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Processing, Utilization and Economics of MESQUITE pods as a Raw Material for the Food Industry

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presented by

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A WEED IS A PLANT, WHOSE VIRTUES
HAVE NOT YET BEEN DISCOVERED

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"I left my heart in San Francisco....."

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1. INTRODUCTION

1.0. Overview

MESQUITE (Prosopis spp.) is a leguminous plant that occurs all around the world in arid and semi-arid zones. The plant grows wild, requires very little water and is capabable to fix nitrogen.

Depending on the specie, as well as the specific climatic situation, MESQUITE develops as a small brush or as a tree of a height of several meters.

MESQUITE produces an annual crop of pods which fall to the ground when ripe. The pods were an important staple food for former cultures in North- and South-America as well as in Asia. The pods were usually ground in mortars and the flour processed into several different products, such as flatbreads or fermented drinks.

In modern times the importance of MESQUITE as a food or feed became nil, due to several reasons:
a) MESQUITE is a weed that -if not controled- can infest grassland in semiarid regions.
b) MESQUITE pods have a very complex and tough morphological structure; no attempts have ever been made to develop a milling and separation process for the pods.
c) MESQUITE pods as an agricultural crop could never match the purely economical criterias of a modern crop.

Only in the last couple of decades man has begun to look at plants (and animals) as part of a complete ecological system where a "weed" suddenly becomes an important factor in the system.

When chemical studies revealed that MESQUITE pods contain a very high amount of sucrose as well as high-protein and galactomannan-rich seeds, some researchers started to consider its use as a food crop again. The increasing under-supply of food in lesser developed countries in arid zones also led to incresed efforts to the establishment of local crops.

Therefore, this work concentrated on the development of a milling and separation process for MESQUITE pods, and on its utilization as a food raw-material. It has been the intention to come up with a immediately realizable model for MESQUITE processing and utilzation along with the consideration of the economical aspects.

1.1. Botany of MESQUITE

1.1.1. Taxonomy, patterns of variation

Among the legumes, the genus Prosopis (common name: MESQUITE) belongs to the subfamily of Mimosideae. There are 44 known species, but only one still exists in tropical Africa, where MESQUITE possibly originated. From there,the ancestors of present day Prosopis may have migrated to east and west during the continental drift at the end of the Mesozoic or the beginings of tertiary times (1).

To identify the correct Prosopis species in the field can be an extremely difficult task, even for someone who thinks he knows MESQUITE, since Prosopis plants can be small shrubs or short trunked trees but can even develop into 20 m tall trees, all depending on the species and/or the availability of water (2).

There are not only differences in size or shape of the tree; even more astounding may be the differences of the pods. They may be 2 cm long curled pods with the characteristic name "screwbean" (P.pubescens) or up to 13 cm long brown pods of P.chilensis, which might almost be confused with the fruit of a carob tree (Ceratonia siliqua).

The thorns are yet another variation. Some species have nasty long thorns which led to proposals to use MESQUITE as a natural barbed wire fence around military installations. The thorns have even caused viscious infections (3). However, there are also species which produce no thorns at all.

