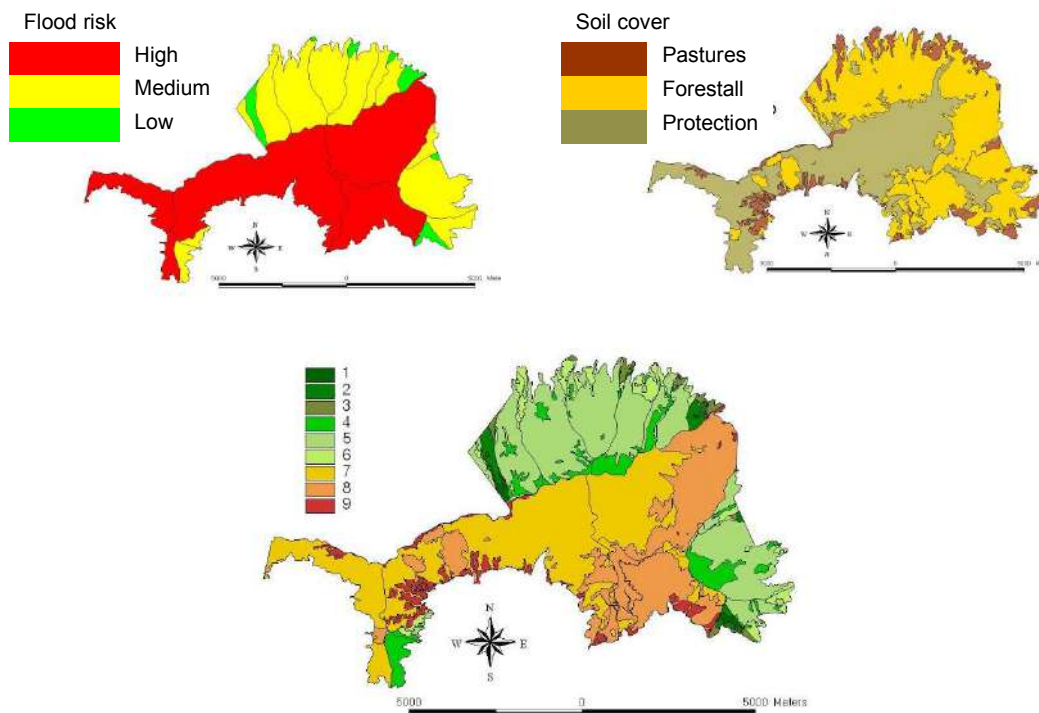
**Figure 4.9** Landslides risk map of São Miguel Island. Source: P. Valadão et al., 2002

#### 4.8.2 Flooding risk

Floods are also an important process in S. Miguel Island that are generally associated with landslides. River basins were characterized for risk level by the Regional Plan for Water as shown on figure 2.11. This classification did not consider soil uses as a factor, for this reason we overlapped the river basins inside the SPA with soil uses inside it. The results are shown in figure 2.12. Protection in the SPA will be preserved or increased, and the SPA can make an important contribution to flood prevention in the adjacent areas to the SPA, especially for the villages of Povoação, Nordeste and Faial da Terra.



**Figure 4.10.** Risk classification for floods in São Miguel basins for a recurrence period of 10 years. Source: Regional Water Plan.



**Figure 4.11** Levels of Protection offered by the SPA on River Basins. Areas numbered 7 are high importance protection areas.

#### 4.8.3 Economic consequences

Catastrophic events associated with landslides have occurred since the beginning island was first populated. One unique event, caused by an earthquake of magnitude X on the Mercalli Modified Scale in 1522 in Vila Franca do Campo. (P. Valadão, 2002). In 1630 the landslides were caused by a volcanic eruption on Furnas (P.Valadão, 2002)

On the 31st of October 1997, hundreds of landslides occurred in the Ribeira Quente and Povoação basins, causing a flooding that affected the village of Ribeira Quente. Factors that contributed to this event were strong Southeast winds accompanied by heavy rainfall (220 l/m<sup>2</sup>); the unconsolidated nature of volcanic soils and previous water saturation of soils due to a long term rainfall (Gaspar and Guest, 1998). Although we cannot establish the probability of recurrence of these climatic characteristics, Gaspar and Guest, 1998 consider that it was not a very rare event. As a consequence of these landslides 29 people were killed in Ribeira Quente, another 7 were severely injured and 69 people remained homeless. Many houses, bridges, roads and electric lines were destroyed and Ribeira Quente village stayed isolated for 12 hours (P. Valadão, 2002). **Total losses of these events were valued in 21 million Euros (Table 2.11)**



**Figure 4.12** Images of the effects of 31st of October, 1997 landslides and flood events in Ribeira Quente.

**Table 4.11** Scioeconomic cost of 1997 landslides and flood in Ribeira Quente. Source: Gaspar and Guest, 1998

	Cost (€)
Repairing and improvement of roads	14 Million
Damages on houses	2,5 Million
Damages on environment and water supply system	1,8 Million
Damages in interior roads leading to agricultural exporations	1,5 Million
Damages to agriculture	800.000
Damages in the fishing sector	450.000
Losses for local commerce	150.000
Losses in education system	100.000

Unfortunately, since we cannot calculate the probably of recurrence of this type of events in this or the other basin in the SPA, we are not able to provide a monetary value for this service. Despite with all available data we can assume this may be one as the most valuable service provided by vegetation on the SPA.

