VEGETATION OF UTAH

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ECOSYSTEMS

In order to organize and facilitate management of Utah's ecosystems, generalization of the ecological variation found across the state is necessary. Ecosystems involve complex interactions between environment and biota, and there have been many efforts to generalize and categorize these interactions in order to gain a better understanding of their structure and organization. The most common method of categorizing ecological variations across large landscapes today incorporates the ecoregion concept. Ecoregions are geographic delineations of landscapes containing ecosystems linked by similar climatic, geologic, soil, and landform characteristics. The primary characteristics used to delineate ecoregions vary depending on the overall goal of the individual or management agency. Therefore, ecoregions vary in their geographic extent and shape, but tend to generally identify similar geographies and ecosystems. Examples of ecoregion delineations in Utah consist of the United States Forest Service Bailey Ecoregions (Bailey, 1995) and the Omernik Ecoregions used by the Environmental Protection Agency (EPA) (Omernik, 1987).

Bailey Ecoregions consist of a hierarchically nested set of units beginning with domains that are the most general and based on variations in climate. Utah falls entirely within the Dry Domain. Within domains are divisions that represent significant climatic variations. Within divisions, provinces are defined based on general natural vegetation cover, and within provinces, sections are defined by terrain features (Figure 7.1). Even within the lowest landscape unit, a section, there exists variation in environmental characteristics that can be further subdivided into progressively finer units. Ecoregions are therefore generally large geographic units of common climatic, vegetation, and landform characteristics that can have significant variation within. A clear example of this is the Henry and La Sal Mountains that have subalpine and alpine zones located within the Northern Canyon Lands Section of the Intermountain Semi-Desert and Desert Province of the Bailey Ecoregions.

Omernik Ecoregions (Figure 7.2), developed for the Environmental Protection Agency, were designed with the intent of generating regional biological criteria and water quality standards and setting goals for nonpoint source pollution. While the areas delineated as individual ecoregions in Omernik's map cover similar geographies to the Bailey delineation, there are significant differences. A major difference is that the Omernik Ecoregions are not hierarchically organized as are Bailey Ecoregions. Furthermore, while the Bailey Ecoregion delineations are based primarily on climatic and geologic differences, Omernik Ecoregions are focused on hydrology.

Levels of productivity and responsiveness to management vary greatly between different kinds of ecosystems and are evident across ecoregions. However, while ecoregions are applicable to regional and global applications, more local applications require a different approach in order to address ecoregion variances and understand differences between vegetation types. In order to distinguish between the kinds of ecosystems found in Utah, and communicate the major differences between them, the following cross-cutting classification system will be used. The major environmental gradient in Utah is climate, particularly precipitation and temperature, which are both highly correlated with elevation. Because of the great variation in elevation in Utah, the principal ecological distinction that has long been recognized is that of life zone. The nomenclature of the Natural Resources Conservation Service (NRCS) that identifies seven individual life zones will be used. The life zones, in order of descending elevation, are alpine, subalpine, high mountain, mountain, upland, semidesert, and desert.

The environmental characteristics that form the boundaries between each life zone tend to vary by user, but generally, there is agreement among land managers as to the individual characteristics of each. In general, precipitation increases and temperature decreases as deserts transition into the semidesert, upland, mountain, high mountain, subalpine, and alpine life zones. With a decrease in temperature as elevation increases, reference evapotranspiration (RET), which is defined as the amount of water that could be evaporated from the surface and transpired from plants, also decreases. The RET assumes that water is not limiting. Therefore, when RET is higher than precipitation, a net deficit in moisture occurs and conditions actually become drier. This relationship forms the general basis for the definition of life zones since water balance, in large part, determines the type and amount of vegetation that can occur in a given Utah environment. Since elevation, precipitation, and RET can be modeled spatially, these variables were used to spatially depict the distribution of life zones in Utah (Figure 7.3).

