

# ASSESSMENT OF COASTAL MEDITERRANEAN LANDSCAPES IN THE ANDALIÉN RIVER BASIN, CHILE

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## I. INTRODUCTION

This study analyzes the Andalién River Basin in the western side of the Coastal Range (36° 42' S and 36° 56' S. 72° 36' W and 73° 04' W), Biobío Region, Chile. This basin drains an area of 775 Km<sup>2</sup> (Jaque, 1996) and is situated near the Concepción-Talcahuano conurbanization, which is the second most populous nucleus in Chile and is important in demographic, industrial, business and cultural aspects (466,409 hab. INE, 2002). Its Mediterranean climate favoured early occupation of the territory and intensive use of its natural resources during economic cycles, developed in Chile and the Region (Cunill, 1971; Guerrero, 1971). In the 16<sup>th</sup> and 17<sup>th</sup> centuries it was a cattle-raising area; in the 18<sup>th</sup> and 19<sup>th</sup> centuries, its principal activity was agriculture (Carmagianni, 1973); and since mid-20<sup>th</sup> century its principal activity is exotic forest plantations (CONAF, 2005). The two most recent economic cycles have been clearly speculative, determined by an intense exploitation of its resources for external and internal markets in short time periods.

Beginning in the 18<sup>th</sup> Century, these speculative economies resulted in the overload of the basin's soils with the early populations concentrated in the upper Basin. In 1885, its population was 8% of the province's total (INE, 1975); at present, it only represents 1% (INE, 2002). Close to 100,000 persons live in the Basin, corresponding to 6% of the regional population; only 10% presently live in the upper and mid Basin, in the coastal mountains, while the remaining 90% are concentrated in the lower Basin (4% of the Basin's territory). Additionally, the urban sector contrasts with the rest of the Basin, where there are important problems of poverty and ecological degradation. From a socio-economic point of view, a large percentage of the poor population is concentrated in this territory with rates slightly higher than the regional average of 20.7%: there is 20.8% poverty in the county of Florida, while the counties of Concepción and Talcahuano located in the lower Basin have poverty levels of 14.7% and 17.6% respectively (MIDEPLAN, 2006). From the environmental perspective, the Andalién Basin is one of the

most degraded areas of the Biobío Region. Indeed, erosion processes are observed in 18% of the Basin, with eroded coverage and extensive badland areas, while only 1.5% of the Region is affected by erosion (Jaque, 1996). According to Cunill, (1971), this degradation would be closely related to the land use. Around 1700, natural vegetation was still present in the Coastal Mountains; after this date, it was increasingly used for charcoal, firewood, and animal grazing. In the context of the present study, geographical systems are conceptualized as landscape units, which form the base of the interpretation of diverse forms of society-nature relations expressed in land use and geofacies, characterising the diverse states of natural medium as products of these relations.

## II. METHODOLOGY

The geographic assessment was studied from the perspective of Geosystems or Integrated Analysis of Natural Systems (Bertrand, 1968, 1978), where large landscape or geosystems were defined by the interaction of two structuring elements of the geographic system, current use and morphology, as well as by the evaluation of the degree of morphogenetic stability. Aerial photographs (SAF, 1992) and seasonal field data collection were used to study the natural system's different components. Geofacies were recognized in each geosystem according to the degree of morphogenetic stability, evaluated according to badland density per area unit and according to the exposure to natural geomorphologic risks. Additionally, the vegetation coverage indexes and their tendency to increase or decrease were evaluated. Geofacies were classified in four types: stabilized in paraclimatic balance; semi-stabilized with progressive evolution; semi-stabilized with regressive evolution; and destabilized or in rexistasy.

## III. RESULTS: THE GEOSYSTEMS OF THE ANDALIÉN BASIN

The study defined five geosystems, within which distinct geofacies were recognized according to the degradation state.

### 3.1. Forestry Geosystem with granitic coastal belts

This geosystem is located in the mid-basin, and is dominated by a hilly relief on the oceanic face of the Coastal Range, consisting in granites and granodiorites from the Palaeozoic Age (González, 1979), which are very susceptible to erosion rain fall processes. It is a recent landscape (< 40 years), which has been able to maintain an important diversity of vegetation with coverage of Laurel (*Laurelia Simpervivrens*), Lingue, (*Persea Lingue*) Roble (*Nothofagus obliqua*) and others (Domeyko, 1835). At present, only a few locations in some of the sub-basins and at the bottom of some gorges present this type of vegetation. In the rest of the area, the moisture conditions facilitate the replacement of native vegetation by rapid growth species, such as Pino (*Pinus Radiata*) and Eucalipto (*Eucaliptus Globulus*), which covered almost 40% of the upper Basin at the end of 2007.

### **3.2. Mixed Forestry-prairie geosystem on platforms granitic**

This Geosystem developed on the relief of the erosion granitic platforms with altitudes between 200 and 300 m.a.s.l. with gentle slopes ( $2.9^\circ$  and  $5.9^\circ$ ), and wavy morphology. This geosystem emerged in the colonial period when cereal crops were planted for exportation, and consequently the more modern elements are from less than 30 years ago and are associated with the first exotics forest plantations. An advanced degree of natural resource degradation, beginning with soil, is observed. Indeed, more than 90% of the basin's eroded areas and the highest badlands density (10 to  $>30$  ha/km<sup>2</sup>) is observed here. The natural forest, which appears as small fragments on the upper platform's hillsides, is being clear cut for use as a fuel and to make charcoal.

