



# Alto Patache fog oasis in the Atacama Desert: Geographical basis for a sustainable development program

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## Abstract

Alto Patache coastal fog oasis is a State protected area due to its rich biodiversity. It is located south of Iquique, Northern Chile, being presently in charge of the Atacama Desert Center (ADC) of the Pontificia Universidad Católica de Chile. On 2007, the Chilean Government bestowed a land stretch covering 1,114.5 hectares to ADC for scientific research, ecosystem protection and environmental education. This oasis has been studied since 1997 from different aspects like climate, fog collection, geomorphology, soil survey, biogeography, flora and fauna distribution, conservation, history and archaeology.

During 2009, a study of the geographical basis to elaborate a general management plan was undertaken to collect information to accomplish the planned out objectives. Through this study, geo-referenced strategic information was compiled to evaluate future actions conducting to a sustainable development within the protected area. This information was translated into geographical thematic maps showing the spatial distribution of the specific variables. The methodology used was the analysis of remote sensing imagery, intensive and systematic field work and GIS as an integration tool.

The paper's core shows that three climate types influence the geography and ecosystems of the area. The biogeographical contrast between the foggy section, and the areas located below the stratocumulus cloud influence and the hills out of its influence in the “sunshine”, show important features for the understanding of the area complexity. Two soil types could be found: Entisols (Torriorthent) and Aridisols. Vegetation consists not only of a very rich lichen and soil crust cover along the foggy area, but also of endangered vascular species associations constituting a very

fragile sub-tropical coastal desert community. Fog oasis runs from 600 - 850 m a.s.l.

Future human activities at place should be restricted to scientific studies, ecosystems conservation, experimental site, environmental education and eco-tourism of special interest. The uniqueness and the fragility of the place are here the most important issues. Questions are: how, where and when these activities can be practiced inside the oasis without risking its vulnerability.

## 1. Introduction

The fog oasis of Alto Patache in the Tarapacá Region has been given in concession by the Chilean Ministry of Bienes Nacionales to the Pontificia Universidad Católica de Chile for 25 years with the objectives of protection and conservation of the ecosystems, research activities and environmental education. It covers 1,114.5 ha lodged in a desert environment possessing significant geographical features. These are: a littoral plain, an abrupt cliff more than 600 m of elevation, a huge climbing sand dune and the first mountains of the Cordillera de la Costa, a major geoform in the Atacama Desert. Its most important trait is the plant ecosystem, where several species of plants and animals survive mainly on the water provided by fog and dew (fog has been studied; dew is an aspect which has to be tackle with in the future).

The main goal of this study was to undertake a detailed survey of all the geographical and cultural features being necessary for the design of a master plan of occupation and protection. It is necessary to do a sustainable use of the area, especially in connection with the future scientific research. The place is seen as a laboratory to test different results of applied research, such as energy resources (eolian and solar), water (fog and dew), architecture (houses and materials designed for arid conditions), land art, environmental education, tourism of

special interest, amongst others. Certainly it is a challenge for arid land sustainability and an example for other similar places in Chile and in deserts of the world.

To exactly define zones for the future different uses of the fog oasis based on its environmental fragility and the needs of creating a natural laboratory for scientific research, is the main purpose of this study.

## 2. The study area

Alto Patache is located in the Tarapacá Region in the north of Chile. It lies in the Coastal Atacama Desert where the precipitation is the minimal in the country, averaging 0.2 mm per year in the last 30 years. Tarapacá has a surface of 42,226 km<sup>2</sup>, with a population of 240,000 inhabitants, mainly located in the neighbor cities of Iquique and Alto Hospicio (95%). Because of its aridity and lack of conditions for agriculture, the rural population is scarce and is located mainly in valleys and inland. At the coast, people live in small villages and are dedicated to fishing activities. Less than 1.000 persons live in that littoral area, mainly because of lack of water which is only available by truck. Mining is the main regional economical activity; the most important copper mines are located in the high Andes; people live in the two coastal cities and work in turns in modern settlements near the mines. In the Cordillera de la Costa population is practically absent (Fig.1).