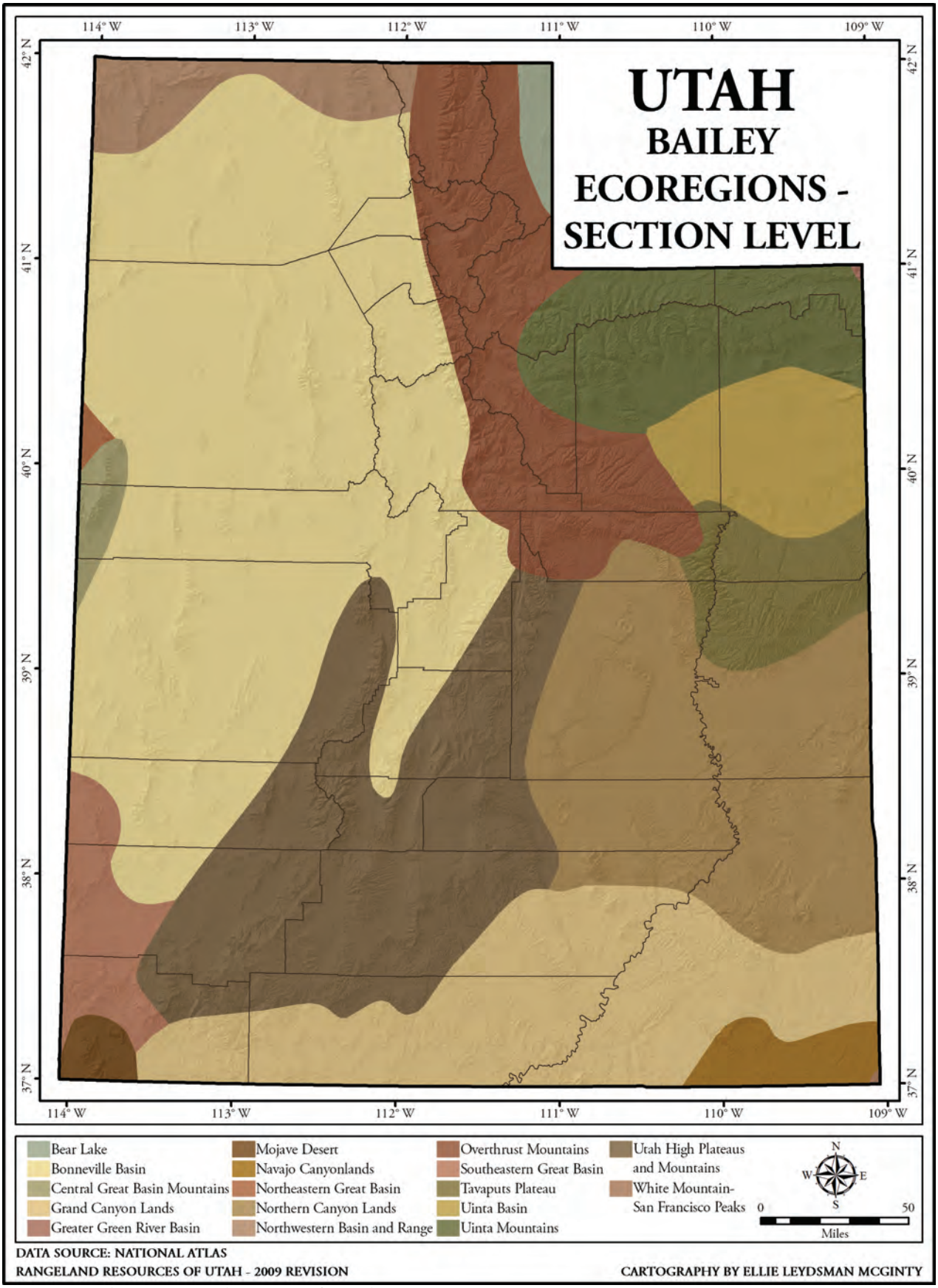


Figure 7.1. Bailey Section Level Ecoregions for Utah.

