Guayule, Jojoba, Buffalo Gourd and Russian Thistle: Plant Characteristics, Products and Commercialization Potential

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Introduction

One-third of the world's total land surface is arid and about half of this area is so dry that it cannot support human life. Approximately 14 percent of the world's population, or 630 million people, live on the world's arid and semiarid lands. The factor common to all the arid areas of the world is climatic variation especially in amount of rainfall received.

Arid-adapted plants have evolved some unique properties to survive in arid environments. Some store water, others mine groundwater and numerous plants drop their leaves and become dormant during droughts. Ephemerals avoid the dry seasons altogether. After adequate rains they germinate, mature, flower and produce seeds during the brief time that soil moisture is available.

Recently some of these plants have been shown to have economic potential as new crops in the southwestern United States. Such plants can be divided into five general categories: 1) food for man and fodder for livestock; 2) wood products for construction and manufacturing; 3) fiber, for various uses; 4) extracts that may provide a variety of materials such as gums, waxes, rubber and pharmaceuticals; and 5) solid and liquid fuels.

This paper discusses four such plants, their products, and their potential for commercialization. These include guayule, a rubber-producing plant; jojoba, an oil-producing plant; buffalo gourd, an oil-, protein- and starch-producing plant; and Russian thistle, a solid-fuel producing plant. Table 1 summarizes potential products, life cycles, cultural operations and levels of commercial development of these four plants (Taylor, 1980).

Description of Plants

Guayule

Although approximately 2,000 species of plants are known to contain some kind of latex, few are potential sources of significant supplies. Only two, the rubber tree (*Hevea brasiliensis*) and guayule (*Parthenium argentatum*), have been commercial sources of natural rubber. The modern rubber products industry has been based on *Hevea* production, but guayule and *Hevea* yield rubbers that have similar characteristics.

Approximately 70 percent of the total rubber consumed in the United States is used by the tire industry. Increased use of radial tires, which require more natural rubber than conventional tires, is expected to increase the demand for natural rubber (Foster et al., 1980)

Guayule grows naturally on upland plateaus in northeast Mexico and west Texas (Figure 1). Figure 2 shows a natural stand of guayule growing in Mexico. Precipitation on these plateaus is limited and erratic. In 1910, guayule rubber provided 10 percent of the world's natural rubber supply and it continued to be a minor, commercial source of natural rubber for nearly 40 years.

During World War II, a guayule-growing program, the Emergency Rubber Project (ERP), was conducted by the U.S. Forest Service in the Salinas Valley of California. Thirty-two thousand acres of guayule were planted to offset wartime loss of *Hevea* rubber imports (McGinnies, 1978). The ERP's survey of the southwestern United States indicated that 37 million acres in California, Arizona, New Mexico and Texas were suitable for guayule production.

Guayule rubber production ceased between World War II and the 1970s because of the development of cheaper synthetic elastomers and the reinstitution of open international

Table 1. Potential Economic Arid-Adapted Plants

Plant	Scientific Name	Life Cycle	Parts Used	Products	Cultural Operations	Level of Commercial Development
Guayule	*Parthenium argentatum*	Perennial	Whole Plant	Rubber, Resins	Mechanized	Relatively Advanced
Jojoba	*Simmondsia chinensis*	Perennial	Seed	Liquid and Hard Wax	Hand Labor/ Mechanized	Experimental/ Demonstration
Buffalo Gourd	*Cucurbita foetidissima*	Perennial	Seed and Roots	Protein, Edible Oil, and Starch	Mechanized	Experimental
Russian Thistle	*Salsola kali*	Annual	Above-ground Portion	"Tumblelogs" or Pellets for Energy	Mechanized	Experimental/ Demonstration

trade of *Hevea* rubber. The escalation of crude oil prices since 1973 is increasing the costs of synthetic rubber since oil is the primary feedstock for synthetic rubber. Concurrently, *Hevea* rubber prices have also increased. The increasing costs of available rubber supplies caused guayule rubber production to be potentially competitive with *Hevea* rubber during 1979-1980. It was estimated that guayule rubber could compete when costs of *Hevea* rubber reach $.90 per pound (Taylor, Wright and Foster, 1981). Natural rubber prices in 1980 briefly exceeded $.80 per pound, but are now fluctuating between $.40 and $.45 per pound on the New York market. Annual yields with current technology are projected to be about 500 pound of rubber per acre with a three-to-four year harvest cycle.

Guayule by-products include resins that may prove to have substantial economic value. The bagasse, or plant residue from processing, has sufficient estimated energy value to power an energy-independent processing facility (Nivert, Glymph and Snyder, 1978).

