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THE DESERT AND OTHER TRANSMONTANE PLANT COMMUNITIES OF SOUTHERN CALIFORNIA¹

Robert F. Thorne

Abstract.—Transmontane southern California, less than one-quarter of the state's area, has a rich, specialized flora and vegetation due to most varied topography, substrata, and climate. Of the perhaps 5075 species in 145 vascular plant (129 angiospermous) families indigenous in California more than 2100 species in 123 families, more than two-fifths of the state's flora, are represented in transmontane southern California. About 935 species, of which 868 are in the south, 180 of the state's 880 indigenous genera, and 18 families are exclusively or effectively transmontane. A table lists the number of indigenous species of various transmontane ranges and other areas. Numerous, diverse habitats have led to the recognition of 32 different plant communities and 10 subcommunities, or 42 of the 88 recognized for the state by the author. A table lists the communities arranged in a hierarchy according to decreasing altitude from alpine through subalpine, montane, and transition to desert and alkaline scrub communities. These are each discussed briefly with comments on distribution, dominant or otherwise characteristic plants, and outstanding environmental features of the habitats occupied. Many communities are illustrated.

INTRODUCTION

Transmontane southern California, as defined here, consists of all of Alta California from the crest of the Sierra Nevada and the Transverse and Peninsular dividing ranges east to the Nevada and Arizona state lines and south from the Sweetwater Mts. north of Bridgeport in Mono County to the border with Baja California, Mexico. This land of little rain is perhaps the most exciting part of California geologically and botanically, possibly of all the conterminous United States.

In this land-locked region, rather less than one-quarter of California and approximately equal in area to the state of Indiana, is a most varied topography ranging in altitude from 4415 m on the peak of Mt. Whitney down to -86 m at Bad Water in Death Valley. To the east of the Sierra Nevada, a huge uplifted block with its steep side the transmontane slope, lies the Great Basin, a semidesert region broken into north-south-trending fault-block mountains separated by deep troughs, like Death Valley and Panamint Valley, largely filled with detritus eroded from the surrounding ranges. South of the Great Basin is the "high" Mojave Desert separated in part by the

San Bernardino and Little San Bernardino ranges from the "low" Colorado Desert, part of the great Sonoran Desert. The largely buried ranges and broad, shallow basins of the Mojave and Colorado deserts have axes trending in various directions.

Thus, in about 91,000 km² are packed land forms as varied as sharp-crested mountains and rounded domes; snow fields, glacial terrain, cirques, deep alpine lakes, and moraines; mud hills and badlands; cinder cones, black lava flows, pumice fields, solfataras, mud volcanoes, and hot springs; numerous, large Pleistocene lakes, now dry; an inland saline sea (Salton Sea), a graben well below sea-level; desert rivers, one continuously flowing (the Colorado), but most intermittent and soon vanishing into the desert sands; plateaux, mesas, and great desert sand dunes (the Algodones, Kelso, and Eureka, for example) and smaller crescentic barchan dunes; active faults, including the long San Andreas Fault, producing a plethora of earthquakes every year; desert ranges separated by broad undrained basins (bolsons), with pediments, varnished desert pavement, bajadas (alluvial gravel fans), deep arroyos and shallow sandy washes, tanks (tinajas), springs and seeps, and saline dry lakes (playas or salinas); not to mention the complexity of geologic formations supplying great areas of limestones, dolomites, marbles, gypsum, and other salts, volcanics ranging from pumice to basalts and rhyolites, soils rich in copper or other heavy metals, and other substrata conducive to plant endemism.

Rather diverse also are the transmontane climates with the limited precipitation, mostly falling during the winter months, ranging from 946 mm at Piute Lake at 3350 m west of Bishop and 496 mm in the White Mts. at 3800 m east of Bishop down to 160 mm at Bishop at 1251 m, 133 mm at Independence at 1200 m south of Bishop, 139 mm at Palm Springs in the Colorado Desert, and 40 or 50 mm in Death Valley (Major 1977). Temperatures have ranged as high as 56.7 C (134 F) in the shade (July 10, 1913) in Death Valley (Salitore 1973) to winter extremes probably as low as -31.7 C (-25 F) in the desert ranges. Total radiation ranges from 176 kcal cm⁻² per year in cismontane Riverside to 207 at Inyokern in Indian Wells Valley east of Walker Pass (Major 1977).

The desert climates are cool to cold and humid in the winter to hot and arid in the summer. Precipitation is not only meager in the desert but quite unreliable and episodic. Only near the Colorado River is there any significant amount of summer precipitation, probably accounting in part for the large number of distinctive species found in the eastern Mojave ranges. The higher, more northern Mojave Desert is moister and cooler with frost present 20-150 days of the year; whereas, the lower, more southern Colorado Desert is drier and hotter with frost present only about 10 days a year (Major 1977).

The flora of transmontane southern California, despite the aridity of much

of the area, is rich and highly specialized, adapted primarily to survival under alpine, montane, or desert conditions. Of perhaps 5075 species indigenous within state boundaries, at least 2100 occur in the area under discussion, or more than $\frac{2}{5}$ of the state's native plants within less than $\frac{1}{4}$ of its area. Because there is no flora for transmontane southern California, the above estimate is derived from the study of various floras (DeDecker 1974; Henrickson 1980; Kurzius 1981; Lloyd and Mitchell 1973; Munz 1974; Munz and Keck 1959; Thorne, Prigge, and Henrickson 1981; Twisselmann 1967), the RSA-POM herbarium, and my own knowledge of the flora of southern California. At least 123 of 145 vascular plant families (129 angiosperm families as listed in Thorne 1981) indigenous in California are represented in transmontane southern California, with four more known from transmontane northern California.

According to Raven and Axelrod (1978) 935 species are restricted in California to transmontane areas, with 67 known only in northern transmontane California. Of the 868 southern transmontane species 81 are believed to be endemic in transmontane southern California, and 37 more range only slightly into adjacent areas of Nevada or Arizona. At least 131 of about 880 indigenous California genera are restricted to transmontane areas, and 50 more with light representation in cismontane California are essentially transmontane. Seven families have only southern transmontane representation: Arecaceae, Burseraceae, Fouquieriaceae, Krameriaceae, Buddlejaceae, Rafflesiaceae, and Simaroubaceae. Six more, Acanthaceae, Bignoniaceae, Elaeagnaceae, Ephedraceae, Martyniaceae, and Zygophyllaceae, are barely represented in cismontane California, at least the Acanthaceae and Martyniaceae probably being adventive there. Also the Crossosomataceae, Lennoaceae, Loasaceae, Simmondsiaceae, and Ulmaceae have most of their indigenous representation in southern transmontane areas of the state. Thus 18 of California's 145 native vascular plant families are exclusively or largely transmontane. Table 1 summarizes some of our present knowledge of transmontane floras of California and immediately adjacent Nevada.

The topographic, geologic, and climatic diversity of transmontane southern California produces a rather large number of plant habitats. The 14 or 15 plant communities into which Munz and Keck (1959) attempted to squeeze this transmontane vegetation are quite inadequate for any serious discussion of the ecological distribution of the 2100 or more species involved in this rich flora. Nearly 20 years of field work in the Mojave and Colorado deserts and California mountains have led me to accept tentatively the following taxonomist's classification of the desert and other transmontane plant communities. Table 2 lists 32 plant communities and 10 subcommunities, or 42 of the 88 I currently recognize in my classification of the vegetation of California. Seven desert communities or subcommunities have been added to, and one deleted from, my earlier classification of the state's vegetation

Table 1. Selected transmontane floras.

	Number of indigenous species
Transmontane San Diego Co., W Colorado Desert and desert slopes (R. M. Beauchamp 1979*).	714 (of 1505**)
Deep Canyon Watershed, Santa Rosa Mts., Riverside Co., W Colorado Desert (J. Zabriskie 1977*).	527
Joshua Tree National Monument, Riverside-San Bernardino Cos., mostly S Mojave Desert (L. Loetterle, 1973*).	560
Transmontane San Gabriel Mts., Los Angeles-San Bernardino Cos., W Mojave Desert slopes (R. F. Thorne*).	650 (of 1000**)
Transmontane Kern Co., W Mojave Desert and desert slopes, incl. those of Pinos and Piute Mts. (Twisselmann 1967).	ca. 630 (of 1463**)
E Mojave Desert Mts. and Kelso Dunes, NE San Bernardino-S Inyo Cos. (Thorne, Prigge, and Henrickson 1981).	717
Coso Geothermal Study Area, Inyo Co., SW Great Basin (Henrickson 1980; R. Zembal 1978*).	361
Owens Valley, Inyo Co., SW Great Basin (M. DeDecker 1974*).	503
Inyo Mts., Inyo Co., SW Great Basin (M. DeDecker 1973*).	452
White Mts., Inyo-Mono Cos., SW Great Basin (Lloyd and Mitchell 1973).	707
Panamint Mts., Inyo-San Bernardino Cos., SW Great Basin (A. Romsper 1979*).	467
Grapevine Mts., Death Valley Natl. Mon., Great Basin, Inyo Co. (Kurzius 1981).	483
Charleston (Spring) Mts., Clark Co., Nevada, S Great Basin-NE Mojave Desert (Clokey 1951).	651
Nevada Test Site and Central S Nevada, Great Basin and transition to E Mojave Desert (Beatley 1976).	899

* Personal communications, mimeographed lists, and personal files.

** Total number of indigenous species in county or mountain range.

(Thorne 1976). The communities are arranged in Table 2 essentially by decreasing altitude, beginning with the fell-field cushion community from above timberline in the highest mountains through the transmontane subalpine and montane forests and woodlands and transitional communities to the scrubs of the higher deserts and woodlands of the lower desert areas, and finally the alkaline communities of the undrained basins and desert sinks.

In the brief discussion of each community following the table, I have commented on its distribution, its dominant or otherwise characteristic plants, and outstanding environmental features of the habitats occupied. Unless listed, authorities for the scientific names of both species and genera can be

Table 2. Plant communities of transmontane southern California.

