Guayule: A Rangeland Source of Natural Rubber

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The United States is entirely dependent on foreign sources for its supply of natural rubber, a critical and strategic material. Almost one billion dollars is spent annually for imports of natural rubber from the rubber tree (*Hevea brasiliensis*) (USDA 1984). The range of the rubber tree is restricted to tropical zones, where political unrest and economic changes could influence the availability of *Hevea* rubber. The South American leaf blight has devastated *Hevea* in its native Brazil and should the disease reach Southeast Asia, the tropical supply of rubber could be threatened.

Over 2,000 plant species are known to produce rubber; however, the rubber tree and guayule (*Parthenium argentatum*) have been the only continuing sources of commercial rubber. Guayule (wy-oo-lee), a member of the Compositae (sunflower family), occurs in native stands scattered throughout 130,000 square miles of rangeland in the Chihuahuan Desert and surrounding regions. Guayule is the most promising source of domestic natural rubber which can be grown successfully in the United States.

**Early History**

Lloyd (1911) reported that a Jesuit Priest saw Indians playing with rubber balls in northcentral Mexico in the middle of the eighteenth century. The rubber was extracted by communal mastication of the guayule bark, a common practice of the time. Lloyd expressed little doubt that this practice predated the invasion of Mexico by the Spaniards.

Another early use of guayule was fuel for Mexican smelters, which depleted thousands of acres of the shrub. The absence of guayule stands in certain regions in north and northcentral Mexico is due to this destructive process.

Guayule was first “discovered” in 1852, near Escondido Creek, Texas, by Dr. J.M. Bigelow, a member of the Mexican Boundary Survey party. Specimens were sent to professor Asa Gray at Harvard University, where Gray first described the plant.

**Early Commercialization**

Public attention was first drawn to guayule in 1876 by an exhibition sent by the Mexican Government to the Centennial Exposition at Philadelphia. Later, in 1888, the New York Belting and Packing Company obtained 100,000 pounds of guayule from Mexico and extracted the rubber by immersion in hot water. In 1902 several American businessmen financed an experiment in Mexico to develop a mechanical extraction method. The pebble mill extraction process was perfected and the first lot of rubber was shipped to the United States in 1904. The Continental-Mexican Rubber Company was formed and a large factory was constructed in 1906 near Torreon, Mexico. Other factories were built in Mexico and in 1909 a mill was located in Marathon, Texas, by the Texas Rubber Company. Mexico exported 9,542 long tons of guayule to the United States in 1909 (Hammond and Polhams 1965).
Sustained harvesting of entire plants (tops and roots) resulted in depletion of the native guayule stands and many Mexican plants closed. The Continental-Mexican Rubber Company remained in operation and in 1910 anticipated the need to establish cultural experiments to maintain adequate guayule stands for processing. The Mexican Revolution forced the company to transfer its operation to the United States. Headquarters were established by W.B. McCallum near San Diego, Calif., in 1912 as the American Rubber Producers, Inc., of the Intercontinental Rubber Company. After a move to Arizona in 1916, permanent headquarters were located in the Salinas Valley, California, in 1925. The Depression of the 1930's caused rubber prices to fall and the guayule industry was arrested. However, between 1931 and 1941 nearly 3 million pounds of guayule were processed.

Guayule during World War II

The U.S. War Department, in 1930, anticipated the loss of *Hevea* rubber in the event of an Asian War. Major Dwight D. Eisenhower and Major Gilbert Van Wilkes were appointed to study the feasibility of guayule as an alternative rubber source. It was recommended that guayule development be supported by the government. The plan was ignored and in December 1941 the Allies lost more than 90% of their rubber supply when Japan invaded Southeast Asia.

Holdings of the Intercontinental Rubber Company were purchased by the U.S. Government in March 1942 and the Emergency Rubber Project (ERP) was created. The program was administered by the USDA with the Forest Service organizing and directing the production and research. A massive research program was initiated to investigate all facets of guayule rubber production and nearly 32,000 acres were planted and 3 million pounds of rubber produced by war's end. With the development of synthetic rubber and renewed availability of *Hevea* rubber, the ERP was liquidated in December 1946. The remaining shrub stands (accounting for about 21 million pounds of rubber) were destroyed.

A reappraisal of the rubber situation indicated that synthetic rubber was not satisfactory for certain uses, and that natural rubber was still a critical material. Therefore, a new research program was initiated by the USDA in 1947 at Salinas, Calif. In December 1950, a program of stockpiling reserves of natural rubber was initiated. Nurseries were established in California for seed production and in Texas for possible use in a production program. By 1952 with 26,334 pounds of seed stockpiled, the program was discontinued.

