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PLANTS AS POTENTIAL ECONOMIC RESOURCES IN ARID LANDS

by

Jack D. Johnson*

I. INTRODUCTION

JACK D. JOHNSON

Approximately one-third of the world's land surface lies within arid regions. While many of these areas are relatively uninhabited, many are being developed to take advantage of the natural resources they contain, for instance, underground water, soil, minerals, recreation, or grazing.

The U.N. Conference on Desertification was called in response to the extreme pressures experienced in the Sahel zone of Africa where the lengthy drought during the late 1960s and early 1970s caused much human suffering and death as well as heavy loss of livestock. The land in the Sahel was so severely overgrazed in some areas that the popular notion of the "creeping desert" or "advancing Sahara" attained international prominence. In a conference paper on "Desertification in the United States,"** it was pointed out that, in fact, desertification was a problem in the United States as well, with an economic impact estimated to be in excess of $1 billion annually.

Desertification problems of both the Sahel and the United States are primarily attributed to man's use of arid lands without full recognition of the limitations imposed by nature. The only truly constant factor common to the arid areas of the world is climatic variability. Mean precipitation values have no real validity because a 200 millimeter (mm) average annual rainfall may be based on 400 mm rainfall one year and none the next. Further, the precipitation received in arid areas is quite variable spatially, making reasonably accurate predictions of precipitation or drought seemingly beyond the current capabilities of science.

Given the problems inherent in man's attempts to manage totally unpredictable arid ecosystems, it appears evident that we should be attempting to exploit these arid lands through use of plants native to these regions, plants which have survived by developing mechanisms to accommodate extreme climatic variability.

Arid land plants have evolved numerous ways of surviving with very little water. Some store their own water, like the cacti; others, like palo verde and ocotillo, survive the heat and drought by shedding leaves and becoming dormant; a few plants mine water—mesquite roots, for instance, have been found 175 feet down in a copper pit (Felger, 1975); and the final major group of desert plants are the ephemerals or annuals: the rains come and they sprout, grow, flower, and produce seeds before the water is gone.

In the process of evolving to survive in arid environs, these plants have developed some unique properties. Plants that store their own water frequently have unusual chemicals to prevent water loss: agave leaves are coated with waxes, some stems have rubber-like substances, many seeds have unusually high oil concentrations, annuals and ephemerals can be extremely productive in short time periods (Cruse, 1949, 1973).

While all plants are affected by drought, those adapted to survive in arid zones have the ability, through one evolutionary mechanism or another, to withstand the impacts of severe drought, the only effects often being periods of dormancy or of reduced flowering and vegetative growth.

Representative investigations delineating both the use of desert plants by native peoples and some of the current work reported in research literature, or which is being conducted to determine the economic potential of certain vegetation, are presented herein, particularly those related to arid land vegetation in the southwestern part of the U.S. and Sonora and Baja California.

The field of ethnobotany traces man's use of vegetation back into history. While this report is not to be construed as an ethnobotanical one, we have included some information from the literature of this field and cited selected references in the appended bibliography.

Four National Academy of Sciences publications are worthy of special attention (NAS, 1975-A, 1975-B, 1977-A, 1977-B), and the University of Arizona's Office of Arid Lands Studies also has several pertinent publications relating to arid

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lands plants (Sherbrooke and Haase, 1974; McGinnies and Haase, 1975-A, 1975-B), as well as the serial publication *Jojoba Happenings.*

Since this is by necessity a summary paper touching only upon selected desert plants which appear to have economic potential, we then must apologize to those many plants which have been omitted whether intentionally or through ignorance. Plants discussed are categorized by use as building materials, fuel, dye, food, gums and waxes, and alcohols and medicines. Plants given special attention are those currently receiving much attention from the scientific community as well as from certain research funding agencies. Two major plants in this category are jojoba and guayule.

II. SPECIAL INTEREST ECONOMIC PLANTS

1. *Simmondsia chinensis* (jojoba)

Jojoba (pronounced ho-hó-ba), an exciting new development in economic crops, is a shrub which grows naturally in the Sonoran Desert in the U.S. (California and Arizona) and in Mexico (Sonora and Baja California). The seed from this thick-foliaged shrub is about 43 percent liquid wax with chemical properties identical in most respects to the oil of the endangered sperm whale. Activities aimed at domesticating and cultivating jojoba are being pursued actively in Arizona, California, Sonora and Baja California in Mexico, and Israel. Attempts at cultivating jojoba are under way in Saudia Arabia, Ghana, Iran, Egypt, and undoubtedly in many other countries.

The expression of jojoba seed yields a liquid wax which requires little or no refining for use as a lubricant. The wax content of the seed not only does not decrease with long-term storage, but is remarkably resistant to bacterial degradation. There is a wide variety of potential uses. Because jojoba oil does not become rancid, it might well replace ordinary vegetable oils where rancidity is a problem, such as in foods, cosmetics, and hair oil. The oil is also a source of long-chain alcohols, useful in the preparation of detergents and as lubricants for precision high-temperature machinery.

Hydrogenated jojoba oil is a hard white crystalline wax reportedly almost as hard as carnauba, for which it may be an attractive substitute. It also has potential in the preparation of waxes for floors and automobiles, waxing of fruit, impregnation of paper containers, manufacture of carbon paper, candles, and many other products.

Tables 1 through 3, adapted from *Products from jojoba: A promising new crop for arid lands* (National Academy of Sciences, 1975-A), delineate the physical and chemical properties of jojoba oil and wax.

While the jojoba plant has appeared in botanical literature since 1821, the earliest record was written in 1789 by the Italian Jesuit Clavijera who described the use of jojoba "berries" as medicine (Sherbrooke and Haase, 1974).

That the liquid wax expressed from jojoba seeds has physical and chemical properties resembling sperm whale oil has been known since the 1930s. There was some research effort on jojoba during and immediately following World War II, but the postwar boom in sperm whale fishing, plus the

Table 1. Properties of Jojoba Oil[a]

Freezing point	10.6-7.0 C
Melting point	6.8-7.0 C
Boiling point at 757 mm under N_2	398 C
Smoke point (AOCS Cc 9a-48)[b]	195 C
Flash point (AOCS Cc 9a-48)[b]	295 C
Fire point (COC)	338 C
Heat of fusion by differential scanning calorimetry	21 cal/g
Refractive index at 25 C	1.4650
Specific gravity, 25/25 C	0.863
Viscosity	
Rotovisco (25 C)	
MV-1 rotor in MV cup	35 cp
Plate and cone with Pk-1	33 cp
Brookfield, spindle #1, 25 C	37 cp
Cannon-Fenske, 25 C	50 cp
Cannon-Fenske, 100 C	27 centistokes
Saybolt, 100 F	127 SUS[c]
Saybolt, 210 C	48 SUS[c]
Iodine value	82
Saponification value	92
Acid value	2
Acetyl value	2
Unsaponifiable matter	51%
Total acids	52%
Iodine value of alcohols	77
Iodine value of acids	76
Average molecular weight of wax esters	606

[a]Oil from expeller-pressed jojoba seeds starts to freeze at 10.6 C (51 F). It solidifies into a thick paste at 7 C. Frozen oil, allowed to warm up, melts at 7 C (45 F).
[b]Smoke and flash points determined according to the official method, Cc 9a-48, of the American Oil Chemists' Society.
[c]Saybolt Universal seconds.

Table 2. Characteristics of Sulfurized Jojoba and Sperm Oils

Test	Sulfurized Jojoba Oil	Sulfurized Sperm Oil
Sulfur, percent	9.88	9.98
Viscosity, at 37.8 C	3,518 SUS[a]	1,961 SUS[a]
Viscosity, at 99 C	491 SUS[a]	201 SUS[a]
Specific gravity at 15.6 C	0.9476	0.9613
API at 15.6 C	17.82	15.71
Flash point	250 C	243 C
Fire point	282 C	280 C
Free fatty acids (oleic)	1.55	2.35
Saponification no.	162	195
Pour point	16.1 C	15.6 C
Corrosion, 90/10, 3 h at 100 C	2A	2A
Color, API. 10% in 1¾ color oil	4¾	8+

Source: H. Gisser.
[a]Saybolt Universal seconds.

Table 3. Hardness of Hydrogenated Jojoba Wax and Several Other Vegetable Waxes

Wax	Hardness[a]
Hydrogenated jojoba oil	1.9
Carnauba wax	2.6
Cane wax	2.1
Beeswax	0.38
Paraffin	0.24

Source: T.K. Miwa.
[a]Brinel Hardness Number at 25 C, 4.3 kg load for 60 sec. on 10.0 mm diameter steel ball.