A. Alpine Fell-field Cushion	E. Transition Communities (contd.)
B. Subalpine Woodlands and Forests	2. Blackbush Scrub
1. Bristlecone Pine Woodland	3. Joshua Tree Woodland
2. Limber Pine Forest	4. Desert Chaparral
3. Lodgepole Pine Forest	F. Desert Scrub
4. Aspen Woodland	1. Desert Rupicolous Scrub
C. Montane Forests and Woodlands	a' Desert Calcicolous Scrub
a. Upper Montane	b' Mixed Desert Scrub
1. Red Fir Forest	2. Creosote Bush Scrub
2. Mountain Juniper Woodland	3. Desert Psammophytic Scrub
3. White Fir-Sugar Pine Forest	4. Stem-succulent (Cactus) Scrub
4. White Fir-Pinyon Woodland	5. Desert Wash Scrub
5. Mountain Riparian Woodland	G. Low-desert Woodlands
b. Lower Montane	1. Desert Microphyll Woodland
1. Yellow Pine Forest	2. Desert Oasis Woodland
2. Pinyon-Juniper Woodland	3. Desert Riparian Woodland
D. Freshwater Meadow, Marsh and Aquatic	H. Alkaline Scrub and Meadow
1. Mountain Meadow	1. Saltbush Scrub
2. Streamside Marsh	a' Shadscale Scrub
3. Lake, Pond, and Quiet-stream Aquatic	b' Allscale Scrub
4. Reservoir and Tank Subaquatic	c' Fourwing Saltbush Scrub
E. Transition Communities	d' Desert-holly Scrub
1. Sagebrush Scrub	e' Hopsage Scrub
a' Mountain Sagebrush Scrub	2. Gypsicolous Scrub
b' Great Basin Sagebrush Scrub	3. Alkali Sink Scrub
c' Pigmy Sagebrush Scrub	4. Alkali Meadow and Aquatic

found in Munz (1968, 1974) or Munz and Keck (1959), hence are deliberately omitted here to save space. I have continued to define "plant community," as by Oosting (1948) and Munz and Keck (1959), as "an aggregation of living organisms having mutual relationships among themselves and to their environment." I have not tried to classify the communities sociologically as plant associations. I prefer to leave that to the ecologists. The communities listed are easily recognized by field taxonomists and have considerable predictive value. Following each of the discussions I have listed, where available, those sources offering the most useful information about each community. Twenty figures illustrate many of the plant communities. Additional illustrations can be found in the references cited, especially in Thorne (1977), Thorne, Prigge, and Henrickson (1981), and Vasek and Thorne (1977).

DISCUSSION OF PLANT COMMUNITIES

A. *Alpine Fell-field Cushion*

In southern California alpine fell fields are found above timberline only on the highest mountains, usually above 3300 m in the Sierra Nevada, 3600

m in the White Mts., 3500 m on San Gorgonio, and 3200 m on the north slope of San Jacinto Peak. This is an extremely difficult habitat for plants because most of the precipitation (635 to 890 mm) falls as snow, peaks are swept by winter gales, killing frosts can strike at any time, growing seasons are brief (from one to two months), radiation is high, and insolation is intense. The vegetation, hence, consists mainly of perennial herbs forming a low turf or cushions, tufted graminoids, or sprawling shrublets scattered over the rocky terrain. Among the commonest and most characteristic plants of the community are species of *Androsace*, *Antennaria*, *Arabis*, *Arenaria*, *Calyptridium*, *Castilleja*, *Carex*, *Cryptogramma*, *Draba*, *Erigeron*, *Eriogonum*, *Festuca*, *Haplopappus*, *Heuchera*, *Hulsea*, *Ivesia*, *Juncus*, *Koeleria*, *Lewisia*, *Monardella*, *Luzula*, *Oreonana*, *Oxyria*, *Oxytropis*, *Pellaea*, *Phleum*, *Phlox*, *Poa*, *Polemonium*, *Potentilla*, *Raillardella*, *Ranunculus*, *Sedum*, *Selaginella*, *Sibbaldia*, *Silene*, *Sitanion*, *Stipa*, and *Trifolium*. The few woody plants are represented by shrublets of *Holodiscus*, *Leptodactylon*, *Phyllodoce*, and *Ribes*. (Hall 1902; Hanes 1976; Klyver 1931; Lloyd and Mitchell 1973; Major and Taylor 1977; Mooney, St. Andre, and Wright 1962)

B. Subalpine Woodlands and Forests

Below timberline on the highest mountains are the subalpine woodlands or forests dominated by such timberline white pines as *Pinus longaeva*, *P. flexilis*, *P. balfouriana*, and *P. albicaulis*, by *Pinus contorta murrayana*, and by the aspen *Populus tremuloides* from 3600 or 3500 m down to about 2450 m.

1. *Bristlecone Pine Woodland*.—In the high desert ranges, as the Inyo-Whites, Telescope Peak of the Panamints, and Charleston Peak of the Spring Mts. across the Nevada state line, *Pinus longaeva* is the true timberline tree, with an altitudinal range from 3540 m down to 2620 m in the White Mts. At its highest elevations, especially on the nutritionally deficient dolomites, it can form pure stands, seldom taller than 18 m but often very old (Methuselah in the Schulman Memorial Grove (Fig. 2) in the White Mts. is said to be older than 4600 years). At somewhat lower elevations and on more acidic, granitic slopes and ridges it is accompanied usually by *Pinus flexilis* and by various low shrubs and perennial herbs, as *Chamaebatiaria millefolium*, *Artemisia tridentata*, *Chrysothamnus viscidiflorus pumilus*, *Ribes cereum*, *R. montigenum*, *Leptodactylon pungens*, *Arenaria kingii*, *Cymopterus cinerarius*, *Linanthus nuttallii*, *Koeleria macrantha*, *Sitanion hystrix*, and other grasses. (Billings and Thompson 1957; LaMarche 1969; Lloyd and Mitchell 1973; Mooney 1973; Mooney, St. Andre, and Wright 1962; Schmid and Schmid 1975; Vasek and Thorne 1977; Wright and Mooney 1965)

Figs. 1-2. 1. Alpine elfin woodland, or krummholz, of prostrate, shrubby *Pinus flexilis* above timberline and near summit of Mt. San Gorgonio (3508 m), San Bernardino National Forest, San Bernardino Mts.—2. Subalpine bristlecone pine woodland of *Pinus longaeva* on dolomite in the Schulman Grove at ca. 3260 m in the White Mts., Inyo Co. Pine Alpha in this grove is estimated to be 4300 years old and Methuselah more than 4600 years old.

2. *Limber Pine Forest*.—From the Sweetwater Mts., along the eastern crest of the southern Sierra Nevada, on the desert ranges as the Inyo-White, Panamint, and Spring Mts., and the higher desert-fronting mountains of southern California from Mt. Pinos to San Jacinto and the Santa Rosas, *Pinus flexilis* forms the timberline community or part of it, with *P. albicaulis* and *P. balfouriana* on Sierran crests, *P. longaeva* on the desert ranges, and often with *P. contorta murrayana* (Fig. 3), *P. jeffreyi*, and *Abies concolor* in the southern mountains. In the Sweetwaters limber pine occurs at about 3350 m, in the Panamints from 2950 m to the peak at 3370 m, in the Whites most abundantly between 2900 and 3355 m, in the Inyos as low as 2225 m, at 2694 m on the peak of Mt. Pinos, and on the more southern peaks of the Transverse and Peninsular ranges at elevations of about 2590 m, to 3355 m on San Gorgonio Peak. On the last peak at timberline (Fig. 1) to the summit at 3508 m, it forms an elfin woodland, or krummholz, of prostrate, gnarled shrubs. On the southern peaks it is commonly associated with its dwarf-mistletoe parasite *Arceuthobium cyanocarpum*, the cushion-forming *Eriogonum kennedyi alpigenum*, and such shrubs and perennial herbs as *Arctostaphylos patula platyphylla*, *Cercocarpus ledifolius*, *Chrysolepis sempervirens*, *Chrysothamnus nauseosus*, *Erigeron breweri jacinteus*, *Eriogonum umbellatum minus*, *E. wrightii subscaposum*, *Heuchera elegans*, *Holodiscus microphyllus*, *Monardella cinerea*, *Oreonana vestita*, *Penstemon caesius*, *P. grinnellii*, *Phyllodoce breweri*, *Ribes cereum*, *R. roezlii*, *Senecio ionophyllus*, *Silene verecunda platyota*, *Sitanion hystrix*, and *Stipa parishii*. (Clokey 1951; DeDecker 1973; Hall 1902; Hanes 1976; Kurzius 1981; Lloyd and Mitchell 1973; Mooney, St. Andre, and Wright 1962; Parish 1917; Rundel, Parsons, and Gordon 1977; Thorne 1977; Twisselmann 1971; Vasek and Thorne 1977)

3. *Lodgepole Pine Forest*.—*Pinus contorta murrayana* on the transmontane slopes of southern California forms a more open, xerophytic forest, often a woodland, than it does in the wet, subalpine forests of more northern California. In the White Mts. it is sporadic in northern canyons between 2745 and 3200 m. It does form extensive forests on the higher southern

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Figs. 3–4. 3. Subalpine woodland of mixed limber pine (*Pinus flexilis*) and lodgepole pine (*P. contorta murrayana*) on a south slope at ca. 3125 m in the San Gorgonio Wilderness Area, San Bernardino National Forest, San Bernardino Mts.—4. Subalpine lodgepole pine forest on the north slope of Mt. Baden-Powell, 2440 m, Angeles National Forest, San Gabriel Mts., Los Angeles Co. This stand of *Pinus contorta murrayana* is nearly pure but more open than usual, allowing sizable colonies of *Chrysolepis sempervirens* and *Ceanothus cordulatus* to occupy the openings as a low understory.