#### 4.9 Water purification & waste management

Water quality is an important service guaranteed by the conservation of natural ecosystems and threatened in the Azores by the increase of the pasture areas and management practices associated to them. In its 2007 Annual Report on Water and Waste Sector in Portugal, the councils of Nordeste and Povoação were identified as having more than 5 per cent of water resources outside of legal parameters. (Relatorio Anual dos Sectores de Aguas e Residuos em Portugal 2007 - Volume 4)

This leads to high family expenses for bottled water. Conservation policies in the SPA should lead to a reduction in pastures in the area, which would improve water quality. We can use these expenses to provide a **replacement-cost valuation** for the quality of water. Each family in the Azores spends, on average, **€46.5** per year on bottled water (Regional Water Plan of the Azores). Considering an average family of 5 members, we can estimate the average expenses in the councils of Nordeste and Povoação (Table 2.13).

**Table 4.12** Replacement cost for water quality.

	Populatio n	Families	Expense on bottled water (€)
Povoação	6,726	1,345.2	<b>61,879</b>
Nordeste	5,291	1,058.2	<b>48,677</b>
TOTAL			<b>110,556</b>

Conservation of the SPA will lead to a reduction on cattle in the area and therefore an improvement of water quality that would reduce the need of consumption of bottled water by the population. Therefore, management policy in order to improve these services should be focused on reducing cattle pressure in the SPA, near water sources. **Doing so could deliver a financial benefit worth €110,556.**

#### 4.10 Genetic / species diversity maintenance

Biodiversity maintenance, associated with Laurel forest, is of global importance. Many species in the Laurel Forest are endemic and many others may have started speciation processes that could be of potential interest in the future.

Table 2.14 presents a review of endemic species both from the Macaronesian Region and Azores present in the SPA, which demonstrates that biodiversity in the SPA is of high importance. By protecting the SPA Pico da Vara / Ribeira do Guilherme we are protecting near 40 per cent of Azorean plant diversity, almost all Azorean vertebrates diversity and 12 per cent of arthropods diversity.

**Table 4.13** Biodiversity rate in the SPA in relation to the Azores archipelago. Source: 1 Biodiversity Database of the Azores (<http://www.azoresbiportal.angra.uac.pt/>) & 2 Management Plan, 2005.

Vascular Plants	Azores	SPA	RATE
Total diversity	947 <sup>1</sup>	142 <sup>2</sup>	14,99 per cent
Endemic species of Macaronesian region	80 <sup>1</sup>	33 <sup>2</sup>	41,25 per cent
Endemic species of the Azores	68 <sup>1</sup>	30 <sup>2</sup>	44,12 per cent
Vertebrates	Azores	SPA	RATE
Total	60 <sup>1</sup>	26 <sup>2</sup>	43 per cent
Endemic subspecies of the Azores	13 <sup>1</sup>	11 <sup>2</sup>	84,62 per cent
Endemic species of Macaronesian region	4 <sup>1</sup>	4 <sup>2</sup>	100 per cent
Endemic species of the Azores	3 <sup>1</sup>	3 <sup>2</sup>	100 per cent
Arthropods	Azores	SPA	RATE
Total	22091	89 2	4 per cent
Endemic species	2671	33 2	12,36 per cent

In economic terms we can only underline the importance of Azorean Blueberry (*Vaccinium cylindraceum*) as a genetic variety provider for Blueberry breeding (Ehlenfeldt, 1997). The remains an option value to preserving the forests given the number of other species which, if researched, could have human applications.