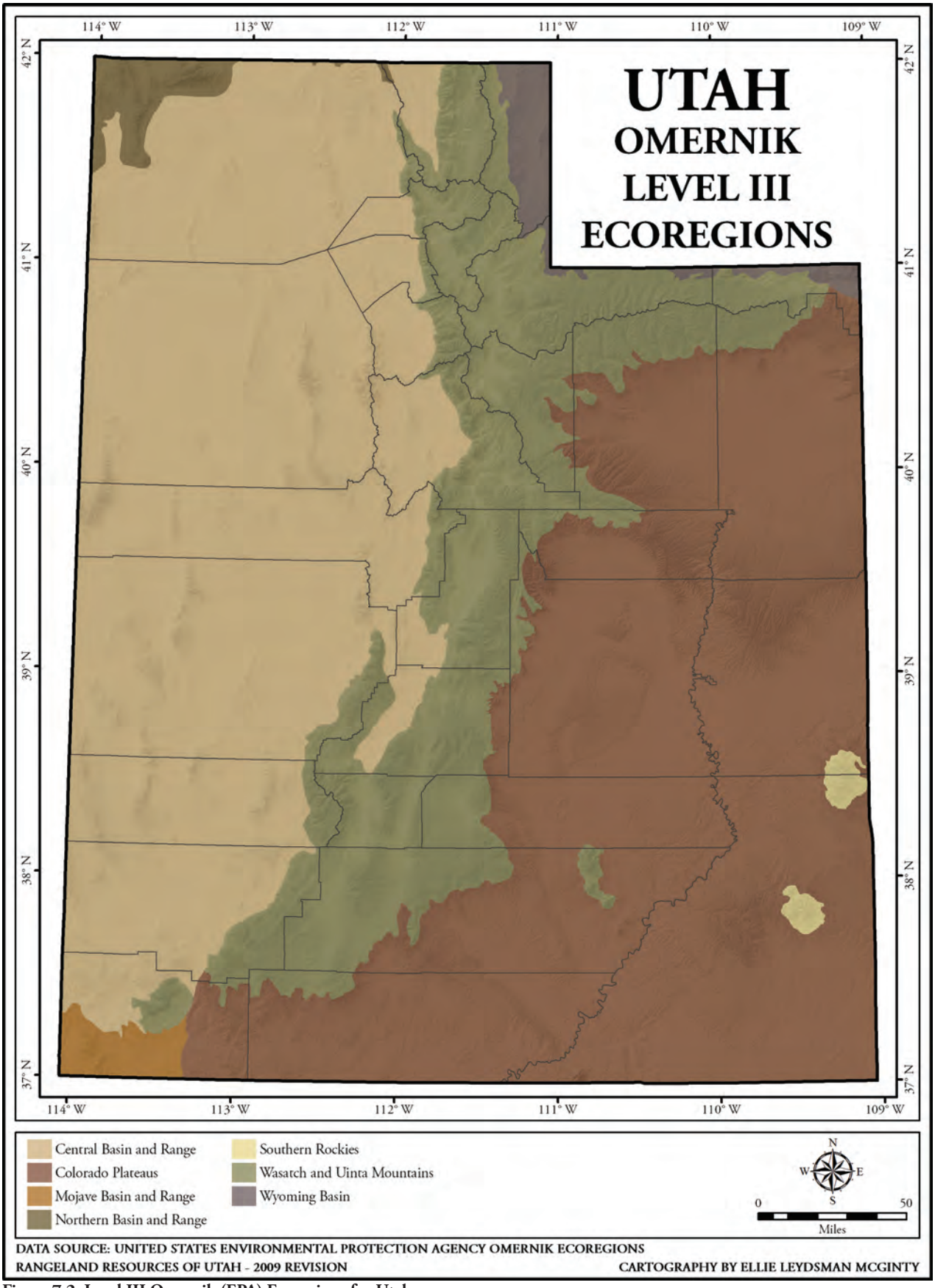


Figure 7.2. Level III Omernik (EPA) Ecoregions for Utah.

A shortcoming of the zonal approach is that some ecosystem types with unusual soils or hydrologic regimes do not easily fit. Examples are sand dunes, wet meadows, and marshlands which often occur in multiple life zones. Those that occupy large acreages or are unusually productive should be considered separately.

Because the efficiency of the precipitation that falls increases northward as average temperatures decrease, the altitudes of each life zone also decrease progressing northward. There is also considerable difference in the seasonality of precipitation from east to west. Accordingly, geography is included in the classification. To accomplish this, the Major Land Resource Areas (MLRAs) used by the NRCS were adopted (Figure 7.4). Those occurring in Utah and their percent occurrence in the state are:

MLRA	NAME	PERCENT
28A	Great Salt Lake Area	36.37
47	Wasatch and Uinta Mountains	23.38
35	Colorado and Green River Plateaus	19.57
34	Central Desertic Basins, Mountains, Plateaus	11.65
39	Arizona and New Mexico Mountains	2.12
48A	Southern Rocky Mountains	1.94
28B	Central Nevada Basin and Range	1.36
29	Southern Nevada Basin and Range	1.25
25	Owyhee High Plateau	0.93
30	Mohave Basin and Range	0.73
37	San Juan River Valley Mesas and Plateaus	0.50
13	Eastern Idaho Plateaus	0.11
43	Northern Rocky Mountains	0.09

It is often difficult when standing at a particular location to determine the life zone or MLRA. Elevations of the most appropriate zone for a given vegetation type vary considerably on different slopes and aspects of a given mountain. The plant indicator concept helps solve this problem. Plant species, particularly perennials, by their presence/absence and vigor, indirectly indicate a great deal about local effective environments. By using knowledge of these relationships, the relative abundances of particular plants can gauge the similarity of both adjacent and distant patches of land. In this way, vegetation becomes relatively easy to determine on the ground when transitioning into another kind of ecosystem. In the following, information is provided on how the most abundant (dominant) plants respond to various environmental conditions.

An individual could look across a landscape of interest, and by noting the repeating patterns of the vegetation, classify it into ecosystem types. This process has, however, already recently been done for Utah through the SWReGAP project (http://earth.gis.usu.edu/swgap) (Lowry et al., 2007). It is from this database that the acreages for each of the ecosystem types discussed in this document were derived.

The SWReGAP project subdivided the state into too many classes of vegetation to conveniently discuss here. Thus, they are aggregated into coarser vegetation types discussed within the zonal context (Figure 7.5). Table 7.1 shows where these coarser SWReGAP vegetation types fit in terms of life zone.

Primarily for reasons of simplicity, a brief consideration of ecosystem types at the highest elevations moving downward will be discussed. Consideration of the alpine zone will be first.