mountains from 2440 m on north slopes or 2600 m on south slopes to the tops of the mountains, about 3050 m on Mt. San Antonio, 3234 m on Mt. San Jacinto, to 3508 m on Mt. San Gorgonio. It may reach as low as 1985 m or 2015 m on moist, shaded, north-facing slopes (Fig. 4). At higher elevations it is often associated with *Pinus flexilis* (Fig. 3), sometimes with it as krummholz at timberline. Also associated with it in the more open stands are *Pinus jeffreyi*, *Abies concolor*, *Juniperus occidentalis australis*, *Cercocarpus ledifolius*, *Ceanothus cordulatus*, *Chrysolepis sempervirens*, *Phyllodoce breweri*, *Ribes cereum*, *R. montigenum*, *Sambucus microbotrys*, *Holodiscus microphyllus*, mycotrophic herbs like *Corallorhiza maculata*, *Chimaphila umbellata occidentalis*, *Pterospora andromedea*, *Sarcodes sanguinea*, and *Pyrola* spp., such ferns as *Cryptogramma crista acrostichoides*, *Polypodium hesperium*, *Woodsia oregana*, and *W. scopulina*, and such perennials as *Arabis breweri pecunearia*, *Sedum niveum*, and *Sibbaldia procumbens*. (Hall 1902; Hanes 1976; Minnich 1976; Parish 1917; Rundel, Parsons, and Gordon 1977; Thorne 1977)

4. *Aspen Woodland*.—Stands of *Populus tremuloides* are rare in transmontane southern California, reported only from the eastern slopes of the Sierra Nevada, the eastern slopes of the White Mts., and along Fish Creek in the San Gorgonio Wilderness of the San Bernardino Mts., though it is relatively abundant in the Sierra San Pedro Martir to the south in Baja California. Basically a subalpine or montane, open, riparian woodland, it usually is found on the margins of wet meadows or along streams, especially in conjunction with lodgepole pine forest, though sometimes scattered on drier slopes and at lower elevations. Aspen woodland ranges between 1830 and 3355 m in the White Mts., and is considered the most productive woodland there, including some 14 herbaceous species. The groves on Fish Creek on San Gorgonio (Fig. 5) range from 2135 to 2320 m on the canyon floor and slopes along the creek on decomposed granite in yellow pine forest. On Sierran slopes the aspen is associated with *Salix* spp., other *Populus* spp., *Betula fontinalis*, various conifers, and many large, showy perennials, as well as numerous grasses and sedges. The Fish Creek groves are accompanied by such species as *Pinus jeffreyi*, *Abies concolor*, *Calocedrus decurrens*, *Populus trichocarpa*, *Salix lasiolepis*, *Ribes cereum*, *R. nevadense*,

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Figs. 5–6. 5. Aspen woodland, *Populus tremuloides*, in lower montane Jeffrey pine forest, *Pinus jeffreyi*, along Fish Creek, ca. 2300 m, on San Gorgonio Mt., San Bernardino National Forest, San Bernardino Mts.—6. Lower montane pinyon-juniper woodland, *Pinus monophylla* and *Juniperus osteosperma*, with an understory of pigmy sagebrush scrub, *Artemisia nova*, on limestone in Forsellesia Canyon, ca. 1700 m, Clark Mountain Range, E Mojave Desert, NE San Bernardino Co.

Rosa woodsii, and a rich herbaceous flora including such large perennials as *Aquilegia formosa*, *Artemisia ludoviciana*, *Castilleja miniata*, *Heracleum sphondylium montanum*, *Hypericum formosum scouleri*, *Lilium parryi*, *Lupinus latifolius*, *Sphenosciadium capitellatum*, *Stachys albens*, and *Urtica dioica holosericea* (Nutt.) Thorne (*U. holosericea*). (Lloyd and Mitchell 1973; Minnich 1976; Mooney, St. Andre, and Wright 1962; Rundel, Parsons, and Gordon 1977; Thorne 1977)

C. Montane Forests and Woodlands

Below the lodgepole pine forests and aspen woodlands of transmontane mountain slopes are mostly open woodlands dominated by firs, junipers, mountain-mahogany, Jeffrey or ponderosa pine, and pinyons, some of which are components of Sierran coniferous forests and others of Great Basin coniferous woodlands, which meet and mingle to a considerable extent in transmontane California.

a. *Upper Montane*.—It may be useful to divide the mostly coniferous forests and woodlands into two subzones, the upper of which consists of red fir forest, mountain juniper woodland, or white fir-sugar pine forest in the Sierra Nevada and Transverse and Peninsular ranges and of Rocky Mountain white fir-pinyon woodland on the desert ranges. Arising often in the subalpine and traversing both montane subzones is the nonzonal mountain riparian woodland.

1. *Red Fir Forest*.—Below the lodgepole pine forest on upper transmontane slopes but only on the Sierra Nevada south to Sunday Peak in Kern Co. is the forest dominated by *Abies magnifica*. Often in nearly pure stands, it is found at elevations of 2900 m down to about 2135 m, but it is entirely lacking from the Transverse, Peninsular, and desert ranges. At higher elevations it is often associated with *Pinus contorta murrayana* and lower down with *Abies concolor*. The dark, closed stands with dense litter allow slight understory vegetation other than such mycophytes as *Corallorhiza maculata*, *Chimaphila umbellata*, *Pterospora andromedea*, *Sarcodes sanguinea*, and *Pyrola* spp. (Brown and Livezey 1962; Klyver 1931; Rundel, Parsons, and Gordon 1977; Smiley 1921; Thorne 1976; Twisselmann 1967, 1971).

2. *Mountain Juniper Woodland*.—In the Sierra Nevada from Mt. Owen northward and in the San Gabriel and San Bernardino ranges of southern California an open woodland dominated by picturesque, gnarled, and probably often ancient *Juniperus occidentalis australis* is found on dry, rocky, exposed ridges and slopes between about 2900 and 2050 m. The mountain juniper itself ranges up into subalpine forests and down even into lower montane pinyon woodlands. Often associated with the mountain juniper on

the highest ridges are equally scattered specimens of *Pinus jeffreyi*, *P. contorta murrayana*, *Abies concolor*, and *Cercocarpus ledifolius*, such shrubs as *Arctostaphylos patula platyphylla*, *Chrysothamnus nauseosus*, *Chrysopsis sempervirens*, *Holodiscus microphyllus*, *Prunus virginiana demissa*, and *Ribes roezlii*, and many rupicolous perennial herbs. In the San Bernardino Mts., this woodland is more extensive on the dry flats and rocky slopes, especially in Bear and Holcomb valleys, where the trees are usually 6–15 m tall and very irregular in shape. There the accompanying woody plants are usually *Pinus jeffreyi*, *P. monophylla*, *Cercocarpus ledifolius*, *Quercus kelloggii*, *Q. chrysolepis*, *Amelanchier utahensis*, *Artemisia tridentata*, *Ceanothus greggii*, and *Fremontodendron californicum*. (Minnich 1976; Thorne 1976, 1977; Vasek and Thorne 1977)

3. *White Fir-Sugar Pine Forest*.—On the moister, steep, north- and east-facing slopes and ridges at higher elevations, mostly between 1675 and 2590 m in the Transverse Ranges, *Abies concolor* and *Pinus lambertiana*, often accompanied by *Calocedrus decurrens*, form their own community. Often associated with them are their several *Phoradendron* and *Arceuthobium* parasites and such understory shrubs as *Ribes nevadense*, *R. roezlii*, *Rubus parviflorus*, *Salix coulteri*, and *Sambucus caerulea*. On moister slopes within the yellow pine forests also most of these species, including the two dominant conifers, are often normal components. (Hall 1902; Minnich 1976; Rundel, Parsons, and Gordon 1977; Thorne 1976, 1977)

4. *White Fir-Pinyon Woodland*.—On the higher desert ranges of the eastern Mojave Desert, the Kingston, Clark, and New York mts. of San Bernardino County and the Spring Mts. of adjacent Clark Co., Nevada, *Abies concolor concolor*, the Rocky Mountain race of white fir, forms with *Pinus monophylla* open groves on steep, mesic, north-facing canyons and upper slopes (Figs. 7 and 8) mostly just below the mountain crests, 2345–1900 m in the California ranges and 3300–2270 in the Spring Mts. on either granitic or limestone substrata. The white fir of the Transverse and Peninsular ranges has also been identified as *Abies concolor concolor* (Hamrick and Libby 1972), but is there mostly associated with component species of the Sierran forests and should be carefully restudied. The more characteristic species associated commonly with the Rocky Mountain white fir and pinyon are *Acer glabrum diffusum*, *Amelanchier utahensis covillei*, *Carex brevipes*, *Fendlerella utahensis*, *Fraxinus anomala*, *Halimolobos diffusa jaegeri*, *Heuchera rubescens pachypoda*, *Holodiscus microphyllus*, *Leptodactylon pungens hallii*, *Lomatium parryi*, *Oryzopsis micrantha*, *Philadelphus microphyllus stramineus*, *Ribes cereum*, *R. velutinum*, and *Symphoricarpos longiflorus*. (Beatley 1976; Griffin and Critchfield 1972; Henrickson and Prigge 1975; Miller 1940; Prigge 1975; Thorne 1976; Thorne, Prigge, and Henrickson 1981; Vasek and Thorne 1977)

5. *Mountain Riparian Woodland*.—Not restricted to a vegetational zone, mountain riparian woodland follows streams down the mountainsides from the subalpine through the montane zones, and often out into the transitional desert communities, though the floristic composition of the woodland may change with decreasing elevation. Down from the highest elevations the more characteristic components are *Populus tremuloides* (Fig. 5), *Salix* spp., *Acer glabrum diffusum*, *Jamesia americana*, *Fraxinus velutina coriacea*, *Betula fontinalis*, *Alnus rhombifolia*, other *Populus* spp., *Platanus racemosa*, *Datisca glomerata*, *Vitis girdiana*, *Rosa woodsii*, *Acer negundo californicum*, *Urtica dioica holosericea*, *Baccharis viminea*, and in the more southern ranges often *Washingtonia filifera* and other desert species. Various of the montane conifers often follow the riparian woodlands down into the valleys, as in the Owens Valley. (DeDecker 1974; Hanes 1976; Minnich 1976; Thorne 1976; Vogl 1976)

b. *Lower Montane*.—Below the mountain juniper, red fir, and white fir-sugar pine forests on transmontane slopes of the Sierran, Transverse, and Peninsular ranges are extensive forests of yellow pine, replaced still lower by pinyon-juniper woodlands. The desert ranges of California lack the yellow pine forests; hence, the white fir-juniper woodlands grade into pinyon-juniper woodlands at their lower edge. These lower montane conifer forests and woodlands range approximately down from 2440 to 1525 m in southern California.