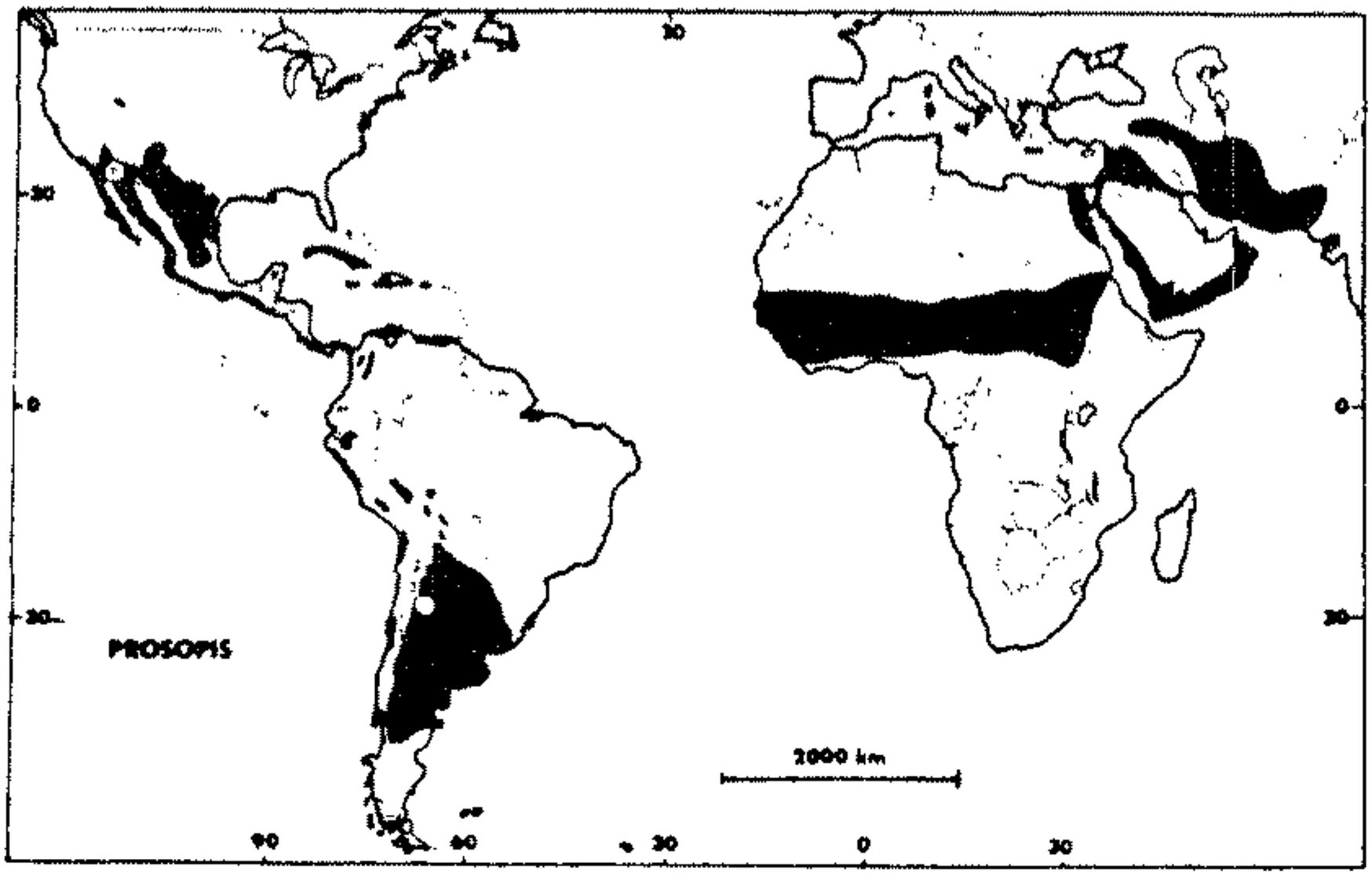
On top of all this variability, Prosopis crossbreads among species, and it is therefore often almost impossible to determine with which specie one is dealing.

1.1.2. Adaptation to environmental conditions

MESQUITE covers 35 million hectares in the United States alone, and is found all around the world in arid and semi-arid zones (Figure 1).

Harsh conditions like extreme temperature, drought, poor soil quality and wind in arid and semi-arid zones pose severe constraints on the growth of a plant. To overcome these problems, MESQUITE possesses special features in the morphology and physiology of its roots, conducting system and leaves.

Figure 1: Worldwide distribution of Prosopis species (14)



The potential water reservoir available to MESQUITE is large compared to other desert shrubs. The trees develop two different rooting system. Tab roots which use ground water (if there is any) have been reported to reach 80 m deep (4). There is also a lateral rooting system, which can extend to 20 m from the tree (5).