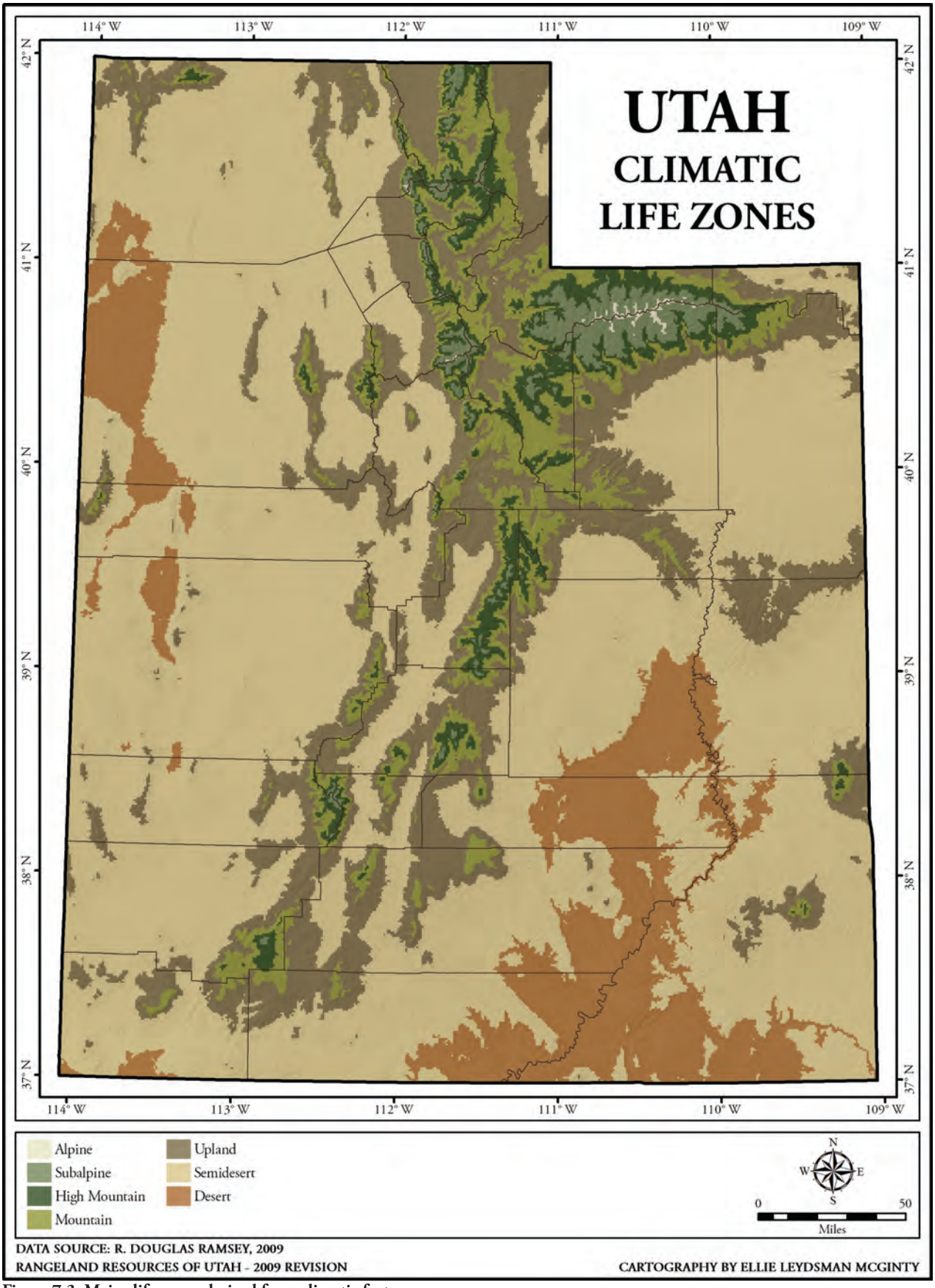


Figure 7.3. Major life zones derived from climatic factors.

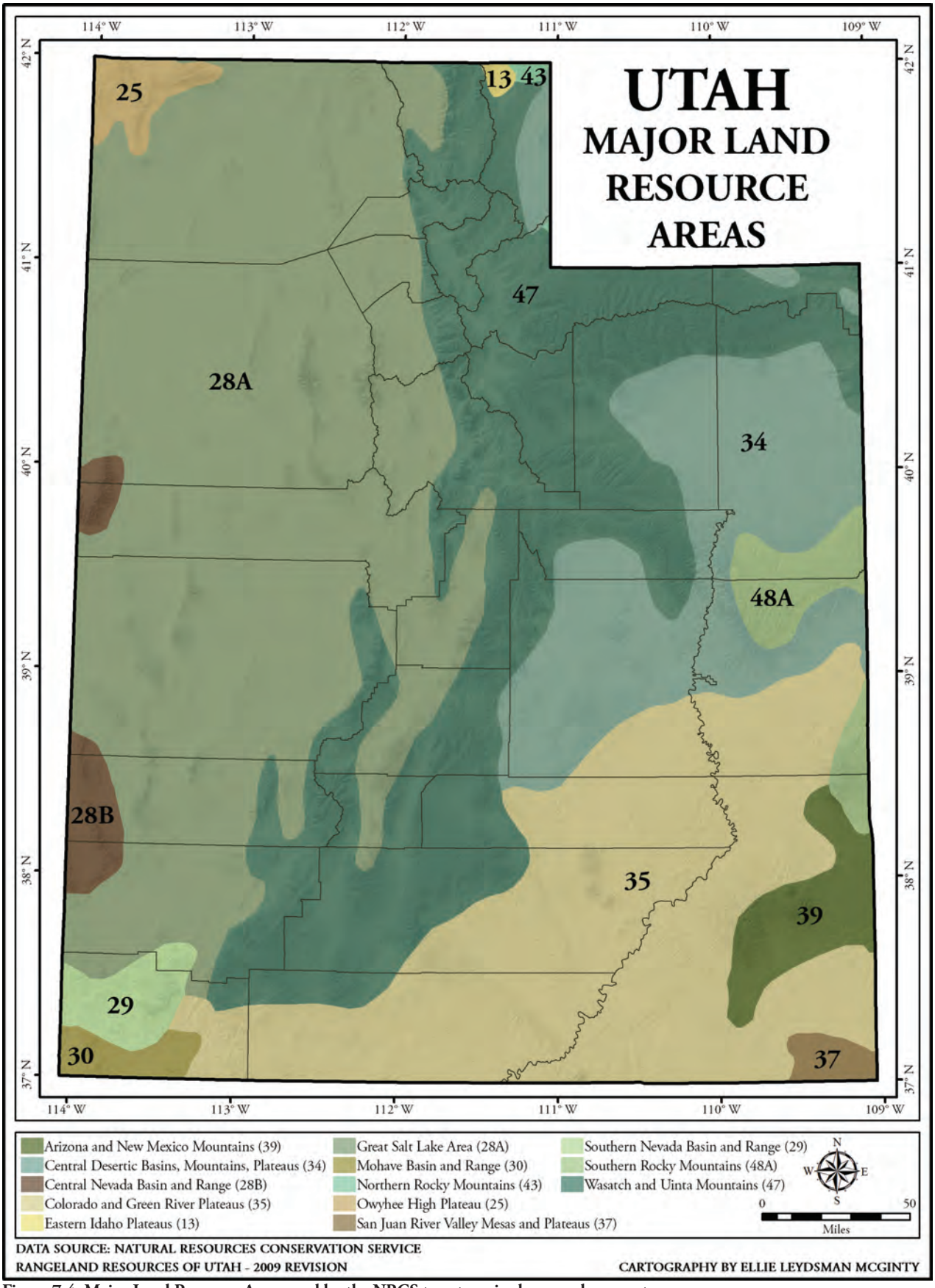


Figure 7.4. Major Land Resource Areas used by the NRCS to categorize large-scale ecosystems.

