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# The science policy gap regarding informed decisions in forest policy and management. What scientific information are policy makers really interested in?

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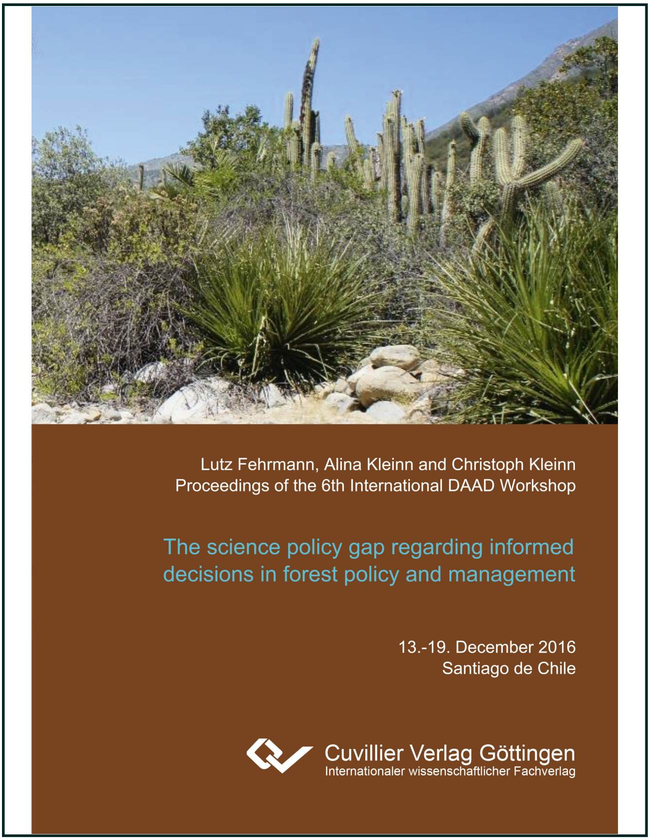


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# Chapter one
# Conservation & Biodiversity

# Inventory and assessment of ecosystems with relict tree species as a tool for establishing criteria for public forest policy

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## Abstract

In subtropical regions, there is a presence of fragmented ecosystems which are considered as relict since they contain forest species endemic to genera of boreal distribution. The management of natural resources has evolved from criteria based on the use of wood and sustainable production of the same to criteria of sustainability of the ecosystems considering the conservation of ecosystem services and biodiversity. These public policies related to biodiversity conservation, prevent the use of relict species so it is necessary to carry out an analysis of their structure, diversity and ecological aspects in fragmented ecosystems in order to take the right decisions for their management.

## 1 Introduction

When we think about forest areas we think of the products that are provided to us. These are materials like wood or some environmental services like those of the hydrological kind. Of all types of vegetation, forest areas are presented as the most complex ecosystems that, in order to be developed require special climatic, soil and physiographic conditions.

Throughout history man has used the natural resources, thereby obtaining food and materials necessary for his subsistence. In the beginning the first humans made a moderate use of the resources; they used only what was necessary for their daily consumption due to their nomadic lifestyle. The interaction with nature changed drastically when the first human settlements were established. Before land ownership appeared, the cultivation of edible species began in deforested areas. Construction materials and fuel wood were obtained from around the village areas because they had no owner and in this land everyone could make use of the forest vegetation.

## 2 Public forest policies

In first instance, the land that belonged to no one was credited as state property. The regulations imposed by the public forest policies were shaped during the medieval age in the forest permanencies. At the beginning of the industrial revolution the need for raw materials increased. Public policies in this regard were shaped at this time to try to obtain a continuous non-declining production, with the maximum possible extraction (sustainable production). The search for technical options to achieve this led to the creation of forestry schools that would lay the scientific basis for forest production.

At present time the constant growth of the human population and the demand for products of all kinds has had a strong impact on the environment. The paradigms in forest policies have changed from regulating the technical interventions to the forest in order to obtain wood to trying to conserve the ecological functions of the forests and their diversity, as well as to maintain the environmental services that they provide. This later paradigm also includes carrying out activities for the restoration or rehabilitation of degraded areas or with diminished resources (Jardel et al., 2008, Jardel 2012).

## 3 Biodiversity use

The term "biodiversity" - a jargon contraction of "biological diversity" - has been particularly contentious or misunderstood, giving rise to conflict and confusion at high levels of policy and science and among the public. Is however one of the aspects that are considered important in maintaining the stability of forest ecosystems, which does not only concern the diversity of species within ecosystems, but also the diversity of ecosystems and genetic diversity within populations of the same species.

This genetic diversity manifests itself within the same population or within the same species in different environmental gradients. Maintaining this genetic diversity is important for the persistence of species. Reducing this diversity would increase the vulnerability of the species.