Some species can even absorb moisture (dew) through their leaves and translocate it to the roots (6). On the other hand the water losses are minimized by the ability of Prosopis spp. to fold their leaflets together at midday (7).

Some Prosopis species have been found to perform crassulacean acid metabolism (CAM), where the plant closes its stomata during the day to prevent moisture loss and fixes nitrogen at night (60). In addition, Prosopis is capable to absorb water held with high matrix forces and to carry on photosynthesis at xylem water potentials of less than -40 bars (8). The reported figures for water use efficiency differ from 250 water/kg dry matter (9) to 19 700 kg water/kg dry matter (10). The range points out the enormous genetic potential that exists in MESQUITE.

MESQUITE also has the ability to tolerate highly saline conditions. Certain species can grow through a salt crust of several feet (11), and others tolerate a pH value of 9.5-10.0 and a soluble salt content of 0.54-1.0 % which is even better than Acacia arabica (12).

It has been shown that Prosopis spp. are capable to fix nitrogen and are therefore able to grow even in nitrogen-free soil (13).

Not surprisingly, MESQUITE prefers hot temperatures. Optimum shoot growth occurs at 29°C (15), whereas most species do not survive frost at -5.6°C (13).

1.1.3. Pods

As much as the appearance of the tree from different species varies, as astounding is the diversity in size and shape of the pods.

To demonstrate the range of the differences, four species shall be looked at more closely (Figure 2):

P.velutina: The pods are about 10-15 cm long, slightly bent and of a light brown to yellow colour.

P.chilensis: Pods are up to 20 cm long, quite fleshy and light to dark brown. They resemble the pods of the carob tree.

P.tamarugo : Length of the pods about 3-5 cm, slightly brown color.

P.pubescens: Twisted pods, about 5 cm long pod. Their common name "screwbean" is descriptive of the bean, which is screw shaped.

Inspite of these obvious differences, all the pods have certain identical characteristics as well. They are indehiscent and have a similar botanical structure (pericarp/seed; see chapter 2.2.)

1.1.4. Fruit growth and dispersal

MESQUITE trees usually start to carry pods at the age of three to five years and reach a maximal production from year eight to fifteen (16).

Figures 3-6 show the pod-development from flower to the ripe pod of Prosopis velutina. The pictures were taken in the Imperial Valley in Southern California.