Figure 7.5. Southwest Regional Gap (SWReGAP) Landcover - reclassified to 45 classes.

Table 7.1. Percent occurrence of each cover type by life zone. Sum of percent of each cover type equals 100.

LEGEND	COVER TYPE	ALPINE	SUBALPINE	HIGH MOUNTAIN	MOUNTAIN	UPLAND	SEMI-DESERT	DESERT	ACRES
1	Agriculture				1%	24%	74%	1%	2,268,637
2	Aspen		4%	27%	47%	21%	1%		1,865,047
3	Badland						55%	45%	451,380
4	Barren Lands						67%	33%	10,551
5	Bedrock Scree	14%	69%	13%	3%	1%			201,263
6	Big Sagebrush		1%	3%	11%	31%	54%		8,507,705
7	Bigtooth Maple		4%	20%	48%	27%	1%		218,765
8	Blackbrush-Mormon Tea						37%	63%	2,242,282
9	Cliff and Canyon		8%	7%	11%	34%	40%		488,546
10	Creosote-White Bursage						65%	35%	202,209
11	Developed				3%	35%	55%	7%	765,031
12	Disturbed		1%	11%	15%	24%	49%		303,644
13	Dune						39%	61%	447,263
14	Dwarf Shrub	8%	91%	1%					27,035
15	Fell Field	13%	86%	1%					43,621
16	Foothill Shrub				2%	86%	12%		62,160
17	Oak			4%	26%	62%	8%		1,631,329
18	Grassland			1%	5%	17%	65%	12%	643,784
19	Greasewood						88%	12%	1,805,404
20	Ice Field	61%	39%						5,239
21	Invasive				1%	7%	84%	8%	1,213,659
22	Limber-Bristlecone Pine		27%	17%	42%	14%			17,280
23	Lodgepole Pine		14%	43%	35%	8%			448,230
24	Low Sagebrush					2%	98%		375,728
25	Marsh					24%	69%	7%	118,848
26	Mat Saltbush						68%	32%	749,958
27	Meadow	1%	35%	30%	16%	12%	6%		241,362
28	Mesquite						34%	66%	756
29	Mixed Conifer		2%	10%	32%	45%	11%		774,468
30	Mixed Shrub		1%	10%	32%	45%	12%		203,321
31	Mogollon Chaparral				3%	46%	51%		143,194
32	Mountain Mahogany		1%	10%	34%	49%	6%		153,943
33	Open Water				2%	7%	81%	10%	1,663,042
34	Pinyon-Juniper				1%	24%	75%		10,567,696
35	Playa						66%	34%	2,787,471
36	Ponderosa Pine				7%	67%	26%		500,466
37	Riparian		2%	7%	13%	22%	53%	3%	365,718
38	Salt Desert Shrub						90%	10%	3,829,998
39	Sand Shrubland						58%	42%	212,370
40	Shrub Steppe						92%	8%	2,056,220
41	Spuce-Fir		26%	33%	28%	13%			1,111,750
42	Tableland					1%	57%	42%	3,513,036
43	Tundra	7%	46%	23%	24%				72,425
44	Volcanic Rockland			12%	19%	12%	56%	1%	80,394
45	Xeric Sagebrush					4%	96%		888,915
	TOTAL								54,281,146

ALPINE ZONE

The alpine zone occurs in high mountain areas where the mean annual precipitation is above 41 inches and the RET is the lowest in the state (Figure 7.6). These areas occur above the upper timber line. The vegetation consists mainly of small cushion plants on rocky slopes. Elevation ranges from 10,800 feet to 13,528 feet above sea level (ASL). Snow tends to persist in these areas most of the year, and in some areas, snow pack does not disappear, depending on topography and the year.

The climate is characterized by long, cold winters and short, cool growing seasons of less than 60 days (Figure 7.7). Even then, frost can occur at any time. Although total annual precipitation is usually over 40 inches, soil water is often in frozen form because the mean annual temperature is well below 32 degrees Fahrenheit.

Much of the alpine zone is comprised of steep, barren and exposed bedrock or loose scree and fell fields (72 percent). Some of this is permanent snow and ice (7 percent). Soils usually develop between rocks and in pockets of gentler terrain where fine particles accumulate (Photographs 1 and 2).

The alpine zone in Utah occupies about 50,650 acres, of which only about 16 percent is well vegetated (Table 2). The Uinta Mountains have the most area at these elevations, but the Wasatch, Tushar, Deep Creek, and La Sal mountains also have smaller true alpine areas.

Tundra plants are all low growing due to the mean cold temperature and frequent high winds. Perennial herbs, especially grass-like sedges, prostrate shrubs, mosses, and lichens share dominance. Alpine vegetation is characterized by a patchwork of many different plant communities. Individual stands of relatively homogeneous turf may occupy only a few square yards and seldom exceeds 20 acres. The boundaries between communities vary from abrupt to diffuse, with the latter case being more common (Photographs 3 and 4).

