Environmental Effects of Harvesting the Wild Desert Shrub Jojoba

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Introduction

The botany of arid regions has been of fundamental economic importance to the quality of life of every desert-dwelling group of people. For them arid-land vegetation played or plays an important role in nearly every aspect of life: food, shelter, clothing, protection, health, religion, and recreation.

Modern concepts of property ownership coupled with dry-farming, irrigation farming and grazing have caused this historic pattern to disintegrate, however, and many groups of people were forced to gather wild desert plants with commercial uses simply to survive.

The patterns and processes of change were clearly established in the United States when several industries based on wild desert plants were abandoned after World War II because of a lack of labor. Mexico, however has continued to produce many of the same projects from arid-land vegetation growing in the Chihuahuan and Sonoran deserts. The increased opportunities for personal mobility due to modern transportation, roads and urban growth led these gatherers of economic products from the desert to become increasingly dissatisfied with low income, insufficient health services, and limited educational and recreational opportunities. Trends up to the early 1970s were an exodus of workers with a consequent decline and abandonment of traditional desert-plant industries in the arid regions.

The Arab oil embargo, however, has created a heightened awareness that renewable natural resources should play an increasingly important role in our economic future. Extensive efforts are underway to commercialize desert plants such as jojoba (*Simmondsia chinensis*, Figure 1).

Jojoba grows naturally over an extensive area in the Sonoran Desert that covers parts of Arizona, California and Mexico as shown in Figure 2. Jojoba seeds contain a yellow, odorless, oily liquid commonly called "jojoba oil." Chemically, the oil is a liquid wax consisting of non-glyceride esters composed almost entirely of straight chain acids and alcohols that are difficult to synthesize commercially.

This unique liquid (hereafter referred to as oil) has a wide variety of industrial applications in lubricants, cosmetics and pharmaceuticals. Jojoba oil also can be hydrogenated to produce a hard, colorless solid (wax) resembling carnauba wax and beeswax in both chemical structure and properties.

The National Academy of Sciences (NAS) (1977) concluded that the future of a jojoba industry lies in developing the natural shrub into a cultivated crop. In support of this recommendation the NAS further suggested that techniques be developed for breeding and propagation for better cultivation in plantations and that techniques for harvesting and handling the seeds be developed.

Recent Developments

Since the early 1970s the possibility has emerged of again developing industries based on harvesting wild desert plants. The bases for developing these industries today are to provide jobs and to strengthen the economic base of U.S. Southwest Indian tribes, tribes that control large land areas used predominantly for grazing cattle.

In 1972 the Indian Division of the Office of Economic Opportunity (OEO), U.S. Department of Commerce, initiated activities to lead to developing an industry based on the economic uses of jojoba seed oil. OEO requested that NAS perform a scientific and technical assessment based on test results of practical uses of jojoba oil. In the summer of 1972, more than 87,000 pounds of jojoba seed were hand harvested by Indians in Arizona and California. This harvest provided a stockpile for testing of jojoba oil. NAS (1975) later concluded that jojoba oil and its hydrogenated products have marketable properties; that jojoba oil can be used as a substitute for sperm whale oil; that jojoba could become the basis for viable Indian-owned and -operated industries; and that jojoba can improve the productivity of arid lands not suitable for conventional crops.

Since 1972 annual wild harvests have provided the supply of seeds necessary to continue developing a jojoba agroindustry in the Southwest, and will continue to provide the essential supply of seeds for the next five to ten years until cultivated plantations have become established and are producing commercial quantities of seeds (Figure 3).

The natural populations of shrubs grow on some 100,000 square miles in the Sonoran Desert in Mexico and in the United States between latitudes 25 degrees and 31 degrees north. It is estimated that these natural shrubs produce between 11,000 and 18,000 tons of clean, dry seeds each year and that 300 to 550 tons of clean, dry seeds could be harvested annually in Arizona, California and Mexico (National Academy of Sciences, 1977). Actual harvest information for 1978 indicates that about 300 tons of clean, dry seed were harvested (Office of Arid Lands Studies, 1978). The 1978 harvest represents the best organized harvest effort to date, yet only 2 percent to 3 percent of the probable available seeds were gathered.

Environmental Consequences of the Wild Harvest

Cultivated jojoba plantations comprise more than 6,000 acres in Arizona, California and Texas, but until commercial quantities of seed become available in the mid-1980s the developing industry must continue to depend upon the wild sources of seeds. This continuing harvest of wild stands of jojoba will produce various impacts on the plant communities and the surrounding environment. Short- and long-term impacts are not clearly understood, and little quantitative data exist for direct measurements. To assess systematically these impacts, an in-depth literature review and a limited field survey were initiated in 1977 to determine the history of impacts and then to evaluate them. This work was conducted in conjunction with a study to determine the social, economic and environmental consequences of establishing an Indian-based jojoba agroindustry (Foster et al, 1979).