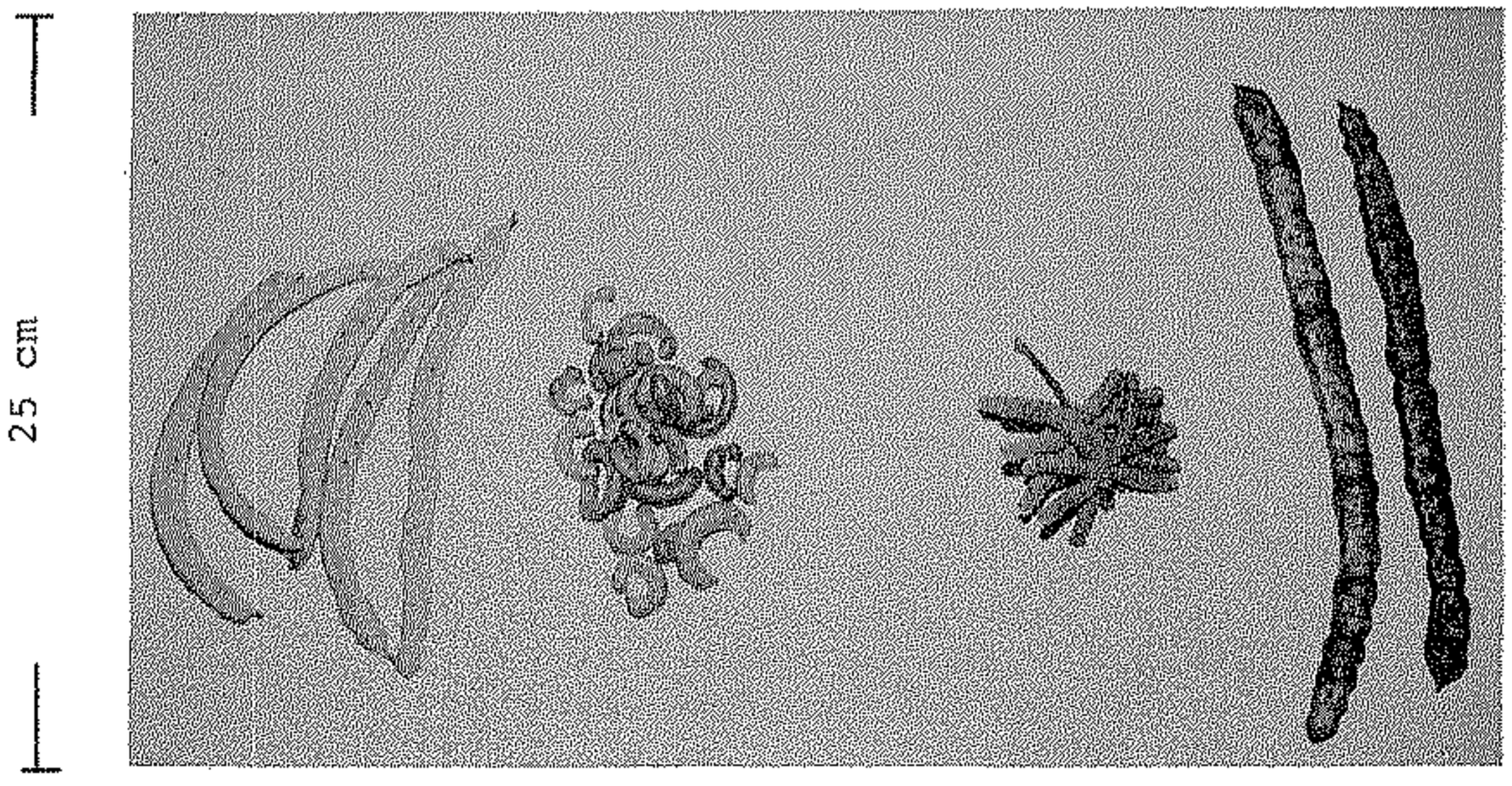
Like all members of the Leguminosae, species of MESQUITE produce their seeds in pods, though unlike many other legumes, the MESQUITE pods do not split open at maturity (indehiscent).

In nature the seeds would never be able to germinate lying on the dry ground. The reproduction cycle requires either mechanical scarification or the involvement of animals. The pods are avidly eaten by coyotes, rabbits, sheep and other mammals, which seem to like it because of its sweetness. Examination of scats of wild animals and feces of domesticated cows and goats reveal that up to 91 % of the seeds pass through the digestive tract of these animals unharmed (20).

This system serves multiple functions in that the seeds are dispersed away from the parent tree (which avoids competition of new plants for the limited water in arid regions); the digestive fluid kills the internal seed parasites and partially hydrolyses the seed coat. Excreted with the moist and mineral rich manure, the seeds are then in a ideal fertilizer. Under these conditions, seeds can then germinate after only six hours at 34 C (17,18).

It could be shown (19), that this natural system provides a much higher germination rate than any other mechanical or chemical treatment of the seeds.

