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Description of the Environment

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DESCRIPTION OF THE ENVIRONMENT

Utah is situated largely between 37 and 41 degrees north latitude and 108 to 114 degrees west longitude. It occupies some 219,990 square km. Elevation ranges between about 660 and 4,126 m, with the lowest elevation being in Beaver Dam Wash in Washington County and the highest at the summit of Kings Peak in the Uinta Mountains (astride the Duchesne-Summit County line).

The state is divided roughly into two halves by the mountain-plateau axis formed by the mountains of the Wasatch Range and the plateau of central and southern Utah. West of the mountain and plateau system lies the Great Basin, a portion of the Basin and Range Province, whose drainage has no outlet to the sea. East of the dividing line, water falls ultimately to the Colorado River through a large number of tributaries. The Weber, Bear, and Sevier rivers rise to the east of the northeast-southwest trending axis but fall ultimately to the west through canyons that cut the major ranges. The two portions of the state are also roughly divided by the margin of the overthrust belt that extends into Utah from Idaho and exits the state into Nevada along a line that marks essentially the southern edge of the Great Basin. The geology is fundamentally different between the two halves.

The Basin and Range Province is marked with numerous, north-south trending, essentially parallel ranges. The ranges are the result of block faulting and expose strata of sandstone or quartzite, limestone, and dolomite that vary from Precambrian to Permian age (Hintze 1972). The mountain ranges stand with their bases buried in their own detritus. Valleys are filled with the products of erosion. The valley bottoms are frequently occupied by saline pans, salt flats, or fresh to saline lakes or ponds. Slopes above the pans to the mountains proper consist of complex assemblages of alluvial fans coalesced into gently to moderately sloping bajadas. Alluvium is graded in size down slope, with the coarser materials near the montane sources and finer accumulating in the bottoms. Salt is likewise carried to the valley bottoms, where it is abandoned by the moisture that served to transport it there.

Sand is sorted by the prevailing westerly winds and tends to stack along the east sides of valleys. Dunes are present especially in the Sevier Desert (the Luddyl Dunes are the largest), but they occur also in small portions of many of the western valleys.

Valleys that drain from the Great Basin ranges tend to be short on the west side and drop steeply to the valley floor. Those on the east sides tend to fall less steeply and to be longer. Perennial streams are few, and those frequently disappear into the valley bottoms. Springs are relatively numerous but small. Exceptions are found especially in Snake Valley and the Sevier Desert. Large lakes tend to be saline (Great Salt Lake) or fresh (Utah Lake). Sevier Dry Lake contains water only during exceptionally wet weather cycles.

Because of the closed hydrological system in the Great Basin, the surface flow is concerned, the geological and topographic influence on vegetative cover is significantly different from that of the Colorado Drainage Basin. The Colorado drainage is an open system, where water flows from the basin to the sea, carrying with it alluvium that would have otherwise persisted as valley fill, alluvial fans, and bajadas. Old pedimental surfaces, consisting of rounded cobble and gravel, persist for a time, perched on ancient erosional surfaces now abandoned by contemporary drainages cut below them. An exception to the low amount of valley fill in the Colorado drainage system is found where that drainage impinges upon the Basin and Range Province, as it does in the southwestern portion of Utah in the Beaver Dam Wash vicinity. There great accumulations of fanglomerate are now exposed along the entrenched drainage of Beaver Dam Creek.

Geological strata are exposed over vast areas of the Colorado Plateau, either with the raw stratum or weathered colluvium as the surficial material. Large alluvial deposits are not typical of the landscape. Each particle removed by erosion is being moved down river to the sea.

Exposed geological strata in the Colorado drainage system consist of shale, mudstone, siltstone, sandstone, and conglomerate sequences. They vary in age from Precambrian to Tertiary, with late Tertiary, Pleistocene, and Recent (Hintze 1972) alluvial deposits being either perched or along drainage bottoms in valleys. Sand dunes are present, especially on the foot of the eastern slope of the San Rafael Swell, near Kanab, and west of Hurricane.

Plant species distributions tend to be correlated with geology, especially where the geological strata are exposed essentially unmodified at the surface. The distributions are likewise secondarily influenced by the presence of alluvium and soils, their texture, salinity, and derivation. Hence, it is not possible to understand plant taxonomy without consideration of the substrate occupied by the particular plant being investigated. The raw and col-luvial surfaces available for plants in the Colorado drainage system present an entirely different array of possibilities than in the Great Basin. The basic stratigraphies of the two areas are different—the Great Basin gray and mainly calciferous, the Colorado Basin varicolored and of greater diversity of substrate. Much of the vegetation of the Great Basin is on alluvium, whereas most of that in the Colorado system is directly on the geological strata. Mountains proper in the Great Basin offer exposures of strata, but often the valleys do not.