Description

Guayule is a profusely branched shrub which reaches a height of 1 to 3 feet (Correll and Johnston 1979). This bushy perennial has small gray-green leaves covered with a silvery pubescence, hence, the species name *argentatum*. Mature leaves are characterized by one or two teeth located near the middle of each margin. Small yellow flowers, which may appear continuously throughout the season if soil water is available, are borne in heads on long axes extending above the canopy. The roots form a modified taproot system. Successive production of laterals soon obscures the primary root and the mature system is fibrous in appearance (Muller 1946). In native stands adventitious shoots (retoños) may form on shallow roots exposed by erosion.

Current Distribution

Native stands of guayule occur in the Trans Pecos of southwest Texas and northcentral Mexico, and persist within a wide range of climatic tolerances. Annual precipitation averages 10 to 15 inches and occurs mainly in late spring and early fall. Moreover, the shrub grows extremely well under irrigation in Texas, New Mexico, Arizona, and California. Temperatures are known to range from lows of –10°F during winter in the northernmost limit near Fort Stockton, Texas, to near 120°F in summer.

Distribution is generally at altitudes of 2,300 to 3,500 feet in Reeves, Pecos, and Terrell counties, Texas, the northern limit of occurrence. Farther south in the Big Bend in Presidio and Brewster counties, stands are found from 3,500 to 4,200 feet. Some Mexican stands may occur at elevations of 6,000 to 6,500 feet.

The altitudinal range, restricted to a narrow transitional zone located between desert and grassland elevations, is the result of two limiting factors (Muller 1946). The lower limit of guayule occurrence is set not by competition, but by the severity of the desert climate which includes low and uncertain rainfall, high percentage of sunshine, low atmospheric humidity, high daily temperature, great range in daily temperature, and high soil surface temperatures (Shreve 1942). The upper limit is fixed by competition with highly developed grassland
communities, occurring above 5,000 feet elevation and where the annual rainfall exceeds 14 inches. Guayule distribution between these limits is determined, in part, by the presence of favorable sites on rocky slopes where competition is limited. Lloyd (1911) stated that the formation of retosnos was a significant factor in the survival of guayule in native stands.

**Rubber Distribution in the Plant**

Rubber is located principally in the woody portions of the guayule shrubs, with two-thirds in the stem and branches and the remainder in the roots (National Academy of Sciences 1977). The bark is the main site of rubber synthesis and may contain 75 to 80% of the total rubber weight. Guayule rubber is not concentrated in latex ducts as in *Hevea*, but occurs in single cells located in the vascular rays of phloem and xylem.

![Cultivated guayule at the TAES Guayule Research Site near Fort Stockton, Texas.](image)

When guayule is actively growing, rubber is not accumulated. Rubber synthesis occurs in the late fall and winter when night temperatures reach 40° - 45° F (Goss et al. 1984). In native stands rubber accounts for, on the average, about 8-10% of plant dry weight. Nonetheless, great variation exists, with some plants containing close to 20% and others almost none. Guayule contains resins that account for about 10% of the plant dry weight.

**Prospects for Future Commercialization**

Guayule accounted for 10% of the world's natural rubber supply in 1910 and continued to be a minor source for nearly 40 years (National Academy of Science 1977). After World War II there was no need for an alternative source of rubber; nevertheless, the outlook for natural rubber has changed. Natural rubber is preferred for products that require elasticity, resilience, tackiness, and low heat buildup. It is especially useful for automobile tires (particularly radials), airplane tires, and where heat buildup under severe conditions could be critical. Radial tires require almost twice as much natural rubber as the bias ply tires.

Petroleum supplies are exhaustible and coupled with the chaotic situation in the Middle East, are not assured. Since petroleum is the essential raw material for synthetic rubber, supplies of this product may eventually become limited. Guayule rubber is a viable alternative to manmade rubber derived from petrochemicals, and importantly is a renewable resource.

Surpluses and associated low prices for traditional crops have resulted in a new emphasis being placed on viable, alternative crops. Furthermore, energy and water costs are forcing American farmers to consider other crops which may be more water-use efficient. During World War II and more recently in west Texas and other states in the Southwest, guayule has been successfully cultivated.