History of Impacts

Natives of the Sonoran Desert long have been aware of jojoba's presence and its usefulness in meeting many of their medicinal, cosmetic and nutritional needs (Sherbrooke and Haase, 1974; Serbrooke, 1978a and cited references) when European missionaries first explored the northwest of New Spain (Sherbrooke, 1978b).

Gentry (1972) suggested that even long before ruminant livestock introduction, jojoba may have been subjected to considerable browsing pressure from the now extinct North American Pleistocene megafauna. Jojoba was subjected to a new browsing pressure not experienced before the coming of Europeans with the introduction of cattle, goats and sheep. The importance of jojoba as a browse plant, particularly for cattle, has been recognized widely (Sherbrooke and Haase, 1974 and included references).

In the modern era jojoba seed collecting from native stands has continued every year since 1972 as interest in jojoba and demand for its seeds and oil have grown.

Potential Environmental Consequences of Seed Removal

Of minor consequence in the activities associated with seed removal are branch pruning by pickers and removing seed-hulls that possibly could influence soil texture and fertility over the long term. But seed removal might produce more lasting concerns: 1) a reduction in natural plant propagation; and 2) reduced resources for seed-eating rodents.

Annual seed harvest impacts on plant propagation basically are influenced by three factors: 1) accessibility to the stand; 2) level of seed production as determined by density of plants and individual plant

Figure 1. Representative plant of Jojoba.

seed productivity; and 3) thoroughness of picking. These factors vary considerably both yearly and geographically, in part because harvesters respond to changes in seed abundance. But the net effect of these factors is that seeds are harvested completely from all areas every year.

Sherbrooke (personal communication; 1977) observed 219 seedlings for four years and found 27, 8, 4 and 3 survivors respectively at the end of each year. Good conditions for seed germination are infrequent and many seeds do not germinate every year. Also, conditions favorable to seedling survival vary from year to year and may be appropriate for establishment only once in 10 or more years.

Years of high germination and high seedling survival do not necessarily correspond. High levels of seedling germination might occur during a season, but all could die. During another season, a few seedling germinations may experience a high survival rate. Years when conditions are ideal for both germination and survival probably are very rare. Few seeds become reproducing adult plants. A shrub must produce thousands of seeds during decades just to replace itself. But if each female shrub in a particular community produces only one male seed and one female seed that propagate successfully the population of jojoba shrubs will remain stable.

The impact of seed harvesting on natural propagation could be significant if seeds were depleted during a year, or years, that could have high levels of germination and seedling survival. The frequency of such years and their long-term importance is not well understood and impossible to predict, but the time span of sustained seed harvesting from wild

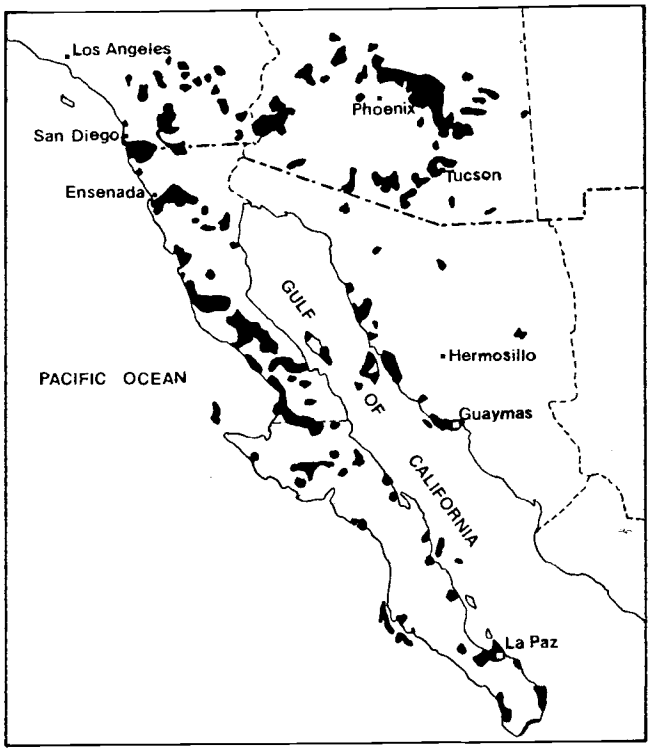

Figure 2. Distribution of *Simmondsia chinensis.*

stands is an important consideration in evaluating long-term impacts. If the wild seed harvest spans only 10 to 15 years and ends when plantations begin production, the impact on reproduction probably would be minimal. But, if seed harvests from wild populations are sustained during several decades the impact on natural reproduction could become substantial.

