Research title:

"Environmental assessment of urban river and stream riparian zones and their potential as greenways in Santiago de Chile.

Cases studies of Mapocho River, Macul, De Ramón and Nido de Aguíla streams".

Autor: Alexis Vásquez

1.0. Introducction

In year 2002, almost 9 of 10 Chileans lived in cities (INE, 2002), and all projections indicate that this proportion will continue to increase. For this reason, cities are actually the main ecological niche for Chilean people. In thirty years, Santiago has increased three fold its size (Romero *et al*, 2007), replacing with urban land uses previous agricultural lands, native forests and shrubs, and occupying rivers beds and streams (Romero and Vásquez, 2005). These land use and covers changes have had dramatic environmental consequences.

Santiago de Chile is situated in a fairly closed watershed, surrounded at the eastern side by the high Andean mountain chain with altitudes of 5000 m. and at the western border by the Coastal Range of lower altitudes. From the Andean mountain, a large river (Mapocho), and a set of large and small streams transport water and sediments, often torrentially, towards the Pacific Ocean, located just 250 kilometers from the Andean summits. The streams, canals and rivers are structural components of the Santiago landscape, they should function as key links between urban social and natural system and provide ecological and social services, helping to reduce environmental problems and improve the quality of life.

Traditionally the analysis of river and stream sides had been focused on rural and natural landscapes as well as environmental protection and nature conservation (Hellmund and Smith, 2006). However, nowadays there is an increasing interest and necessity to understand the environmental status, functions and possibilities of riparian zones in urban environments, in order to delineate and plan greenways which provide social and ecological benefits.

Few studies have been conducted to evaluate the environmental status of urban riparian zones and even less to assess these areas in terms of their potential as multi-functional greenways (Miller *et al*., 1998; Conine *et al*., 2004). New efforts should be conducted to improve and complement these first approaches.

2.0. Aim and questions

This research project is focused on the understanding of the environmental state of the urban river and stream riparian zones in Santiago de Chile and the assessment of their potential as urban multifunctional greenways.

In this project, I propose to develop a comprehensive approach to assess the greenway potential of urban riparian zones to provide scientific knowledge as basis for the planning process.

Research questions:

- What are currently the dominant land use patterns along riparian zones and what land use changes dynamic have affected them?

- Which are the current environmental characteristics and functions of the riparian zones, in social and ecological terms?

- How to assess greenway potential so that all the many functions are properly incorporated and the benefits are maximized?

3.0. Material and Methods

3.1. Research Strategy

The research strategy has three main parts, which represent information levels; and each one of them will provide at the same time increasingly complex scientific knowledge about the environmental status of the riparian zones and specific products for the next step.

- Land use/cover changes analysis
- Environmental Characterization
- Greenway Potential Assessment

A key element of the proposed strategy is a vertical organization of information into three levels representing increasing stages of data integration (figure 1). Level I will provide information about the land use/covers evolution in the riparian zone as well as land demands. Level II involves the identification and mapping of raw data for abiotic, biotic, and cultural resources, organized to permit an identification of social and ecological functions as well as the identification of ecological and socio-cultural valuable areas, this level will provide a summary picture as well as a better understanding of current environmental characteristics and function of the riparian zone. Level III is the final integration level and will permit the identification of areas with the highest potential as greenways, this will be performed through a comprehensive method, which involves a greenway suitability analysis, identification of opportunities and constraints as well as the consideration of the land use/cover analysis, the landscape analysis and the identification of ecological and socio-cultural valuable areas performed at level I and II.

The first two levels are focused on the GIS and remote sensing techniques and level III is a more participatory process with emphasis on governance and planning.

3.1. Land Use/Cover Changes

Recognition of land uses / cover changes will be implemented through photo-interpretation, employing the classification proposed by Romero et al. (2007), level 2, amended from CORINE (1990) and Pauleit (2005). Four periods of time will be considered: 1955, 1985, 1992 and 2007.

To analyse the evolution of land uses / covers will be used the Land Change Modeler Module of Idrisi Andes (Eastman, 2004), which delivers data on gains and losses of each category. Besides, it will be used the application V-Late of ArcGis 9.2, to perform analysis based on landscape metrics, such as numbers of patches by category, average patch size and Shannon Index to measure landscape diversity.

Land demands and land use/covers changes can be identified through transition probabilities analysis; information will be provided about development trends that may be threats to some greenway objectives. Having some sense of which areas may get developed in the future can also alert greenway planners about some areas that might be served by future trails or otherwise provide future residents with close-to-home access to nature (Hellmund and Smith, 2006).