### **3.3. Forestry geosystem in process of urbanization on littoral platforms**

This geosystem has a limited extension (763 ha.), is very dynamic, and is located in the lower part of the basin. It has grown on top of the littoral platforms of the lower Andalién River. The platforms' relief has moderate slopes ( $6.0^\circ$  to  $11.9^\circ$ ), especially in the inter-fluvial parts, and this area represents one of the few spaces reserved for urbanization in the counties of Concepción and Penco. Adult pine tree plantations ( $>15$  years) are observed in the extreme northwest portion of the territory. The most urbanized areas are located to the south of the Andalién River with densities between 2,000 and 5,000 hab/Km<sup>2</sup>, while the less urbanized areas are located to the north of the river with densities between 50 and 100 hab/Km<sup>2</sup>. Even though these are not originally apt for urban uses, the physical medium has been adapted using artificial fillings.

### **3.4. Urban geosystem of littoral plains**

This is an urban landscape unit that includes part of the fluvio marine plains of Concepción, the Rocuant marsh, its dunes and littoral belts, the Andalién flood plain and the Nonguén river valley. A variety of uses are found, although urban use is the priority. Its habitat is concentrated, presenting population densities between 5,000 hab/km<sup>2</sup> a 15,000 hab/km<sup>2</sup>, (INE 2002). The most important ecological resources are the estuaries, marsh, lagoons, and swamps, even though they are highly degraded.

### **3.5. Agricultural geosystem of local alluvial plain**

The zones that most retain moisture are located on the alluvial terraces and plains, with slopes of less than  $1^\circ$  and altitudes between 70 and 125 m.a.s.l. These areas have the greatest capacity for agriculture and livestock use. This geosystem presents mixed use: in some valleys there are renewed native forest areas, while the terraces are used for agriculture, gardens, and improved natural prairies. The morphometric, morphological, and natural hazard characteristics are similar throughout the geosystem. In this particular territorial system, some of the limiting factors are due to the topographic and morphological plain conditions, which do not present significant level differences with the fluvial bed ( $< 1$ m.),

facilitating flooding. Additionally, its low position with respect to the surrounding relief acts as a natural receptor of the hills' eroded sediments, fossilizing the soil. Indeed, total suspended solid measurements indicate rates higher than 570 mg/100ml.

#### **IV. DISCUSSION AND CONCLUSIONS**

The geographic assessment presented here, show a high degree of anthropization of the natural territorial systems of this area, and in the Basin's five geosystems. The most stabilized systems correspond to the forestry systems, whose anthropization is more recent. In contrast, the geosystems in rexistasy are associated with strong, long-term agricultural pressures and a particularly aggressive, more recent urban use. In the Basin's territorial system, human action has changed both landscape structures and functions, although the natural medium also limited the development of human activities (Bifani, 1982). The state of the natural systems in the Andalién Basin is due to past use of these landscapes. Humans, with the distinct land uses, have been the most dynamic agents that explain the structural changes in this territory. Indeed, in the Andalién Basin, land use has responded more to the needs of external and speculative markets than to those of local communities. In the 19<sup>th</sup> and beginning of the 20<sup>th</sup> Century, practically all the Chilean frontier region suffered the impact of a pioneer economy, with massive cutting and burning of the native forest in order to plant wheat. In the first years, the yields were high; and when the yields of the first fields began to drop, new areas were colonized. First the Coastal Mountains north of the Biobío River were occupied, and subsequently the Malleco piedmont. The results were similar in these new locations: soil degradation and poverty (Guerrero, 1971, 1973).

The degradation of any natural system negatively affects the production levels as well as the population's quality of life and their attachment to the territory. García Ruiz (1993) stands that population abandoned the Spanish Pyrenees in the 17<sup>th</sup> century because the erosion, due to agricultural and grazing activities, reached critical levels. Migration processes associated to soil degradation and the consequent drop in productivity was also detected by Araya and Gallardo (1991) for the period 1982-1991 in the County of Navidad and by Márquez, (1991) for the County of Melipilla, pointing out that the population dropped in all the County's rural districts for the period 1940-1982. In the Andalién Basin, the population has had a similar response with respect to soil deterioration since its population has constantly decreased since the end of the 19<sup>th</sup> century, reaching 20% for the period 1885-1907. The rate of decrease between 1982 and 2002 was 0.3%, indicating a tendency towards stability of this process. Araya and Gallardo (1991) and Álvarez (1994) indicate that extreme rural poverty is concentrated in the 2.3 million hectares affected by severe erosion. Gálvez and González (1994) also relate ecosystem fragility with low biological productivity and the concentration of poverty and social marginality.

It has been demonstrated that the relation between the natural systems in progressive evolution and in equilibrium and degraded natural systems and with regressive evolution is from 55% to 45%. In other words, in the Basin's total surface area of 77,780 ha., only 38,790 ha are morphogenetically stabilized and with evolution towards an equilibrium state. This environmental situation, which does not necessarily imply pedogenetic evolution, is associated to granite strips and littoral platforms preferentially used for forestry with

exposure to the moist Western Winds. This geosystem's stability is essentially given by the high coverage indexes produced by the forestation even when it is a fragile stability that could be altered when the forests are harvested.

On the other hand, 22.4% of the basin's geosystems' surface area presents regressive evolution, towards a state of rexistasy. If the same levels of intervention and coverage conditions are maintained, these geofacies will form part of the destabilized geofacies. Finally, 14.2% of the Basin's geosystems surface area is in rexistasy or destabilized, and consequently requires management plans to return to equilibrium at a human scale. In sum 36% of the basin's surface area presents factors that limit the development of productive activities, and thus practices which tend to overcome these limiting factors should be considered when planning.