Vegetative growth-proliferation from underground stems is also of possible importance in reproducing jojoba. Gentry (1958) photographed a "ring" of jojoba plants apparently originating from the same individual. The adult shrub was in the center of the ring. It died later but after it contributed new shoots to the ring of descendants. How important this form of reproduction is in jojoba populations has not been determined, but Rost (1978) has found additional examples in California.

Little is known of the seed removal impacts on insects and wildlife species. The report of jojoba seed use by Bailey's pocket mouse *(Perognathus baileyi),* by Sherbrooke (1976) suggests a strong interaction between these two species. The potential impact of seed removal on the stability of rodent communities in jojoba areas could be severe.

Bailey's pocket mice store as much as 800 grams of jojoba seeds in their burrows. In contrast to three other heteromyid rodents, Bailey's pocket mice are capable of using jojoba seed in their diet because of their unique ability to detoxify the cyanid containing compound, simmondsin, in jojoba seeds. This heavy jojoba seed use by *P. baileyi* suggests that populations of this species might become food-limited in harvested jojoba stands and could suffer reduced population levels.

In addition, Sherbrooke (1976) suggested that seed-eating rodent species diversity may be influenced by the relative density of jojoba shrubs. *P. baileyi* would be predominant in very dense jojoba stands as the only seeds available in abundance would be jojoba seeds. In more species-rich plant communities other species of seed-eating rodents would coexist, but they would be influenced by *P. baileyi* population fluctuations.

Sherbrooke (1976) also discussed the potential role of *P. baileyi* in jojoba seed dispersal and propagation as an inadvertent outcome of its hoarding and seed storage activities. It remains to be demonstrated, but this species of pocket mouse could be playing an important role in maintaining some jojoba populations. If jojoba seed harvests reduced or eliminated *P. baileyi,* impacts could reach beyond affecting only that one rodent species. It could affect interspecies competitions, animals higher in the food chain and jojoba reproductive establishment.

Pruning has been a natural response of jojoba to its environment throughout its evolutionary history. In northern areas, young branches are frozen off at the ends during many winters. Natural pruning may influence seed yields during the following season by directly reducing the number of buds available for flowering and fertilization. When seeds of one year are ripening, flower buds for the following season are forming in the axils of leaves, both on new growth and old branches (Sherbrooke, 1978).

Jojoba also has been subjected to and has been responding to grazing by large mammals for thousands of years (Gentry, 1972). Therefore, the amount of structural damage currently inflicted on jojoba plants by hand harvesting seems inconsequential.

Incidental to the seed harvest process, most harvesters later remove the hulls surrounding the seeds before the seed is processed for oil extraction. Removing these hulls from the environment probably reduces the buildup of organic matter under jojoba shrubs (result of an accumulation of dead leaves, hulls, twigs, etc.). The water retention properties and nutritive value of organic material under shrubs