3.2. Environmental Characterization

This step involves the description, mapping, and recording of natural, social, recreational as well as cultural characteristics and resources of riparian zones. The latter are organized to permit an identification of social and ecological functions as well as the identification of ecological and socio-cultural valuable areas. This level will provide a summary picture and a better understanding of current environmental status and ecological or social functions of the riparian zones. The thematic maps and outcomes of this step should be the basis for the further assessments and discussions.

Many data sources will be employed, including field work, spatial satellite images, land-use maps, census data, municipal inventories, vegetation distribution and socio-economic statistical information. Information on some of the most important characteristics is available in government's institutions and literature, but many of the critical data for the characterization and further assessment will be developed during the research.

3.3. Greenway Potential Assessment

The Greenway Potential Analysis (level III) is the final integration level and it will permit the identification of areas with the highest potential as greenways, this will be performed through a comprehensive method which involves a greenway suitability analysis, identification of opportunities and constraints, the consideration of the land use/cover analysis, the landscape analysis and the identification of ecological and socio-cultural valuable areas performed at level I and II.

This model is principally based on the development of the Greenway Suitability Analysis (GSA) in GIS environment, which will provide a multiple functions suitability map, it involves identifying sites that satisfy a set of rules or characteristics. This analysis is focused on the structure and characteristics of spatial units.

This map will be modified later to include legal considerations, cultural issues, a landscape level analysis and temporal dynamics analysis.

First, the ecological and socio-cultural valuable areas will be incorporated into the final suitability map; these areas will be identified by focus groups of experts and stakeholders, who will take in consideration the information generated in the environmental

characterization and their own knowledge of the study area. This analysis will focused on recognizing areas that due to their environmental role or performance, complexity, cultural significance or some other condition must be included in the greenway, and due to the nature that GSA cannot be identified.

Also will be included in this map the results of the landscape analysis. This landscape analysis will be assessing the connectivity in an area wider of the 400 meters of the area under analysis and this will permit the identification of nodes (green and transport), routes and areas of high connectivity requirements. This will be done through network analysis and expert opinion, particularly with regard to the demands of connectivity.

Finally, the corrected and final map will be presented to a stakeholders panel as well as the information regarding land use changing trends, relevant legislation, land ownership , flood risks, plans and projects, to identify opportunities and constrains for greenway development. This process will produce the latest changes on the greenway suitability map and provide a description of the key factors to consider greenway planning.

4.0. References

Conine, A., Xiang. W., Young, J. and Whitley, D. 2004. Planning for multi-purpose greenways in Concord, North Carolina, *Landscape and Urban Planning* 68, no. 2-3: 271-287.

Eastman. 2004. IDRISI Kilimanjaro, guía para SIG y procesamiento de imágenes.
Clark Labs, Clark University, USA, pp. 312.

Hellmund, P. and Smith, D. 2006. *Designing Greenways: Sustainable Landscapes for Nature and People*, 2nd ed. Island Press.

INE. 2002. Resultados Generales. Censo de Población y Vivienda, 2002. Santiago, Chile.

Miller, W., Collins, M., Steiner, F. and Cook, E. 1998. An approach for greenway suitability analysis, *Landscape and Urban Planning* 42, no. 2-4: 91-105.

Pauleit, S., Ennos, R., Goldin, Y. 2005. Modeling the environmental impacts of urban land use and land cover change – a study in Merseyside, UK. Landscape and Urban Planning 71: 295-310. Editorial Elsevier.

Romero, H. and Vásquez, A. 2005. Evaluación Ambiental del Proceso de Urbanización de las Cuencas del Piedemonte Andino de Santiago de Chile. Revista EURE de Estudios Urbanos Regionales, Pontificia Universidad Católica de Chile, Vol.XXXI, Nº94, Diciembre 2005: 97-118 pp.

Romero, H., Molina, M., Moscoso, C., Sarricolea, P., Smith, P. and Vásquez, A.E. 2007. Caracterización de los cambios de usos y coberturas de suelos causados por la expansión urbana de Santiago, análisis estadístico de sus factores explicativos e inferencias ambientales. In: Santiago de Chile: Movilidad espacial y reconfiguración metropolitana, Carlos de Mattos y Rodrigo Hidalgo, editores. Pontificia Universidad Católica de Chile.