Guayule rubber occurs as a liquid suspended within the cell sap throughout the stems and roots of the guayule plant. Rubber can be extracted in a dispersion of the latex by solvent extraction or it can be agglomerated as a resinous or deresinated rubber.

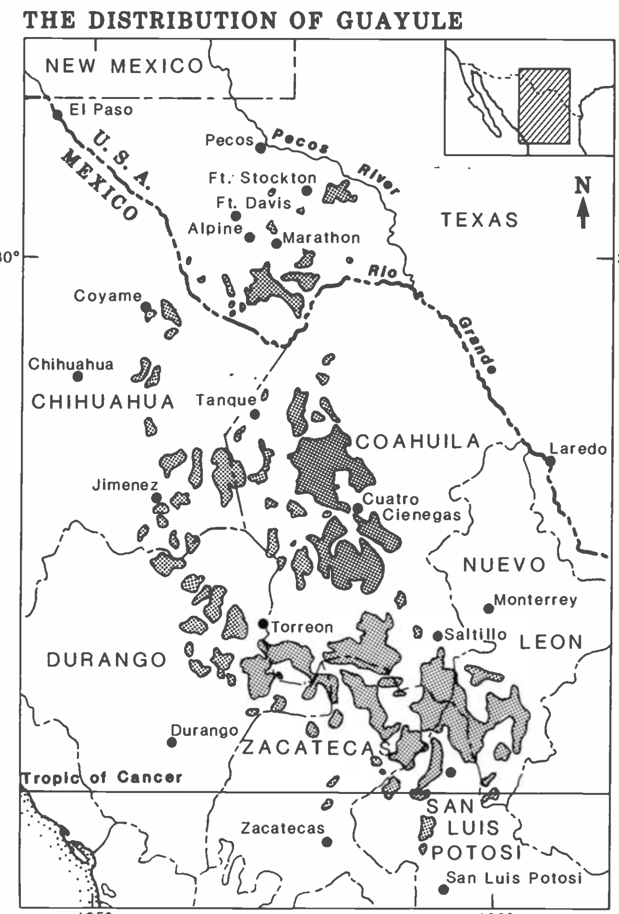

Figure 1. *Distribution of Native Guayule in Mexico and Texas. Source: National Academy of Sciences, 1977a.*

Jojoba

Jojoba (*Simmondsia chinensis*) is an evergreen shrub, with thick, leathery leaves. It grows naturally in the semiarid regions of southern Arizona, southern California and along the Gulf of California in Mexico (Figure 3). Economic interest in jojoba is based on the oil extracted from its seed. The oil is a unique, unsaturated liquid wax of non-glyceride esters composed almost entirely of straight-chain acids and alcohols. Such waxes are difficult to synthesize in commercial quantities.

A limited supply of jojoba oil now comes from hand-harvested wild stands in Arizona, California and Mexico. An estimated 25,000 acres in California, Arizona and Texas have been planted with jojoba (Figure 4). Some of these plantations have begun to produce a limited amount of seed; however, they are not expected to produce significant quantities of seed until 1984.

The oil is similar in physical properties to the oil of the endangered sperm whale. Although jojoba oil is currently being used primarily by the cosmetics industry it has potential for use as a chemical feedstock; as a replacement for vegetable oil in foods and hair oils since it does not become rancid; a high-pressure lubricant; and as an antifoam agent for the penicillin industry.

The hydrogenated oil is a hard, white crystalline wax with potential uses as a floor and car wax, and in other applications.

The National Academy of Sciences (1977b) estimated a market of 275 million pounds per year of jojoba oil if the price stabilizes between $.40 and $.75 per pound. Midwest Research Institute (1980) estimates a U.S. market for approximately 15 million pounds of liquid jojoba oil by 1990, with a cost range of $1 to $1.50 per pound.

Yields of plantation-grown jojoba are unknown. In the wild, annual yields range from .25 pounds to 10 pounds of seed per female shrub. If an annual average yield of 3 pounds per mature shrub can be maintained, then 1,400 pounds of seed per acre