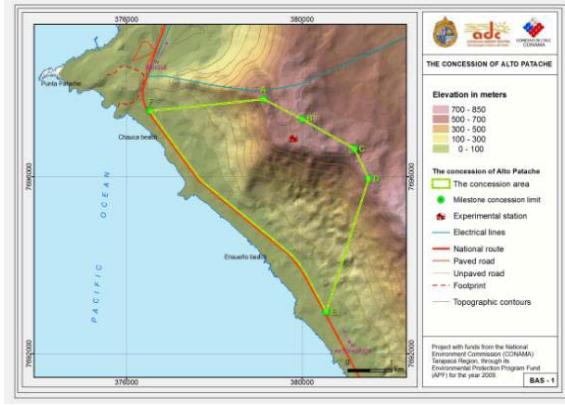


Figure 1: The study area in the Tarapacá Region.

## 3. Methodology

The general objective of the study was to evaluate the geographical conditions of the fog oasis of Alto

Patache with all its natural and cultural features, which may allow tracing a master plan of site occupation. The specific objectives were: a) to make a detailed survey of the climate types and fog present in the area; b) to study its geology, geomorphology, ecosystems, soils, flora and fauna; and c) the cultural aspects such as archaeology and historical evidence.

Almost all the information needed was extracted from our own studies done during the last 12 years [1-9]. The Geomorphology and Soils required a specific study only [10].

Several geographical studies of fog oases have been presented by our team in the four Conferences on Fog and Dew, since 1998 being Tarapacá the area showing the great majority of investigations related to fog and its spatial and temporal distribution. The climatic zones presented here were defined based on 3 official Meteorological Stations and 2 years of temperature and humidity sensors in Patache [2, 5]. Fog water potential collection comes from Standard Fog Collectors (SFCs) located at different elevations and exposures in the Alto Patache oasis [1, 3].

The geological and geomorphological surveys were practiced using satellite-photo-interpretation of the area geo-forms and substrate identification [10]. The soil survey was done through soil morphology evaluation, to answer explanations about some important properties of arid soils, digging trenches in specified sites to get samples for soil texture and structure, bulk density, electrical conductivity and others, distributed in a soil map, showing soils types and properties at a 1:10.000 scale.

Site ecosystems were studied during the last 12 years; vegetation has been surveyed following different soil features influenced by the stratocumulus cloud, fog and wind direction [4]. Botanical studies identified the species present [8] and the botanical ADC team has been working in spatial distribution and seed bank studies. The entomological chart was constructed on the basis of 5 year trapping records already published in several papers, including a Fog Conference [9]. The cultural aspects reflected in the archaeological and historical record, were based on several field surveys and two student theses now in process [6, 7].

## 4. Results

According to the objectives and the methodology described, the following results were obtained. Alto Patache fog oasis was mapped in ARC GIS 9.3 with the official boundary and official marks; important sites such as the field station, experimental nursery and the educational site, the location of SFCs, trails, were marked in map together with the local denominations assigned by the team.

Two different climates types according to the Chilean classification can be found in the study area: at the coast, BWn, that is “Desert with Abundant Cloudiness” and BW “Normal Desert”. After the researches done in Patache, a BW fog type of climate for Chile has been proposed. [3]. These maps also include areas of light and dense fog (Fig. 2).

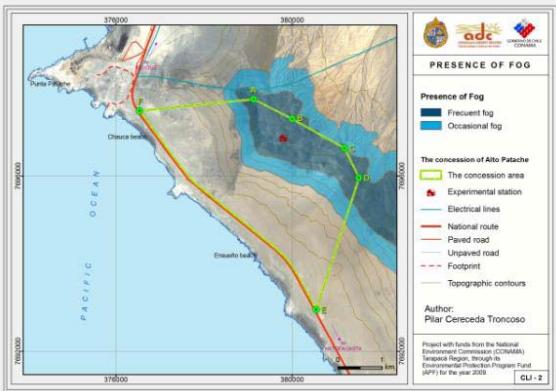


Figure 2: Presence of fog.

Fog oases are located usually near the coast, in mountain slopes, cliffs or plains at altitude between 600 and 1200 m a.s.l. The marine cliff represents a major geomorphic feature near Iquique dated from Upper Miocene age with Pliocene transgression reaching 800-900 m of altitude in Alto Patache area. At the base of coastal cliffs area, sea sandy terraces are found from 0-300 m (Fig. 3).