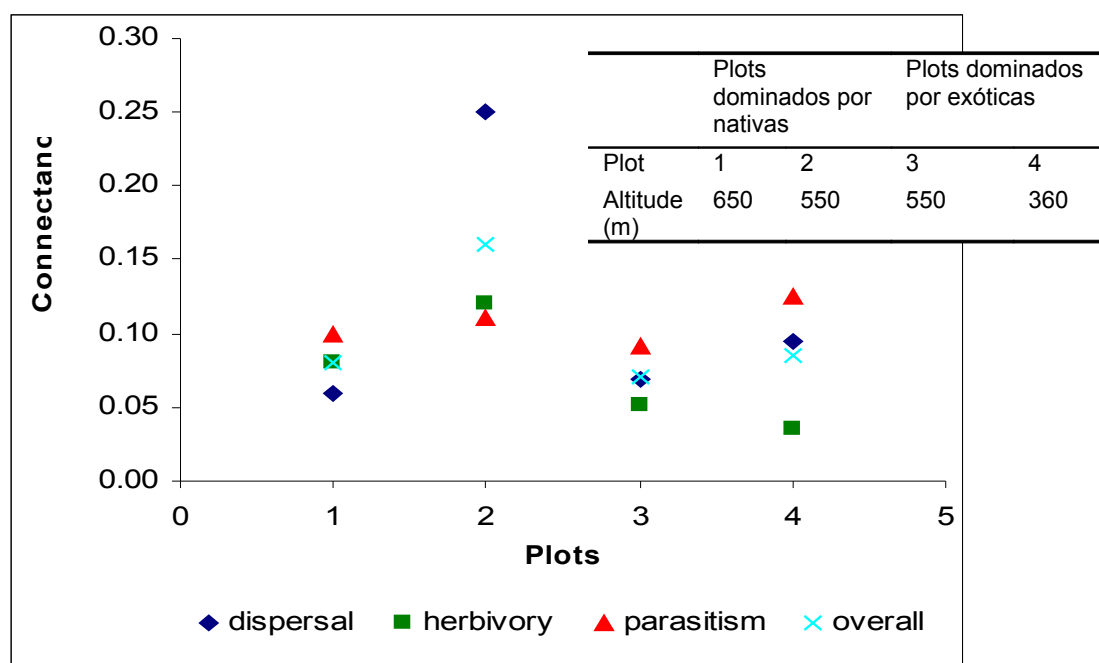
#### 2.2.11 Supporting Services

Biodiversity is a guarantee of resilience of ecosystems, and therefore a guarantee for services provision. Higher biodiversity and more complexity in an ecosystem will lead to higher adaptability and resistance to environmental changes.

In order to value supporting services in SPA Pico da Vara / Ribeira do Guilherme, we use Connectivity indexes that measure the number of interactions inside an ecosystem. These indexes as well as biodiversity indexes will vary from one type of habitat to another. In figure 2.14 (from Heleno et



al., 2009,) we can see the effect of exotic vegetation invasions on connectivity which will result in a reduction of its resilience and the capacity to provide certain services.



**Figure 4.13** Conectance for each type of interaction (dispersal, herbivory and parasitism) in the four study areas. Source: Heleno et al., 2009

This insurance value of biodiversity may become increasingly important over time as climate change impacts may subject the SPA to further external shocks. Despite its importance, it is very difficult to quantify or value.

## 4.12 Wider Socioeconomic Benefits

Apart from ecosystem services, conservation the of Natura 2000 SPA Pico da Vara / Ribeira do Guilherme, provides important revenues and socio-economic benefits for the local and regional population. The following benefits were calculated as an annual mean of benefits provided by the LIFE-Priolo Project (LIFE NAT/P/000013) that ensured the future management of the SPA between 2003 and 2008.

Since LIFE Priolo project was intended to settle the basis for future management of the SPA, we can consider that this project expenses and the associated socioeconomic benefits are equivalent to those provided by a good management of the area.

### 4.12.1 Direct employment

The LIFE-Priolo project supported a mean of 21.6 full time jobs (FT) for 4 years, with some increases in the summer.

A 4 member permanent technical team was responsible for SPA management. Apart from this staff, LIFE-Priolo Project supported a mean of 4 annual national and international employees, financed by different programs.

Turnover was higher in the fieldwork team, making it more difficult to calculate the total of employment created. This employment had a marked seasonality, with more workers in summer. In table 2.15 we show the Full Time Jobs created by the LIFE Priolo Project.

**Table 4.14** Direct employment in field workers team.

		Nº workers	of Full Time jobs
7 <sup>1</sup>	200	Nordeste	22
		Povoação	11
6	200	Nordeste	35
5	200	Nordeste	59
TOTAL			13,1F T

#### 4.12.2 Indirect employment

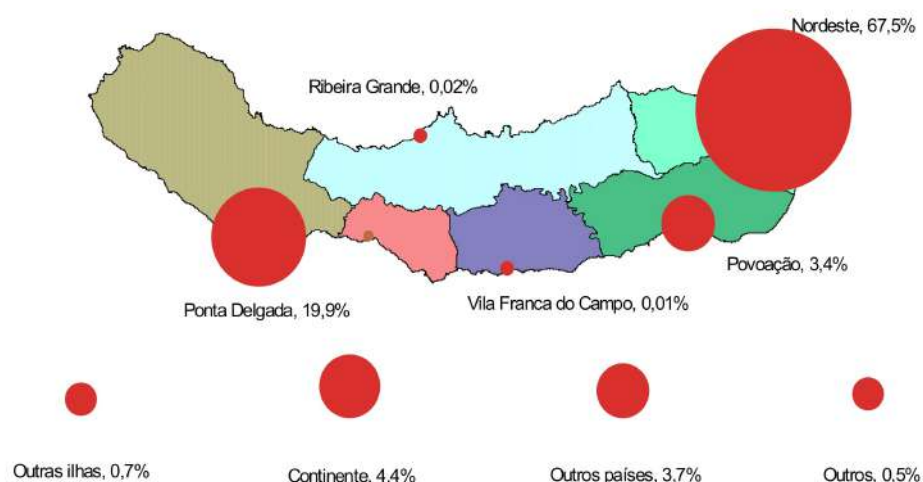
Based on an analysis carried by the RSPB (Rayment et al. 2002) 1 Full time equivalent job is created for each €47,290 spent in management of nature reserves. Regional data from the Department of Prospective and Planning (Departamento de Prospectiva e Planeamento, 2005) showed that every €26,316 spent by the government, supported one full time job. The multiplier effect of governmental funds should be higher than the conservation since it affects many sectors, and that small islands multiplier effects are smaller, since there is always a part of the capital that leaves the island for supplies (Baaijens et al. 1998), we use multipliers ranging from € 26,316 to € 47,290.

