

Agroforestry Systems in the Sonora River Watershed, Mexico: An Example of Effective Land Stewardship

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Abstract.—The Sonora River watershed is located in the central part of the state of Sonora, Mexico, and is one of the most important watersheds in the region. Much of the state's economy depends on the natural resources, products, and productive activities developed in this watershed. Many natural areas along the river and its tributaries have been converted to a large variety of agroforestry systems, providing the inhabitants of the region with food, timber, medicines, economic inputs from agricultural crops, forage for livestock, and services like recreation. Land tenure forms are private and communal properties. Private owners use more advanced technology being dedicated to more extensive and intensive exploitation activities. Communal producers usually rent their lands or get little income from their land use activities.

Introduction

Watersheds are geographic areas that are often rich in natural resources that provide inhabitants with food, medicines, construction materials, and recreation. However, the spatial distribution of these resource types does not necessarily follow a uniform pattern within a watershed. This is caused by climatic, edaphic, and physiographic conditions varying irregularly from upland origins of a watershed to the discharge zone, generating a mosaic of ecosystems, each providing resources destined to different types of utilization.

According to Young (1994), the term *agroforestry* refers to sustainable land-use systems in which woody perennials are grown in association with herbaceous plants, and/or livestock, generating ecological and economic interactions between the trees and the other components of the system. Although the agroforestry system concept is well known and has been applied in many geographic areas throughout the world, its potential has not been fully explored in the drylands of Sonora, Mexico. Although producers practice agroforestry in distinct ways in this region, they have not fully perceived the role of such production systems in terms of productivity, socioeconomic importance for rural communities, and significance for wildlife species and recreational activities. They also are not familiar with methods to classify their

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agroforestry systems based on how the elements of the system are distributed.

The objective of this study was to characterize the agroforestry systems along the Sonora River watershed, contributing to the understanding of the potential these systems have in improving the living conditions of the inhabitants, and to encourage the utilization of the natural resources in a more efficient and sustainable manner.

Watershed Description

The Sonora River watershed is located in central Sonora, covering an approximate area of 26,010 km² of state land. Mean annual precipitation for the area is 375 mm, which occurs in late summer-early fall and winter-early spring. Slopes along the river range from steep in the upper part, to gradual in the valleys (INEGI 1993). The watershed supports a variety of vegetation types defined largely by latitudinal, elevation, temperature and precipitation gradients. Considering Brown and Lowe (1994) criteria, five biotic communities are found in the area. In order of importance by area covered, these are the Sinaloan thornscrub, plains of Sonora subdivision, semidesert grassland, Madrean evergreen woodland, and central gulf coast subdivision. The watershed is subdivided into six smaller watersheds. This study was carried out in the largest subdivision, which occupies 45% of the entire watershed; it is approximately 300 km in length and about 11,690 km² in area (figure 1).

Natural Resources

A variety of natural resources are found in the study area. This allows the application of different land-use options to local inhabitants for exploitation. Native and introduced species of flora and fauna, minerals, freshwater reservoirs, and thermal water springs represent the usable resources in the area. Vegetative communities are mainly used for livestock grazing, as a source of firewood

Sonora River Watershed

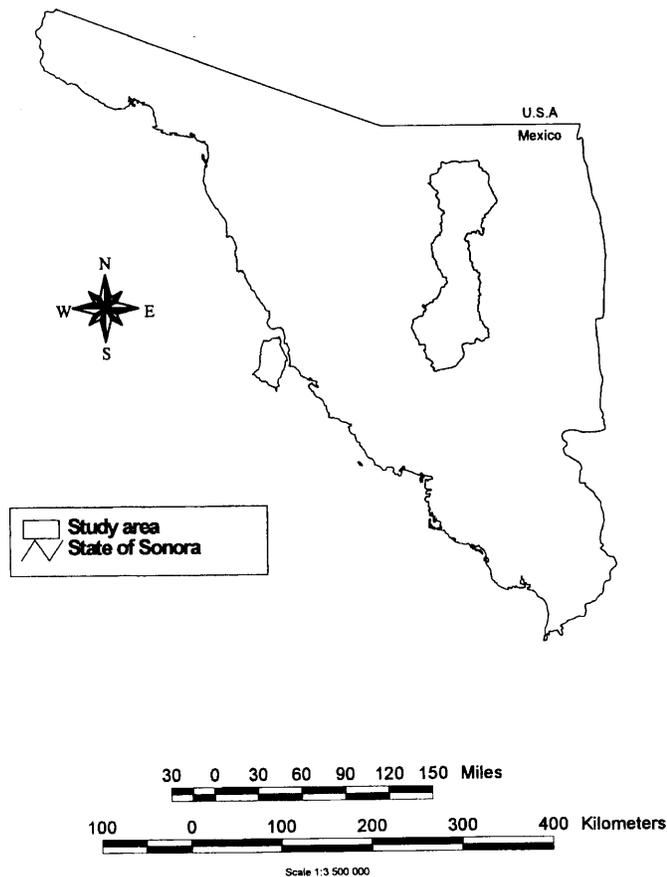


Figure 1. Location of study area.

and local construction materials, and recreational activities. The ranchers commercialize with cattle, milk, and cheese, and some also exploit native and exotic wildlife species by selling hunting permits to Mexican and international hunters. Mining activities are important in the area, especially copper extraction from the mine at Cananea City. This mine generates hundreds of jobs for local and regional inhabitants. Freshwater reservoirs and the river itself are places where people fish or spend their leisure time. A thermal water spring located in Aconchi, in the central part of the watershed, was remodeled by the state government and currently serves as an additional public recreational place within the watershed.