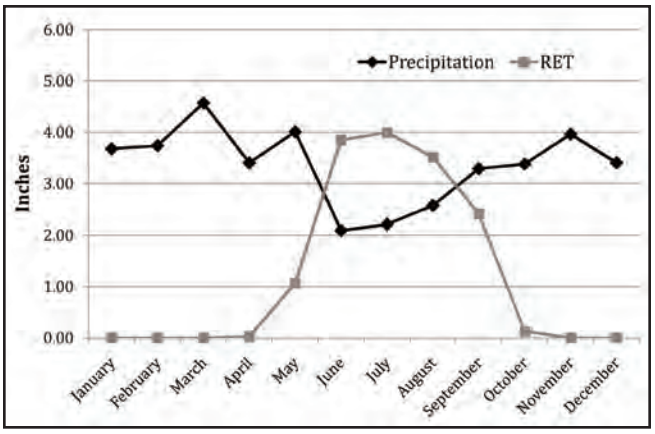


Figure 7.6. Monthly distribution of precipitation within the alpine zone contrasted with modeled reference evapotranspiration (RET). Extracted from Daymet climate models (Thornton et al., 1997).

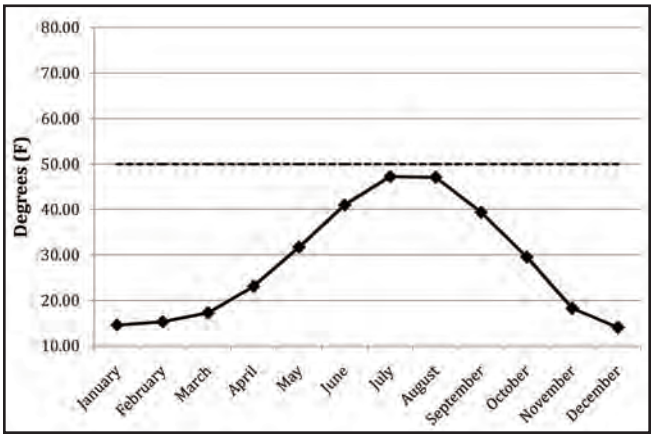


Figure 7.7. Average monthly temperatures within the alpine zone showing number of months with average temperatures over 50 degrees Fahrenheit. Extracted from Daymet climate models (Thornton et al., 1997).

Table 7.2. Distribution of generalized SWReGAP land cover types across the alpine zone in Utah.

LANDCOVER	ACRES	PERCENT
Bedrock Scree	27,901	60
Fell-Field	5,861	12
Tundra/Meadow	5,399	16
Ice Field	3,210	7
Dwarf Shrub	2,293	5
TOTAL	48,391	100

The amount of soil moisture available during the growing season is the main factor that determines which plant species will be found in a particular stand. Aspect, slope, and wind exposure control snow distribution and timing of melting (Figure 7.8). Aboveground plant production and forage availability can vary greatly between points only a few yards apart. The most productive sites are those with moderate amounts of soil moisture. Less productive are the tarns centered around small ponds. The least productive locations are freely drained rocky ridges exposed to desiccating winds and places where the lingering snowpack results in too short a growing season for much of any vascular plant development.

Ten to 15 species constitute the bulk of the plant cover in the Uinta Mountains (Lewis, 1970). A rosaceous forb, Ross' Avens (*Geum rossii*), is the most common. The sedge *Carex scirpoidea* was found in about half of the locations sampled by Lewis (1970); tufted hairgrass (*Deschampsia caespitosa*) was found in both dry and wet meadows. Lewis (1970) recognized five plant communities distinguished by the following dominant species:

Cushion Plant: *Silene acaulis*
Paronychia pulvinata
Minuartia obtusiloba
Trifolium nanum
Carex rupestris

Dry Meadow: *Geum rossii*
Carex rupestris
Carex scirpoidea
Carex elynoides
Kobresia myosuroides
Deschampsia caespitosa