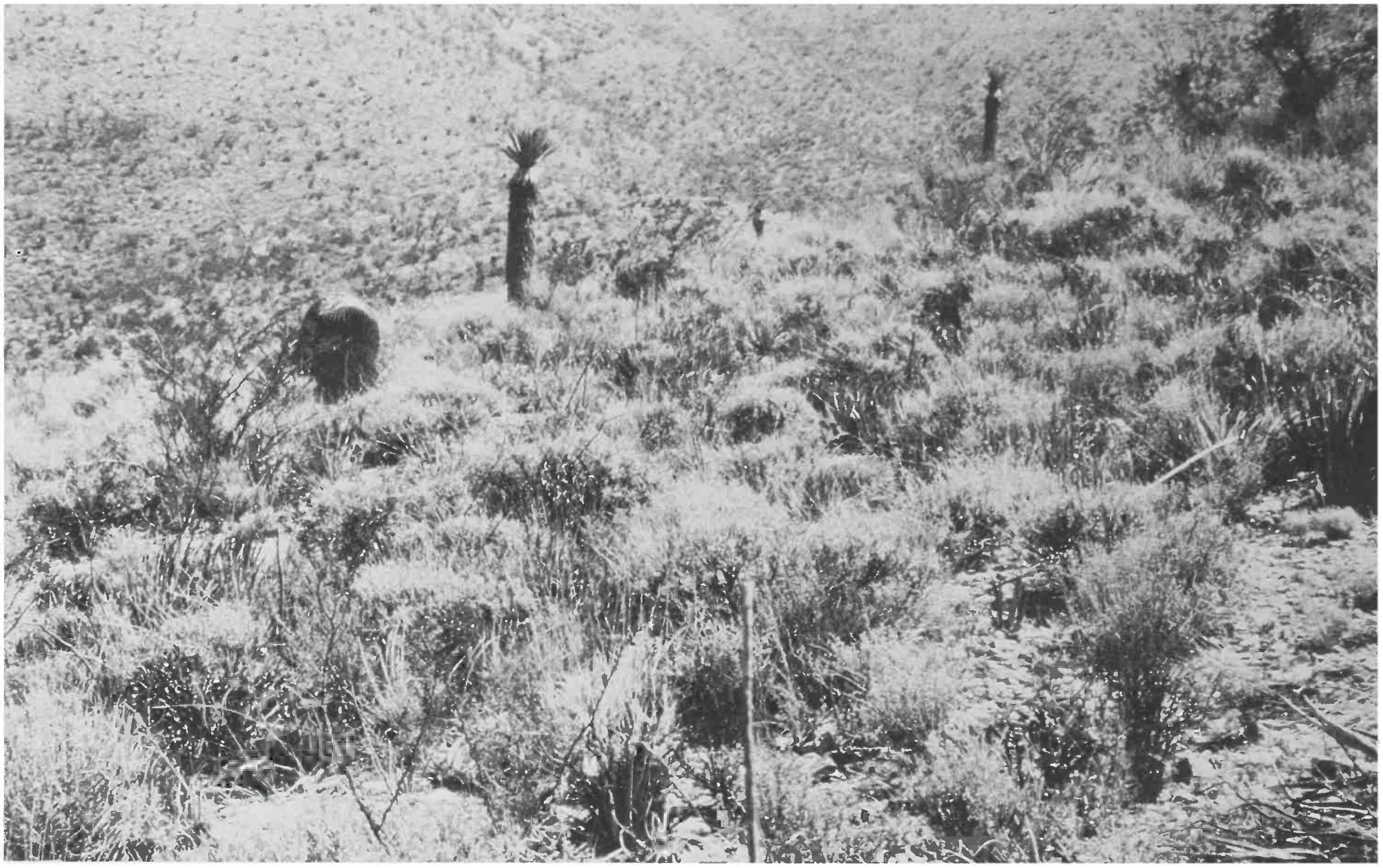

Figure 2. *A natural stand of Guayule in Mexico.*

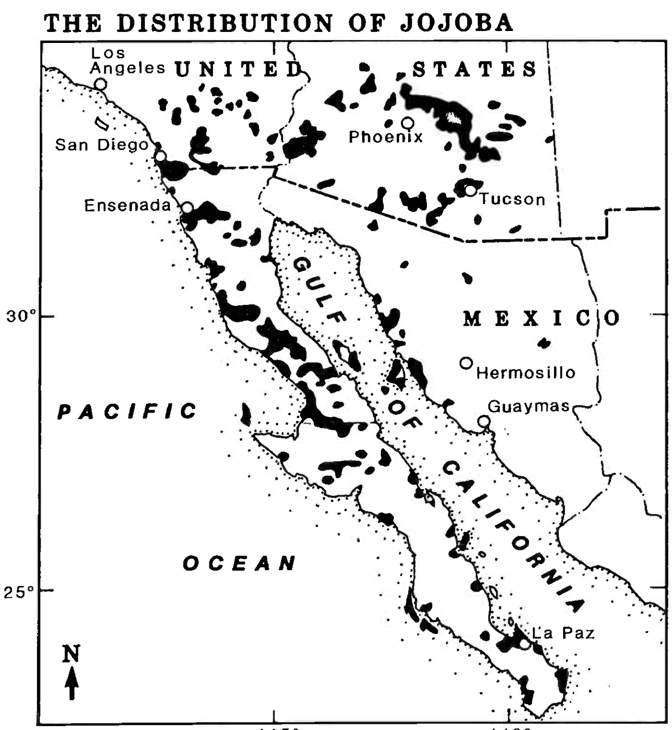

Figure 3. *Distribution of Jojoba. Reproduced and adapted with permission from Hastings, Turner and Warren (1972).*

could be expected from 470 producing plants, which would yield approximately 600 pounds of oil.

