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Dendroecology of *Prosopis flexuosa* woodlands in the Monte desert: Implications for their management

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Abstract

In the Monte desert of Argentina open woodlands of several species of *Prosopis* occur in areas with accessible underground water. The great latitudinal extent of the Monte (26–43°S) exhibits strong climatic gradients involving temperature, rainfall seasonality, and wind regime. *Prosopis* woodlands have been a source of subsistence for human communities for several centuries and continue to be exploited by the local inhabitants. The ''mining'' of this resource has led to severe desertification and consequent impoverishment of the local people. In order to suggest strategies for the better management and recuperation of these woodlands we studied the population structure and productivity of *Prosopis flexuosa* from multiple plots at Pipanaco (27°58′S), Telteca (32°20′S), and Ñacuñán (34°03′S). For each plot we measured the density of *P. flexuosa* trees, number of stems, basal diameter (DAB), height and canopy diameter of each tree. Tree ring data were used to determine the growth rates, annual wood production and biological rotation age for each area. The ecological structure of the woodlands differs between the three sites. Along this north–south transect, there is a decrease in adult tree density, mean basal diameter, mean tree height, canopy cover, productivity and total wood biomass. Consequently, the potential sustainable use of these woodlands varies. Only the northern, Pipanaco, woodlands have the potential for lumber production. In contrast, the short, multi-stem and low-productivity trees in the Telteca and Ñacuñán areas can only sustain a combination of local firewood production and activities such as extensive grazing by livestock. The present, uniform regulations for harvesting wood in these areas must be changed to acknowledge these differences in order to optimize wood production in, and conservation of, these woodlands.

Keywords: Monte desert; Arid lands; Wood productivity; Biological rotation age; Woodland structure; *Prosopis flexuosa*

Introduction

Prosopis species dominate the arid and semiarid woodlands of Argentina. The structure and productivity of these woodlands varies between the different biogeographical regions. In the semiarid Chaco the canopy

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cover is almost 100%, whereas in drier areas the structural complexity and the cover of the tree layer decreases (Cabido et al., 1993). In the Monte desert, the drier temperate zone of Argentina, a shrubby steppe dominated by Zygophyllaceae is the typical plant community, while open woodlands of several species of *Prosopis* only occur in areas with accessible underground water. These woodlands are the focus of this study.

The Monte desert is bioclimatically defined as an arid or semiarid region with mean annual rainfall between 30 and 350 mm. Consequently, water is the main limiting factor for growth across the region. This biogeographical region extends over 460,000 km^2 in Argentina, from 24°35′S in Quebrada del Toro (Salta Province) to 44°20′S in Chubut Province; and from 69°50′W at the foot of the Andes to 62°54′W on the Atlantic coast (Morello, 1958). This latitudinal extent of the Monte is characterized by a climatic gradient involving temperature, rainfall seasonality, and predominant wind regime. The northern Monte has 70% of the rainfall in summer whereas precipitation is more evenly distributed throughout the year in the southern Monte (only 19% in summer). Long dry periods of up to 7 months duration may occur in the northern Monte but are very short in the southern Monte. Mean annual temperature varies from 18 °C in the north to 12 °C in the south.

Two different forms of socioeconomic organization coexist in the Monte: a formal economy based on irrigated oases and a subsistence economy in the surrounding arid areas. About 90% of the population lives in the irrigated oases located in valleys with perennial rivers. These oases occupy only 3% of the Monte area (Ministerio de Ambiente y Obras Públicas, 1997).

In the arid areas, *Prosopis* woodlands have been a source of subsistence for human communities for several centuries, and continue to be exploited by the local inhabitants. Woodlands have provided people with shade, firewood, charcoal, timber and food, and domestic livestock with shade and food. The strongest woodland exploitation occurred during the first decades of the 20th century, when the stumps were used as vineyard posts and the wood provided firewood and charcoal for railways and gas for city lighting (Abraham and Prieto, 1999). The exploitation of these woodlands has followed a "mining" philosophy, i.e. there was no attempt to balance the rate of extraction and the rate of renewal of the forest products. Therefore the resources from these *Prosopis* woodlands have effectively "subsidized" the development of the oases without any investment in the knowledge, conservation and management of the *Prosopis* ecosystem. Unfortunately, these arid ecosystems have a low capacity for natural restoration due to the extreme environmental conditions and the present high degradation rate. This has led to a severe desertification and consequent impoverishment of the local people.

In recent years, two strategies have been used to conserve these ecosystems: (1) restriction of wood extraction in some areas, which diverts wood extraction to nearby areas; and (2) the establishment of an arbitrary minimum basal diameter for logging, without any knowledge of the biological productivity of the woodlands. In both cases the ecological and social consequences have been negative.

In order to suggest strategies for the better management and recuperation of these woodlands we studied the structure and productivity of *Prosopis flexuosa* woodlands across a latitudinal gradient that spans a large part of the geographical range of the Monte. We expected that, as a consequence of the different environmental conditions along the gradient, the woodlands would show different population structures and productivity, therefore requiring different management strategies.

Materials and methods

We studied *P. flexuosa* woodland areas at Pipanaco, Telteca and Ñacuñán that experience different environmental conditions along a latitudinal gradient (Fig. 1). Table 1 summarizes the environmental conditions of each area. Population structures of *P. flexuosa* were analyzed in 24 plots at Pipanaco, 34 at Telteca, and 40 at Ñacuñán. The area of each plot varied between 0.25 and 1 ha. Plots were randomly located on subjectively determined homogeneous areas of *Prosopis* woodlands. For each plot we recorded the density of *P. flexuosa* trees and measured the number of stems, the basal diameter (DAB), height and canopy diameter of each tree. From the canopy diameter of each tree we estimated the total coverage for each site. We classified adult trees as those with a basal diameter greater than 7.5 cm.

Synthetic structural variables were analyzed through a one-way analysis of variance and means were compared through a Tukey test for unequal samples size (Zar, 1984).

The presence of annual growth rings in this species allows us to use a dendroecological approach to determine the growth rates (Villalba, 1985). We took core samples and transverse sections of randomly selected individuals ($n = 36$ in Pipanaco, $n = 20$ in Telteca, and $n = 20$ in Ñacuñán) that were mounted, polished and dated following the standard dendrochronological methods (Stokes and Smiley, 1968). As basal area (rather than tree diameter) is linearly related to their economic volume (Cony, M.A. and Villagra, P.E., unpublished data), we estimated current annual basal