With this range we can consider that project expenses of **€ 421,000** supported 9 to 16 FTE jobs in the first four years of the project, which mean between 2,2 and 4 FTE jobs every year.

We can also add up indirect jobs supported by the project' workers and volunteers, since we couldn't find data for Portugal, we used data from RSPB report on Reserves and Local Economies (Rayment et al. 2002) that indicates that every FTE job directly created by the management of natural reserves in UK supports 0,1 FTE jobs in local economy. The LIFE-Priolo supported directly about 8 FTE jobs in the technical team and 12 in the field workers team. These 20 annual workers led to the creation of a further 2 FTE indirect jobs in local communities.

#### 4.12.3 Reserves direct expenditure

LIFE-Priolo Project expenditure from 2003 to August 2007 was €1,485,441.28 that benefited a large number of local, regional, national and international enterprises. About 90 per cent were used in regional economy (figure 2.15)



**Figure 4.14.** Geographical distribution of expenses by LIFE Priolo Project.

<sup>1</sup> January to August

A report from the Department of Prospect and Planning (Departamento de Prospectiva e Planeamento, 2005) suggest that every €100 spent by the regional government increases regional GNP by € 90.40. **We estimate that the €1,486,000 spent by the Project, will increase Azorean GNP by € 1,337,400, which means a mean of € 335,000 per year.**

GNP in the Azores in 2004 was of € 2,890,000,000 (SREA, 2004), **this means that the SPA supported an increase of 0.12 per cent in Azorean GNP.**

#### 4.12.4 Spending created by Natura 2000 site employees and volunteers supporting local economy

In total technical team workers and volunteers spent 341 months in the Azores, Surveys carried out November/December 2006 established that mean expenses for assistant staff were €711.60 and for internships and volunteers it was of about € 323.81. WE can estimate total expenses of LIFE Priolo (until August 2007) technical team on **€194,657, corresponding to €49,700 per year.**

This money was divided between 27 establishments most of which were from the councils of Nordeste (72.17 per cent) and Ponta Delgada (19.32 per cent).

#### 4.12.5 Natura 2000 site's role in supporting rural and regional development

##### Infrastructure Development creation

The LIFE Priolo Project created a series of infrastructures to help conservation of the Priolo. Since 2003, 14 km of trails, one Environmental Centre and 3 orchards planted with traditional and endemic varieties of fruits were developed by the project

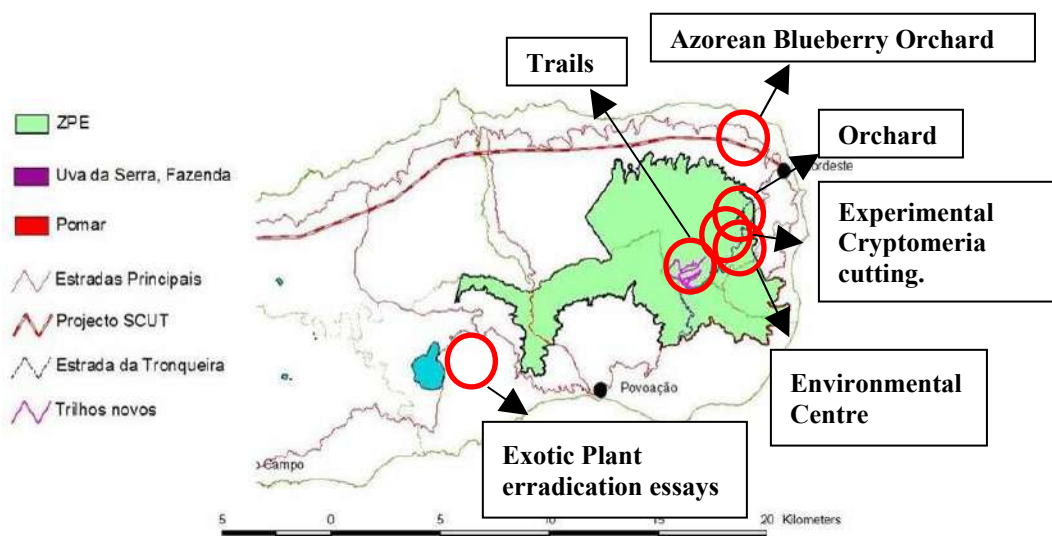


Figure 4.15 Infrastructures created by LIFE-Priolo Project

##### Training of qualified workers in exotic plant removal and restoration

All field workers of the project have received training on the removal of exotic species As a result of the LIFE Priolo Project a total of around 100 workers have been trained.

##### Development of new techniques of restoration and eradication of exotic plants

Techniques for eradication of different exotic plant species were trialed and improved during the developing of the LIFE Priolo Project. Works in the SPA, contributed to increasing know-how on



conservation and restoration techniques for Laurel Forest areas that could be useful for other protected areas with similar problems.