Presently, hand-harvesting is the only proven method to gather seed. Some nut-crop and fruit or berry harvesting equipment, blueberry harvesters for example, appear to be adaptable to jojoba, and one firm is offering a mechanical harvester for purchase.

A hydraulic expeller press or solvent extraction can be used to remove the oil from the seed. Several processing facilities using mechanical presses with capacities of 800 to 1,000 pounds of whole seed (approximately 400 pounds of oil) per hour are in operation.

Buffalo Gourd

Buffalo gourd, (*Cucurbita foetidissima*) occurs as a weed in the western United States in areas receiving less than 20 inches of rainfall per year. It is a perennial with an ability to spread rapidly without seed (Figure 5). Buffalo gourd generally has a 120-day growth period during summer months. The plant occurs as a spreading prostrate vine with extensive root systems. Large quantities of water and nutrients that can sustain the plant through periods of drought are stored in the fleshy roots, which can grow to 100 pounds.

The primary harvested crop would be the seeds that are produced in the yellow and green striped gourds. There is potential economic value from use of the vines as forage, and from starch in the roots, although commercial use of the latter

Figure 4. *Six year old Jojoba growing on the University of Arizona experimental farm near Yuma, Arizona.*

would require destruction of the plants.

Estimates of seed production range from 1,000 to 2,700 pounds per acre per year (Bemis, Berry and Weber. 1979); Theisen, Knox and Mann, 1978). The seeds contain 30 percent to 35 percent protein, with nutritionally essential linoleic acid predominant. In addition, the seeds contain up to 35 percent oil. The seed meal, subsequent to processing, is comparable in quality to soybean and cottonseed meal.

Assuming 800 pounds per acre of vegetable oil and 400 pounds per acre of protein valued at $.25 and $.08 per pound, respectively, a product value of nearly $260 per acre might be realized from buffalo gourd production (Johnson and Foster, 1980).

The University of Arizona has put forth a major effort to domesticate the buffalo gourd and to industrialize its production. However, buffalo gourd production is largely experimental and substantial research is required before it is commercialized.

Russian thistle

The adaptive characteristics that can make a plant a potentially valuable crop occasionally are the same as those that can make a plant a particularly troublesome weed. Such is the case with Russian thistle or tumbleweed (*Salsola kali*), a plant that has a very high rate of biomass production per unit of water used. Russian thistle was introduced to this country by accident as a contaminant in Eurasian flax seed (Foster, Rawles and Karpiscak, 1980). An efficient seed dispersal mechanism, rapid germination and establishment on minimally disturbed soils, relative freedom from diseases or parasites and a high water-use efficiency led to its rapid spread throughout the western United States (Figure 6).

Russian thistle has a high enery content. Tests conducted by Meinel, et al. (1979), indicate that energy content in field-dried tumbleweed range from 6,500 to 6,800 Btu/lb. These values are comparable with the calorific value of lignite, which varies from 5,580 to 7,920 Btu/lb (Foster, Rawles and Karpiscak, 1980).

Wild stand tumbleweed productivity ranges from 1.5 to 4 tons per acre; irrigated plots have produced 6 tons per acre (Meinel et al., 1979; Karpiscak, Rawles and Foster, 1981).

Russian thistle has been successfully formed into synthetic fireplace logs and pellets that can be used as boiler fuel. The value of synthetic fireplace logs currently ranges from $14 to $20 per million Btu compared with a cost of $4.33 to $6.40 per million Btu to produce the product.

A hay or alfalfa swather can be used for harvesting tumbleweed. It is then picked up with a forage chopper and blown into a trailer that dumps into a module builder. It it then compressed into 10-ton modules for transport to a process facility. There it is ground in a hammer mill and augered into the densification machine, which compresses the material into logs.

Although the level of development of tumbleweed as a crop is still in the experimental/demonstration stage, it will not require development of sophisticated agricultural or processing equipment, as does guayule. Thus, it could become commercialized rapidly.