1. *Yellow Pine Forest*.—*Pinus jeffreyi* is the dominant yellow pine on the drier transmontane slopes. The Sierran race of *Pinus ponderosa* is rarely found in southern California on transmontane slopes and then only in moist canyons. *Pinus ponderosa scopulorum*, which forms a rather extensive forest on Charleston Peak in the Spring Mts. of Clark Co., Nevada, and the associated *Juniperus scopulorum* do not join *Abies concolor concolor* on the adjacent but lower California Mojave ranges. Although *Pinus jeffreyi* may range up to 3050 m in the subalpine zone and as low as 1830 m, the open parklike Jeffrey pine forest covers the drier slopes mostly between 2440 and 1700 m. Its usual associates are *Pinus monophylla*, *Quercus kelloggii*, *Cercocarpus ledifolius*, and such common undershrubs as *Arcostaphylos patula platyphylla*, *Artemisia tridentata*, *Ceanothus cordulatus*, *Chrysolepis sempervirens*, *Prunus virginiana demissa*, *P. emarginata*, *Sym-*

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Figs. 7–8. 7. Several trees of Rocky Mountain white fir, *Abies concolor concolor*, in upper montane white fir-pinyon woodland on north-facing limestone headwall, ca. 2200 m, of Clark Mt. in Fir Canyon.—8. Same location but broader view of white fir-pinyon woodland on north-facing limestone cliff and snowclad slopes in November.

phoricarpus parishii, *Tetradymia canescens*, and various species of *Chrysothamnus*, *Eriogonum*, *Lupinus*, and *Penstemon*. (Clokey 1951; Griffin and Critchfield 1972; Hall 1902; Hanes 1976; Klyver 1931; Minnich 1976; Parish 1917; Rundel, Parsons, and Gordon 1977; Thorne 1976, 1977; Twisselmann 1967)

2. *Pinyon-Juniper Woodland*.—On lower dry, rocky, transmontane slopes throughout southern California, mostly between 2400 and 1500 m, is a low, open woodland (Fig. 6) dominated by various species of pinyons and junipers, *Pinus monophylla*, *P. quadrifolia*, *Juniperus osteosperma*, and *J. californica* in various combinations. Rarely are the small trees more than 7 or 8 m tall. At higher elevations in the New York Mts. is a two-needle race of *P. monophylla* (Fig. 10), which grades into the one-needle race at about 1800 m. At higher elevations in the Sierran through Peninsular ranges the pinyons often become codominant with *Pinus jeffreyi*, *Juniperus occidentalis australis*, and *Cercocarpus ledifolius*. Common associates of the pinyons and junipers are *Yucca brevifolia* and species of *Quercus*, an abundance of shrubby species of *Arctostaphylos*, *Ceanothus*, *Cercocarpus*, *Chrysothamnus*, *Ephedra*, *Eriogonum*, *Garrya*, *Gutierrezia*, *Haplopappus*, *Opuntia*, *Purshia*, *Rhamnus*, *Salvia*, *Tetradymia*, and *Yucca*, *Coleogyne ramosissima*, *Cowania mexicana stansburiana*, *Fallugia paradoxa*, *Fremontodendron californicum*, *Prunus fasciculata*, and *Rhus trilobata anisophylla*, species of *Stipa* and numerous other perennial grasses and forbs. (Castagnoli, de Nevers, and Stone 1981; Hanes 1976; Hart, Stein, and Warrick 1979; Henrickson 1980; Kurzius 1981; Lloyd and Mitchell 1973; Mooney, St. Andre, and Wright 1962; Twisselmann 1967, 1971; Vasek and Thorne 1977; Vogl 1976)

D. Freshwater Meadow, Marsh, and Aquatic

The freshwater aquatic and semiaquatic communities are not very abundantly represented in transmontane southern California, where aridity and

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Figs. 9–10. 9. Great Basin sagebrush scrub, silvery-leaved *Artemisia tridentata* with darker, taller shrubs of bitterbrush, *Purshia glandulosa*, N of Symmes Creek, W of Independence, Owens Valley, Inyo Co., ca. 1700 m, with Mt. Williamson, 4385 m, in the background.—10. Lower montane pinyon-juniper-oak woodland, here at 1675 m representing transition desert chaparral, in Caruthers Canyon, New York Mts., E Mojave Desert, NE San Bernardino Co. The *Pinus monophylla* and *Juniperus osteosperma* are much enriched by *Quercus turbinella*, *Q. chrysolepis*, *Garrya flavescens flavescens*, *Arctostaphylos pungens*, *Ceanothus greggii vestitus*, *Cowania mexicana stansburiana*, and other shrubs. The pinyon-juniper woodland above the chaparral on the slopes of New York Peak is dominated by the two-needle phase of *P. monophylla*.

heavy salt accumulation result generally in alkaline communities. However, the higher mountains produce enough runoff and seepage to support mountain meadows, marshes along the semipermanent streams, and a few permanent streams containing submersed and floating aquatics. Natural tanks and artificial reservoirs in desert areas also sometimes support a limited flora of semiaquatics.

1. *Mountain Meadow*.—Along the Sierran, Transverse, and Peninsular ranges where moisture is adequate from alpine to montane levels there are wet meadows, narrow along the streams and more extensive where there is more level terrain. Even in the steep, arid San Gabriel Mts. there are a few meadows, locally called cienegas, and snow-melt gullies that support a rather rich Sierran flora of sedges, grasses, rushes, and other herbs. Especially good examples of mountain meadows can be observed at Onion Valley in the Sierra Nevada, at Big Pines in the San Gabriel Mts., and at Bluff Lake in the San Bernardino Mts. Among the more prominent genera represented in such meadows are *Agrostis*, *Allium*, *Aquilegia*, *Aster*, *Barbarea*, *Carex*, *Castilleja*, *Dodecatheon*, *Eleocharis*, *Epilobium*, *Erigeron*, *Frasera*, *Galium*, *Geranium*, *Glyceria*, *Habenaria*, *Helenium*, *Heracleum*, *Hypericum*, *Iris*, *Juncus*, *Lilium*, *Lotus*, *Lupinus*, *Luzula*, *Mimulus*, *Muhlenbergia*, *Oenothera*, *Pedicularis*, *Perideridia*, *Phacelia*, *Poa*, *Polygonum*, *Potentilla*, *Ranunculus*, *Ribes*, *Rubus*, *Salix*, *Saxifraga*, *Senecio*, *Sisyrinchium*, *Sphenosciadium*, *Stellaria*, *Taraxacum*, *Tofieldia*, *Trifolium*, *Trisetum*, *Veratrum*, and *Viola*. (Hall 1902; Klyver 1931; Major and Taylor 1977; Rundel, Parsons, and Gordon 1977; Thorne 1977; Twisselmann 1967)

2. *Streamside Marsh*.—Mountain canyons on transmontane slopes and in desert ranges often have permanent or semipermanent streams, usually quite shallow and flowing over rocky or sandy bottoms. Like the mountain meadows their flora consists largely of emersed plants but the water table is usually above the surface in marshland. In these rather narrow fringing marshes the bulk of the vegetation consists of species of *Baccharis*, *Berula*, *Carex*, *Cicuta*, *Cyperus*, *Eleocharis*, *Juncus*, *Mimulus*, *Nasturtium*, *Polygona*, *Rorippa*, *Rumex*, *Salix*, *Scirpus*, *Typha*, and *Veronica*. (Thorne 1976, 1977; Thorne, Prigge, and Henrickson 1981; Twisselmann 1967)

3. *Lake, Pond, and Quiet-stream Aquatic*.—Lakes, ponds, slow streams and canals, and man-made reservoirs in which water levels do not fluctuate severely and in which the water is not too alkaline, turbid, polluted, or deep often have a special flora of floating and submersed aquatics. They are, however, quite rare in the transmontane areas of southern California. Hot Creek north of Crowley Lake, parts of the Owens River and adjacent sloughs, Little Lake, Lost and Jackson lakes, two sag ponds along the San Andreas Fault in the San Gabriel Mts., and the All-American and Coachella canals

in Imperial County are among the few good examples. Among the aquatics found in such habitats are the free-floating Lemnaceae and *Azolla* spp., attached floaters like species of *Ludwigia*, *Polygonum*, *Potamogeton*, and *Ranunculus*, and submersed plants such as *Ceratophyllum demersum*, *Elo-dea canadensis*, *Najas marina*, *Zannichellia palustris*, and species of *Cal-litriche*, *Limosella*, *Myriophyllum*, and *Potamogeton*. (Beauchamp et al. 1977; Thorne 1976, 1977; Twisselmann 1967)

4. *Reservoir and Tank Subaquatic*.—Reservoirs with frequent and severe water level fluctuations generally lack true aquatics but support on their desiccated mud banks a few semiaquatic plants able to tolerate these fluctuations, including *Crypsis vaginiflora* (Forssk.) Opiz (*C. niliaca*), *Gnaphalium palustre*, *Juncus bufonius*, *Lythrum californicum*, *Sida leprosa hederacea*, and *Verbena bracteata*. (Thorne 1976, 1977)

E. *Transition Communities*

Grouped here are those plant communities which are transitional between the montane coniferous woodlands and desert plant communities, mostly at elevations of 3300 down to 1220 m.