Figure 2: Pods of different MESQUITE species



Figures 3-6: The development of MESQUITE pods from the flower to the ripe pods

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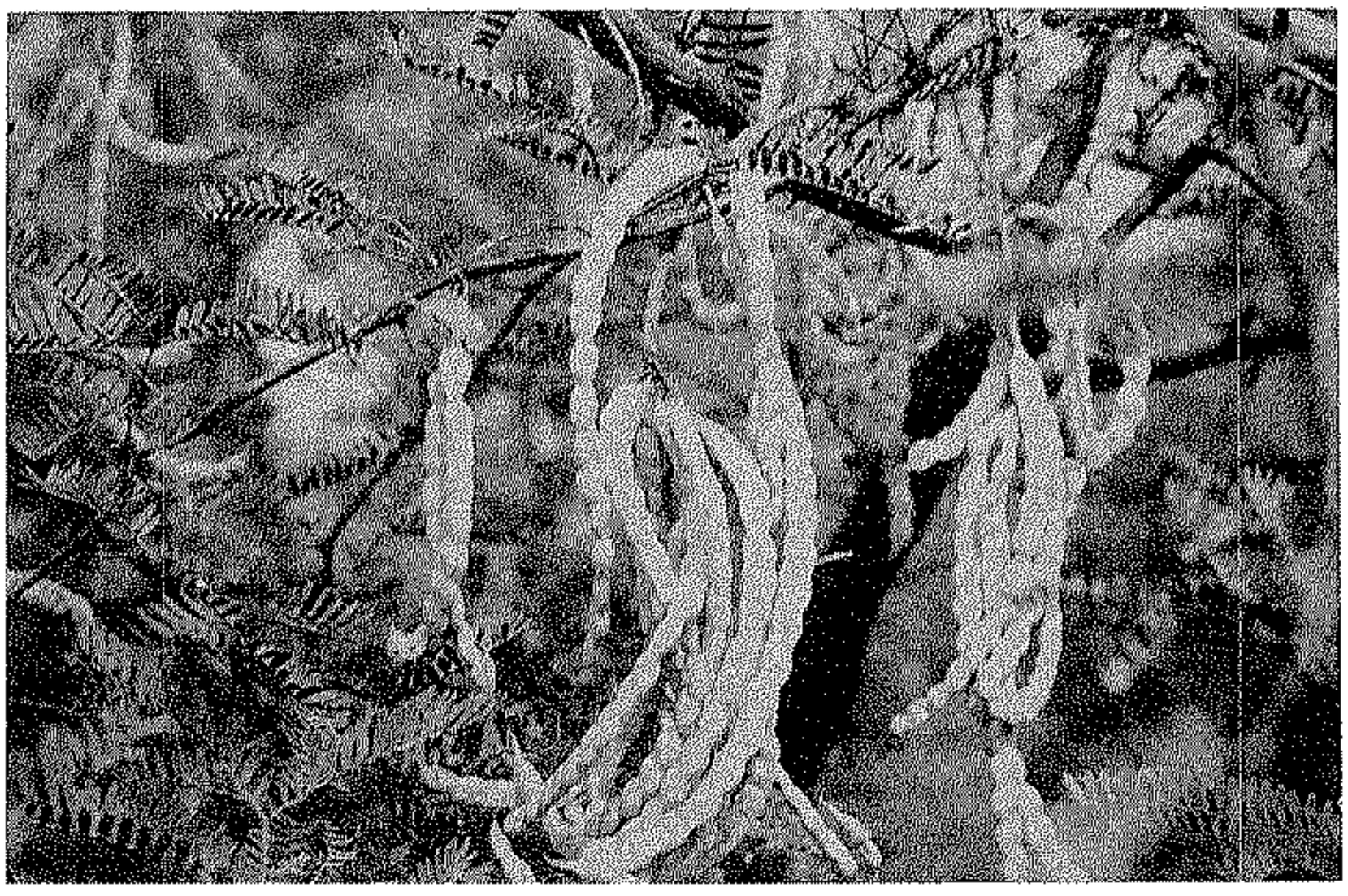


1.2. MESQUITE in the ecosystem

1.2.1. From weed to blessing

The image of MESQUITE varies widely: from a profit robbing nuisance to a valuable asset to mankind, depending upon **who** is asked, and **where** it grows.