### **National and international disclosure of the Azores and the councils in the SPA.**

LIFE Priolo Project participated in 10 International and 121 National events that contributed to disclosure of the Priolo and its habitat and also the Azores as an interesting tourism destiny for eco tourism. This is a mean of 2.5 International and 30.25 National events each year.

### **Social Participation Encouragement**

The development of the SPA's Management Plan involved 21 regional institutions collaborating in meetings. This contributes to the acceptance of the conservation plans improving social participation.

## **5. FUTURE PROSPECTS OF THESE BENEFITS**

---

### **5.1 Food**

Use of Azorean Blueberry (*Vaccinium cylindraceum*) for manufacturing jams and liquors is currently only a potential benefit that should be captured by creating adequate conditions for its development. This product would always be dependent on tourism in the island, although, if the price was not too high, it would also be purchased by local people. Exploiting this potential benefit depends on local and global economic situation and on regional government awareness of the potential economical interest of this product, since creation of incentives for this production would be essential in developing it commercially.

### **5.2 Ornamental resources**

Ornamental endemic resources are currently only a potential benefit that could only be put into value by a change on forestry policies in the area. An increase on production of endemic plants is necessary in order to increase use of these plants in gardening. At this moment such a use is impossible due to unavailability of plants.

### **5.3 Water supply**

Water supply provided by the SPA Pico da Vara/ Ribeira do Guilherme is actually of great importance for the councils of Nordeste and Povoação. Most of the water consumed in these councils comes from water retention by vegetation preserved in the SPA.

Regarding future climatic change trends (Santos et al., 2004) that predict drier summers, this retention and aquifer recharge granted by vegetation of the SPA will gain even more importance in maintaining water supply for both councils. Recovery of Laurel forests and peat would be necessary in order to assure future demands of water.

### **5.4 Ecotourism and recreation**

Ecotourism and recreation activities related to the SPA Pico da Vara / Ribeira do Guilherme exist, but could be developed further to add value to SPA management.

### **5.5 Cultural values & inspirational services**

Educational and Scientific values of the area are reasonably known within scientific and educative communities; nevertheless, both uses should be encouraged by management of the SPA in order to maintain the importance of this site. Creation of Priolo's Environmental Centre will help support and encourage these activities, helping this way to revert into society the owl potential of the site for scientific, educational and artistic purposes.

## **5.6 Landscape & amenity values**

Landscape and amenity values of this site were protected until the present by limited access. Developing other services could, potentially, put this service at risk. It will depend on the Management Policy to assure that development of tourism, scientific, educational and artistic uses of the SPA do not affect their landscape and other amenity values.

This conservation policy must also be a guarantee of sustainability for other activities since they are strongly dependant on the conservation of landscape and amenity values, specially the tourism, which is also the most dangerous use in term of degradation.

## **5.7 Climate / climate change regulation**

The Carbon content of vegetation preserved in the SPA calculated in this report was only an indicative estimation. In order to estimate future trends of carbon content it would be interesting to understand how carbon fluxes work in the area. Potentially, this service could be very valuable to the global community. However, future conservation methods will lead to a net carbon release, since most important management activity in the SPA is eradication of exotic plants that at least in its first stages will lead to liberation of carbon stored, although it is possible that afterward carbon storage quality would improve.

Therefore, we can consider that climate change regulation of the SPA is not an assured service and will depend on Management policy. As an example, a change on forestry policies from *Criptomeria japonica* plantations to *Picconia azorica* plantation would in mid-term result in a net increase on carbon storage in the SPA. Invasive species eradication although representing a net release of carbon in short-term, may also in mid/long-term result in an increase of carbon storage, although data so far is not available.

## **5.8 Water regulation**

Water regulation processes are currently one of the most important services provided by the SPA, especially regarding hazard risk reduction. Vegetation cover in the SPA is a guarantee of reduction of processes such as landslides and floods.

Regarding future climate change trends (Santos et al., 2004) these services will gain even higher importance. Both scenarios predicted for Azores predict higher intensity of rainfall in winter, leading to a reduced recurrence period of floods and landslides. Therefore, vegetation cover will be of big importance in mitigating these events in the future.

## **5.9 Water purification & waste management**

Main sources of pollution for water are pastures. This activity should be reduced in the SPA, both for conservation and water quality purposes. Reduction on intensity of use of pastures as well as reduction of pasture cover, will lead on an improvement of water quality in the area.

## **5.10 Genetic / species diversity maintenance**

Genetic diversity is a service maintained by Laurel Forest, since diversity in other habitats of the SPA is very low. Therefore conservation of Laurel Forest is the main guarantee for these services.

## **5.11 Supporting services**

Supporting services in the SPA are related to the preservation of biodiversity and interactions in the Laurel Forest. Therefore, all efforts on restoring and preserving Laurel Forest will result in improving these supporting services.

## **5.12 Wider socioeconomic benefits**

Socioeconomic benefits provided by LIFE Priolo project, would be maintained by assuring the developing of the Management Plan of the SPA and guaranteeing a correct financial support for it. It should also be important to maintain the Management policy of assuring that most of the expenses of the SPA revert on local and regional economy.