Fig. 1. Wild jojoba seed developing on female bush, Santa Catalina Mountains, near Tucson, May 1977. *—Photo by Wade Sherbrooke*

increased use of synthetics, removed jojoba from further serious consideration until the early 1970s. This increased interest was brought about primarily as a result of the sperm whale being placed on the endangered species list. Further impetus for research on jojoba came about when it was observed that much of the natural jojoba populations are on American Indian reservations in the Southwest. A major jojoba development thrust occurred in 1972 when the U.S. Government contracted with the University of Arizona and the University of California (Riverside) to harvest the natural stands on Indian reservations, to express liquid wax, and to distribute the wax and meal for industrial testing. Approximately 44 tons of seed were harvested during the summer of 1972. Since that time the liquid wax and hydrogenated wax have been tested by private industry for possible commercial applications.

As of the date of this publication, liquid wax is selling for as much as $8 per pound for use in shampoos and hair oil, and $5.50 per pound for bulk sale to major cosmetic firms using the jojoba liquid wax in proprietary formulations. Current projections forecast a per-acre yield from mature jojoba plants (7 years old) of 1,760 pounds of seeds, which, in turn, yield about 750 pounds of liquid wax.

The San Carlos Apache Indian Tribe is making special candles with the hydrogenated wax. Depending on the amount of jojoba wax used in the formulation, the value returned can be as high as $12 per pound.

2. *Parthenium argentatum* (guayule)

Guayule (pronounced wī-ōō-lē) is a rubber-producing shrub native to the Chihuahuan Desert in southwestern Texas and northern Mexico, and was in fact a commercial source of rubber in the early 1900s. During World War II the U.S. Emergency Rubber Project actually planted 32,000 acres of guayule, and Congressional plans projected placing 500,000 acres under production. Of 32 million acres of land in the west, southwest, and midwest surveyed, five million acres in California, Texas, New Mexico, and Arizona were declared suitable for guayule cultivation before development of synthetic rubber and the easing of World War II emergency conditions led to cancellation of the guayule program (McGinnies and Haase, 1975-A).

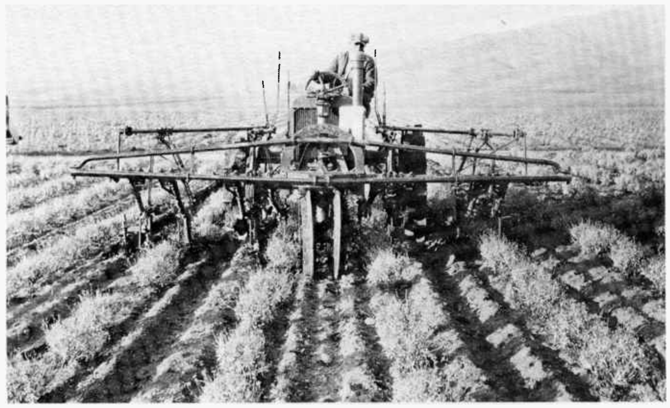

Fig. 2. Six-row cultivator used during World War II to cultivate guayule planted in the Salinas area, California. *—Photo by U.S. Forest Service, courtesy W.G. McGinnies*

Tests indicate that guayule rubber has chemical and physical properties essentially identical to that produced by the Malaysian "rubber tree" (*Hevea brasiliensis*). The principal barriers to economic viability are cultivation, harvest, and processing costs. If guayule can produce favorably under large-scale cultivation, it can become a major contributor to an arid-region economy because of the worldwide demand for rubber. This is true whether that guayule rubber-producing region is the Americas, Africa, Asia, Australia, or the Middle East.

The Comisión Nacional de las Zonas Aridas (CONAZA) has a rubber research production program and a pilot extraction-processing plant in Saltillo, Coahuila, Mexico, the scene of a recent (August 1977) International Guayule Conference.* CONAZA estimates that from wild guayule alone it can produce 30,000 tons annually (Comisión Nacional de las Zonas Aridas, 1976).

Guayule yield figures are not available except as estimated from the Salinas Valley in California where between 1931-1941, 4,400 acres had a yield of over three million pounds of guayule rubber (McGinnies and Haase, 1975-A). Kelly (1975) shows higher yields from one special test plot producing 1,336 pounds per acre over a 21-month period, or about 700 pounds per acre per year. Hilgeman (1975) estimates 235 pounds per acre per year from guayule rubber-production experiments in Arizona. Schechter (1975) stated

*Proceedings (in Spanish and English) will be issued late 1977 by Centro de Investigación en Química Aplicada (CIQA), Oldama Ote 371, Saltillo, Coahuila, México.

Fig. 3. Pilot extraction-processing plant, Saltillo, a joint project of CONAZA-CONACYT-CIQA. *— Photo by W.G. McGinnies, 1977*

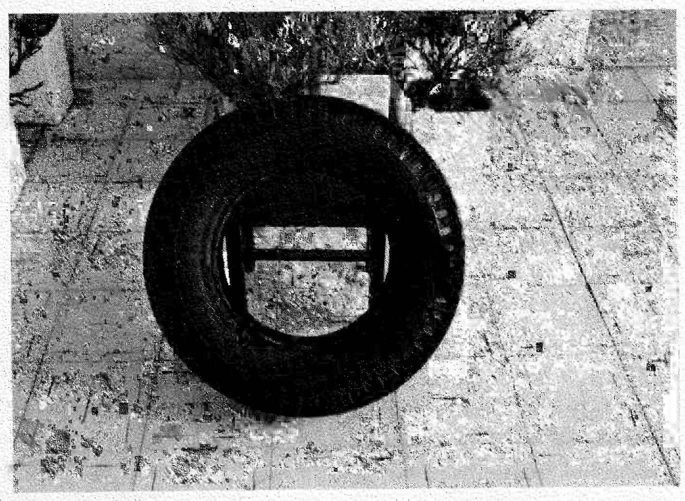

Fig. 4. Tire fabricated in Mexico from natural guayule rubber and synthetic. Saltillo. *— Photo by W.G. McGinnies, 1977*

the need to produce a sustained annual yield of 1,150 pounds per acre in Israel if the selling price of guayule rubber remains at $690 per ton.

III. FOOD PRODUCTS

The burgeoning world population and the recent drought in the Sahel of Africa have turned the world's hungry eyes to the deserts in search of more food. Ethnobotanical studies of the use of desert plants for food point to the many potentialities available where people native to arid lands have survived immemorially by their dependence on such sources.

The list of arid zone plants used as food sources over the period of recorded history is indeed long. Because only selected plants are discussed herein, however, the reader may wish to review Duisberg and Hay (1971), Burgess (1965), Felger and Moser (1971, 1973, 1974), Felger and Nabhan (1977), or Felger (1975) for a wider coverage.

1. Cactus

The cactus family, native to the Western hemisphere, includes several thousand species. Coyle and Roberts (1975) have prepared an interesting text, illustrated with color pictures of many plants of the Baja California region, which offers brief explanations regarding use of arid zone plants. For example, they say of the *Ferocactus* genus (Barrel cactus) that

> . . . These fruits can be fried or stewed and eaten. The cactus commonly lists to the south or southwest; thus its other common name compass cactus. The pulp of the stem can be chewed in time of emergency for its water content. Indians used the barrel cactus for cooking pots by cutting off the tops, scooping out the pulp and placing hot stones with meal into the cavity. The spines have been used [as] awls and needles for tatooing.

The following quotation from Duisberg and Hay (1971, p. 252-253) very succinctly states the case for the *Opuntias:*

> . . . No desert plants have been more studied and none are more controversial than the various species of prickly pear *Opuntias.* Over several centuries, these have spread throughout the world from their American points of origin.
>
> Peasant peoples in Mexico and many areas of North Africa and the European Mediterranean depend on the tunas, or fruit, as a major source of carbohydrates and vitamins. This commerce within Mexico alone amounts to over 30,000 tons, not including the great quantities used in the subsistence economy. Small commercial plantations have been established in Mexico, Chile, Brazil, Argentina, the United States, and many other countries; and tunas, jellies, and other products are finding their way into the luxury trade as specialty items. On the other hand, the plant is considered a pest in Australia, South Africa, the United States and elsewhere, and great sums are expended on biological and chemical methods to control its spread through grazing lands.
>
> In the 1960s a comprehensive scientific study was initiated in Mexico aimed at production of high-quality edible fruit, tender pads for vegetables, and forage. Results to date indicate that 8 tons per hectare of fruit [are] possible at rainfall levels of about 700 mm and [this level of production] is said to be maintainable [for] at least 200 years. In forage species, 200 tons per year of edible pads [have] been produced per hectare in experimental trials. While the protein content is low, these are impressive results, and the commercial possibilities are similarly impressive. Unfortunately, comparable work has not been done for the more arid desert regions where the land has no use except grazing at about 100 hectares per animal unit.