Stockpiling natural rubber, to ensure that it will be available if normal supplies are disrupted, provides added support for developing a domestic rubber industry. The Federal Emergency Management Agency has established a stockpile goal of 813,000 long tons of crude natural rubber. Currently there are only 119,000 long tons on hand.

**Economics**

Research and past experiences have demonstrated that it is technologically feasible to produce natural rubber from guayule. However, there is little commercial expertise available to adequately assess the economic implication of guayule cultivation in the United States. Most production costs are based on information from the ERP and current research data. Recent economic studies, based on broad agronomic and economic assumptions, suggest that guayule can be an economically competitive crop (Cornforth et al. 1980, Wright 1984).

It is generally accepted that for guayule commercialization to be feasible, some combination of improved rubber yield, favorable production costs, or increased rubber price must occur. A viable guayule industry would lessen the dependency on imports of *Hevea* rubber, improve the balance of trade, and maintain national security goals.

**Current Research Activities**

The Federal Government has established policy on the development of guayule as a domestic agricultural crop. Congress passed the Native Latex Commercialization and Economic Development Act in 1978 (P.L. 95–592). The Act stated: "It is the policy of the Congress, therefore, to provide for the development and demonstration of economically feasible means of cultivating and manufacturing *Parthenium* and other hydrocarbon-containing plants for the extraction of natural rubber and other products to benefit the Nation and promote economic development." In 1984, Congress amended this act and renamed it the Critical Agricultural Materials Act (P.L. 98–284) and restated its commitment to guayule commercialization.

With renewed interest in guayule, the Firestone Tire and Rubber Company initiated a guayule research program in 1978 near Fort Stockton, Texas. They established about 200 acres of cultivated guayule and leased the site to the Texas Agricultural Experiment Station (TAES) in 1983. Presently TAES scientists are investigating guayule harvesting techniques, direct seeding, chemical weed control, irrigation, dryland production, seed harvesting and cleaning procedures, and germplasm selection. A laboratory for rubber and resin analyses has been established at the research site.
Scientists at the TAES Guayule Research Site are cooperating with researchers in the agricultural experiment stations of Arizona, California, and New Mexico and the USDA/ARS in evaluating guayule selections for regional adaptability and rubber production. Studies in conjunction with scientists in the TAES Department of Biochemistry and Biophysics are focusing on the effects of selected bioregulators on guayule rubber synthesis. Cooperating researchers with the Texas Engineering Experiment Station's Food Protein R&D Center have developed a solvent extraction method for guayule processing. Firestone has also established a pilot processing plant at Akron, Ohio.

Summary

Guayule, a semidesert shrub native to the Trans Pecos of southwest Texas and Mexico, produces natural rubber. Significant supplies of guayule rubber were produced in the early 1900's, and more recently during World War II. Political and economic situations worldwide have caused a renewed interest in guayule as an alternative source of natural rubber. The development of a domestic rubber source would alleviate the dependence on foreign supplies and provide an alternative crop for farmers in the Southwest. Past experience has indicated that technologically, guayule can be cultivated for the production of natural rubber. Current research is committed to improving existing production, harvesting, and processing technologies to develop an economically viable guayule production system in the United States.

Coyotes, Guard Dogs, and Electric Fences

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Editor’s Note: The reader may wish to refer to the following articles for further information on coyote predation and control.


In 1983 sheep were introduced on the Jornada Experimental Range (JER) in southwest New Mexico to determine if cattle and sheep grazing would lead to more efficient utilization of the range. It was rumored that there were many coyotes in the area and predation was expected to be a serious problem. A year after the sheep were introduced, the Fishery and Wildlife Sciences Department at New Mexico State University (NMSU) in cooperation with USDA estimated from scent-post visitations and helicopter gunning that coyote density was 1 per 2.7 square miles (Kumm 1985).

Loss of Sheep in an Unprotected Flock

In early February 1983, 144 aged, Rambouillet-type range ewes were placed in a fenced area to study the effects of nutritional environment on ovulation and to evaluate predation. A smaller representative sample of 54 ewes from the same source were maintained in drylot on alfalfa hay. This article presents an assessment of the predation problem, subsequent predator management practices which were instituted, and changes which occurred in the incidence of predation on large, expansive, brush-covered, fenced pastures. Two noncharged high-tensile smooth wires were added to the lower part of an existing 4-strand barbed wire cattle fence to contain the sheep in 2 major areas on the range. One area (East Area) included 2 pastures (4,463 and 2,537 acres). The second area (West Area), 5 miles from the first area, also had

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Literature Cited