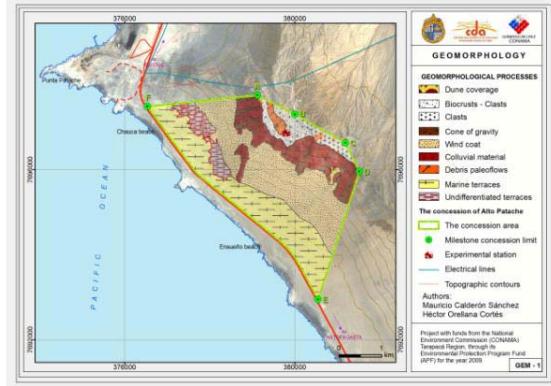


Figure 3: Geomorphology map

The Patache soils from the coastal area were classified as Torriorthent, with sandy texture, low organic matter content and salt abundance in profile

while the soils located at cliff barriers are classified like gypsic and sodic Solonchack, with a 100% base saturation percentage and a 15-52 dS/m of Electrical Conductivity. The traditional land use pattern of these soils is basically used for wildlife, with a land use capacity type VIII and extensive problems of eolic erosion.

A special map shows the different vegetal associations in their exact location in relation to altitude and topography, indicating the species present in the area. The local flora appears only in the foggy area, and their distribution is strongly related to topographical factors such as the relief, exposure to the winds, type of substrate and soils (Fig. 4).

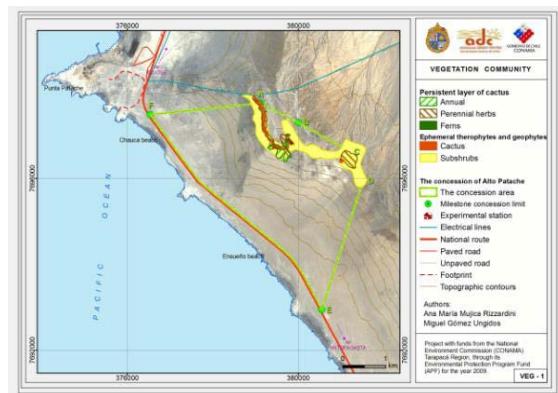


Figure 4: Vegetation map

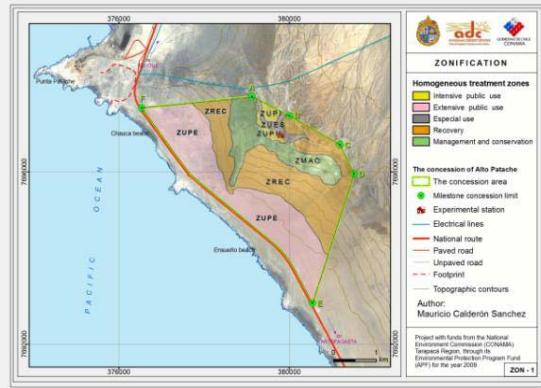


Figure 5: Zonification map

Alto Patache ecosystem shows a variety of shrub and herb species, depending on altitude, type and orientation of relief, plateau or cliff. Furthermore, this geomorphic aspect are relevant in soil types formation with high level of salts, dry profile and scarce evolution, where despite its aridity some cacti, perennials and annual plants occur, generating the “lomas” formations, restricted to fog-zone locations. The results of the surveys were summarized in a map offering a first proposal of management, where 5 homogenous zones were identified: i) intensive public area, ii) extensive public use, iii) special use, iv) recovery and v) conservation (Fig. 5).

## 5. Conclusions

Alto Patache fog oasis has been studied from several viewpoints, since 1997. A set of 12 maps scale 1: 10.000 show the variety of themes so far studied. More than 30 publications (including doctoral thesis) have been edited.

Totally isolated, its fauna and flora reveals a high percentage of endemism. Several species of small arthropods, lichens and soil crusts wait still for a scientific identification. Various insect and flora local species have been identified as new species since 2000. Oasis ecosystem, being very fragile, urgently needs special protection. At present, it shows many plant specimens dying or decaying.

Alto Patache fog oasis suffers nowadays a severe desiccation process due to global heating, decrease of precipitations and probably also to nearby industrial processes contaminating the whole area.

Until present, this northern coastal fog oasis is the only one in Chile to be subjected to diversified studies dealing with geography, archaeology, history, climatology, biology, pedology and specially about the possibilities of community involvement in its use.

The spot, showing a defined new type of climate in Northern Chile, seems particularly apt for environmental education. Hundreds of local school children have been instructed *in situ* on the peculiarities of this fog ecosystem and is open to students of the region, Chile and of the world.

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