### 5.13 Financial Forecast and Scenario Foresight

A correct financial forecast of what are going to be the economic needs, is crucial in order to support a correct financial planning, being this a source of stability for the SPA's management (Sustainable Financing of Protected Areas, 2006). The analysis of previous experiences and their related expenses is essential to know what the financial needs of an specific area are. Since the amount of available funds might vary it will also be interesting to develop a scenario foresight of what could be the fulfillments within the area.

LIFE Priolo project and the SPA's Management Plan (split into different actions) are essential experiences to develop these financial forecast and scenario foresights. In order to know what are going to be the financial needs, it is important to define the following points: objectives definition and actions, expected future expenses (human and material needs to fulfill the objectives) and, to assure a proficient management, definition of an effective control to monitor the management actions.

LIFE Priolo experience as been an opportunity to observe which are the cost related to the implementation of Management Plan actions. A table such as following can be developed to show how the financial needs for different periods are evolving with time. This information must be carefully considered as it is based on a specific time of the SPA's life, when the LIFE Priolo project was operating in the area. Managers must think on different financial support, such as alternative founding in order to increase the area auto-sustainability.

	2009-2010	2011-2015	2016-2025	2016-2030	Actions
<b>SPA</b>					
Technical Staff	389,760€	1,081,433€	2,707,032€	4,391,869€	
Conservation actions	780,634€	2,134,413€	5,342,843€	8,668,190€	D3-4-5-8
Orchard	-	-	-	-	C1
Azorean blueberry production	-	-	-	-	
Communication	23,957€	40,243€	100,735€	163,432€	E4-5-7-13, F4-
Research	20,232€	55,317€	138,470€	224,652€	F6
Monitorizing	11,013€	12,767€	31,959€	51,850€	D3-4-5-8
Merchandising	61,418€	71,200€	178,228€	289,156€	E13
Environmental Center					
2 assistants	200,726€	556,938€	1,394,122€	2,261,813€	
Other expenses	313,635€	870,215€	2,178,315€	3,534,082€	
<b>TOTAL</b>	<b>1,801,376€</b>	<b>4,822,527€</b>	<b>12,071,704€</b>	<b>19,585,044€</b>	

Doing this financial forecast exercise would be more useful if the available founding was already allocated. Actually this is not the case. The description of alternative scenarios is a good option to describe what would be the different management orientations and objectives depending on the available funds. It allows to give different pictures of what could be the management area.

LIFE Priolo experience is essential to know Priolo's and its habitat conservation needs. This experience will be the reference for the scenario foresight. This presents different scenarios considered reasonable. Renouncing to founding is not an option for nature conservation. All the knowledge, the know-how and the achievements reached so far would be lost if there was a total stopping of founding.

The proposed scenarios are the **pessimistic**, the **realistic** and the **optimal**.

**Pessimistic scenario** would consist on maintaining the Laurel forest areas recovered by LIFE Priolo project. This will not guarantee the laurel forest and Priolo conservation as the recovered area only represents around 5% of the SPA. Also new threats (such as new invasive plants) have been detected and require extra conservation efforts. This scenario would not suppose any added value for the area and will only employ 5 conservation workers.

**Realistic scenario** means the continuation of LIFE Priolo economic financing at similar level. This founding would be vital as these areas' conservation requires constant efforts. The scenario would consist on maintaining previously recovered areas and increasing new ones. The annual financial needs would be similar to LIFE Priolo project, around 500,000€/year. These founding would permit to insure a better Priolo and Laurel forest conservation, to increase benefits generated by the SPA (in terms of ecosystem services), to open new doors for long term SPA's management and to develop some projects that will increase the area added value (Azorean blueberry production, ecotourism, research, invasive species control...).

Finally the **Optimal scenario** is a scenario that integrates a series of solutions. It would mostly consist on keeping LIFE Priolo project level of efforts and developing alternative solutions to assure the SPA's sustainable management. This scenario is only feasible with a higher level of stakeholders' implication. It will maintain the LIFE Priolo conservation efforts adding to these an SPA integrated management where timber production forest would be used as a protection for invasive species, the benefits from timber selling would help financing conservation projects. The annual required founding would be similar to LIFE Priolo project (500,000€/year) with an extra founding from timber production benefits. The scenario would suppose improved nature conservation actions; this would mean increasing of ecosystem services' benefits. The team could also share its knowhow in terms of laurel forest conservation which could be used in other Azorean natural areas. The project would broader benefit scientific research areas (Laurel forest, Priolo and promoting national and international scientific attractiveness), conservation (Priolo, its natural habitat and its resilience) and finally other added values could be on employment creation, rat control, azorean blueberry production (*Vaccinium cylindraceum*), tourism, ecosystem services, ratio investment/utility and creation of a Priolo brand (applied to the area products).

This way of managing the area, increasing alternative founding, could mean, in the long term, the diminution of stakeholders' financing and the area auto-sustainability.

The following table summarizes the different scenarios achievements in different action fields.