The large columnar cactus category includes the huge *Carnegiea gigantea* (saguaro), *Lemaireocereus thurberi* (organ-pipe cactus), and *Pachycereus pringlei* (cardon), the largest cactus in the world, growing to heights greater than 15 meters. While these giant species are very interesting and their fruits and seeds often are used for human consumption, slow growth and physical size may prevent domestication.

Machaerocereus gummosus (pitahaya agria), a cactus of Mexico's Baja California and coastal Sonora, bears fruit along its stems. The fruit is about the size of a small apple and covered with spines which tend to fall off when the fruit is fully ripe. The pulp is usually bright crimson-red, very juicy, and both sweet and tart. Pitahaya agria is considered a delicacy among the delicious fruits in the world. Inhabitants of the region harvest the fruit with enthusiasm. The pulp formerly was used for making wine.

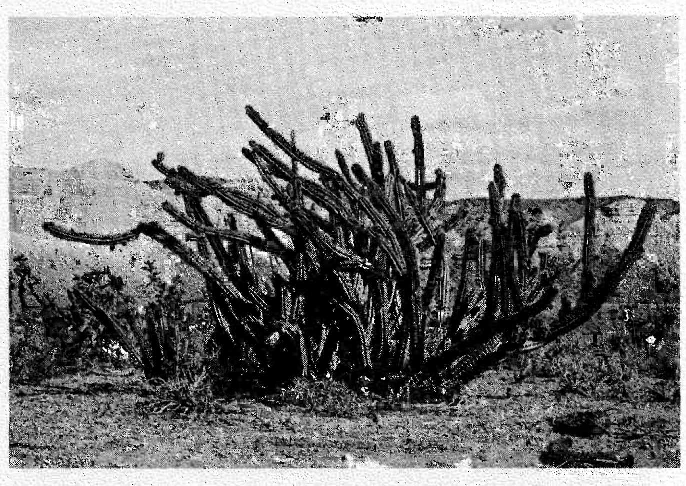

Fig. 5. Specimen of *Machaerocereus gummosus* (pitahaya agria), Baja California. — *Photo by James R. Hastings, courtesy Raymond H. Turner*

There are several other cactus species growing in the Sonoran Desert which have been or are used by the region's inhabitants. Cultivation is not practiced to any extent, but as Felger (1975) points out:

> . . . In certain regions, such as the arid portions of the Indian subcontinent and the Sahel, it would be particularly important to choose species or varieties which produce fruit during the pre-monsoon dry season—the times of most urgent local food shortage.

2. *Cucurbita*

Some *Cucurbita* species offer potential for economic development, including *Cucurbita foetidissima* (buffalo gourd or calabazilla) and *Cucurbita palmata* (coyote melon). Fruits of the buffalo gourd were cooked and eaten by Arizona Indians, or were dried and stored for consumption during the winter months. The seeds of the buffalo gourd were eaten in the form of a mush by Indians.

According to Jacks, Hensarling, and Yatsu (1972), *Cucurbita* species are indigenous to both arid and temperate regions of the earth, but require long periods of warm dry weather for optimal growth. They note that

> . . . They are frost-sensitive, drought-tolerant, and intolerant of wet, poorly drained soil. In arid regions xerophilous cucurbits have developed large, fleshy tap-roots, reaching depths of 45 feet below the soil surface, to obtain and store sufficient water to support their strikingly abundant growth.

They also note, however, that

> . . . Since production of the carbohydrate-rich fruit is generally the topic of concern regarding cucurbit products, seed yield is seldom investigated. When reported, however, wide variations in sizes of seeds, in numbers of seeds per fruit and, with wild plants, in numbers of fruits per plant, are noted. These observations indicate that selection and clonal propagation might improve yields.
>
> Yields from *Cucurbita foetidissima, C. digitata,* and *C. palmata* growing wild in desert areas, are estimated from 500 to 3,000 lbs. of seeds per acre, calculated from very limited observations. Experimental plantings of *C. foetidissima* in northwestern Texas produced from 706 to 1,977 lbs. of seeds per acre. *C. pepo* produced from 300 to 1,200 lbs. of seeds per acre and lines of "naked seed" (*C. pepo* that develops without seed coats) were improved by breeding to yield from 1,200 to 1,400 lbs. of seed per acre (most precocious lines). These yields are comparable to yields of commercially grown oilseeds.

Research by Jacks, Hensarling, and Yatsu leads them to conclude that

> . . . Cucurbit seeds can be classified as oil seeds because decorticated seeds contain by weight 50% oil and 35% protein. The oil is unsaturated and generally edible; however, the contents of conjugated trienoic fatty acids in the oil of a few species preclude edibility but increase industrial values as drying oils (similar to linseed oil for use in protective coatings). Proteins of cucurbit seeds appear edible and supplementation with certain amino acids increases the nutritional value of the protein. However, the possibility that a meal or protein from a given species might be inedible, e.g., through presence of a toxic compound in the seed, must be determined by appropriate feeding tests with the seed products.
>
> Thus cucurbits are potentially valuable oilseed crops. Of special interest are certain xerophilous species that grow particularly well in desert regions. Propagation of these species on currently unproductive wastelands could provide an additional source of oil and protein for industrial and edible purposes.

3. Ephemerals

Some desert plants (ephemerals) grow rapidly when moisture is available, producing large amounts of seeds. Desert Indians of the southwestern U.S. made extensive use of the seeds of ephemerals. Felger (1975) believes the genus *Amaranthus,* including pigweed and tumbleweed, may be particularly well suited for development as a food source in arid regions. All amaranth seeds are edible.

Ephemerals grow fast and mature quickly, completing life cycles in as little as four to six weeks. Once growth begins, ephemerals tend to produce seeds. Low rainfall may diminish seed numbers but usually does not prevent production as may happen with most crops. Desert ephemeral plant seed production is high and inexpensive, especially when compared with cultivated crop energy inputs—water, fertilizers, pesticides, and labor.

American Indians usually ground the seeds into flour. Amaranths were also consumed by American Indians as a leafy vegetable. Spaniards exploring the region discouraged use of amaranths as food, probably because the small size of the grains made them less attractive than corn. However, with modern techniques, small grains present no processing problems. Amaranth seeds contain about 17 percent protein and 7 percent oil (Felger, 1975).

Teparies are annual plants of the *Phaseolus* genus and are leguminous. Many species produce edible beans containing about 30 percent protein. Teparies have been cultivated and their beans harvested from wild populations as well. Because teparies grow quickly and require minimal supplemental water, they should be considered a potential field crop. Crossing teparies with commercial varieties of pinto bean strains might produce strains with greater drought tolerance.

4. Perennials

Some arid land tuberous plants may be developed into potato substitutes requiring minimal irrigation. Those mentioned by Felger (1975) or Burgess (1965) include *Dichelostemma pulchellum, Solanum jamesii, S. fendleri, Amoreuxia palmatifida, Jarilla chocola, Salpianthus macrodontus,* and others. Gentry (1963) states that the Seri Indians of Sonora, Mexico, cook the bark of the *Amoreuxia* root to make a tasty dish similar to refried beans, only better. Further, flowerbuds, flowers, fruits, and leaves are often delicious. Most arid land tuberous plants have high starch content and some protein. The roots, tubers, and fruits of several of these species occasionally are sold in the markets of Sonora and Baja California in Mexico. While most will require minimal irrigation under the extremely arid conditions, they offer promise as possible potato substitutes with benefits accruing because of the minimal water requirements and the use of other plant parts for food.

5. Other Plants

Agave is an arid land plant genus mentioned several times in this report because its uses are many [see also below under "Wood and Fiber Products" and "Extracts"]. Young *Agave* is roasted and eaten when it reaches what is called the "asparagus stage" (Coyle and Roberts, 1975). The *Agave* is the source of tequila and mescal, its seeds are made into flour, and the blossom exudes a sweet nectar considered a rare treat by Indians. The *Agave* probably has fostered the greatest economic and industrial development of any arid land plant, with the possible exception of cotton, an industrial development that undoubtedly will continue to grow.