The use of biodiversity in the forest sector has served to identify the best native populations of a species in order to migrate some individuals within their range of distribution from less favorable environments to those with better conditions for their development, and in this way, improve wood production. These studies of origin have been the basis for the development of forest plantations and of timber species in the world.

## 4 Biodiversity conservation policies

The conservation aspect of maintaining biodiversity in forests is meant to foster ecosystem connectivity, maintain the heterogeneity of the landscape, the structural complexity of forests and aquatic ecosystems (Holmgren P. and R. Persson 2002).

Strategies have been put in place to conserve biodiversity at the regional level, at the landscape level or at the forest ecosystem level. At the regional level, the establishment of large ecological reserves such as national parks or natural protected areas is proposed.

At the landscape level, it is being considered to conserve areas without forest production, to maintain areas of influence along the aquatic ecosystems, to properly design the road network, and to maintain an adequate special and temporary arrangement of the forest product harvesting units, as well as improving proper fire combat practices.

With respect to forest management, it is pertinent to maintain the structural complexity of ecosystems with rotation of harvest areas over longer periods and of adequate silvicultural practices. In this respect, the Mexican regulation to allow forest management provides for the classification of areas into areas of conservation and restricted use, production areas, restoration areas, protection areas and other uses.

The classification into an area of conservation and restricted use is considered when the property where the forest management plan is elaborated belongs to a protected natural area. The land-use is restricted in the same way in areas of protection along the rivers, on slopes greater than 100% or 45 degrees, in mountainous areas with altitudes higher than 3,000, in areas with mangroves or fog forests or in areas that are habitat of species or subspecies of flora or fauna that are at risk or are protected.

In order to determine which species are at risk, international or national criteria are used. The international level used corresponds to the World Union for Nature (IUCN) criteria, established in the Red List and at national level, the Official Mexican Standard NOM-059 are used. The first considers the criteria Extinct (Ex), Extinct in the wild (EW), in critical danger (CR), endangered (EN), Vulnerable (VU), near threatened (NT) and little concern (LC) (IUCN 2016). In the Mexican Standard, the following classifications are used: Probably extinct in the wild, in danger of extinction, threatened and subject to special protection (SEMARNAT, 2010).

## 5 Forest tree species at risk in Mexico

In Mexico, we can find the southern distribution of tree species from the Neartic ecozone, these grow in extreme climatic conditions (low humidity and high temperature) and are in some cases endemic for a region. These species have been logged for their timber by local sawmills. This use is now being discouraged for conservation reasons. The spruce species are distributed in northern Mexico as shown in figure 1, in northeast Mexico we find Martinez's Spruce (*Picea martinezii*), in the same forest ecosystem with others species in risk categories like Vejar's Fir (*Abies vejarii* ), Mexican Yew (*Taxus globosa*) and Douglas Fir (*Pseudotsuga menziesii*.).

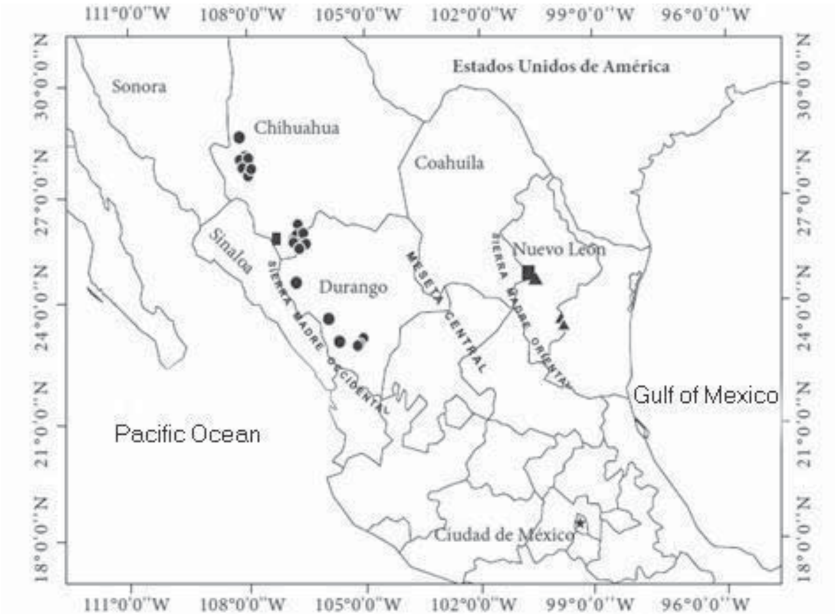


*Figure 1. Distribution of spruce populations (Picea martinezii ▲), (P. mexicana ■) & (Picea chihuahuana ●) (Mendoza-Maya et Al. 2015).*

Although wood of species of the genus Picea is used all over the world, in Mexico all species are protected by law. In the case of Martinez's Spruce (Picea martinezii), the species is on the Red List Category of the NICU and in the category of danger of extinction. In the NOM-059 it is registered as endemic. It is distributed between 2155 and 2990 above sea level. At present it occupies 48 ha in four localities, and the population is severely fragmented as a consequence. The population is likely to decrease due to forest fires and pests.