In the United States, especially in Texas, where MESQUITE grows on an estimated 22.7 million hectares (20), most ranchers desire to eliminate it from their rangeland because it competes strongly with desirable forage. Nevertheless the attempts to get rid of MESQUITE have not been very successful. All methods i.e. fire, herbicides orbulldozing destroy most of the desired vegetation as well, and since MESQUITE seems to be one of the toughest of all plants, it is the first that reoccurs. As a result, the surface coverage of MESQUITE increased dramatically in the last two centuries (21).

In other countries of the world, MESQUITE was and still is, a highly welcome plant. Therefore, plantations have been established (Saudi-Arabia,Chile) for the following different reasons:
-Trees stabilize sand dunes, stop desertification and provide shade
-The pods are used as feed for animals and the wood can be utilized by people in such regions as lumber

A typical example of the bias effects of MESQUITE has been reported from India. A row of MESQUITE had been planted along a jowar plantation. It was observed, that the growth of the field crop was reduced along the MESQUITE belt, but its function as a shelter belt against wind and sand increased the crop on the whole orchard by a factor of 1.5 to 2 . Thus MESQUITE is now recommended as shelter belt on farms (22).

Figure 7 illustrates the general role of MESQUITE in the ecosystem, which is one that would fit almost exactly the requirements of a plant to be used in a concept of "Three dimensional forestry" (23). The following chapters explain certain aspects in more details.

1.2.2. Feed for animals

Many properties of Prosopis fruits and characteristics of their production make them an important resource for numerous animals. The pods being predictable, abundant, nontoxic, and highly nutritious, naturally attract numerous herbivores, many of which destroy the seeds, but the only invertebrates known to use the pods as a food source are insects.

Insects that feed on Prosopis can be divided into two groups, those that feed from the outside and those that feed inside the fruits (24). Mozena obtusa (the hemipteran leaf footed bug) is one of the most abundant external fruit feeders in North America (25). Its damage to the honey MESQUITE in Texas was estimated at 50% of the potential fruit production (26).

Long-horn beetles of the genus Lophopoeum are known to develop inside the pods in Argentina and to consume all of the seeds within the pods while developing. The same damage to MESQUITE pods is done by members of the bruchid family, which are by far the most numerous and best known insects that use Prosopis pods as a food resource (27).

Many wild and domesticated mammals, birds and reptiles are also known to feed on MESQUITE leaves and pods. The following list is not ment to be complete:

Desert cavy, leaf eared mice, hare, jackrabbit, coyote, deer, armadillo, fox, goat, sheep, cow

For many of these animals, MESQUITE pods can be a big part of their diet. It has been reported that jackrabbits can get more than 50% of their calories from them (28).