	Pessimistic scenarion	Realistic scenario	Optimal scenario
<b>Scientific research</b>			
Laurel forest	*	***	****
Priolo	*	***	****
Area scientific attractiveness	*	**	****
<b>Conservation</b>			
Priolo	*	**	***
Laurel forest	*	**	***
Laurel forest resilience	*	***	****
<b>Added values</b>			
Employment creation	*	***	***
Rat control	*	**	****
Azorean blueberry production	*	**	****
Tourism	**	***	****
Ecosystem services	*	**	***
Ratio investment/utility	*	**	****
Priolo brand	*	***	****
<b>TOTAL AVERAGE</b>	*	***	****

## 6. CONCLUSION

---

### 6.1 Conservation of ecosystem services

Many of the services considered in this study area strongly associated with the conservation of the natural Laurel Forest and peat areas in Planalto dos Graminhais, Conservation of these areas should be of maximum importance in order to guarantee quality of ecosystem services.

Continuation of eradication of exotic plants, as well as forestry policies alteration in order to promote endemic plants instead of *Cryptomeria japonica* plantations could help maintain and improve the ecosystem services provided by the area.

Water services are currently sustainably managed because the population in the councils of Nordeste and Povoação is low, although this situation could change in future scenarios of Climate Change (Santos et al., 2004). These scenarios predict an intensification of heavy rainfall periods in winter and a decrease of rainfall in summer that could lead to and increase in problems of water supply respectively. If vegetation cover is protected this service can be maintained. It is therefore very important to maintain a policy of vegetation cover conservation and improvement, since some of the vegetation covers are better at guaranteeing this service. Invasive plant eradication if done with appropriate techniques in order to avoid uncovered soils will have a positive effect in these services.

Tourism, amenities and inspirational services should be well promoted and strategies in place to capture these values so the benefits derived from these services can benefit local people. These strategies should identify the carrying capacity of the site for tourism, since it is very important that development of this sector does not affect other services provided by the SPA.

### 6.2 Ecosystem services affecting local population

Local people are potential beneficiaries of many of the services studied in this report, but the truth is that up to this moment, local people are not receiving much benefit from the SPA or are not aware of those benefits they receive. Creation of incentives for local people to develop sustainable activities within or around the SPA would help the long term improvement of the management of the SPA as well as an increase of social support for the SPA. Publicising actual benefits provided by the SPA, would help increase local people's support for the SPA and in general for Natura 2000 areas.

Socioeconomic characteristics of the area, such as low development and its rural nature may be a problem in order to assure conservation goals in the area. Economic considerations in the councils of Nordeste and Povoação are strongly related to the use of land and which could create conflict when trying to modify land uses in order to achieve conservation goals.

The promotion of ecotourism and other sustainable activities based on Laurel forest and endemic resources (food and ornamental values) should encourage other areas in the Azores to increase their protection on this forest.

The Tourism potential of the site provides the opportunity of establishing a new source of funding for the management of the SPA. Ecotourism is related to cultural and ecological preservation of the area in which it takes place; therefore, creating a good strategy for the development of this Ecotourism could result in financing for the SPA. But it is important to note that focusing only in enhancement of touristic value of the area, could bring both conservation and cultural problems, therefore it is important to establish a well defined strategy to assure that touristic increase does not affect other important services in the area.

### 6.3 Further research

Some of the valuations considered in this report were only an estimation based on benefits transfer technique. Therefore further research on real effect of existent habitats on Ecosystem Services would be important, especially for those services considered as highly important, water supply and water regulation. It would also be interesting to establish the carbon flow within the habitats of the SPA in order to improve its potential as a sink of carbon.

It would also be interesting to value the different contribution of other habitats to these ecosystem services, since this could help establish more informed criteria for territorial planning.

## 6.4 Consequences for SPA Pico da Vara/ Ribeira do Guilherme Management

As a conclusion we can affirm that management of the SPA should guarantee:

- Conservation of Priolo and Laurel Forest vegetation;
- Continuation of the economic efforts to assure management and especially eradication of exotic plants from the SPA;
- Continuation of the socioeconomic effects of the Management of the SPA to the local population;
- Conservation of Ecosystem Services provided by the SPA;
- Integration of the SPA into local and regional economy;
- New opportunities of sustainable development for the area.

And we can identify key actions in order to assure these objectives such as:

- Continuation of Management field actions and maintenance of expenses policy, assuring that most of the expenses of the reserve revert into the region.
- Promotion of Eco-tourism in the area regarding strategies defined in the European Charter for Sustainable Tourism.
- Promotion of other sustainable activities in the area such as Azorean Blueberry orchards, endemic wood or endemic plants as ornamentals.
- Promotion of scientific research in the area. This promotion will promote a service of the area and at the same time allow increasing knowledge on ecological processes taking place, helping in conservation and management of other services not so well known in the present.
- Promotion of Educational value of the area.
- Awareness campaigns among population on services provided by the SPA and on the importance of preservation of the SPA.
- Local, regional, national and international disclosure of Laurel Forest and the Priolo.

## BIBLIOGRAPHY

---

AVALIAÇÃO DO IMPACTO DOS PROGRAMAS OPERACIONAIS, REGIONAIS (QCA III) EM 2000-2003, LISBOA 2005, Departamento de Prospectiva e Planeamento.