Agroforestry Systems

Most of the agroforestry systems found in the study area are along the riparian areas, with the exception of

some grazing lands that occur in the uplands or small valleys away from the river floodplains. Native tree species, such as willow, mesquite, and cottonwood, are used to define the boundaries of land properties and as wind-breaks. Other non-native tree species like pecans are also serve this function. Most of the plant species utilized as medicine, food and forage, are exotics. Only a few native species are exploited in these ways.

Classification

There are different criteria on how agroforestry systems can be classified. One set of criteria are based on functional, structural, ecological and socioeconomic bases (MacDicken and Vergara 1990, Nair 1993, Ffolliott et al. 1995). Agroforestry system classes can change in time according to the method of utilization. Therefore, agroforestry crop rotation systems (shifting cultivation) differ in time from permanent systems (Ffolliott et al. 1995). Agroforestry systems established along the Sonora River watershed are largely productive systems with a commercial criterion. However, some of them are subsistence systems. There are agrisilvicultural, agrosilvipastoral, and silvipastoral systems in the study area. Agrisilvicultural systems are characterized by native trees surrounding croplands, while agrosilvipastoral systems are represented by irrigated pastures fenced by native tree species, and non-irrigated pastures where introduced grasses like *Cenchrus ciliaris* (buffelgrass) grow in association with native vegetation. Silvopastoral systems are characterized by native trees, shrubs and grasses all supporting ranching activities.

The spatial arrangement of the elements within the agroforestry systems vary from a complete mixture of plant species to a well defined monoculture surrounded by trees. There are systems represented by a random mixture pattern of components (often characteristic of silvipastoral systems); irrigated pastures planted with a mixture of grass species, fenced off by trees; or areas where people grow flowers, fruit trees, vegetables, and medicinal plants simultaneously or shifted in time. Other producers establish plantations following a regular pattern represented by alternate rows or alternate strips, combining fruit trees (different varieties of citrus, peaches) with maize, beans or vegetables. Agroforestry systems such as monocultures of vegetables or grasses bordered by trees are also established in the study area. Some systems display a mosaic of different agroforestry components. For example, part of a individual's property can show a regular pattern of alternating rows or strips or both, while other pieces of land included cultivated plants following a random mixture pattern; this is common in areas known by the local people as *Huertos Familiares* (orchards for the family).

Technological Inputs

Capital-intensive commercial plantations are farmed using modern technology. The application of pesticides and fertilizers is common, and many farmlands are cultivated, irrigated, and harvested with advanced machinery. Subsistence agroforestry systems, in contrast, are farmed with hand tools and irrigated by small channels with water diverted from the Sonora River and local wells. Fertilizers, herbicides, or other agrochemicals not used in these systems, which are labor-intensive in operation. Weeding and harvesting of products from these subsistence systems is accomplished mostly by hand.

Socioeconomic Considerations

Farmers, ranchers, and homeowners were interviewed to gain a better understanding of the local socioeconomic conditions. Most of the inhabitants can be grouped in a communal-type of land tenure called *ejido*. Some ejido members work together over the entire area of the ejido; after the commercialization of the products, they divide the profits. In other ejidos, the members own individual pieces of land, which can be exploited or rented to other farmers to obtain income. There are also private-property owners of farmlands and rangelands. These owners tend to be the producers with higher technical education (agronomists, veterinarians, and livestock breeders) and the users of more advanced agricultural equipment and technologies. They also rent tracts of land from other farmers to extend their areas of exploitation. For these reasons, private property owners have the highest economic incomes within the watershed.

The majority of the products derived from the agroforestry systems of the watershed are sold *in situ*. The producers do not need to transport their animal or plant products to markets away of the closest towns because buyers coming from big cities (Hermosillo, Cananea, and Agua Prieta) acquire the products directly from them. Sometimes, the ranchers transport calves to the border and export them to the United States.

There are regional and state associations that group producers from rural areas into more economically efficient bodies, and provide them with advise on how to get bank credits, low-cost inputs like fertilizers and pesticides, and implement better land management practices and crop production; this enables participants to commercialize their products locally or outside the state or the country. Unfortunately, the smaller farmers are not participants in these kind of associations. Only people largely dedicated to cattle industry are organized and grouped in regional and state organizations, for example, the Asociacion Ganadera Local and Union Ganadera Regional de Sonora, receiving advisory services in range manage-

ment and cattle production and animal and products commercialization, among other benefits.

Conclusions

A variety of agroforestry systems furnish the people of Sonora with opportunities to generate needed incomes while sustaining a high level of environmental quality. These agroforestry systems have been matched to the capabilities of the land to produce commercial and subsistence outputs. Relatively low levels of capital investments in some of these agroforestry systems allow almost all the people living in the Sonora River watershed to actively participate in these multiple-cropping interventions. This integrated form of sustainable land stewardship will continue, and likely will expand in the region into the 21st century with increasing technological inputs.

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