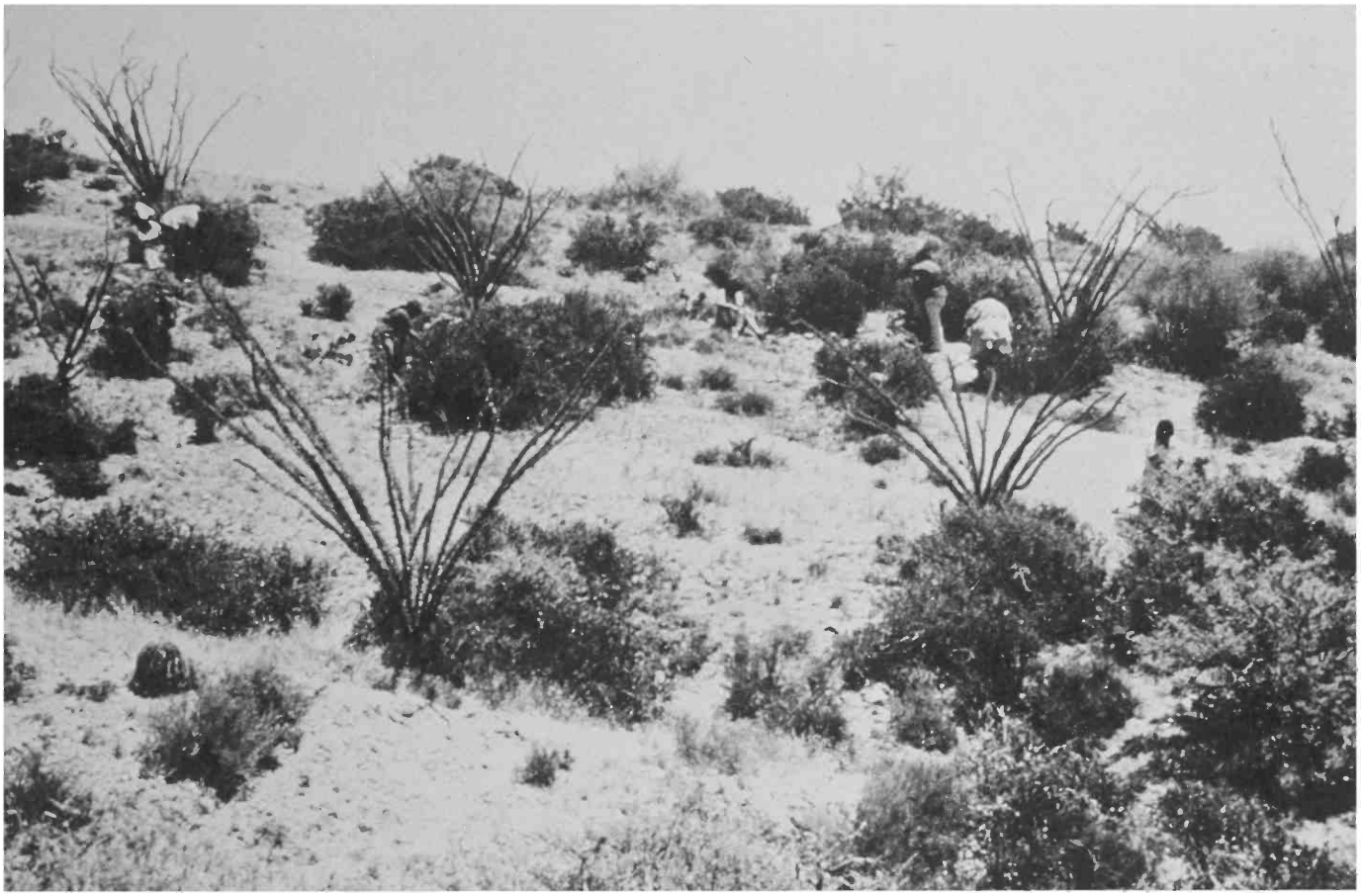

Figure 3. Harvesters in a native stand of *Simmondsia chinensis.*

are important to the many annuals that use this microenvironment for desert survival (Muller, 1953). The long-term impact of removing seed hulls that contribute to the organically rich soil layer buildup is not known, but this microenvironment appears to be important in establishing jojoba seedlings (Sherbrooke, 1977).

Seed productivity in jojoba stands varies considerably from year to year and from one population to another (Gentry, 1958; Sherbrooke and Haase, 1974). Jojoba seeds remain viable for a decade or more (Gentry, 1958) and the "seed bank" in the soil may be an important resource in new plant establishment. Seed production variability between populations and from year to year influences the amount of seed available to harvesters as well as the amount available for germination. Indeed, the quantity available for germination is highly variable even when jojoba seeds are not being harvested by humans.

Conclusions

Because jojoba is a long-lived plant, sometimes surviving for more than 100 years, the impacts of seed harvesting on natural population replacement may go unnoticed for some time. Also, because of the natural seedling establishment pattern, an impact on natural reproduction may be serious one year and of no consequence during another year. It is not possible to predict which years the impact will be important. The impact of seed harvest on natural plant replacement is likely to be cumulative during several decades.

One species of pocket mouse, *P. baileyi,* appears to use jojoba seed extensively. Removing this seed resource could alter population levels of this rodent and may change the rodent community competitive structure. As this pocket mouse can live on seeds of other species also, it is not likely that some jojoba seed removal would result in local extinction of this rodent. But Bailey's pocket mouse also appears to

play a role in jojoba's reproduction. Pocket mice store reserves of jojoba seed and may inadvertently be responsible for "planting" new jojoba shrubs. Thus, reducing the level of Bailey's pocket mice in jojoba communities could influence the future reproductive success of the plant.

It is estimated that in the short-term, over a matter of a few years, little significant impact on jojoba's natural replacement pattern will occur as a result of seed harvests. Its life cycle strategy is adapted to many years of unsuccessful reproductive efforts. Also, seed harvesters will not pick seeds in areas of low productivity and the seeds fall to the ground. These unharvested areas will change from year to year due to local climatic variability. Wild seed harvests during a 20-year period could reduce levels of natural replacement. Due to the long life of jojoba plants and lack of known correlation between size and age, this reduction might not be perceived early unless a monitoring program were established.

If harvesting wild stands is continued in excess of a decade, from 1972, an experimental program aimed at determining the impact of harvesting on long-term reproduction should begin. Such a study necessarily would take considerable time to provide the data needed to evaluate the potential impacts. If a 10-year study were initiated in 1981, the results would provide some basis upon which to make decisions in 1991 regarding the wisdom of entering the third decade of jojoba wild-seed harvest.

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