Prosopis (mesquite) beans were and in some areas are the staple in the diet of many North and South American Indians, although mesquite is considered a pest in many parts of the southwestern U.S. Its control has been the object of much research in this country, even though a related species is cultivated in South America for cattle food. Felger (1977) makes a strong case for cultivating the leguminous mesquite because flour made from its high protein seed can be used to make a nourishing mesquite cake requiring no cooking.

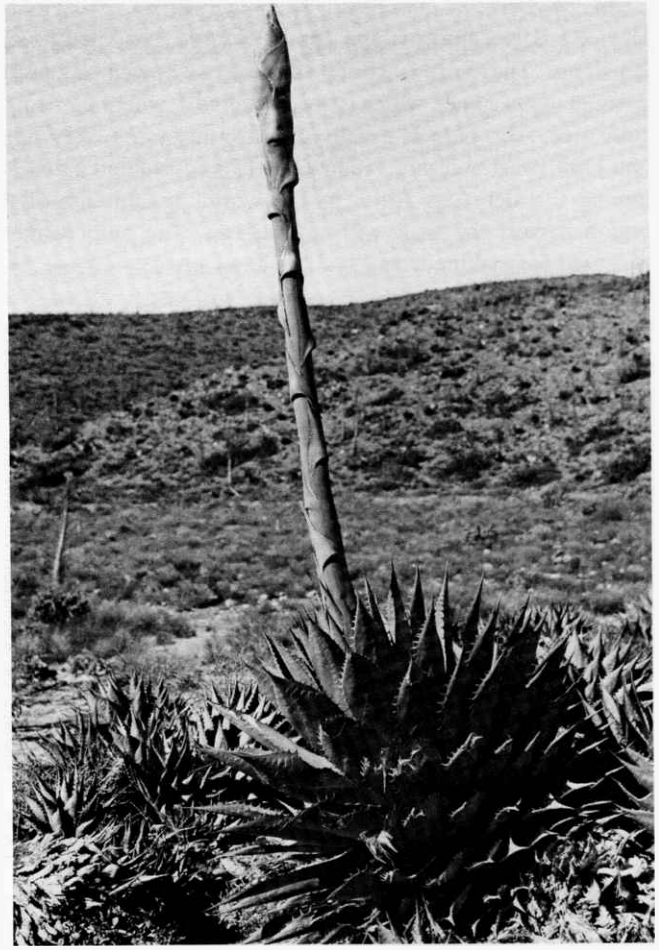

Fig. 6. A species of the *Agave* genus, Baja California.
—Photo by James R. Hastings, courtesy Raymond H. Turner

The sea grasses, of which there are about 50 species, thrive in the saline habitats of coastal deserts and in nearshore ocean waters and estuaries. According to Felger and Moser (1973) the seed of *Zostera marina* (eelgrass), one of the most important traditional foods of the Seri Indians in northwestern Mexico, is still harvested occasionally by them. Its seed has about 13 percent protein and 50 percent starch.

CONAZA (1976) reports planting 4,000 *Ceratonia siliqua* (carob tree) near Ensenada, Baja California, about 12 years ago. Although yield data are not provided, carob is being marketed as a chocolate substitute and as an ingredient for flour formulations.

IV. WOOD AND FIBER PRODUCTS

The *Agave* family heads the list of utilized arid land vegetation. Species such as *Agave sisalana* is cultivated extensively in Mexico, Haiti, Israel, Kenya, Mozambique, Cuba, Brazil, Indonesia, Tanzania, and others (Duisberg and Hay, 1971). The following quotes from Duisberg and Hay (p. 252, 248-249) indicate the extent of *Agave* use.

. . . Henequen from *Agave fourcroydes* is primarily produced in the Yucatan, Mexico. More than 100,000 hectares are in production in the Yucatan. . . .

The average fiber production in the Yucatan plantations is about 1,000 kilograms per hectare annually, or about 7 percent of the leaf weight. The juice and the bagasse remaining are used only for fertilizer. Considerable work has been done to try to develop products from other constituents, including the 0.2 percent of wax. In the case of *Agave sisalana* in Tanzania, the asponin hecogenin, a precursor of cortisone, is produced as a by-product, even though the concentration in that species is low for the *Agaves.*

Sisal is from *Agave sisalana,* also indigenous to Mexico, but interestingly enough the plant is not grown there to any extent. It is, however, the principal hard-fiber desert plant grown in most other countries.

It is important commercially in Haiti, Israel, Kenya, Mozambique, Cuba, Brazil, Indonesia, Tanzania, and other countries. In the Saint Marc area of Haiti, the rainfall varies from a humid 1,000 to 1,500 mm; the plantations are located on the poorest soils with low water-holding capacity, and short droughts are frequent.

The henequen and sisal industries are the largest and most advanced desert-plant industries. The United States, for instance, imports a total of 175,000 to 300,000 tons of fiber per year. There is a great competition and consequent fluctuation in price, and the value of imports into the United States has varied between $18,000,000 and $70,000,000 per year. This great fluctuation in price and demand has played havoc with the smaller and higher-cost industries, and many have failed after building expensive plants. Two recent examples occurred in the Azua Peninsula of the Dominican Republic and in western Venezuela, with considerable economic hardship on the employees displaced. Intense competition between the different producing countries leaves industry vulnerable to increasing competition of synthetic fibers.

More than 20 additional arid-zone plants of the general *Agave, Furcraea, Bromelia,* and *Attalea* are also grown in various countries to produce smaller amounts of hard fibers, generally for their local needs.

The *Agave lechuguilla* is common in northern Mexico and western Texas of the United States in areas averaging 150 to 200 mm of rainfall; it is the source of the hard fiber ixtle. The last attempt at industrialization of this resource failed in the United States about 1950. Mexican production has shown a downward trend but still amounts to some 10,000 tons of fiber annually, which is marketed for export through a national monopoly. The value of the product is about $3,000,000. The harvesting is done by hand, with transport usually by mules. The method of harvesting permits regrowth, and the plant is very abundant; therefore only a small portion of the potential supply is used. The most important external uses are for rope, upholstery tow, and cheap brushes.

The harvesters live at a subsistence level and obtain a meager income by extracting lechuguilla fiber at home at a rate of 6 to 8 kilograms per day. Attempts have been made to develop machines to harvest the wild plant, but these have failed. Decorticating machinery has been developed on the basis of the principles well known for henequen and sisal. The profits have been marginal, however, and they have accounted for only a small part of the production.

In view of the facts that (a) sisal and henequen grow under less arid plantation conditions, (b) synthetic fibers are increasingly strong competitors, and (c) the harvesters will require increasing financial incentives to remain working isolated under primitive conditions, it is expected that costs will rise and markets continue to contract.

The list of arid land plants used for arrows, fishhooks, drills, flutes, and shelter structures is indeed long, including species of cactus and other succulents plus desert-living trees such as mesquite, juniper, pinyon, sycamore, willow, desert ironwood, cottonwood, and others. Duisberg and Hay (1971), Burgess (1965), and Coyle and Roberts (1975) present excellent review of the potential for use of arid land plants as building materials.

V. EXTRACTS

The extracts category is in actuality a catchall which includes gums and waxes, medicine, alcohol, resin, perfume, and dyes.

Again, *Agave* heads the list because it is a major economic plant used to produce mescal and alcohol. According to Duisberg and Hay (1971, p. 252):

> . . . In Mexico the alcohol tequila is made from *Agave tequilana* and related species, and the alcohol mezcal from *Agave atrovirens.* In both cases the central portions, or heads, are cooked in ovens to convert the glucosides into sugars. The juices are then extracted, fermented, and distilled. The distilling equipment is generally rudimentary and fiber is produced as a byproduct.
>
> The production and values of these alcohols are increasing. In the case of mezcal, annual production increased from about 1.90 million liters in 1950 to 2.05 million liters in 1960.

According to Burgess (1965), some 35 species of desert plants have been used to produce mescal.

Teas, wines, coffee substitutes, and alcohols have been produced from many other desert plants, with most deriving from cactus fruits.