Large areas of the Great Basin and mountains and high plateaus of Utah bear surficial deposits of igneous material, either intrusive or extrusive in origin. These igneous outcrops offer a not so subtle control of the vegetative cover. Especially is this control demonstrated on the complex igneous outcrops of the Marysvale volcanic center, which displays a great thickness and diversity of substrates from low to high elevations. Further, portions of the igneous rocks have been again modified by thermal activities, and this thermal modification adds to the number of habitat types.

Survivors on the raw or colluvial surfaces in the Colorado system tend to be specialists, those plant taxa that can survive on the harsh substrates without serious competition. Plants of a similar nature in the Great Basin tend to occupy the mountain ranges proper, with exceptions mainly occurring on low-elevation exposures. Alluvium tends to be occupied by generalists, those plants that can tolerate a wider degree of habitat variation and more persistent competition by other generalists. Even a thin cover of detritus or alluvium over geological strata in the Colorado Basin, especially, is sufficient to allow for vegetative composition to change abruptly. Where alluvial
fans thin toward their edges, they are as effective in
insulating the underlying geological strata from plants as
where thicker toward the mouth of a draw or canyon.
Insulation of plants from parental materials of geologi-
cal strata can result from soil development or from bury-
ing with alluvium. Soil development is a function, at least
in part, of the amount of water available. In Utah, alluv-
ium is produced at all elevations, but water from precipi-
tation increases with elevation. And, since temperature
tends to decrease at a uniform rate (approximately 1.8
degrees C per 305 m), evaporation is lower at the higher
elevations and more moisture is available for both plant
growth and soil development. Soils, like alluvium, tend to
be occupied by generalists. However, despite the occu-
rence of high precipitation at higher elevations, there are
places where the larger amounts of water are ineffective.
Rock outcrops, cliffs, margins of plateaus, and ridge tops,
because of lack of penetration, tend not to be well watered
in spite of the large amount. Endemism in Utah is corre-
lated with the availability of raw or colluvial substrates
(Welsh 1978a), and these are present in broad, low-
to-high-elevation expanses in the Colorado Basin and
plateaus—but mainly in the Great Basin they are mon-
tane.

Plant Communities

Plant community descriptions, for the purposes of this
work, have been simplified. Communities have been
determined subjectively by the plant collector, who
recorded that information on specimen labels, and by the
individual author of a specific group. Generally the plant
communities are characterized by one or more obvious,
typically woody species, growing in any given area.
Grasslands, those areas dominated mainly by grass spe-
cies, occur widely in the state, but the total area occupied
by them, when compared to that dominated by woody
and herbaceous species together, is not large. In some
instances it has been useful to give a general designation
to groups of communities within a given elevational and
broad vegetational type. In general, the following group-
ings of plants and some of their most obvious habitats
species are treated, starting at low elevation and moving
upward.

Warm Desert Shrub — Creosote bush, Joshua tree,
blackbrush, cholla, desert willow, burro-bush, sand (old
man) sagebrush, and Hilaria rigida. Hot, dry slopes, rock
outcrops, and drainages of Washington, Kane, and San
Juan counties support most of the warm desert shrub
vegetative type in Utah.

Chaparral — Turbinella live-oak, Ceanothus greggii,
Arctostaphylos pungens, and Garrhyra flavescens.
Chaparral is mainly developed in the Pine Valley and
Hanging gardens are Maidenhair ferns, Eastwood
monkeyflower, cardinal monkeyflower, cave primrose,
helleborine orchid, golden sedge, and many others.
Hanging gardens occur along exposed water sources,
mainly in sandstone along canyon walls in the southern
portion of the state.

Sand Desert Shrub — Sand (old man) sagebrush, Van-
delea, Eriogonum leptocladon, Sporobolus species,
Yucca species, Indian ricegrass, Psorolobum junceum, P.
lanceolatum, and Amsonia tomentosa. Sandy areas are
mainly at lower elevations in the valleys of western and
southeastern Utah.

Cool Desert Shrub — Big sagebrush, black sage-
brush, winterfat, rabbitbrush, blue-grama, galleta, Indian
ricegrass, and dropseed species.