1. *Sagebrush Scrub*.—Dominated by species of *Artemisia*, the sagebrush scrub communities form a variable complex of arid scrubs that clothe the nonforested or open-forested transmontane slopes of southern California mountains from above timberline down to about 1220 m. They are commonly accompanied by shrubby species of *Cercocarpus*, *Chrysothamnus*, *Coleogyne*, *Ephedra*, *Eriogonum*, *Purshia*, *Ribes*, *Symphoricarpos*, *Tetradymia*, and other genera, with an understory of various bunch grasses.

a' *Mountain Sagebrush Scrub*.—This high-elevation scrub often covers dry, treeless or open-wooded transmontane slopes from about 2400 m to well above timberline. Although the scrub is characterized by the associated species, the two dominant plants are the sagebrushes, *Artemisia tridentata*, on deeper soils, and *A. nova*, on shallower, rocky soils, reaching through the pinyon woodlands to about 3600 m in the White Mts. This scrub often forms the understory of the more open montane and subalpine woodlands. On sandstone at about 3200 m in the White Mts. *A. tridentata* is accompanied by *Arenaria kingii glabrescens*, *Chamaebatiaria millefolium*, *Eriogonum clokeyi*, *Eriogonum ovalifolium*, *Koeleria macrantha*, *Leptodactylon pungens*, *Hymenoxys cooperi*, *Linanthus nuttallii*, *Sitanion hystrix*, and *Stipa pinetorum*. (Beatley 1976; Cheatham and Haller 1975; Kurzius 1981; Lloyd and Mitchell 1973; Mooney, St. Andre, and Wright 1962; Thorne 1976; Young, Evans, and Major 1977)

b' *Great Basin Sagebrush Scrub*.—*Artemisia tridentata*, big sagebrush,

with a vast range in western North America, forms an open, silvery, low scrub or steppe (Fig. 9) on the deeper, sandier soils of arid transmontane slopes from 2500 m down to 1100 m in southern California. Its common associates there are *Atriplex canescens*, *Ceratoides lanatum* (Pursh) Howell (*Eurotia lanata*), *Chrysothamnus nauseosus*, *C. viscidiflorus*, *Ephedra viridis*, *Eriogonum* spp., *Grayia spinosa*, *Purshia glandulosa*, *P. tridentata*, *Tetradymia axillaris*, *T. glabrata*, *Wyethia mollis*, many perennial bunch grasses, and various annuals. Rainfall varies from 200 to 380 mm and the growing season from 3 to 10 months. Reaching elevations of 3300 m *Artemisia tridentata* commonly enters many other transmontane plant communities, especially the Joshua tree woodlands, pinyon-juniper woodlands, and parklike Jeffrey pine forests. (Beatley 1976; Castagnoli, de Nevers, and Stone 1981; Cheatham and Haller 1975; Hanes 1976; Henrickson 1980; Kurzius 1981; Minnich 1976; Thorne 1977; Thorne, Prigge, and Henrickson 1981; Vasek and Thorne 1977; Young, Evans, and Major 1977)

c' *Pigmy Sagebrush Scrub*.—Dominant on shallower, gravelly, residual soils, especially those rich in carbonates, is the low *Artemisia nova*. It replaces *A. tridentata* on limestone soils in the White Mts., where it reaches elevations of nearly 3600 m and apparently replaces *A. tridentata* completely in the Clark Mts. (Fig. 6). Mostly found between the pinyon-juniper woodland and lower blackbush scrub, its common associates are *Chrysothamnus viscidiflorus puberulus*, *Cowania mexicana stansburiana*, *Coryphantha vivipara*, *Echinocereus* spp., *Ephedra nevadensis*, *Gutierrezia microcephala*, *Orobanche fasciculata*, *Yucca baccata*, and such bunch grasses as *Oryzopsis hymenoides*, *Sitanion longifolium*, and *Stipa speciosa*. (Beatley 1976; Lloyd and Mitchell 1973; Prigge 1975; Thorne, Prigge, and Henrickson 1981; Young, Evans, and Major 1977)

2. *Blackbush Scrub*.—*Coleogyne ramosissima*, sometimes in nearly pure stands, contrasts sharply because of its dark color with the often adjacent, silvery sagebrush scrub. Found on dry, stony soils mostly below or among the sagebrush scrub and Joshua tree or pinyon-juniper woodland (Fig. 11) and above the creosote bush scrub at elevations of 1800 down to 1100 m, it often has as associates *Artemisia spinescens*, *Ceratoides lanatum*, *Grayia spinosa*, *Menodora spinescens*, *Salazaria mexicana*, *Salvia dorrii*, *Thamnosma montana*, species of *Chrysothamnus*, *Ephedra*, *Eriogonum*, *Haplo-*

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Figs. 11–12. 11. Blackbush scrub on slopes below Colosseum Mine in Clark Mountain Range at 1525 m. *Coleogyne ramosissima* forms here a low monotonous scrub with scattered specimens of *Pinus monophylla*, *Yucca brevifolia*, *Opuntia acanthocarpa*, and *Artemisia nova*.—12. Creosote bush, *Larrea divaricata tridentata*, dominates an evenly spaced scrub on the

extensive bajada of the calcareous Last Chance Mts., Eureka Valley, Inyo Co., rising from the sandy flat at the north end of the Eureka Dunes, ca. 900 m, with *Oryzopsis hymenoides* and *Sphaeralcea ambigua*.

pappus, *Lycium*, *Opuntia*, *Psoralea* Rydb. (woody spp. of *Dalea*), *Purshia*, *Tetradymia*, *Yucca*, and such bunch grasses as *Hilaria rigida*, *Sitanion longifolium*, and *Stipa speciosa*. (Beatley 1976; Cheatham and Haller 1975; Prigge 1975; Thorne, Prigge, and Henrickson 1981; Vasek and Barbour 1977)

3. *Joshua Tree Woodland*.—Perhaps the most characteristic plant of the Mojave Desert, *Yucca brevifolia* forms an open, bizarre woodland of bayonet-leaved, branched, dendroid lilies to 15 m tall on sandy or gravelly, well-drained, desert mesas and slopes of gentle topography, usually between 1055 and 1525 m (but up to 2285 m in the San Bernardino Mts.), north to Owens Valley, west to Antelope Valley, and east to southern Nevada and northwestern Arizona, thus largely outlining the Mojave Desert as generally accepted. Often overlapping above with pinyon-juniper woodland and sagebrush scrub and below with creosote bush scrub, Joshua tree woodland has a rich flora of shrubs (Fig. 13) and perennial grasses (and annuals in "wet" years), including species of *Atriplex*, *Ceratoides*, *Coryphantha*, *Echinocereus*, *Ephedra*, *Eriogonum*, *Haplopappus*, *Hymenoclea*, *Krameria*, *Lycium*, *Menodora*, *Opuntia*, *Psilostrophe*, *Salazaria*, *Salvia*, *Tetradymia*, *Thamnosma*, and *Yucca*, and perennial grasses of the genera *Bouteloua*, *Hilaria*, *Muhlenbergia*, and *Stipa*. Though very conspicuous, the Joshua tree is seldom quantitatively dominant and some authors, as Rowlands (1978), have concluded that the community does not exist and would be better designated desert grassland or desert scrub steppe. Johnson (1976) has proposed a special community, Joshua tree grassland, for the grassy woodland of *Yucca brevifolia jaegeriana* about the New York Mts.; however, the degree of abundance of grasses may be dependent upon variable rainfall and grazing patterns. The abundance of annuals in this and other desert communities is also a seasonal, or even less common, phenomenon dependent upon amount and seasonal distribution of precipitation. (Hanes 1976; Henrickson 1980; Johnson 1976; Prigge 1975; Rowlands 1978; Thorne, Prigge, and Henrickson 1981; Vasek and Barbour 1977)

4. *Desert Chaparral*.—Although most chaparral communities are restricted to cismontane areas, an open, sclerophyllous scrub of typical chaparral

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Figs. 13–14. 13. Joshua tree woodland on the north slope of the Mid Hills-New York Mts. near Cottonwood Springs, ca. 1450 m, with *Yucca brevifolia*, *Y. schidigera*, *Opuntia acanthocarpa*, *Coleogyne ramosissima*, *Sphaeralcea ambigua*, and numerous other shrubs, perennial grasses, and annuals. View is across Cima Valley toward the Ivanpah Mts. and Ivanpah Valley.—14. Mixed desert scrub on rocky, granitic slopes W of Borrego Springs, ca. 500 m, Anza-Borrego State Park, San Diego Co. with *Encelia farinosa*, *Opuntia bigelovii*, *Ferocactus acanthoides*, and *Agave deserti* visible.

species in such genera as *Adenostoma*, *Arctostaphylos*, *Ceanothus*, *Cercocarpus*, *Dendromecon*, *Fremontodendron*, *Garrya*, *Quercus*, *Prunus*, *Rhamnus*, and *Rhus* can be found on the dry, rocky or sandy transmontane slopes of the southern California dividing ranges and on the higher slopes of the desert ranges, often as an understory to the Joshua tree and pinyon-juniper woodlands (Fig. 10). Many of the species are the same as those in cismontane chaparral, but other species are distinctive, like *Arctostaphylos pungens*, *Ceanothus greggii*, *Cowania mexicana stansburiana*, *Fallugia paradoxa*, *Prunus fasciculata*, *P. fremontii*, *Purshia glandulosa*, *Quercus dunnii*, and *Q. turbinella*. (Bradley and Deacon 1967; Hanes 1976, 1977; Minnich 1976; Thorne 1976; Thorne, Prigge, and Henrickson 1981 (as pinyon-juniper-oak woodland); Twisselmann 1967; Vasek and Thorne 1977)

F. Desert Scrub

Mostly below the woodland and sagebrush communities of the higher desert slopes, but sometimes forming a mosaic of communities among them, are various nonalkaline communities of scrub, rock, or dune plants, mostly edaphically controlled as to their distribution and specific composition in the California deserts.