> . . . One of the most common plants of the Mexican and southwestern United States deserts and the arid lands of western Argentina is creosotebush. During World War II this plant was found to contain nordihydroguaiaretic acid, which proved to be a powerful antioxidant for fats and oils and

> was of great value for several years. Once again, however, cheaper synthetic chemical antioxidants succeeded in usurping its market. Meanwhile, interest had been aroused in other byproducts. Studies on the resins indicated good possibilities for paints and varnishes, but they coincided with the period in the paint industry when synthetics began to displace the natural resins, and therefore the resin studies were discontinued (Duisberg and Hay, 1971, p. 250).

Gums have been produced commercially from *Acacia senegal* in the Sudan and from *Astragalus* in Iran. Mesquite and creosotebush provided gums to American Indians who used the gums for waterproofing or as glue. To date, gum production from arid land plants depended greatly upon raw material supplied from wild stands harvested by cheap labor. Continuation or improvement of gum production from arid land plants will require further agronomic research and development.

Oils and waxes are produced from several arid land plants including jojoba, discussed earlier. Products derived from species of *Agave, Yucca, Euphorbia,* and *Cucurbita* have been used by earlier peoples, but except for jojoba and candelilla, little currently is being accomplished in exploiting the products' potential of these plant families.

Duisberg and Hay (1971, p. 249) comment on candelilla:

> . . . Candelilla wax comprises about two percent of the *Euphorbia antisyphilitica* plant and has the relatively high melting point of 67.5°C. It formerly ranked second to wax from the carnauba palms in demand as a hard wax for floor polishes; it was also used in a number of other products from phonograph records to pomades.

CONAZA (1976) is conducting research on *Yucca* and the Mexicans are anticipating a large *Yucca* industry based on product uses including chemicals, medicines, food, and alcohol. This organization forecasts an annual production capability in Mexico of 400,000 liters of candelilla which can be used as a fruit preserving emulsion. In 1975-1976, 10,000 liters of candelilla derivative emulsion were produced and sold to preserve limes, focusing increased attention on the Mexican industry.

Tannins are produced commercially from *Acacia decurrens* and *Rumex hymenosepalus* (canaigre). Mexico hopes to provide all of its leather tanning needs by planting 2,000 hectares of canaigre. Preliminary research in Mexico indicates a yield of about 40 tons per hectare (CONAZA, 1976). Plantations of *Acacia decurrens* are planted in its native Australia and South Africa. The adult plant yields 20 to 25 kg. of bark which contains about 35 percent tannin. Wattle *(Acacia)* bark remains one of the best and most important tanning agents (Duisberg and Hay, 1971, p. 252).

Several arid land plant species have been used to produce medicines, including ephedrine made from the genus *Ephedra* for commercial sale. *Ephedra sinica* and *E. gerardiana* have been used to produce ephedrine in large volume in China and Pakistan, respectively. *Euphorbia hirta* is a plant used to manufacture drugs for the treatment of asthma and bronchitis. *Lophophora williamsii* (peyote), *Claviceps purpurea* (ergot), various poppies, mushrooms, and other arid land plants are used either as medicines or hallucinogens. Many warm-desert plant species contain antitumorous agents and are being tested and developed to treat cancer and various skin disorders, including ulcers and wounds. Although employing arid land plant derivatives as medicines appears to be promising and may result in high-value pharmaceutical products, there is very little sponsored research on domesticating these many plants for medicinal purposes (Caldwell, 1965; Duisberg and Hay, 1971; Coyle and Roberts, 1976).

Many arid land plants also are used to make dyes, but the list of these plants is long, and none apparently are cultivated to produce dyes.

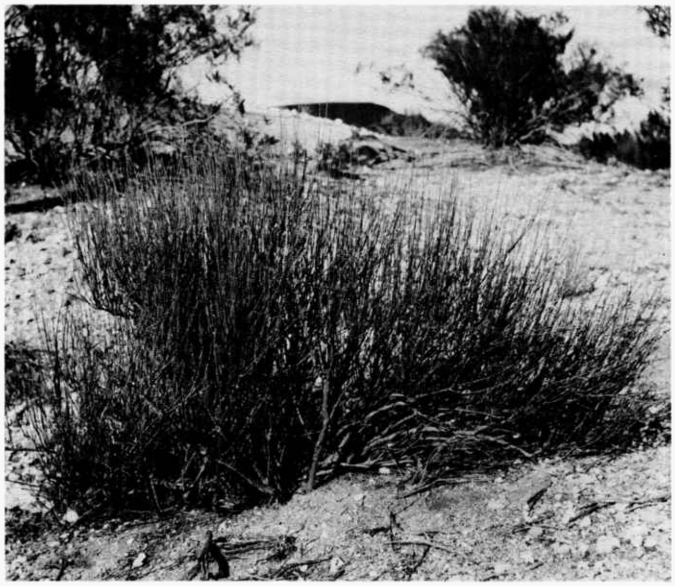

Fig. 7. A species of the *Ephedra* genus, Baja California.
— Photo by James R. Hastings, courtesy Raymond H. Turner

VI. ENERGY PRODUCTS

Several plants adapted to arid lands have been or are being used for cooking or as heating fuel, but often this use has led to environmental problems. Destruction of tree stands often upsets the habitat so that plant symbiosis is defeated, barren soil becomes eroded, and desertification occurs. While there is large potential for use of trees such as *Acacia,* mesquite, and desert ironwood for fuels, it can be successful only when cropping is accompanied by an appropriate reforestation program. The *Pinus eldaraca* (Mondale pine or Afghanistan pine) is receiving considerable attention currently because of its heat tolerance as well as its phenomenal growth rate. Although considerable investigation is necessary to determine which trees should be brought under cultivation, the potential for developing new fuel sources certainly seems to justify selected research programs.

Rather than simply burning woody material, why not process that material into a cleaner and less bulky fuel? Three basic processes for accomplishing this are fermentation, pyrolysis, and reduction. The fermentation process employs microorganisms to digest organic material, converting it into alcohols; however, if the process is anerobic the products are carbon dioxide and methane. Pyrolysis is the process in which organic materials, especially cellulose, are heated in the absence of oxygen. The products of pyrolysis are usually an oil and a solid, both of which can be used as fuel. The reduction process requires gaseous hydrogen or carbon monoxide as a reducing agent which reacts in a high-temperature, high-pressure reactor; the product is usually an oil. Regardless of the process, arid-land plants should be considered as a potential fuel stock.

Meinel and Meinel (1977) discuss the exciting prospect cultivating *Salsola pestifer* (tumbleweed). They propose that tumbleweed be pelletized and used directly as boiler fuel, but where appropriate it could also be used as fuel stock for energy conversion. According to the Meinels, tumbleweed has the potential value of $320 per acre if their yield of 2.5 kg/m^2, the energy value of 4.0 kcal/g, and an energy value of $2 per million Btu hold true.

SUMMARY

While only selected arid land economic plants have been discussed in this report, I believe their potential uses have been demonstrated. In this era when we no longer talk of free water and unlimited energy, and when we now realize that resources are limited, we need to look with firm determination at employing our renewable natural resources, particularly in arid areas where water is in short supply, and what water there is, is often expensive. With the exception of a few oil-rich countries, we in other arid areas must pay a high price to import energy. We do enjoy plentiful solar energy and arid land plants appear to be efficient solar energy converters.

Finally, the economic use of arid land plants must be placed in a framework where we can anticipate crop production with minimal water and energy inputs on land which may not be economically suitable for other uses. In terms of income per acre, we must think in terms of comparing new crop development with other potential uses for the same piece of land, and not make comparisons with more humid area income per acre potentials.

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Editorially speaking

POURQOUI? MADOA? WARUM? ¿POR QUE? LIMADHA?

We have a bad reputation for asking questions to which there are seemingly no answers. Why? we keep asking. Why not? we insist. Must we forever submit to the sense of helplessness in the real world, to a sense of being borne along by events, to a sense of being manipulated by mean-spirited leaders reluctant to surrender the privileges of power, to a sense of being enmeshed in events over which we have no control? We think we do **not** need to submit, and that if we continue to make a tiresome nuisance of ourself by asking embarrassing questions about the wasteland of bureaucracy, the bleak routines of paperwork and "governmentese" – in whatever language, we can indeed force new strategies to turn old mistakes into new successes.

Q: Why are countries with the highest birthrate and the lowest per capita income so timid about pressing vigorously for birth control?

A: Well, you must try to understand that culturally these populations are accustomed to think of many children as security for labor. They are often illiterate, dominated by religious concepts that have traditionally intimidated their followers from entertaining anything so radically in opposition to centuries-long ways of life.