Baaijens *et al.* (1998) Explanatory Meta-Analysis of Tourist Income Multipliers. Vrije Universiteit Amsterdam

Biodiversity Database of the Azores (<http://www.azoresbioportal.angra.uac.pt/>)

Botelho, R.; Gil, A.; de la Cruz, A.; Silva, C.. 2008. Mapeamento do coberto vegetal na ZPE Pico da Vara/Ribeira do Guilherme. Relatório não publ.. Sociedade Portuguesa para o Estudo das Aves. Lisboa.

Ehlenfeldt, Mark K. 1997. BREEDING BLUEBERRIES FOR THE NEW CENTURY. Acta Hort. (ISHS) 446:227-234

F. Worrall, M. Reed, J. Warburton and T. Burt, Carbon budget for a British upland peat catchment, Science of Total Environment, 312 (2003)

Fernández-Palacios, J.M., García Esteban, J.J., López, R.J. & Luzardo, M.C. 1991. Aproximación a la estima de la biomasa y producción primaria neta aéreas en una estación de laurisilva tinerfeña. Viera, 20: 11-20.

Fukuda, M., T. Iehara, and M. Matsumoto. 2003. Carbon stock estimates for sugi and hinoki forests in Japan. For.Ecol. Manage. 184(1-3): 1–16.

Gaspar, J. L. and Guest, J. The 31st October 1997 landslides at S.Miguel Island, Azores: a dramatic lesson for the future, Volcanic Hazard Assessment, Monitoring and Risk Mitigation; Advanced Study Course, European Commission, 43, 1998.

Gaspar, J. L., Wallenstein, N., Coutinho, R., Ferreira, T., Queiroz, G., Pacheco, J., Guest, J., Tryggvason, E., and Malheiro, A.: Considerações sobre a ocorrência dos movimentos de massa registados na estrada de 31 de Outubro de 1997 na ilha de S. Miguel, Açores,

Gil, A. 2005. Plano de Gestão da ZPE Pico da Vara/ Ribeira do Guilherme. Relatório não publ.. Sociedade Portuguesa para o Estudo das Aves. Lisboa.

King & Mazzota: <http://www.ecosystemvaluation.org>  
Luck, GW; Daily, GC & Ehrlich, PR Population diversity and ecosystem services Trends in Ecology & Evolution, 2003

Millennium Ecosystem Assessment (2003). Ecosystems and Human Well-Being: A framework for assessment. Island Press, Washington D.C.

Nunes P. A. L. D. and van den Bergh, J. C. J. M. (2001). Economic valuation of biodiversity: sense or nonsense? Ecological Economics, Volume 39, Issue 2, November, pp. 203-222.

Olson, J.S., Watts J.A., and Allison L.J.. (1985). Major world ecosystem complexes ranked by carbon in live vegetation: A Database. NDP-017, Carbon Dioxide Information Center, Oak Ridge National Laboratory, Oak Ridge, Tennessee. doi: 10.3334/CDIAC/lue.ndp017 (Revised 2001)

Plano Regional da Água da Região Autónoma dos Açores.

Plano Regional da Água dos Açores.

Rayment, Sheil & Burton (2002) RSPB Reserves and Local Economies. RSPB. Available on RSPB website.

Red List of Threatened Animals-IUCN - <http://www.iucnredlist.org/>

Relatório Anual dos Sectores de Águas e Resíduos em Portugal 2007 - Volume 4

Relatório Técnico-Científico 17/DGUA/97, Centro de Vulcanologia, 28, 1997.

Rosenberger, R S and Stanley T D (2006) Measurement, generalization, and publication: Sources of error in benefit transfers and their management Ecological Economics, Volume 60, Issue 2, 1, pp. 372-378.

Heleno R. H., Ceia R. S., Ramos J. A., Memmott J. (2008) Effects of Alien Plants on Insect Abundance and Biomass: a Food-Web Approach. Conservation Biology, 23, 2, 410-419.

Santos, F.D., M.A. Valente, P.M.A. Miranda, A. Aguiar, E.B. Azevedo, A. Tomé and F. Coelho (2004): "Climate Change Scenarios in the Azores and Madeira Islands", World Resource Review, 16, No 3, 473-491

Serviço Regional de Estatísticas dos Açores (2003) Principais Resultados Definitivos dos Censos 1991 e 2001 Açores.

Troy, A. and Wilson, M. A. (2006). Mapping ecosystem services: Practical challenges and opportunities in linking GIS and value transfer. Ecological Economics, Volume 60, Issue 2, 1, pp. 435-44.



Valadão, P.; Gaspar, J. L.; Queiroz, G.; Ferreira, T.(2002) Landslides density map of S. Miguel Island, Azores archipelago. Natural Hazards and Earth System Science, Volume 2, Issue 1/2, 2002, pp.51-56

Wilson, M. A and Hoehn, J. P. (2006) Valuing environmental goods and services using benefit transfer: The state-of-the art and science. Ecological Economics, Volume 60, Issue 2, 1, pp. 335-342.