1. *Desert Rupicolous Scrub*.—Under California desert conditions soil development on mountain slopes is much restricted. Rock particles eroded from the outcropping rock must collect in crevices or under the larger boulders; otherwise it is carried down-slope as alluvium. The scrub that occupies rocky, desert slopes is open and often rather sparse, and mostly lacks dominance by one or a few species. Two subcommunities seem to be recognizable, one restricted to limestones, dolomites, marbles, and other carbonate-rich substrata, and the second more widely distributed on sandstones, shales, quartzites, granites, many volcanics, and similar noncalcareous substrata.

a' *Desert Calcicolous Scrub*.—Many of the rupicoles found on limestones, dolomites, marbles, basalts, and other basic substrata are restricted to such rocky, calcareous habitats. Among the most characteristic species of such basic rocks in the Clark, Providence, New York, Mesquite, Kingston, Grapevine, Last Chance, San Bernardino, and other desert ranges (also the adjacent Spring Mts. of Nevada) are the ferns *Cheilanthes feei*, *Notholaena cochisensis*, and *N. jonesii*, the shrubs *Agave utahensis*, *Artemisia bigelovii*, *Buddleja utahensis*, *Cercocarpus intricatus*, *Fendlerella utahensis*, *Forsellesia nevadensis*, *F. pungens*, *Mortonia utahensis*, *Petrophytum caespitosum*, and *Salvia funerea*, and such herbs as *Cryptantha tumulosa*, *Cymopteris aboriginum*, *Erigeron uncialis*, *Eriogonum intrafractum*, *Frasera albomarginata*, *Hedeoma nanum californicum*, *Hymenoxys acaulis arizonica*, *Maurandya antirrhiniflora*, *M. petrophila*, *Mimulus rupicola*,

Penstemon calcareus, *P. thompsoniae*, *Phacelia perityloides*, *Physaria chambersii*, and *Scopulophila rixfordii*, and perennial grasses like *Blepharidachne kingii*, *Enneapogon desvauxii*, *Muhlenbergia arsenei*, and *Tridens muticus*. (Beatley 1976; Prigge 1975 (as anomalous desert scrub); Thorne 1976; Thorne, Prigge, and Henrickson 1981)

b' *Mixed Desert Scrub*. One of the most complex and least understood desert plant communities is the open, mixed scrub found on rocky, mostly noncalcareous slopes of desert mountains in both the Mojave and Colorado deserts, but perhaps best developed in the southern desert (Fig. 14). It presumably was included in creosote bush scrub by Munz and Keck (1959), Burk (1977), and Vasek and Barbour (1977) but apparently was recognized, in part at least, as the arid shrub association in Kern County by Twisselmann (1967), complex desert scrub by Cheatham and Haller (1975), nonbasic rock plant and Colorado Desert semisucculent scrub by Thorne (1976), *Yucca-Opuntia-Coleogyne* scrub in the Granite Mts. by Hart, Stein, and Warrick (1978), mixed desert scrub in the Coso Mts. by Henrickson (1980), *Nolina* woodland in the Kingston Mts. by Castagnoli, de Nevers, and Stone (1981), and mixed shrub zone by Kurzius (1981). Although varying floristically with latitude, rainfall, and substrata, basically this community of rocky, noncalcareous slopes is an impressive mixture of species displaying most of the various desert growth habits: stem-succulent cacti as species of *Echinocereus*, *Ferocactus*, *Mammillaria*, and *Opuntia* (both prickly-pears and chollas); leaf semisucculents like *Agave*, *Nolina*, and *Yucca* spp.; leaf-succulents of the genus *Dudleya*; the ocotillo, *Fouquieria splendens*; shrubby species of *Artemisia*, *Bernardia*, *Brickellia*, *Chrysothamnus*, *Cleome*, *Coleogyne*, *Crossosoma*, *Encelia*, *Ephedra*, *Eriogonum*, *Euphorbia*, *Fagonia*, *Grayia*, *Haplopappus*, *Hibiscus*, *Keckiella*, *Krameria*, *Larrea*, *Leptodactylon*, *Lycium*, *Peucephyllum*, *Psorothamnus*, *Purshia*, *Salvia*, *Simmondsia*, *Sphaeralcea*, *Thamnosma*, *Trixis*, *Viguiera*, and *Zizyphus*; perennial herbs of the genera *Arabis*, *Arenaria*, *Brickellia*, *Cryptantha*, *Galium*, *Lotium*, *Lotus*, *Mirabilis*, *Monardella*, *Perityle*, and *Pleurocoronis*; perennial grasses of genera like *Hilaria*, *Melica*, *Poa*, and *Stipa*; rock ferns like *Cheilanthes*, *Notholaena*, *Pellaea*, and *Pityrogramma* spp.; and many annuals, especially of the genera *Eriogonum*, *Gilia*, and *Phacelia*. Although it intergrades below with creosote bush scrub, cactus scrub, desert wash scrub, or microphyll woodland and above with blackbush scrub and pinyon-juniper woodland, it mostly is found on rocky slopes between 1800 down to 125 m. There are no obvious dominants in mixed desert scrub though certain species are especially conspicuous, as *Agave deserti*, *Encelia farinosa* (Fig. 14), *Ferocactus acanthoides*, *Fouquieria splendens*, *Nolina wolffii*, *Peucephyllum schottii*, and *Yucca schidigera*. This scrub needs much careful study and definition by ecologists for it may involve more than one

community. A splendid representation of it can be observed in Deep Canyon of the Santa Rosa Mts. in Riverside County.

2. *Creosote Bush Scrub*. The creosote bush, *Larrea divaricata tridentata* (Sessé & Moç. ex DC.) Felger & Lowe (*L. tridentata*), is present over most of California's desert lands on nonalkaline soils from about 1400 m down to below sea level (as in Death Valley and the Salton Sea Basin) either as a dominant or conspicuous shrub. Creosote bush scrub is considered here to be that complex of subcommunities dominated by *Larrea* on well-drained, nonalkaline, sandy to gravelly soils, with or without a well-developed desert pavement, of bajadas, flats, and basins, where rainfall is usually only 50 to 150 mm per year, highly unreliable, and not excessive during the winter, and temperatures vary greatly both diurnally and seasonally. Although *Larrea* on some bajadas (Fig. 12) or in some basins is the only common woody plant, openly and evenly spaced, it is commonly codominant with *Ambrosia dumosa*, *Atriplex confertifolia*, *Grayia spinosa*, and *Lycium* spp. Other common associates are shrubby *Acamptopappus*, *Amphipappus*, *Atriplex*, *Ephedra*, *Krameria*, *Opuntia*, and *Yucca* spp., *Cassia armata*, *Ceratoides lanatum*, *Chrysothamnus nauseosus*, *Encelia farinosa*, *Haplopappus cooperi*, *Hymenoclea salsola*, *Lepidium fremontii*, *Machaeranthera tortifolia*, *Prunus fasciculata*, *Psilostrophe cooperi*, *Psoralea emoryi* (occasionally containing the stem-parasite *Pilosyles thurberi*), *Salazaria mexicana*, *Sphaeralcea ambigua*, *Stephenomeria pauciflora*, and *Thamnosma montana*, and such perennial grasses as *Erioneuron pulchellum*, *Hilaria rigida*, *Oryzopsis hymenoides*, and *Stipa speciosa*. In years when the precipitation has been adequate and well spaced, the community becomes floriferous with an abundance of annual species of many genera, including *Abronia*, *Amsinckia*, *Astragalus*, *Camissonia*, *Chaenactis*, *Chorizanthe*, *Coreopsis*, *Cryptantha*, *Descurainia*, *Eriastrum*, *Eriogonum*, *Eschscholzia*, *Geraea*, *Gilia*, *Linanthus*, *Lupinus*, *Malacothrix*, *Mentzelia*, *Monoptilon*, *Nama*, *Nemacladus*, *Oenothera*, *Pectocarya*, *Phacelia*, *Plantago*, *Rafinesquia*, and *Syntrichopappus*. (Beauchamp et al. 1977; Beatley 1976; Burk 1977; Castagnoli, de Nevers, and Stone 1981; Cheatham and Haller 1975; Hart, Stein, and Warrick 1979; Henrickson 1980; Kurzius 1981; Prigge 1975; Shreve

Figs. 15–16. 15. Desert psammophytic scrub at Eureka Dunes, Eureka Valley, Inyo Co. with elevation of sandy flat ca. 915 m. The dunes tower above the valley floor by ca. 215 m. Visible are *Sphaeralcea ambigua*, *Astragalus lentiginosus micans*, and *Larrea divaricata tridentata*. The dark patches on the dunes are colonies of the endemic, strongly rhizomatous grass *Swallenia alexandrae*.—16. Stem-succulent (cactus) scrub in an arroyo on the S side of the Eagle Mts., Riverside Co., at ca. 400 m. Visible are *Opuntia bigelovii*, *Ferocactus acanthoides*, *Echinocereus engelmannii*, and *Larrea divaricata tridentata*.