[Comment: This is an answer?]

Q: Why are religious beliefs allowed to destroy potential relationships that would be beneficial to all concerned?

A: It is not so simple, as you imply, that two such adversaries get together over the fence and agree that since one has solved a mutual problem, the other can adopt it and everybody wins by a handshake. Generations may have been indoctrinated to hate in what may seem to **you** to be an irrational way, but you should try harder to put yourself in the other person's place and not judge behavior by what **you** would do in an identical situation.

[Comment: Is this an acceptable answer?]

Q: Why will you not concede that my graduate student friend's $3.27 solar cooker could be used widely where firewood is scarce, on an experimental basis? What is there to lose? Why do you shrug him off and just say it isn't feasible, that nasty word?

A: As we have tried to explain to you before, Madame Editor, your friend's $3.27 solar cooker will not function after sundown when families wish to eat their suppers.

[Comment: This is an answer?]

Q: Are you bored?

A: Frankly, yes.

Well, about those solar cookers: For the cost of a two-weeks' trip to Mali by one doubting speaker at a seminar here at which this question was brought up, Mali, where the land is denuded of even the barest semblance of firewood, our friend maintains he could manufacture one thousand simple primitive but workable solar cookers (and he has demonstrated it by roasting hotdogs for lunch in the parking lot outside our office, admittedly at noon and not after sundown!). We are not saying that one thousand solar cookers will reverse the process of desertification in the Sahel (any more than the cynic speaker's two-weeks' trip did), or that one hundred thousand would succeed worldwide. What we **are** saying is that the technology of solar cookers transferred to a thousand villages where the firewood is gone, where even the roots are gone, would indeed permit the desertifying marginal lands the barest chance for regeneration.

This is a simple fable, and will be dismissed by those who cannot scale down their thinking and planning and talking, and yes, doing, to the level where it might function successfully. The feasibility of our student friend's solar cooker would have to be the subject of high level conferences, at a cost of not a thousand but perhaps a million cookers.

Why? – or why not?

– *Patricia Paylore*

PERU ESTABLISHES NEW ARID ZONE CENTER

During a recent visit of several weeks by the Director of the Centro de Investigaciones de Zonas Aridas (CIZA), Universidad Nacional Agraria, Lima, **Dr. Carlos López Ocaña** talked at length with staff of the Office of Arid Lands Studies and other University of Arizona faculty, including the *Arid Lands Newsletter* Editor.

An agronomist by training, with a doctorate from the University of Nevada (1973), López Ocaña admitted freely that he looked to arid lands institutions in Norte America for guidance in structuring the new Centro which he now directs. He paid particular tribute, nevertheless, to Dr. Frederic Engel, the distinguished French anthropologist who was the guiding light for the Universidad's own Instituto de Antropología y Agricultura Precolombiana from 1965 until it was incorporated into the new Centro de Investigaciones de Zonas Aridas. López Ocaña believes that in the matter of survival in an arid land, we have much to learn from those who survived before us, hence his interest in Dr. Engel's earlier investigations into pre-Colombian sites, agricultural practices, water uses, and habitat. It is expected that a continuation of these studies will be built into the new CIZA, and indeed, in addition to Dr. Engel who remains on the staff as one of its chief scientists, there is another anthropologist as well, Dr. Miriam Vallejos. An atlas of such archaeological sites along the Peruvian coast and the western slopes of the Andes is in preparation, as well as plans for excavations of specific locations that are expected to reveal some of the answers to earlier occupations of this great coastal desert.

Our interview became philosophical when we took up considerations of arid lands development, how the dynamics of many disciplines interacting on a single environment work, what the future of the world's arid lands may be.

We talked at some length about the geography and climate of the Peruvian "costa" and its historic development as an agricultural area along the extensive river valleys debouching from the Andes. While the dry flat plains and sand dunes that characterize the coast include approximately eleven percent of the national territory, it carries the greatest population, growing dramatically in the last decade of migration from the Selva and the Sierra. López Ocaña is cognizant of the problems this migration creates, and hopes that the work of the Universidad in general and the CIZA in particular can help Peruvians deal intelligently with such growth aspects as the need for more productivity of agricultural lands, the impact of irrigation on desert areas, and the creation of markets, transportation facilities, and agricultural extension services.

He spoke of several important development projects along the arid Peruvian coast which CIZA hopes will be the model for use through the length of the Costa's 1,400 miles, where by careful monitoring such ancient afflictions as erosion, drainage, salinity, plant diseases, drought can be controlled if not eradicated.

Acknowledging that these are not peculiar to the Sechura or any other portion of Peru's coastal desert, he nevertheless recognizes the problems, has tried to learn how others have met and conquered these immemorial enemies of man in the desert, and hopes to apply these lessons to his own country. He knows that all deserts are not alike, that the Peruvian Desert is not exactly like the Namib, nor like Baja California's western littoral. But scarcity of water, salt buildup, waterlogging through poor drainage, and the social burdens of overpopulation, energy costs, and economic constraints are present everywhere as developing nations and developed nations intersect at that point where the latter is forced to scale down its wasteful demands just as the former's "rising expectations" are creating the markets we are abandoning.

Nevertheless, we each of us in our own ways must seek and find and apply solutions. It will be no comfort to any if we all go down together.

– Patricia Paylore

REMOTE SENSING PROJECT IN PERU

In February 1977, Dr. Federico Anavitarte Condemarín, Rector, Universidad Nacional Agraria, Lima, and Dr. John P. Schaefer, President, University of Arizona (shown left), signed a formal cooperative agreement on behalf of the Centro de Investigación de Zonas Aridas [see interview with its Director, above] and the Office of Arid Lands Studies of the two institutions respectively, that said in part:

. . . With the best part of a century of research, education, and public service behind them, the two universities, both with a strong arid lands tradition, believe they have much to give each other and their appropriate governmental planning agencies by embarking on this cooperative linkage.

As the first implementation of this affiliation, Arizona sent a team of three specialists to Lima in August 1977 to conduct a two-week workshop in remote sensing: Dr. David Mouat, a remote sensing specialist, and Dr. A. Wayne Wymore and Eugenio Castaño, systems analysts. A recognized technique applied to solutions to resource management problems such as those confronting Peru and other desert regions, remote sensing can provide information not only on the spatial characteristics of resources but also changes through time. In Peru sessions designed to solve some of that country's resource problems through remote sensing data focused on analysis of the data through a systems approach. The field work is to be completed shortly, with the final management program scheduled for January 1978.

THE GEOGRAPHY OF THE SAHARA: A PHYSICAL AND CULTURAL OVERVIEW

University of Arizona arid lands buffs were treated to a special summer seminar on August 9, 1977, when the distinguished German geographer Heinrich Schiffers and his colleague Hartmut Redmer visited the Office of Arid Lands Studies. Schiffers, professor at the University of Cologne, author of *Die Sahara u. Ihre Randgebiete* (3v., 1971-72), electrified his audience by whipping out a small pocket notebook, opening it to the date August 9, 1927, and reminding us that it was the fiftieth anniversary of his first setting foot on that greatest of all the world's deserts.

Herr Redmer spoke of current developments in the Sahara, including settlement trends that have abandoned the best of older ways of surviving in that harsh climate, in favor of the worst of the developed world's shanty towns. Que lastima!

Members of Dr. Schiffer's party were taken on a field trip by Office of Arid Lands Studies staff to the San Carlos Apache Indian Reservation to observe the jojoba developments there, and on the long day's journey to see something of the Sonoran Desert.

INTERNATIONAL VISITORS TO OALS/UA

ARGENTINA:

Ernesto A. Sourrouille, Soils Scientist, INTA.

Jorge Velasco Suarez, Centro Nacional Patagonico.

AUSTRALIA:

Alan Jones, Senior Lecturer in Photogrammetry, University of New England, Armidale.

T.B. Brealey, CSIRO Division of Building Research, Highett, Victoria. Author of *Living in Remote Communities in Tropical Australia* (1972), Brealey is on a world tour to determine the "state of the art" of settlement technology, building design for hot climates, and remote communities environments.

CAPE VERDE:

Jorge Querido, National Director of Water, Ministry of Rural Development, Cidade da Praia.

INDIA:

Dr. R.K. Gupta and P.R. Mishra (left, below), Division of Plant Sciences, Central Soil and Water Conservation Research and Training Institute, Dehra-Dun.