Figure 5. *An experimental planting of Buffalo Gourd. Courtesy of William P. Bemis.*

Prospects of Commercialization

Commercial production of these plants depends on the technical and agronomic aspects of production as well as interactions between economic, environmental, social and political factors. Driving forces and constraints, which encompass regional concerns and which could promote or constrain commercialization, are identified and summarized below.

Driving Forces

A number of factors at local and regional levels are operating to stimulate alternative crops for farmers in the southwestern United States. These factors include potential for crop diversification, water conservation, arid land use, and increasing energy costs.

Crop diversification: A farmer's willingness to grow new crops relates directly to the annual net returns per acre that might be realized from such crop production when compared to net returns of other crops. Cotton continues to be the favorite annual crop in the region. Marginal profitabiity, nevertheless, for wheat, barley, pasturage and sorghum could make new crops an attractive alternative.

Arid land usage: Future commercialization and production of new crops could occur on two types of land: agriculturally productive land, and retired agricultural land. Irrigation will be required in both categories in southern California, Arizona, New Mexico and West Texas. A dependable supply of water, not land availability, will be the limiting factor to production. Under natural rainfall conditions, portions of California and the Texas High Plains could sustain production without irrigation. For example, buffalo gourd and Russian thistle could be grown in these areas.

Irrigated agriculture production in the southwestern United States traditionally has been accomplished on the best land to maximize yields. Farmers have increased acreage only in periods of high crop return. Those areas not considered prime agricultural lands generally lie fallow if commodity prices do not merit their use.

With a dependable water supply to sustain only prime-land agriculture, acreage expansion to accommodate new crop production on new or marginal lands is not expected to occur (marginal lands are defined as deficient in adequate water for traditional crops or as having poor soil characteristics for plant growth). Water-conserving and energy efficient new crops could be readily integrated into the southwestern agricultural economy. Farmers are beginning to search for cash crops that maximize return rather than yields, and that require less irrigation water and energy to produce. Those lands previously farmed, but that have marginal water supplies for existing crops, may be prime growth areas. Thus, new land would not have to be brought into production and non-productive prime land already developed for irrigation could be utilized.

Figure 6. *Russian Thistle growing on retired farmland in the Avra Valley, Arizona.*

Agricultural water use and conservation: New crops must be grown with less water than many of the agricultural crops now being farmed in the southwestern United States, where dwindling irrigation water supplies are negatively impacting the agricultural and economic potential of the region. A diminishing irrigation water supply and retirement of once productive land typifies agricultural development in much of Arizona, New Mexico, West Texas and the Texas High Plains. Irrigated acreage in Arizona, for example is expected to decline from 1.2 million acres in 1970 to 700,000 in 2020 (Arizona Water Commission, 1977).

Some irrigation for successful production of new crops would be required in most areas of California. Certain localities in California, however, such as the Sacramento and San Joaquin valleys are areas of potential adequate water supply.

Constraints

A number of factors at the local and regional level will inhibit new crop development. These factors include uncertain economic returns, crop displacement conflicts, and institutional decisions to limit agricultural water pumping.

Economic uncertainties: The inexact and preliminary nature of estimated cost and income projections for new crop production constrain commercialization. The synthetic approach to estimating costs uses the "best" information available and does not reference any specific operation. Both variable and fixed costs must be calculated, such as costs for land, machinery operation, labor, chemicals, fuel and repairs.

Before farmers will venture into production or before lenders will provide capital, field plantings and processing on a sufficient scale are required. High interest rates also restrain new crop development. These problems are further compounded by a lack of clear, consistent leadership and economic commitment from either the government or the private sector.

Land, water and commodity trade-offs: Commercialization would imply resource and product development tradeoffs. In general, committing agricultural land, water, and labor would be at the expense of producing other crops.

Conservation of scarce water resources, reduction in energy costs, or reactivation of idle farmland are positive incentives for introducing new crops. Future institutional decisions to conserve water for industry and municipalities, however, may constrain introduction and production of both traditional and new crops.

Extensive new crop production could result in reductions in regional cotton production. Declines also could occur in sugar beet, barley and sorghum production if new crop cultivation

continued on page 126

continued from page 117

utilizes large acreages. Barley, cotton, and sugar beets all require more annual precipitation and/or irrigation water than the potential new crops discussed.

In the final analysis, the extent to which new crops can compete with conventional crops is dependent upon economic dynamics. For example, sugar beets, which represent one regional agricultural feedstock for alcohol production, may compete aggressively in the future for land and water resources if the use of alcohol in vehicle fuels becomes more widespread.

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