*Figure 2. Martinez's Spruce (Picea martinezii)*

Globally, more than 40 species of Abies (Pinaceae) grow in boreal forests. In Mexico Eguiarte and Furnier (1997) mention that there are eight species of Abies, six of these endemic, distributed in the highlands of the country. All of them are protected.

The Vejar's Fir (Abies vejarii) is endemic to northeastern Mexico, it is extended over 144 km2, at elevations ranging from 1,900 to 3,300 meters and is found in mixed pine forests. It is considered by Mexican law as threatened and internationally as Near Threatened (IUCN). The population is likely to decline because of forest fires and deforestation and is considered severely fragmented.


*Figure 3. Vejar's Fir (Abies vejarii).*

The Mexican Yew (Taxus globosa, Schltdl.) is located in an approximate area of 2,000 km 2, in small and severely fragmented populations, in an altitudinal range between 1,000 and 3000 meters above sea level. At national level it falls under theprotection category and at the international level it is considered as threatened. It has recently been studied due to the medicinal qualities of Taxol that it contains (García & Castillo, 2000, Shemluck et al. 2003, Barrios et al. 2009).

Douglas Fir (Pseudotsuga menziesii, (Mirb.) Franco) is a species of tree with a wide distribution and many subspecies: from sea level in the north to the high mountain in the south. It is the tree with the best logging performance in North America. In Mexico it is protected by law; subpopulations are often isolated and have been described as distinct species. This variety is present in many protected areas, including some national parks.

The current distribution of these species is influenced by climate change, not only the one that has appeared in the last century. The last glacial period changed the landscape of the Earth. Even though many of the plants and animals of the Quaternary Period are virtually the same as those living today, there are some important differences in their distribution. The vegetation was displaced by the ice and returned to the same location when the ice melted, leaving some isolated species in latitudes south of their original distribution, leaving fragments of vegetation with an affinity to the boreal forests in the mountains.

*Table 1. IVI Values of trees in ecosystems with relict species in northeastern Mexico. (González Cubas, 2015).*

| Species | Altitude in m | | | |
|---|---|---|---|---|
| | 2400 | 2500 | 2600 | 2700 |
| *Abies vejarii* | 29.4% | 29.5% | 16.9% | 18.4% |
| *Cupressus arizonica* | | 31.5% | | |
| *Quercus affinis* | 18.5% | 8.6% | 24.1% | 24.7% |
| *Quercus mexicana* | 17.2% | | | |
| *Quercus polymorpha* | 9.2% | | | |
| *Picea martinezii* | 8.7% | | 22.6% | |
| *Taxus globosa* | 8.7% | 2.2% | 13.1% | |
| *Pseudotsuga menziesii* | 1.9% | 11.7% | | |
| *Zanthoxylum fagara* | 1.6% | | | |
| *Pinus ayacahuite* | 1.6% | 14.4% | 14.3% | 20.9% |
| *Ulmus craassifolia* | 1.6% | | | |
| *Arbutus xalapensis* | 1.5% | | | 12.7% |
| *Pinus pseudostrobus* | | 2.3% | 9.1% | |
| *Pinus teocote* | | | | 18.2% |
| *Quercus fulva* | | | | 5.1% |

In order to establish the horizontal, vertical and floristic structure of these communities, as well as to know their ecology, a network of permanent forest research sites were established. Following the scheme proposed by Corral et al. 2009, the sampling sites have an area of 2,500 square meters. In these plots, the dendrometric variables and the position of each tree were recorded. Each tree is numbered to perform measurements every 5 years in order to see its increase in diameter and height. Soil samples are taken for physical, chemical and biological analysis. This analyzes the seed bank of the forest species of interest. The seedlings of the forest are quantified and the phenology of 25 trees in each site is recorded monthly for two years to determine the periods of leaf renewal, flowering and fruiting. Samples were taken from the spruce leaves and transported to the laboratory for genetic analysis.

As an example, the analysis of four forest ecosystems with Northern exposure at altitudes of 2400, 2500, 2600 and 2700 meters above sea level is presented. The four populations are close but do not form a continuum. Taking the importance value index (IVI) to describe the floristic structure, Table 1 shows that *Abies vejarii, Quercus affinis* and *Pinus ayacahuite* are present in the four localities. The IVI values for Abies are between 20% and 30% when decreasing the altitude, the oak is dominant as second order in all localities and pine values decrease with altitude. The Mexican yew is found in the three lower altitudes, Douglas fir in the two smaller ones and spruce in two 2400 localities with low values and at 2600 with values of 23%

## 6 Conclusions

The concept of biological diversity has been particularly controversial or misunderstood, leading to conflict and confusion at high levels of policy, science and among the public. In many cases, the public reacts poorly to alarming information, with or without scientific knowledge, on issues such as climate change, habitat destruction or loss of biodiversity. The environmentalists present initiatives to the political authorities in order to create public policies without sufficient scientific information. As a consequence, their good intentions produce negative economic impacts for the owners of the resources or negative ecological impacts in the ecosystems, because the regulation avoids management actions that assure the permanence of the ecosystems.