ISRAEL:

Joel Schechter, Director, Research and Development Authority, Ben-Gurion University of the Negev, Beer-Sheva, 84110. On leave from his Negev post for the year past to do research at the Massachusetts Institute of Technology's Center for Alternative Policies, Schechter flew to Tucson in late April 1977 to advise on jojoba matters with Mr. Bill Miller (right, below), an official of the Bureau of Indian Affairs.

JAPAN:

Dr. M. Toyama, Sand Dune Research Institute, Tottori University, Tottori.

Dr. Iwao Kobori, Department of Geography, Faculty of Science, University of Tokyo. Kobori has been co-opted by the International Geographical Union's Working Group on Desertification, to accept responsibility for East Asia coverage for the supplementation of the Desertification Bibliography produced last year for the Ashkhabad meeting. In Tucson in July 1977, he was particularly interested in the Arid Lands Information System which operates under the aegis of the Office of Arid Lands Studies.

MALI:

Koke Dembele, Governor, Gao Region, Gao.

I. Brahina Dicko, Economic Counselor to the President, Bamako.

MAURITANIA:

Mohamed El Mokhtar Ould Zamel, Member, National Assembly, Nouakchott.

MEXICO:

A contingent of Mexican officials and scientists conferred on July 28, 1977, with U.S. delegate Jack D. Johnson (Office of Arid Lands Studies) and others on coordination of positions relating to the UNEP Desertification Conference.

PAKISTAN:

Dr. Islam Sheikh, Vice-Chancellor, University of Engineering and Technology, Lahore.

SAUDI ARABIA:

Mr. Ziyad Adham, Director General, Research, Ministry of Agriculture and Water. Adham spent the month of August on the University of Arizona campus as a trainee in management under the auspices of the USDA Foreign Development Division, International Training. His interest particularly was in integrated research systems that involve state governments with institutions.

Dr. A.M. Al-Taweel, Director, Research Center, Faculty of Engineering, Riyadh University, Riyadh.

SUDAN:

Mohamed O. El-Karouri, Director, SOBA Agricultural Research Station, Khartoum.

Ali Darag Ali, Deputy Director, Range Administration, Ministry of Agriculture, Khartoum.

A.G. Seif el Din, Senior Research Officer, Gum Research Division, El Obeid.

TUNISIA:

M'hamed Sta M'Rad, Institut National de la Recherche Agronomique de Tunisie, Tunis.

Schechter, Joel (1977). **DESERTIFICATION PROCESSES AND THE SEARCH FOR SOLUTIONS.** Interdisciplinary Science Reviews 2(1):36-54.

Results of research and development have indicated that the enlightened intercession of man can contain and reverse this process. Sound management and conservation of existing land and water resources seem to be the basic needs, and are perhaps the easiest technology to transfer to the desert farmer and the nomad. Introduction of drought-hardy trees and bushes of economic value to bind drifting sand dunes and to regenerate overgrazed pastures have also proved their value. Recent research has shown the possibility for better utilization of water resources including brackish water for irrigation of agricultural crops. Many other fields of technology are being applied to this problem, but the major focus will undoubtedly have to be on man himself: social organization, nomadism and sedentarization, technology transfer, population control, education.

ALA: AFRIKA-LATIJNS AMERIKA-AZIE (1976). Vol. 1, No. 1. College voor de Ontwikkelingslanden, A. Goemaerelei 52, B-2000 Antwerpen, Belgium.

This first issue of a new periodical published by the College for Developing Countries has articles in English and French on various aspects of socioeconomic problems in the Third World, with summaries in other languages. Contributions of articles on this topic are solicited. Distribution is without charge in exchange for publications in related fields.

Eckholm, Eric, and Brown, Lester R. (1977). **SPREADING DESERTS–THE HAND OF MAN.** Worldwatch Paper 13. 40 p. paper. 1776 Massachusetts Ave., N.W., Washington, D.C. 20036. $2.00.

Prepared at the request of the Secretariat of the 1977 United Nations Conference on Desertification, this latest in the series discusses desertification as a global problem, food prospects in desert lands, and social causes and social solutions. "Too commonly lacking," say these authors, "is a political commitment to the reversal of desertification commensurate with the size of the challenge. Faced with immediate crises–famines, strikes, and political intrigues–governments find it difficult to devote substantial resources to combatting a seemingly long-term and nearly invisible problem like ecological deterioration. They are especially reluctant to do so when a shift in national priorities and investment patterns goes against the short-term personal interests of powerful elites. Governments that procrastinate too long, however, may one day be forced by events to see that their deteriorating agricultural landscapes are mirrored in deteriorating social and economic conditions. The varied consequences of desertification–undernutrition and famine, unemployment and migration, deepening poverty and human desperation–are neither distant nor invisible."

Nelson, Michael C. (1977). **THE WINTERS DOCTRINE: SEVENTY YEARS OF APPLICATION OF "RESERVED" WATER RIGHTS TO INDIAN RESERVATIONS.** University of Arizona, Tucson, Office of Arid Lands Studies, Arid Lands Resource Information Paper 9. 150 p. paper. $10.00.

An in-depth study of the general and legal literature relating to this doctrine, first enunciated in 1908, commonly used to designate Indian water rights implied by the courts from treaties and other government agreements involving Indian tribes. Included are chapters on the nature of Indian reserved water rights; western water law and Indian reserved water rights; a case law development–Winters through Arizona v. California, 1963–which describes in detail twelve major cases that have determined the bounds of Indian reserved water rights; and judicial protection of Indian water rights under the McCarran Amendment. A list of 64 additional related cases is given, with brief annotations, arranged chronologically, then by court level, and finally those reserved water rights cases currently pending before the courts, 28 in number. An 87-item annotated bibliography of the general literature dealing with Winters is appended.

Long, Gilbert, et al. (1977). **EXPERIMENTATION SUR L'UTILISATION DES DONNEES LANDSAT POUR L'ETUDE ECOLOGIQUE DES ZONES ARIDES DE TUNISIE.** Expérience ARZOTU. Paper read at the 4th Canadian Remote Sensing Symposium, Quebec, 16-18 May. 9 p. paper.

These investigators from the Centre National de la Recherche Scientifique and the Centre d'Etudes Phytosociologiques et Ecologiques L. Emberger, Montpellier, France, report on results in southern Tunisia of remote sensing imagery during 1975-76. Tunisian agencies cooperating include the Institut National de la Recherche Agronomique de Tunisie and the Office de la Recherche Scientifique et Technique Outre-Mer (Montpellier), Gabés unit. They perceive applications of this system as (1) inventory of Tunisia's cereal producing areas, (2) monitoring vegetation in the pastoral zones, and (3) tracking the extent of desertification.

Maasai Rural Training Centre (1976). **ANNUAL REPORT OF THE AGRICULTURAL SCHEME IN MAASAI, MANAGED BY THE DIOCESE OF NAIROBI.** P.O. Isinya, Kajiado, Kenya. 21 p. paper.

This report concentrates on a year of drought and their efforts to minimize its effect on those who live in this area through various training courses and aid programs. Extension work is carried out in remote locations where travel to centers is difficult. Demonstration activities relate to controlled grazing, food-for-work programs, tannery development, and specific short courses.

Kobori, Iwao (1976). **NOTES ON FOGGARA IN THE ALGERIAN SAHARA.** University of Tokyo, Department of Geography, Bulletin 8:41-55.

Will the introduction of artesian wells and a shortage of labor to undertake the strenuous tunnel digging replace the role of the foggara as a water supply? Kobori summarizes the historical and physical background of existing foggara in the Algerian Sahara. 215-item bibliography.

Simpson, B.B., ed. (1977). **MESQUITE [PROSOPIS], ITS BIOLOGY IN TWO DESERT SCRUB ECOSYSTEMS.** Dowden, Hutchinson and Ross. 288 p. $25.00.

Discusses how mesquite copes with desert environments and compares the biology of different species of the genus in two widely separated but climatically similar arid scrub ecosystems. Points out parallels and differences between mesquite and their relationships to climate, plants, animals, and people in the Americas.

Cowles, Raymond B. (1977). **DESERT JOURNAL: A NATURALIST REFLECTS ON ARID CALIFORNIA.** University of California Press, Berkeley. 264 p. $10.95.

Battan, Louis J. (1977). **WEATHER MODIFICATION IN THE SOVIET UNION, 1976.** American Meteorological Society, Bulletin 58(1):4-19.