Wet Meadow: *Deschampsia caespitosa*
Polygonum bistortoides

Bog: *Carex aquatilis*
Eriophorum chamissonis

Shrub Thicket: *Salix planifolia*
Salix glauca
Salix drummondiana

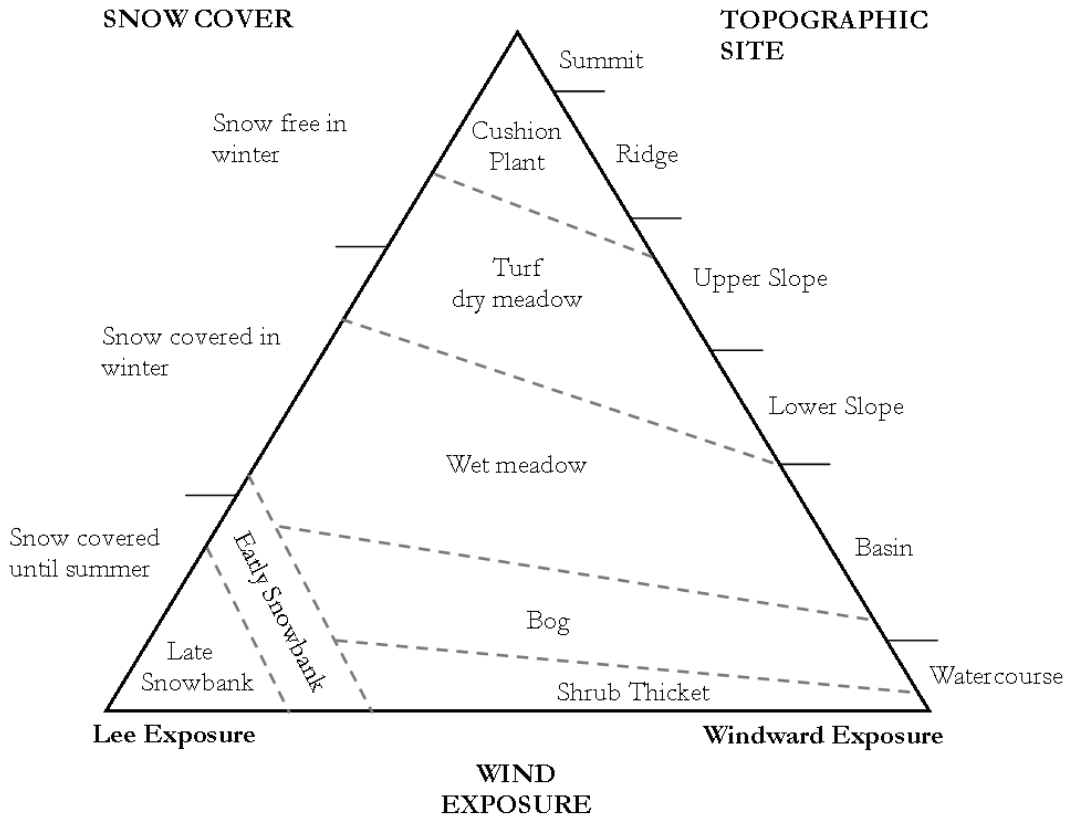


Figure 7.8. Relationship of alpine plant communities to snow cover, wind exposure, and topographic site (from Thilenius, 1975).

Plant cover varies enormously between these community types with the least cover on the dry, windswept ridges, tarns, and centers of the deepest snow drifts on the lee slopes. There can be near 100 percent cover in the sub-irrigated meadows.

Total herbage production can vary from almost nothing on scree slopes to over 2,500 pounds per acre around the bogs. On intermediate sites, production will vary from 700 to 1,600 pounds per acre. However, these figures can vary as much as 50 percent from year to year, depending on growing season conditions. Aboveground primary production usually peaks 3 to 4 weeks after snowmelt (mid-July), then slowly declines (Figure 7.9). Because nearly all the aboveground tissues die after each growing season, phytomass is similar to annual primary production in most communities. The major difference is the flowering buds that are preformed 2 to 3 years in advance of their expansion (Thilenius, 1975).

While not always easily seen, wild animals are relatively abundant in the alpine zone. Many mammals utilize the alpine ranges for summer habitat, while others may be resident throughout the year. Among the common year-long resident mammals are shrews, pikas, hares, marmots, pocket gophers, deer mice, voles, weasels, and mountain goats. Because of its soil-disturbing activities, the most influential tundra mammal is the pocket gopher. These animals bring large quantities of soil to the surface where strong winds and water runoff can move it downslope. They also consume considerable herbage, focusing on fleshy-rooted forbs. Large native mammals using the alpine zone primarily as summer habitat include elk, mule deer, coyote, red fox, black bear, bobcat, and badger. Moose occasionally enter the alpine zone. Smaller summertime resident mammals include porcupine, marten, chipmunks, and ground squirrels.

