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Use of quantitative methods to determine leaf biomass on 15 woody shrub species in northeastern Mexico

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Abstract

The coast of the Gulf of Mexico is characterized by dry regions with a high variation in climatic conditions. This area is rich in drought-tolerant or subhumid species. In order to determine the most appropriate method in evaluating the leaf biomass of 15 shrubs species in a native matorral (thornscrub) of northeastern Mexico, a study was conducted to compare the following non-destructive methods: (1) Adelaide, (2) double sampling or dimensional analysis and (3) double sampling of branches. The non-destructive methods allow indirect relationships between leaf biomass and some ecological characteristics of the plants by using regression models. The methods were used to estimate leaf weight in each species. Ecological and morphological characteristics of these species were determined using a structural analysis. No single standard method estimated leaf biomass for all species on site, because of the diversity of forms in these species. However, Adelaide and the dimensional were the most precise, practical and simplest methods so they could be considered the method of choice for measuring the forage leaf biomass of many shrub species like *Acacia rigidula* Benth. ($r^2 = 0.98$), *Bernardia myricaefolia* Wats. ($r^2 = 0.94$), *Caesalpinia mexicana* A. Gray ($r^2 = 0.92$), *Leucophyllum frutescens* (Berl) I.M. Johnst. ($r^2 = 0.95$) y *Zanthoxylum fagara* (L.) Sarg. ($r^2 = 0.93$), *Celtis pallida* Torr. ($r^2 = 0.99$), *Cordia boissieri* A. DC. ($r^2 = 0.83$), *Parkinsonia aculeata* L. ($r^2 = 0.83$), among other species.

Keywords: Shrubs; Leaf biomass; Structural analysis; Tamaulipan thornscrub; Matorral; Mexico

1. Introduction

The great variability in climatic and edaphic conditions of arid and semiarid zones causes extremely diverse shrublands in terms of the species composition, height, density and plant associations (Battey, 2000; Eviner, 2003).

The various species occurring in the northeastern region of Mexico can be categorized in several groups based on their ecological adaptations and forestry uses. The Tamaulipan shrubland occurs in the state of Nuevo Leon, extending from the coastal plain of the Gulf of Mexico to the southern rim of Texas, USA (Foroughbakhch, 1992; Foroughbakhch et al., 2001).

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Woody plants of shrubberies are an economically important forage source for rural population (von Maydel, 1996). Grazing and fragmentation in large scale has been practiced for 350 years in these areas (Fahring, 2003). This type of grazing, in the long run, results in loss of both quality and quantity of biomass and forage plant species, followed by reduction in the plant layer which covers and protects the soil (Reid et al., 1990).

This situation could only be improved through a management plan under a sound livestock and agroforestry scheme, in which foliar biomass production of the shrubland is related to animal productivity. So far, the animals have received more attention than plants, despite the fact that plants indeed form the basis for livestock exploitation (Blair, 1990). Furthermore, little effort has been done in measuring the foliar biomass production of woody species (Ludwig et al., 1975; Clutter et al., 1983).

To fill this gap, studies are required to estimate forage potential of shrubs on site. Therefore, use of non-destructive methods might be a good alternative for evaluating the production of the leaf biomass of wood producing plants (Grigal and Ohmann, 1977).

In the light of the aforementioned, a study was conducted with the objective of evaluating the non-destructive methods to quantify leaf biomass of 15 woody plant species of Tamaulipan thornscrub. Another objective of this research was to determine whether or not the precision level of these methods varied with morphological characteristics of the species under study.

2. Materials and methods

2.1. Description of the study area

The experimental area is situated on the plain at 430 m altitude in the piedmont of the Sierra Madre Oriental in Mexico (24°27′ north latitude and 99° 32′ west longitude). Originally all the area was covered by the typical tamaulipan thornscrub dominated by woody plants, which was mainly cleared to support cattle production and crops. Some areas with permanent matorral were conserved as reserves and those that have been used for forestry and silvopastoral vegetation dynamic and ecological studies.

The climate is semiarid with two rainy seasons (summer and autumn) and a dry spell between November and April. Mean annual precipitation is 749 mm (Foroughbakhch, 1992). Mean annual temperature is 22.3 °C with temperature over 40 °C during the summer, and frost from December to March. The water budget is unbalanced. The ratio of precipitation to free evaporation is 0.48 and precipitation to potential evaporation is 0.62.

Most soils of region are of rocky type of Upper Cretaceous calcite and dolomite. The dominant soils are deep, dark grey, lime-clay vertisols which are the result of aluvial and coluvial processes. They are characterized by high clay and calcium carbonate content (pH 7.5–8.5) and low organic matter content. Analysis of major nutrients reveals phosphorus and nitrogen deficiencies. Such soil can be 3 m deep or more and are preferred for agricultural seepage. Underground water is hard, but non-saline.

2.2. Selection of shrub species

The choice of species was made only after careful consideration of their ecological importance, uses and preference by the rural population. The tree species selected to determine foliar biomass and structural analysis, were: *Acacia berlandieri* Benth., *Acacia farnesiana* (L.) Wild., *Acacia rigidula* Benth., *Amyris texana* (Buckl.) Wilson, *Bernardia myricaefolia* Wats., *Caesalpinia mexicana* Gray, *Celtis pallida* Torr., *Cordia boissieri* DC., *Helietta parvifolia* (Gray) Benth., *Leucophyllum frutescens* Johnst, *Parkinsonia aculeata* L., *Ebenopsis ebano* (Benth.) Coulter, *Prosopis leavigata* Torr. *Viguiera stenoloba* Blake, and *Zanthoxylum fagara* (L.) Sarg (Table 1).

All the species used in the investigation are native to arid and semiarid zones.

3. Structural analysis

The three methods for leaf biomass estimation employ mathematical equations that require some relevant quantitative data related to the characteristics of the structure of the vegetation, such as the tree total height, tree canopy projection, number of branches and their diameters. The data on the structural analysis for this work was obtained by standard dendrometric