The USSR has a large investment in weather modification research and operations. Major cloud physics experimental facilities exist at the Institute of Experimental Meteorology and at the Institute of Geophysics of the Georgian Academy of Sciences. Hail suppression operations are being carried out over about 5 million ha of farmland. Although claims of success in these activities are more modest than they were in 1969, it is still reported that the benefits far exceed the costs. Research in the Ukraine over the last three years has led scientists there to conclude that ice nuclei seeding of cumulonimbus clouds over a substantial area caused rainfall increase of about 30 percent.

Settlement Study Centre, Rehovot, Israel (1977). **ACCESSION LIST OF REGIONAL PLANS, PROGRAMMES AND PROJECTS, COMPILED BY DEVOIRA AUERBACH.** 95 p. paper. $3.00. Address: P.O. Box 555, Rehovot; telephone: 951787.

A description of approximately 400 settlement projects arranged geographically by some 100 countries, together with a detailed index covering such topics as agriculture, energy, human resources, land economics, recreation, social services, water supply, and others. Arid countries include: Africa–Ethiopia, Kenya, Mali, Morocco, Nigeria, Senegal, Sudan, Upper Volta; Asia–India, Iran, and Pakistan; Oceania–Australia; Latin America–Argentina, Brazil, Chile, Mexico, Peru; Middle East–Iraq, Israel, Jordan, Syria, Trucial States, Yemen; plus information about planning in the U.S. and Canada. The publications cited which describe settlement plans, programs, and projects in these countries carry full bibliographical information to assist users in locating. The Settlement Study Centre is sponsored by the Israeli Ministries of Foreign Affairs, Agriculture, Labour, Interior, and Housing, and by the Settlement Department of the Jewish Agency.

Mundlak, Y., and Singer, S.F., eds. (1977). **ARID ZONE DEVELOPMENT: POTENTIALITIES AND PROBLEMS.** Proceedings of a symposium cosponsored by the American Academy of Arts and Sciences and the Hebrew University of Jerusalem, October 1975. Ballinger Publishing Company, Cambridge, Massachusetts. 293 p.

In addition to an introductory overview, this symposium covers the following topics: water resources in arid lands, land and water utilization in arid zone agriculture, solar energy in arid zones, the economic and social implications of arid zone development, plus an extensive bibliography. To honor Hebrew University's fiftieth anniversary, the symposium was organized to stimulate thinking about development possibilities for arid zones and about research directions that might open up new options or permit informed choice among existing ones. A wide range of topics, from analyses of opportunities and constraints that cultural, political, and economic factors present in arid zone development, to reports or research on specific physical processes, are covered by international experts.

Gillette, Elizabeth R., ed. (1976). **ENERGY, WATER, AND THE WEST.** A workshop focusing on the impact of energy development on western water resources. National Conference of State Legislatures, Office of Science and Technology, Executive Tower Inn, 1405 Curtis St., Denver, Colorado 80202. 87 p. $5.00.

This conference was sponsored by the AAAS and several western regional councils, with funding from NSF and the Ford Foundation. Its conclusions underline the impact of energy development on western water resources as one, if not the most important, factor in energy development. While water apparently is available in the western states, it is not in the right place, and in order to be in the right place at the right time, states and the federal government must develop cooperative policies and programs. For the western U.S. read any other comparable area in the arid world where the lack of such cooperation between regional components creates a similar critical situation.

Forti, M.; Ben-Dov, J.; and Pasternak, D. (1977). **RECOMMENDED DROUGHT AND SALT-RESISTANT ORNAMENTAL PLANTS.** Ben-Gurion University of the Negev, Research and Development Authority, Beer-Sheva, Israel. BGUN-RDA-132-77. 7 p. paper.

The list presented is the result of research and follow-up carried out during the last 12 years in the introduction areas of the Institute for Applied Research in the Negev. Observations in gardens and parks as well as in areas established in the Negev by other institutions adds a dimension of time and space. Lists include trees, tall shrubs, shrubs, dwarf shrubs, prostrate and herbaceous perennials, and salt-resistant ornamental plants.

Paylore, Patricia (1977). **ARID LANDS RESEARCH INSTITUTIONS: A WORLD DIRECTORY.** Revised and updated edition. University of Arizona Press, Tucson. 317 p. paper. $7.50.

This new edition replaced the original 1967 version, and includes a name index of over 1,000 arid lands research specialists, plus descriptions of a number of new organizations in countries not represented in the earlier edition, attesting to the growth of interest worldwide in arid lands research. The Editor comments in "A Note to the User" that the presentation of information here is clearly a reflection of the changed state of the desert world over the last decade: "It reflects in some measure the political instability and consequent restraints on the free communication that should flow between international colleagues with a common purpose. Nevertheless, even though it reflects the growing scientific anxieties of the arid world's specialists, it also expresses, perhaps as never before, the urgency of our combined determination to accomplish together for a world we all share what none of us can do alone."

VEGETATION MAPS

SUDAN:

1974. Ecological map showing major vegetation and grazing zones. Scale 1:4,000,000. Khartoum, Sudan Survey Department.

Shows desert, semi-desert, woodland savanna, flood regions, montane vegetation, low rainfall areas.

CHINA:

1971. Communist China natural vegetation. Scale 1:10,000,000. U.S. Central Intelligence Agency, Washington, D.C.

Shows dominant trees and grasses, with special section on areas where vegetation is sparse or lacking.

IRAN:

1963. Natural vegetation. Scale 1:3,000,000. Tehran, Sahab Geographical and Drafting Institute.

Covers plateau xerophytic, plateau desert, sandy vegetation of Jazmorian, and southern tropical xerophytic and salt desert zone.

– *Information from UA Map News Monthly, Vol. 8, No. 9, May 1977*

??? DID YOU KNOW ???

. . . that the University of Sydney's Energy Research Centre has developed a new "selective surface" for solar energy collection. Funded by a sizeable grant from the State Government of New South Wales, the Centre's Physics Group hopes to increase the efficiency of the selective surface from 85 percent to over 90 percent, and to achieve a 10 percent increase in the efficiency of the white reflective surface behind the collectors. The selective surface (coated onto a smaller tube inside) traps energy from the sun in the visible spectrum but allows a minimum to re-radiate in the infrared spectrum. The device has the advantage that it works even on overcast days because it collects energy coming from all angles: reflected from clouds or walls, or even by dust molecules in the atmosphere. It is estimated that units will be ready for use in Australian homes and factories within five years, and units in homes on trial within the next two years. Contact: Dr. Brian Window, Energy Research Centre, University of Sydney, Sydney, N.S.W., Australia 2006.

. . . that a professional association of social scientists and humanists studying man's adaptation to the world's arid and semiarid environments was established at Denver, Colorado, April 22, 1977. The organizational meeting was chaired by Dr. Clark Knowlton, director of the American West Center and professor of sociology at the University of Utah, Salt Lake City. The new association will be called **The Association for Arid Lands Studies**, and some of its purposes are to encourage an increased general awareness of the problems and potentials of the arid and semiarid lands of the world and of man's adjustment to and impact upon them . . . and, inevitably, to sponsor meetings, and, expectedly, to issue a newsletter. Contact: Dr. Idris R. Traylor, ICASALS, Texas Tech University, Lubbock, Texas 79409.

. . . that the Arid Zone Research Association of India is organizing an International Symposium on Arid Zone Research and Development, February 14-18, 1978, at the Central Arid Zone Research Institute, Jodhpur, Rajasthan, to coincide with the Silver Jubilee celebration of the founding of the Institute. Major objectives set for the symposium include (1) an inventory of technology available for arid zone development, (2) evaluation of developed technology immediately available for rural arid zone application, (3) identification of gaps in scientific knowledge of desert reclamation technology, and (4) evolution of research programs for the future. Contact: Dr. H.S. Mann, Convenor and member of the organizing committee, c/o Central Arid Zone Research Institute, Jodhpur–342003, India.

. . . that the **London International Film Festival of the Environment** is planning to present the best available films on the subject from worldwide sources. They will be chosen by a professional Selection Panel for their impact rather than for their entertainment value. The festival will be noncompetitive and is expected to be held in London at the French Institute on World Environment Day, June 5-9, 1978. Contributions are solicited. Supported by VISNEWS and EARTHSCAN, the festival is the first, so far as we can learn, such effort on a world scale. A series of films depicting some of the world's most dramatic deserts would be in order, *Arid Lands Newsletter* opines. Any ideas out there? Contact: Secretariat, c/o VISNEWS, Cumberland Avenue, London NW 10 7EH.