Pinyon-Juniper or Juniper-Pinyon — Pinyon pine,
Utah juniper, big sagebrush, black sagebrush, mutton
grass, and needle and thread. This vegetative type occurs
over vast areas of the state.

Mountain Shrub — Gambel oak, bigtooth maple, ser-
vice berry, mountain mahogany, and big sagebrush.
Large areas are occupied by mountain brush, mainly on
foothills, but also in canyons at lower elevations.

Ponderosa Pine — Ponderosa pine, manzanita, and as-
pen. This community type is present on the drier sites in
lower aspen communities and more moist portions of the
mountain brush vegetative type. Often it occurs on acidic
substrates.

Fir — White fir, Douglas fir, mixed mountain brush,
and aspen. The fir community is mainly restricted to
north-facing slopes at moderate elevations in mountains.

Aspen — Aspen, mixed mountain brush, big sage-
brush, silver sagebrush, and transitional to the next. The
aspen vegetative type is very important in the mountains
of the state, often forming openings or parklands
occupied by grass, grass-forb, and tall forb communities.

Spruce-Fir — Engelmann spruce, alpine fir, lodgepole
pine, grass-forb, and sedge-forb. Large areas of spruce-fir
forest are present in the mountains of the state, often
forming patches around openings dominated by grass-
forb, sedge-forb, or tall forb communities. Timberline or
tree line occurs at the upper margin of the spruce-fir type.

Alpine Tundra — Various grass (Festuce, Poa), forb,
(Geonm rossii, Arenaria, Stellaria, Silene, Dryas), sedge
(Carex, Kobresia), and shrub (Salix, Vaccinium) species
at or above timberline. Alpine tundra consists of low-
growing plants present in most high-elevation sites in
Utah, mainly above 3,355 m elevation. The sites are cold,
dry, and exposed to long light periods. They are exposed
proportionally greater amounts of ultraviolet radiation
than are the other communities, which are buried be-
neath progressively more atmosphere downward in eleva-

Phytoecography

Phytogeographic considerations in Utah involve the
concepts of floras previous to the recent past, migration
pathways, and development of species in place (the
neoendemics). Evolution of the floras of the Intermoun-
tain Region have been reviewed by Tidwell, Rushforth,
and Simper (1972) and will not be considered further
here.

Migration is a principal means of enrichment or depaup-
eration of a flora. Discussion of depauperation through
outward migration is essentially moot, unless there is
some evidence of a species having existed within an area
in the first place. Enrichment is more easily demon-
strated because the plants now exist within the area under review. Taxa tend not to move as florids, but to move as individuals. Each individual (if not the taxon) evidently has a set of limits that controls where it can grow and a usually finite means of dispersal. Hence, plants tend to move within the habitat available to them along the lines of least resistance. Where such lines of least resistance are available to several or many taxa, as determined by coincidence of distribution patterns, migration routes are judged to exist.

In Utah there are several main patterns of distribution, each correlated in some degree with one or more migration pathways. Hot dry canyon slopes along the major river systems serve as routes for movement of propagules, especially upward along the lower portion of the canyons from the dry desert country to the south. The redbud (Cercis occidentalis) is such a plant, and the pattern can be designated as the redbud pathway. Others with the redbud pattern include numerous Mohavean plants. Two main prongs of this migration pathway occur in Utah, one along the Virgin River and another along Glen Canyon. The arms of this pathway are separated by the highland between the Hurricane fault and the East Kaibab monocline at the Cockscomb (the so-called Dixie corridor). The Utah agave (Agave utahensis) and Thamnosma montana represent slightly shorter extensions of the redbud type, both occurring on the canyons in both Washington County and in or near Kane County along the canyons of the Colorado. Other Mohavean representation is that characterized by Joshua tree, creosote bush, stinking gourd, and their associates of lower elevations in Washington County. Above them evolutionally is developed a chaparral type, dominated by turbinella live oak (Quercus turbinella), Arctostaphylos pungens, and Ceanothus greggii that is unmatched elsewhere in Utah. Both the oak and the Ceanothus (and the stinking gourd) are also sparingly represented along canyons of the Colorado in San Juan County. More broadly distributed plants of Mohavean representation include the cholla cacti as a group, and Opuntia schirpler more especially. This plant occurs sparingly along the drainages of the San Juan and Colorado rivers as far north as Grand County, and to southern Millard County in the Great Basin.