In the case of relict tree species, these may be rare in one region but abundant in others. The information about these ecosystems will allow us to determine the genetic richness, the distribution of the species, the possible uses and its resilience, which presents limitless possibilities for the management of biodiversity.

The study of these highly fragmented populations has shown that despite being under pressure, these ecosystems still preserve their biological richness and their reproductive capacity. It is necessary to present this information in an organized way to change some of the conservation policies, and to manage the species communities in order to expand their distribution and connectedness.

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# Zoning of an Agroforestry System: Organic Coffee Production in Santa Cruz Island – Galápagos

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## Abstract

In the Galapagos Islands, the agricultural land was abandoned due to the explosion of tourism activities, having the spread of invasive species as a consequence. One of the crops that still exist on the island is coffee. One coffee farm produces certified organic coffee under the shade of endemic forest species, and is recognized by tourists and locals as a high quality coffee. One of the most important characteristics of coffee production in the island is that the optimum environmental conditions established in the literature are not met, so it is possible that other environmental factors influence the local success of the crop. This study focuses on the zoning of organic coffee to determine which areas are suitable for producing it. The study is based on the environmental conditions that favor the growing of organic coffee under the shade of native species in the reference farm. The data on environmental factors that influence the coffee production in the farm were obtained from thematic maps of soil, climate and elevation. The factors were reclassified in a range of zero to five, with five being the environmental factor present in the reference system. Then, the Raster Calculator tool was applied for multiplying the reclassified environmental factors and for indicating the suitable areas. Despite of the unfavorable environmental conditions of the Santa Cruz Island, the organic coffee farming is suitable and represents a viable approach to increase agricultural production on the island.

## 1 Introduction

A large number of small-scale coffee producers live in areas with fragile ecosystems and therefore they face big difficulties; however, they must comply the high market expectations and standards especially with regard to the coffee quality, which compromise their ability to compete against large scale coffee producers (Caswell y Méndez, 2012). This is also an issue in the production of coffee in the Galapagos Islands due to the special social and environmental conditions. In the Archipelago the production of coffee must be environmentally friendly and apply the best agricultural practices to ensure an efficient production; additionally, the farmers must confront and manage unusual environmental conditions that limit the production of coffee. For example: limited water, high temperatures and invasive species. Moreover, farmers face the absence of people willing to work in agriculture and high salaries.

Agricultural zoning represents an opportunity for the farmers to identify the areas with the best suitability to improve the agricultural productivity of organic coffee inside a sensitive ecosystem. Furthermore, zoning allows the farmers to address some of the environmental and social challenges mentioned. According to Pineda and Suarez (2014) recent studies demonstrate the potential of zoning at the municipal level, not only for agricultural management but also to generate environmental protection strategies.

The zoning study that this paper is based on was conducted on the Island of Santa Cruz, where the abandonment of farmland resulted in an explosion of invasive species. An agroforestry system to produce organic coffee offers the possibility to respond to this problem and control the invasive species, besides coffee growing may be carried out under the shade of endemic species such as *Scalesias* (Chiriboga, Fonseca and Maignan, 2006). In one of the farms on the island the coffee also grows under endemic tree species like matazarno and palo santo.

According to FAO (1993), agroforestry is the deliberate growth and management of trees, along with agricultural crops and/or livestock, in systems that aim to be ecologically, socially and economically sustainable. In order to conduct the zoning, an agroforestry reference system was identified in the island, in the form of an existing farm.

This agroforestry reference system produces organic coffee with high quality; the system takes advantage of rains from January to April to collect water and irrigate shrubs, it also uses the natural shade of the native and endemic trees of the island. Forest tree species, in addition to providing shade, regulate temperature and are habitat for several species of unique birds.

The final product of the zoning is a map that identifies the areas with the greatest potential to implement an agroforestry system for the production of organic coffee, and thus replicates the system of organic production that is taken as an example. A zoning map is a support tool in the process of decision-making for farmers and local authorities.

## 2 Coffee production in the Santa Cruz Island

On the Santa Cruz Island currently 36 farms produce coffee; some of the coffee farms exceed 20 ha. In the low elevations cattle is raised while in elevated areas with deep soil coffee is cultivated. Coffee production on the island faces challenges such as the low prices and high labour costs; however, the quality of coffee is recognized, reason why the price has increased (Chiriboga et al., 2006).