1951; Thorne 1976; Thorne, Prigge, and Henrickson 1981; Twisselmann 1967; Vasek and Barbour 1977; Wells and Hunziker 1976)

3. *Desert Psammophytic Scrub* (Desert Dune Sand Plant).—Although quite transitional to the sandier phases of creosote bush scrub, with *Larrea* often present and sometimes dominant in the lower, stabilized dunes, the desert psammophytic scrub is distinguished by the rather large number of plants restricted entirely or largely to active dune areas, as *Astragalus lentiginosus micans*, *Oenothera avita eurekaensis*, and *Swallenia alexandrae* on the Eureka Dunes (Figs. 12 and 15); *Abronia micrantha*, *Chaemaesyce parryi*, *Maechaeranthera leucanthemifolia*, and *Phacelia ivesiana* on the Kelso Dunes; and *Ammobroma sonora*, *Astragalus magdalenae peirsonii*, *Croton wigginsii*, *Ephedra trifurca*, *Eriogonum deserticola*, *Helianthus niveus tephrodes*, and *Palafoxia arida gigantea* (M. E. Jones) Turner & Morris (*P. linearis gigantea*) on the Algodones Dunes. Other more widely distributed but characteristic psammophytes include *Abronia villosa*, *Astragalus lentiginosus borreganus*, *Croton californicus mohavensis*, *Dicoria canescens*, *Geraea canescens*, *Hesperocallis undulata*, *Oenothera deltooides*, *Mentzelia longiloba*, *Petalonyx thurberi*, *Rumex hymenosepalus*, and *Tiquilia* Pers. (*Coldenia*) spp. In years with good precipitation some dune areas resemble a desert grassland with an abundance of *Hilaria rigida*, *Oryzopsis hymenoides*, *Panicum urvilleanum*, and other grasses. Most of the California desert dunes lie below 750 m, some of them, as in Death Valley or near the Salton Sea, below sea level. (Beauchamp et al. 1977; Bureau of Land Management 1976; Shreve 1951; Thorne 1976; Thorne, Prigge, and Henrickson 1981)

4. *Stem-succulent (Cactus) Scrub*.—From the Pinto and Eagle mts. of Joshua Tree National Monument south through the Colorado Desert into Mexico and east into Arizona, on bajadas and other gentle slopes, with fine soil texture and mostly facing south, and in well-watered sandy arroyos (Fig. 16) occasionally can be found a low, open, spinescent, succulent-stemmed scrub consisting primarily of *Opuntia bigelovii* and other chollas, various species of *Echinocereus*, *Mammillaria*, and *Coryphantha* clearly dominant in abundance over the *Larrea* and other shrubs that may be present. The Cholla Cactus Garden in the Pinto Basin of the National Monument is a well-known example of this community. The sahuaro, *Carnegiea gigantea*, so abundant and conspicuous in Arizona barely crosses the Colorado River in the Whipple Mts. and at a few other points south to near Yuma. (Burk 1977; Cheatham and Haller 1975; Shreve 1951; Thorne 1976)

5. *Desert Wash Scrub*.—In sandy arroyos and washes across bajadas, generally below 1525 m in the Mojave Desert, is a low shrubby community separable from the microphyll woodland of the Colorado Desert mostly by

the scarcity or absence of dominant, microphyllous trees. It is characterized by those species restricted to washes and sandy canyon bottoms or species most abundant there. Among the more conspicuous members of this rather riparian community are the scattered small trees or large shrubs of *Acacia greggii*, *Chilopsis linearis*, *Ephedra californica*, *Forestiera neomexicana*, *Mahonia haematocarpa* (Woot.) Fedde (*Berberis haematocarpa*), and *Psoralea spinosa* (A. Gray) Barneby (*Dalea spinosa*); the rich flora of smaller shrubby *Ambrosia eriocentra*, *Artemisia ludoviciana*, *Atriplex canescens*, *A. polycarpa*, *Baccharis* spp., *Bebbia juncea*, *Brickellia incana*, *Cassia armata*, *Chrysothamnus paniculatus*, *Cleome isomeris*, *Ephedra* spp., *Eriogonum fasciculatum polifolium*, *Eucnide urens*, *Fallugia paradoxa*, *Grayia spinosa*, *Haplopappus linearifolius*, *Hymenoclea salsola*, *Larrea divaricata tridentata*, *Lotus rigidus*, *Petalonyx thurberi*, *Prunus fasciculata*, *Salazaria mexicana*, *Salvia dorrii*, *Senecio douglasii monoensis*, and *Viguiera* spp.; such perennial herbs as *Amsonia brevifolia* and var. *tomentosa*, *Arctomecon merriamii*, *Asclepias erosa*, *Baileya multiradiata*, *Cirsium neomexicanum*, *Cucurbita palmata*, *Dithyrea californica*, *Datura wrightii* Regel (*D. meteloides*), *Dyssodia cooperi*, *Penstemon palmeri*, *Pholisma arenarium*, *Porophyllum gracile*, *Sarcostemma hirtellum*, and *Stillingia* spp. In good seasons a wealth of annuals sometimes makes the washes even more abundantly floriferous than the adjacent sandy flats dominated by creosote bush. Johnson (1976) has designated this community as cheesebush scrub but Prigge's desert wash scrub has priority (1975). (Beatley 1976; Bradley and Deacon 1967; Castagnoli, de Nevers, and Stone 1981; Cheatham and Haller 1975; Hart, Stein, and Warrick 1978; Prigge 1975; Thorne, Prigge, and Henrickson 1981)

G. Low-desert Woodlands

At lower elevations in both deserts, as along the Mojave and Colorado rivers, and especially in the lower Colorado Desert, the usual desert scrubs give way to taller woodlands about the springs, along water courses, and along the sandy washes and arroyos.

1. *Desert Microphyll Woodland*.—The runoff water stored under and along the sandy or gravelly beds of dry arroyos supports a rich shrubby flora along the larger drainageways of the lower bajadas and intermont plains in the Mojave Desert, as described above. In the Colorado Desert, however, the warmer round-the-year temperatures and perhaps other factors at the lower elevations and lower latitudes, support an open (Fig. 17) to sometimes rather dense woodland of small (to 5 m), microphyllous trees, especially of the family Fabaceae. Among the more conspicuous legumes are *Acacia greggii*, *Cercidium floridanum*, *C. microphyllum* (in the Whipple Mts.), *Olneya tesota*, *Prosopis glandulosa torreyana*, *P. pubescens*, and *Psoralea spinosa*.

nosus, often intermingling with the bignoniaceous *Chilopsis linearis*. Smaller shrubs or perennials also conspicuous along the arroyo margins are *Asclepias subulata*, *Baccharis sarothroides*, *Calliandra eriophylla*, *Cassia armata*, *Condalia globosa*, *Hoffmanseggia glauca* (Ort.) Eifert (*H. microphylla*), *Hymenoclea monogyra*, *Lycium andersonii*, and *Zizyphus obtusifolia canescens* (A. Gray) M. C. Johnst. (*Condaliopsis lycioides canescens*). (Beauchamp et al. 1977; Burk 1977; Cheatham and Haller 1975; Ornduff 1974; Shreve 1951; Thorne 1976)

2. *Desert Oasis Woodland*.—Small oases are found at the heads or in the bottoms of canyons and arroyos and sometimes on steep hillsides where permanent springs or seeps issue from the desert mountains or at least keep permanently moist the roots of community members. Most picturesque of these oases are the clusters of *Washingtonia filifera*, California fan palm (Fig. 19), dominating this community from Twentynine Palms south through the Colorado Desert into Baja California. Other prominent woody plants are *Baccharis sergiloides*, *Celtis reticulata*, *Fraxinus velutina*, *Platanus racemosa* (only on the western margins of the deserts), *Pluchea sericea*, *Populus fremontii*, *Prosopis glandulosa torreyana*, *Quercus chrysolepis*, *Salix exigua*, *S. gooddingii*, *S. lasiolepis*, *Sambucus mexicana*, and the naturalized *Tamarix ramosissima*. Frequently present also are such perennials as *Adiantum capillus-veneris*, *Aquilegia shockleyi*, *Cirsium nidulum*, *Epipactis gigantea*, *Equisetum laevigatum*, *Haplopappus acradenius*, *Juncus* spp., *Phragmites australis*, *Sporobolus airoides*, *Typha domingensis*, and *Urtica dioica holosericea*. (Burk 1977; Küchler 1977; Thorne 1976; Thorne, Prigge, and Henrickson 1981; Vogl and McHargue 1966)

3. *Desert Riparian Woodland*.—Somewhat transitional between desert oasis woodland and alkali sink scrub and alkali meadow are the woodlands that occupy some of the margins of the Colorado and Mojave rivers, All-American, Coachella, and other irrigation canals in Imperial County, and Salton Sea. Dominant in these woodlands are *Aster spinosus*, *Atriplex lentiformis*, *Phragmites australis*, *Pluchea sericea*, *Populus fremontii*, and species of *Baccharis*, *Prosopis*, *Salix*, *Typha*, and the naturalized *Arundo*

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Figs. 17–18. 17. Low-desert microphyll woodland along Araz Wash in the Cargo Muchacho Mts. of SE Imperial Co., elev. ca. 300 m, composed largely of *Prosopis glandulosa torreyana*, *Olneya tesota*, *Cercidium floridanum*, and *Acacia greggii arizonica* Isely. Also present are *Larrea divaricata tridentata*, *Hyptis emoryi*, *Lycium andersonii*, *Fouquieria splendens*, *Bebbia juncea*, and *Condalia globosa*.—18. Shadscale scrub, a subcommunity of the alkaline saltbush scrub, with mostly *Atriplex confertifolia*, elev. ca. 1200 m, W of Independence, Owens Valley, Inyo Co. with Mt. Williamson, 4385 m, in the background.

donax and *Tamarix* spp. This community has received almost no study. (Beauchamp et al. 1977; Thorne 1976)

H. Alkaline Scrub and Meadow

Because of internal drainage and the great excess of evaporation over precipitation, the California transmontane areas possess many flats, playas, sinks, and dry or temporary lake beds with poorly drained, heavy soils, often with an underlying hardpan rich in carbonates, sulphates, and other salts. Even some mesas, bajadas, and rocky slopes have accumulated heavy, alkaline soils, commonly with a caliche layer. These alkaline or saline soils support a low, scattered scrub of halophytic plants, primarily of the Chenopodiaceae, or, where permanently moist, alkaline meadow or pools and shallow lakes with aquatics adapted to brackish or saline water.