This latter extension is matched, at least in part, by the extension of Pruus fasciculata and extended beyond by Lycium andersonii, both principally Mohavean in distribution. Other plants with this extension into the southern Great Basin from the Colorado River Drainage, but not necessarily Mohavean in general distribution, include Bigelow sagebrush (Artemisia bigelovii), Astragalus molliissimus var. thompsonae, and Astragalus longochoropus. Nitrophila occidentalis and Solidago spectabilis are other extensions of the Mohavean type that occur in the southern Great Basin portion of Utah. The migration pathway for these plants, designated as the schirpler extension, seems not to have been directly across the intervening land between the hot deserts of Washington and Clark counties but up the drainages leading northward from the Virgin, especially up Meadow Valley Wash in Nevada and Beaver Dam Wash of Arizona, Utah, and Nevada.

Evidence of movement of plants from higher elevations to lower elevations along the canyon systems is supported by the presence of plants typical of high elevations in the canyon systems far below their usual region of growth. Aspen, Douglas fir, Rocky Mountain juniper, Utah juniper, and many other species of mountains occur along the canyons. Some of these instances are supported by lone waifs that are away from the main body of the species. However, the canyons tend to act as inverted mountains, being shaded for a much longer portion of the day and having, as a result of the cooling shade, more available water than the surrounding arid lands, the habitats simulate those of the mountains.

Habitat for hydrophytes along the waterways of Utah demonstrate the ease with which propagules move from place to place along them. Birds and other animals, including man, have moved along the waterways because of the case the low-elevation corridors provide.

The Great Basin, despite its north-south trending ranges that make movement for people difficult in an east-west direction, is essentially open to movement of propagules at low elevations. Astragalus callithrix, A. uncialis, and Swertia gymnoca are examples of low-elevation Great Basin endemics with representation in both Utah and Nevada. Movement at higher elevations is fraught with difficulties involving the transfer of propagules across broad, low-elevation, xeric valleys, and most of the mountain ranges support one or more narrow endemics.

Influencing the northern portion of the Great Basin is a route for movement of plants from the Snake River region of the Pacific Northwest. Populus trichocarpa is an example of the Snake River Plains extension into Utah. Plants of the Belf River Mountains tend to share affinities with the Pacific Northwest and belong to the trichocarpa example. An expansion of the trichocarpa type of distribution is found in Astragalus pershii, which occurs from the west and northwest into Box Elder, Rich, and Uintah counties. Astragalus lentiginosus var. platyphyllus has about that same distribution pattern but is missing from the Uinta Basin proper (the only place in Utah where A. lentiginosus sens. lat. is not known to occur).

The mountain and plateau axis formed by the Wasatch Range and its mountain chains, the Wasatch Plateau, and the Sevier-Paunsuagunt Plateau form an elevated route along which boreal plants have migrated. The boreal forest trees are examples of plants with access along the mountain ranges. Other examples include Chamaecyparis nootkatensis erecta, which reaches its southern limits in the Tushar and Thousand Lake mountains vicinity. Astragalus australis and Oxytropis riscida show a similar pattern, but with more disjunct colonies northward along the mountain-plateau axis almost to the Uinta Mountains. Dryas octopetala is disjunct in the Uinta Mountains from its usually more northern distribution. The forest trees, especially, have evidently been able to move across the distances between elevated ranges of the Great Basin and the isolated mountains of the Navajo Basin in the Colorado Plateau. Evidence of movement at high elevation from the main ranges of the Rocky Mountains is indicated by ranges of plants in the La Sal and less commonly in the Abajo mountains (e. g., Ranunculaceae). Erigeron vas-
Westward, the steppe flora (in depanacreous form) sweeps to the crest of the Bear River Range. The diminution of species is marked, even in the Utah portion of the steppe flora. *Astragalus geoffroei* gives way at a much lower elevation than does *A. spatulatus*, east of the Bear River divide in Rich County. And, possibly *Bouteloua gracilis* in the Uinta Basin shares the *spatulatus-adsurgens* route from the cold steppes.

Elsewhere in the state, blue grama grass appears to have southern affinities, as do other prairie grasses (e.g., *Sorghastrum nutans*, *Panicum virgatum*, *Andropogon gerardii*, and *Schizachyrium scoparium*). For the most part, the tall prairie grasses tend to occur (probably relictually) in mesic to hydric canyon bottoms, or they cluster around seeps and springs (often in or near hanging gardens).