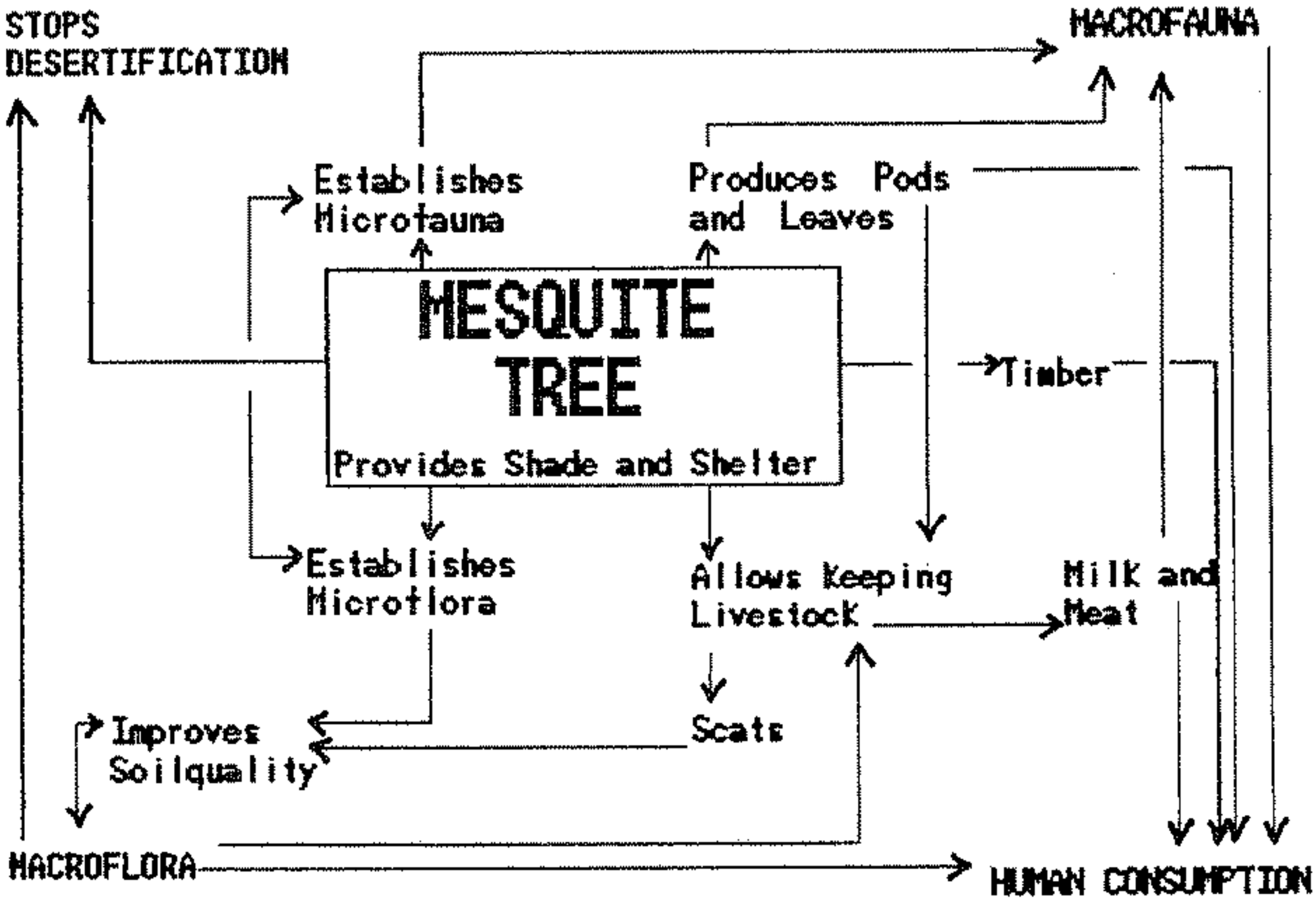
The elimination of MESQUITE can even be responsible for the abundance of animals in certain aeras, as it was observed for scaled squails in New Mexico (29).

Today, many farmers in Central and South America as well as in the Far East use MESQUITE pods in feed mixtures for their livestock. Results of feeding studies showed that up to 20% of the feed can be substituted economically with MESQUITE pods with no deleterious effect on growth of calves (30).

Even in Hawaii, the pods from Prosopis pallida (Kiawe) were of great value prior to the development of inexpensive bulk bin containers for trans-pacific shipment of feedstuff. The pods were often the only available feed during the dry season for dairy cows, cattle horses, donkeys, pigs and chicken (31).

The MESQUITE tree itself is perhaps even more important than the pods. Through its shade and shelter which it provides for animals in the desert and arid zones, the tree is a basic condition to actually establish some livestock.

Figure 7: The role of MESQUITE in the ecosystem



1.2.3. The role of MESQUITE in ancient and modern cultures

A great deal of information is available about the use of MESQUITE by ancient cultures in North and Central America.

The Sonoran Desert which stretches from Southern Arizona to North Western Mexico might be one of the location where MESQUITE played an extremely important role. MESQUITE may have been the second most important staple food to Indians like the Hohokam, who occupied Southern Arizona from about 300 B.C. to 1450 A.C.(32), the Pimas (33), the Mescalero-Apaches and the Seris.