Box 5.10 Tree-seedling establishment in fragmented Mediterranean forests of central Chile

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Mediterranean-type ecosystems are global biodiversity hotspots on all continents. Vegetation cover is extremely fragmented by the combination of natural and man-induced disturbances. Regeneration of these semi-arid ecosystems has proved difficult but can be strongly facilitated by plant-nurse interactions. We studied whether the interaction of micro-climate and herbivores under remnant vegetation patches defines a patch-size threshold for tree seedling recruitment and whether that threshold is dependent on overall climate conditions and plant functional types.

We used a combination of correlational and experimental approaches to investigate this problem. Field observations and experiments were conducted in Andean and coastal Chilean shrublands, representing a gradient in rainfall (350 and 500 mm annual precipitation, respectively). We planted one-year old seedlings of relatively drought-tolerant (*Quillaja saponaria*) and drought intolerant (*Cryptocarya alba*) species under open and shaded conditions considering a gradient of shrub patch sizes (1, 5, 10–15, >30 m in diameter, n = 10 per patch size) and at increasing distances from the canopy edge (5 and 0.5 m outside of the border of the patch, 0.5, 2, 5, 15 m inside of the patch). Half of the seedlings were protected against mammal herbivores (mostly rabbits and horses).

We found no naturally established tree seedlings in the drier foothills of the Andes. In the moister coastal range, seedlings were frequently under the canopy of small and medium-sized shrub patches (5–15 m diameter). Seedlings in open areas were found only at the edge of large shrub patches (>30 m). Herbivore pressure by rabbits and hares is enormous in the Andean foothills where no seedlings survived in the experimental non-protected plots. At the moister coastal range site, herbivore pressure was lower and was further reduced under larger patches. Seedling mortality due to drought stress was reduced under the shrub canopy and significantly decreased with shrub patch size, particularly in the drier Andean site. Large shrub patches are cooler and moister which ameliorates plant thermal and water stress particularly at the drier site. Seedling survival was strongly linked to physiological performance under different water and irradiance conditions.

Our results indicate that shrub fragmentation might be irreversible at the drier end of semi-arid ecosystems as shown in the Andean foothills of central Chile. Conservation of large remnant shrub patches in the landscape, wherever possible, is essential here to facilitate ecological restoration by combining herbivore exclusion and shrub shade. Under moister conditions (coastal sites and wet years), herbivore protection may be sufficient to enhance tree regeneration. In such areas, seedling establishment will also increase along large patch edges and under existing small shrub patches. ENSO events in central Chile increase precipitation to levels comparable to those found in the coastal region, and could potentially increase the probability of seedling establishments in Andean foothills.

Figure 1a, b Discrete shrub patches separated by open areas of herbaceous cover have replaced continuous evergreen shrubland cover in Mediterranean Chile (Photos: M. Holmgren).