Hanging garden plants show diverse phytogeographic relationships. The cave primrose apparently has affinities with boreal species, far to the north of the distribution of this uniquely adapted species. The main area of distribution of saw grass (*Cladium jamaicense*) is in warm temperate and subtropical portions of southern North America and central America (Welsh & Toft 1981).

Thus, the flora of Utah has alliances with many portions of the world. Its understanding must be based on the relationship with those other floras.

Modern Setting and Impacts

The occupation of Utah by mankind has not been without cost to the plant life present in the region. The inroads of modern civilization, mainly in the past 140 years, have been great indeed. Indigenous plants have been displaced by agriculture, buildings, roads, cities and towns, and other appurtenances of this civilization. Valley bottoms and other lands near to water were occupied at once following initial ingress into this area. Very little is known, as a consequence, of the original vegetational composition, although the species present are generally understood through examination of protected relics.

Meadowlands were similarly occupied and many of them have been modified through agronomic and pastoral processes. Much of the meadowland, that still existing, has been subjected to intensive grazing for more than a century. Also, bottom and meadowland early became private property. The combination of private ownership and heavy utilization for grazing and other land use did much to discourage study and collection of plant species. These lands are still only imperfectly known from a botanical standpoint.

Lands considered as suitable for grazing included most of Utah, and much of the state was finally subjected to heavy grazing. Despite the utilization by grazing animals, with their significant impact on spring, seep, and meadowlands, the most important changes in the flora of Utah due to such use appear to belong to two categories—the displacement of species (with attendant reduction in area) and the increase of less palatable plants.

Crop and row agriculture provided another impact on the indigenous vegetation. The native species were eradicated from large areas (about 4.5%) of Utah and replaced by cultivated plants and numerous weeds. Introductions such as cheatgrass and Russian thistle are familiar components of our flora, occupying huge areas in the valleys and foothills over much of Utah. Bindweed and creeping or Canada thistle are pestiferous weeds of consequence that were introduced from the Old World. The poisonous plant hakeakene was first discovered in Utah in the mid-1930s, and it now covers much of the sheep winter range in the state.

Like the crop and row agriculture, the physical appurtenances of civilization—the cities, towns, highways, railways, and industrial structures—tended to be placed in valley bottoms, on alluvium or valley fill, thereby reducing the total area occupied by indigenous plant communities. Although little information of a descriptive nature exists in the historical records, it can be inferred that the plant species displaced in these regions were generalists, plant species that still exist in large areas of Utah.

Certain kinds of industrial development, especially ferrous and nonferrous metal mines, tend to be placed in regions where plant specialists, the endemics, might be expected. Except for the open pit operations, those begun prior to any attempt at searching for rare plants, the surface operations for underground mines occupy only small areas, and their total impacts are relatively small. This is true, fortunately, for coal mines generally in Utah. Only small areas have been subjected to open pit or strip mining techniques. Strip mining should be considered as a last-resort operation, since the strippable land is mainly in arid, low-elevation sites that potentially support endemic plant species.

Recent urban sprawl, especially of cities in the Colorado drainage system, has been forced on to colluvia or raw geological substrates where plant specialists occur. An example is to be found in Washington County where urban sprawl and its attendant human activities impinge directly upon the very limited habitat of the bearclaw poppy.

Other modern industrial expansion that might harmfully influence the narrowly restricted specialists includes electrical transmission lines and structures, substations, highways, pipelines, well sites, and military facilities. These features tend to cross geological outcrops indiscriminately, and their impingement on the nonrandomly placed rare plants is thereby possible.

Federal law, especially the Endangered Species Act of 1973, as amended, provides stipulations for protection of restricted plant specialists. Enforcement of those stipulations should guarantee minimal impact and continuity of the numerous restricted taxa in Utah.

Despite all the impacts of civilization, there is no substantiated account of the extinction of any plant species in Utah during its first 140 years. It is hoped that the same will be said following the next century.

Nevertheless, the net results are cumulative, and the flora of Utah has given way to the impingements of humanity. No part of the state is unchanged, and the potential for increased reduction of native flora is great. And, waiting in the Old World are dozens, if not hundreds, of aggressive, weedy species that could be introduced to Utah inadvertently. During each of the past several decades new and costly importations have reached Utah. Musk or nodding thistle, winged or Scotch thistle, and star-thistle are examples of plants that have spread over Utah in the period from 1950 to the present. More will assuredly follow.