3 ASSESSING FRAGMENTATION AND DEGRADATION OF DRYLAND FOREST ECOSYSTEMS

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Introduction

Spatial patterns of forest cover can be understood as the spatial arrangement or configuration of forested ecosystems across a landscape (Forman and Godron, 1986).The importance of studying spatial patterns of forest cover is now widely appreciated, owing to the complex link between pattern and process in a landscape (Nagendra *et al*., 2004), and the widely documented effects of habitat fragmentation on biodiversity. As a result, diverse studies have sought to develop measures of landscape pattern that may be used to monitor changes in forest cover (Sano *et al.,* 2009; Shuangcheng *et al.,* 2009; Zeng and Wu, 2005).

According to the driving factors that operate in a given landscape, spatial pattern can present a variety of different behaviours over time. For instance, loss and fragmentation of forest cover are among the most important transformations of landscape configuration occurring in many parts of the world (Carvalho *et al*., 2009; Fialkowski and Bitner, 2008). On the other hand, pattern change associated with forest recovery or regeneration may lead to an increase of forest cover and connectivity (Baptista 2010; **Box 3.1**).

Box 3.1 Landscape features associated with the passive recovery of Mediterranean sclerophyllous woodlands of central Chile

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Although Mediterranean ecosystems are considered global hotspots of biodiversity and priority targets for conservation (Myers *et al*., 2000), they are among the most severely degraded and fragmented ecosystems in the world. In central Chile, land-cover of Mediterranean sclerophyllous woodlands (Chilean matorral) has been significantly reduced and transformed by a combination of human activities including logging, firewood extraction, vegetation burning, agriculture, livestock grazing, and the spread of exotic species of herbivores (Fuentes and Hajek, 1979; Holmgren, 2002; see Chapter 2). Ecosystems that have been highly degraded and extirpated from large areas, such as Chilean Mediterranean forests, are difficult and expensive to restore, especially because of the extremely dry and long summer period and strong impact of herbivory. Both factors, in addition to recurrent fire, can stop or retard successional processes (Fuentes *et al*., 1984). Frequently, severely degraded dryland ecosystems cannot be returned to their pre-disturbance condition without expensive management. The less costly strategies to restore vegetation cover in these ecosystems is to combine the passive regeneration of relatively less impacted areas, resulting from relatively slow natural processes, with active restoration activities that stimulate vegetation change from early successional stages to more mature and diverse forest.

Box 3.1 (cont.)

We assessed the regeneration potential of sclerophyllous woodlands of central Chile (33° S) over 50 years at three sites in the foothills of the Andes and two sites in the Coastal Range, and related the rates of vegetation change to specific landscapes features. Each study site (**Fig. 1**) was a mosaic of sclerophyllous forest and open pastures, with an average 40% of woodland cover and an extension of 700 ha on average (range: 631–911 ha) and had not been burned for at least two decades (1985–2008). Vegetation change was determined by comparison of aerial photographs taken in 1955 and 2007 over a regular grid of 250 m of points using standard supervised classification methods. We considered as evidence of woodland regeneration (1) a change in land-cover for a given point in the grid from bare soil or artificial grassland to forest cover. Persistence of the open cover condition was considered as a lack of forest regeneration (0). Any other observed changes in the vegetation or the maintenance of forest cover were excluded from the analyses. We related the recovery of forest cover to topographic variables (slope, orientation, altitude and exposure to solar radiation), as well as to spatial location of the regenerating patch (distance to the closest forest patch present in 1955, and distance to the nearest ravine). We used spatial regression models to control for spatial autocorrelation among sampling points.

We found an average rate of increase in land-cover of sclerophyllous forest from 0.4–1.0 ha/year. The probability of recovery of forest cover increased significantly at shorter distances from remnant (1955) forest patches, especially on south-facing slopes. This effect may be related to fact that patches can be a source of propagules but their environmental conditions may also facilitate tree seed germination and seedling survival (Fuentes *et al*., 1984, 1986; Holmgren *et al*., 2000). The spatial regression models also suggest that regeneration occurs in patches (at a 250 m scale), which could be related to local differences in grazing pressure, resource availability (nutrients and water) and micro-climatic conditions (temperature and air relative moisture).

Our work shows that Chilean sclerophyllous forest, which is considered strongly resistant to passive recovery from severe disturbance, can grow back in unburned sites under certain conditions. The proximity to existing forest patches or seed sources, slope aspect, and the aggregated patch structure of the vegetation are key features to be considered in the design of successful long-term restoration strategies to promote the passive restoration of Mediterranean sclerophyllous woodlands. The removal of herbivores, if possible, could accelerate the passive recovery of woodland vegetation cover (see also Chapter 8).

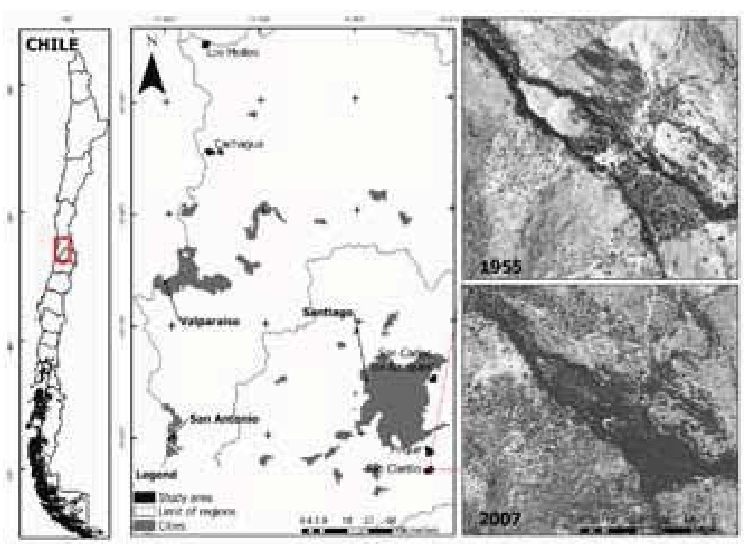

Figure 1 Location of the five study sites in central Chile (Cachagua, Los Molles, San Carlos de Apoquindo, Pirque). The aerial images show vegetation changes between 1955 and 2007 in Río Clarillo. Darker areas represent evergreen forest.