1. *Saltbush Scrub*.—The drier, heavy, alkaline soils, mostly with a shallow hardpan, are dominated by various species of *Atriplex* and the closely related *Grayia*, forming a silvery-leaved scrub (Beatley 1976; Burk 1977; Johnson 1976; Vasek and Barbour 1977). The more distinctive subcommunities of saltbush scrub are discussed briefly here.

a' *Shadscale Scrub*.—*Atriplex confertifolia*, shadscale, is an abundant spinescent, microphyllous shrub with a wide distribution through many communities from about 2450 down to 450 m in dry habitats from alkaline, fine-silty playas, sandy washes, and gravelly flats, up bajadas and rocky, steep limestone slopes, onto volcanic tablelands, and rocky talus at cliff bases. However, below sagebrush scrub from about 1830 down to 900 m, shadscale, in nearly pure stands or as a dominant, forms an evenly spaced scrub on alkaline, heavy, often clayey soils of mesas and closed-drainage basins in the Owens Valley (Fig. 18) and about the Mojave Desert. Commonly associated with shadscale are *Artemisia spinescens*, *Ceratoides lana-*

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Figs. 19–20. 19. Low-desert oasis woodland at Cottonwood Springs, between the Cottonwood and Eagle Mts., Joshua Tree National Monument, Riverside Co. at 925 m with the California fan palm, *Washingtonia filifera*, both young plants and mature individuals with partial skirts of dead leaves, *Populus fremontii*, and *Prosopis glandulosa torreyana* clearly visible. Also present are *Bernardia incana*, *Tetracoccus hallii*, and *Zizyphus obtusifolius canescens*.—20. Alkali sink scrub and alkali meadow and aquatic communities at ca. 1950 m on the NW margin of Mono Lake, Mono Co., in 1975 before stripped of much water by Los Angeles Department of Water and Power. About the salt pinnacles the scrub and marsh were composed of *Sarcobatus vermiculatus*, *Chenopodium glaucum salinum*, *Aster frondosus*, *Muhlenbergia asperifolia*, *Rumex fueginus*, *Ranunculus cymbalaria saximontanus* (Fern.) Thorne, *Cleomeella parviflora*, *Scirpus nevadensis*, and *S. pungens* Vahl (*S. americanum* of California authors). *Zannichellia palustris*, horned-pondweed, was the only submersed aquatic in a small stream then traversing the marsh.

tum, *Grayia spinosa*, *Chrysothamnus* spp., *Ephedra nevadensis*, *Haplopappus acradenius*, *Kochia americana*, *Lycium* spp., *Sarcobatus vermiculatus*, *Tetradymia glabrata*, *Oryzopsis hymenoides*, and other perennial grasses and herbs. Average annual rainfall is from about 80 to 200 mm (Beatley 1976; Henrickson 1980; Twisselmann 1967; Vasek and Barbour 1977; Young, Evans, and Major 1977).

b' *Allscale Scrub*.—*Atriplex polycarpa*, allscale or cattle-spinach, can form pure stands, as on the nonsaline, low carbonate gravel fans in Death Valley, or mixed stands up to 1 m tall on low-saline, silty or sandy loams near the Salton Sea or in Lucerne Valley with other *Atriplex* spp., *Haplopappus acradenius eremophilus*, and *Prosopis glandulosa torreyana*. This subcommunity was suggested by Johnson in 1976 (Burk 1977; Henrickson 1980; Hunt 1966; Johnson 1976; Vasek and Barbour 1977).

c' *Fourwing Saltbush Scrub*.—*Atriplex canescens*, the polymorphic fourwing saltbush, has perhaps an even wider ecologic range than *A. confertiflora*, occurring from -75 m in alkaline flats near the Salton Sea to sandy spits and coastal bluffs along the Pacific Ocean, sandy desert washes and sand dunes, volcanic flats, and dry, rocky slopes at about 2150 m in many different plant communities. However, on deep sandy to gravelly soils (also near some alkaline springs and along saline pans, as along Salt Creek in Death Valley), *A. canescens* is dominant and associated with *Ambrosia acanthicarpa*, *Chrysothamnus viscidiflorus*, *Dalea searlsiae* (A. Gray) Barneby (*Petalostemon searlsiae*), *Ephedra viridis*, *Oryzopsis hymenoides*, *Psoralea polydenius* (Torr.) Rydb. (*Dalea polyadenia*), and a good many annuals (Beatley 1976; Henrickson 1980; Hunt 1966).

d' *Desert-holly Scrub*.—*Atriplex hymenelytra*, desert-holly, is an attractive silvery leaved saltbush that dominates rather saline, carbonate-rich, lower, hot areas of gravel fans in Death Valley, growing with *Larrea divaricata tridentata*, *Suaeda torreyana*, *Tidestromia oblongifolia*, and some 18 annual species, March 1973, among the more conspicuous being *Atrichoseris platyphylla*, *Geraea canescens*, *Malvastrum rotundifolium*, *Mohavea breviflora*, *Nama demissum*, *Phacelia calthifolia*, and *P. crenulata*. Desert-holly scrub, so designated by Johnson (1976), is sporadically but widely distributed in the California deserts from Inyo to Imperial counties on dry, alkaline slopes and washes from 1340 down to -80 m, desert-holly often codominant with creosote bush. (Beatley 1976; Hunt 1966; Johnson 1976)

e' *Hopsage Scrub*.—*Grayia spinosa*, hopsage, is a common and widely distributed, attractive shrub in various plant communities on flats and mesas mostly between 2280 and 760 m in the Mojave Desert. It sometimes forms pure stands in closed-drainage basins with deep, sandy alluvium and noc-

tural cold air, or more commonly is codominant at higher elevations with *Artemisia tridentata*, *Coleogyne ramosissima*, *Larrea divaricata tridentata*, *Lycium andersonii*, or *L. pallidum*. Other common associates are *Ambrosia dumosa*, *Artemisia spinescens*, *Atriplex canescens*, *Ceratoides lanatum*, *Acamptopappus shockleyi*, *Chrysothamnus viscidiflorus*, *Ephedra nevadensis*, *Psorothamnus fremontii* (Torr.) Barneby (*Dalea fremontii*), *Yucca brevifolia*, and various species of *Opuntia* and *Tetradymia*. (Beatley 1976; Johnson 1976)

2. *Gypsiculous Scrub*.—This community on gypsum-rich soils is essentially unstudied in California. The following listed species are those Barry Prigge and I have collected on the Shire Gypsum Deposits, at Bear Poppy Saddle, or along the Powerline Road, or at all these sites in the Clark Mts., which seem to be particularly associated with gypsum: the shrubs *Atriplex confertiflora*, *Echinocactus polycephalus*, *Eucnide urens*, *Peucephyllum schottii*, *Psorothamnus fremontii*, *Stanleya pinnata*, *Sphaeralcea rusbyi eremicola*, *Tiquilia canescens* (DC.) Richards. (*Coldenia canescens*), *Tidestromia oblongifolia*, and *Machaeranthera tortifolia*, and the herbs *Arctomecon merriamii*, *Camissonia walkeri tortilis*, *Cryptantha recurvata*, *Cymopteris gilmanii*, *Enceliopsis nudicaulis*, *Eriogonum trichopes*, *Mentzelia oreophila*, *M. polita* A. Nels., *Prenanthes exigua* (A. Gray) Rydb. (*Lygodesmia exigua*), *Psathyrotes ramosissima*, and *Tricardia watsonii*. Many of these species are otherwise known in California from the Death Valley area, where the endangered Panamint-daisy, *Enceliopsis covillei*, is also suspected of occurring on gypsum soils. This plant community needs serious ecological investigation in California. Other possibly distinct communities on edaphically interesting sites, as the small area in Fourth-of-July Canyon in the New York Mts., where *Eriogonum ericifolium thornei* (Reveal & Henrickson) Thorne is restricted to copper-rich soils (Reveal and Henrickson 1975), should also receive thorough study. (Meyer 1980)

3. *Alkali Sink Scrub*.—This halophytic scrub is sparser and lower than most of the saltbush scrubs and is more nearly restricted to the fleshy, gray, or silvery halophytes of the *Chenopodiaceae*. In southern California it is distributed mostly over moist alkaline flats and playas and about dry lakes with no external drainage, rich in alkali and other salts, mostly in the Salton Sea basin, Mojave Desert, and adjacent great sinks of Death, Panamint, and Amargosa valleys of the Great Basin. Alkaline sinks mostly are found below 1200 m but range from 2060 m down to -85 m at Bad Water in Death Valley. The most characteristic of the chenopodiaceous halophytes of this community are *Atriplex*, *Chenopodium*, *Nitrophila*, *Salicornia*, and *Suaeda* spp., *Allenrolfea occidentalis*, *Kochia californica*, *Monolepis nuttalliana*, and *Sarcobatus vermiculatus* (Fig. 20). Often associated with these chenopods are *Cleome sparsiflora*, *Cleomella* spp., *Cressa truxillensis minima*, *Fran-*

kenis grandifolia campestris, *Heliotropium curassavicum oculatum* (Heller) Thorne, *Iva* spp., *Lepidium dictyotum*, *Oxystylis lutea*, *Sesuvium verrucosum*, and *Wislizenia refracta*. (Beatley 1976; Burk 1977; Henrickson 1980; Hunt 1966; Twisselmann 1967)

4. *Alkali Meadow and Aquatic*.—Heavily alkaline or saline soils of closed-drainage basins kept permanently wet by springs or seeps support permanent alkaline meadows, sometimes with open permanent pools or small lakes, as in the great Panamint and Death Valley sinks, on some borders of Mono (Fig. 20), Little, and Owens lakes and the Salton Sea, and at Ash Meadows on the Nevada state line. The wet meadows consist mostly of the grasses *Distichlis spicata stricta* (Torr.) Thorne, *Muhlenbergia asperifolia*, *Phragmites australis*, *Spartina gracilis*, and *Sporobolus airoides*; *Juncus cooperi*, *J. mexicanus*, and other rushes; and the sedge species of the genera *Carex*, *Cladium*, *Eleocharis*, *Fimbristylis*, *Schoenus*, and *Scirpus*. Other abundant or characteristic species are *Allenrolfea occidentalis*, *Anemopsis californica*, *Asclepias fascicularis*, *Sida leprosa hederacea*, *Sisyrinchium halophilum*, *Triglochin concinna debilis*, *Typha domingensis*, and *Aster* and *Cordylanthus* spp. The shallow pools of brackish water support only such salt-tolerant submersed aquatics as *Najas marina*, *Potamogeton latifolius*, *P. pectinatus*, *Ruppia maritima* (including *R. cirrhosa*), and *Zannichellia palustris*, the pool at Bad Water with only the *Ruppia*. Occasional dense thickets bordering the springy alkaline marshes consist of species of *Baccharis*, *Pluchea*, *Prosopis*, and *Tamarix*. (Beatley 1971, 1976; Hunt 1966; Thorne 1976)

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Footnote

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