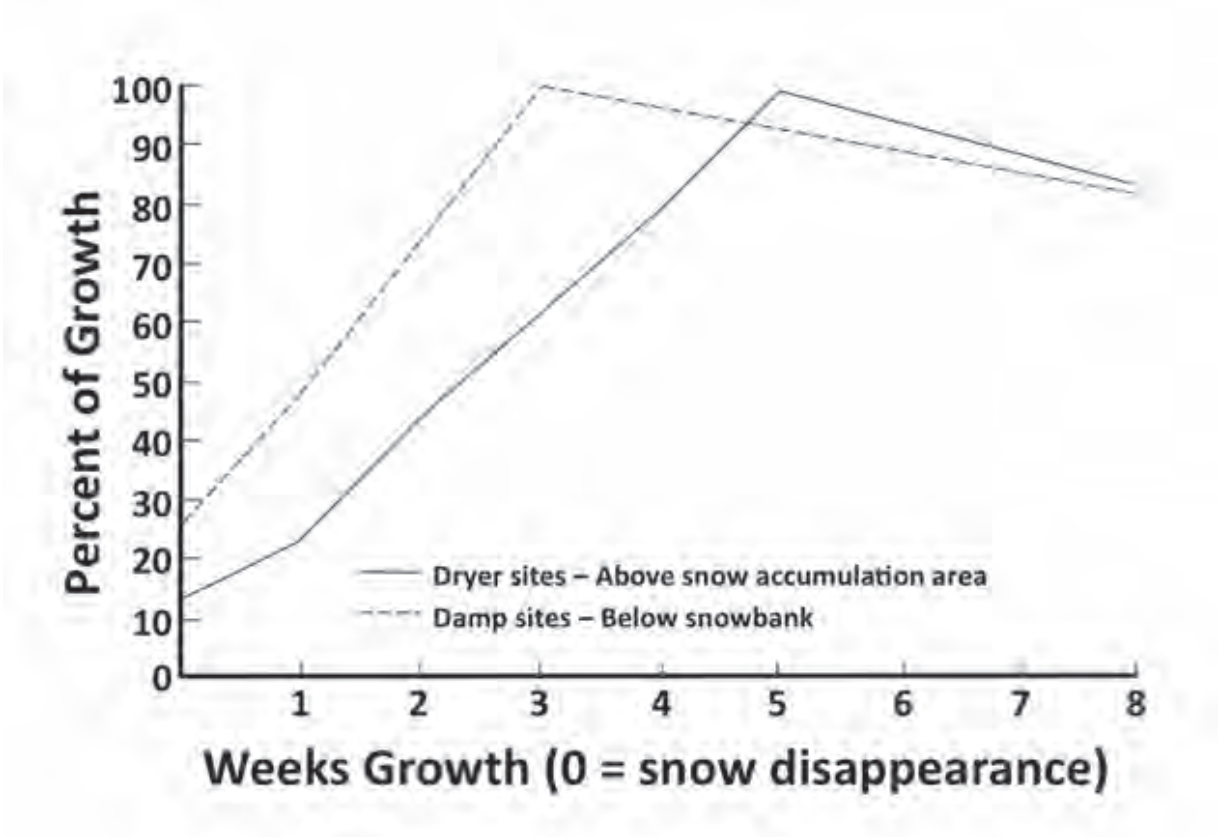


Figure 7.9. Growth curves of alpine plants (from Lewis, 1970).

Many birds use the alpine zone, but the most characteristic species is the ptarmigan that is present yearlong. In summer, the water pipit, rock wren, rosy finch, raven, and several eagles and hawks are present. See Hayward (1952) for a listing of the invertebrates found in the alpine zone of the Uinta Mountains.

Determination of rangeland condition and trend requires special considerations for alpine rangelands. Rather than marked changes in species composition, the changes occurring due to heavy livestock grazing appear as a "wearing out" process (Lewis, 1970). That is, plants are thinned out, reduced in vigor, and soil erosion accelerates. Once an area has been disturbed, upward trend in condition is slow to materialize. Grazing impact studies (Lewis, 1970) show that serious erosion problems develop when about 30 percent of the soil becomes bare.

Primary succession is exceedingly slow in such environments, although several authors have described the *Kolbresia-Carex* meadow on well-drained, deeper soils as the climatic climax. This notion is of little practical value because of the geologic time scale required to think about it. Retrogressional and secondary successional phenomena are much more important. In addition to natural influences such as wind, water, and frost in breaking down vegetation and soils, the possible impact of native animals, humans, and domestic livestock must be considered.

Aboriginal people hunted and gathered during the late summer on the alpine tundra of Utah. Europeans apparently did not visit them much until the present century. The major modern use has been by herded domestic sheep. Overstocking and lack of management has been common in the past on the more accessible parts of the Uintas. Creation of the forest reserves early in the twentieth century resulted in most of the alpine zone becoming managed by the United States Forest Service. Protection of headwaters and watersheds became the first priority. Most of the alpine zone in Utah was designated official wilderness in the 1970s. Only small areas patented under mining law are currently in private ownership and usually occupied by ski-oriented resorts. The lack of motorized access to most of this zone has resulted in relatively little current grazing by domestic livestock.

Revegetation in such environments is very difficult. The alpine environment is so rigorous that there are not any invasive species. Also, there are not any exotics that are easily reseeded. The alpine zone will have to rely on the native pioneers, such as alpine avens and other forbs, to heal the scars from past use. The greatest resource of the alpine zone to all citizens is its role in providing stream flow in late summer and fall when lower zones provide little to none. Unfortunately, global climate change threatens the extinction of these zones in the longer run.

SUBALPINE ZONE

The mean annual precipitation of the subalpine life zone ranges between 31 and 40 inches, with a strong surplus of water given a relatively low annual RET (Figure 7.10). These environments are located just below the upper tree line. Where not excessively steep or rocky, the subalpine zone is vegetated by conifers, aspen, and meadows. Elevations of this zone range between 8,900 feet and 11,000 feet ASL. Plant and animal diversity is somewhat lower than the high mountain zone, since mean annual temperatures tend to be fairly cold, driving much of the wildlife to lower elevations for much of the year. Snow tends to persist in these environments for much of the year save the 3 to 4 months of summer.

According to the SWReGAP generalized land cover dataset, dominant land cover is distributed among a number of cover types, but consists primarily of spruce-fir communities and bedrock scree (Table 7.3). Less expansive types, such as meadow, aspen, lodgepole pine, and mountain big sagebrush, are also commonly found within this zone. While spruce-fir communities occupy a majority of the subalpine zone, the bulk of the spruce-fir type is predominantly found in the high mountain zone and will be discussed in more detail in that zone. The subalpine zone is dominantly located within the Wasatch and Uinta Mountains MLRA with very small proportions (1 percent or less) in the Great Salt Lake Area and Eastern Idaho Plateaus MLRAs.

Forested sites that have been undisturbed by fire for long periods are dominated by coniferous trees [spruces (*Picea engelmannii*, *Picea pungens*) and true firs (*Abies lasiocarpa*, *Abies concolor*)] that are rarely continuous. Intermingled meadows are an important part of the zone, as are the stringers of scraggly, long-lived, five-needled pines (*Pinus flexilis*, *Pinus longaeva*, and *Pinus aristata*) that occupy rocky ridges. Open woodlands of either aspen (*Populus tremuloides*) or lodgepole pine (*Pinus contorta*) occur on sites that have been disturbed by fire within the past 100 years. Thus, the subalpine zone has everything from open meadows dominated by herbaceous vegetation to open woodlands or dense forest depending on a combination of site conditions and disturbance history. The common denominators are the heavy winter snowpack, cool summer temperatures, and short growing season (Figure 7.11).

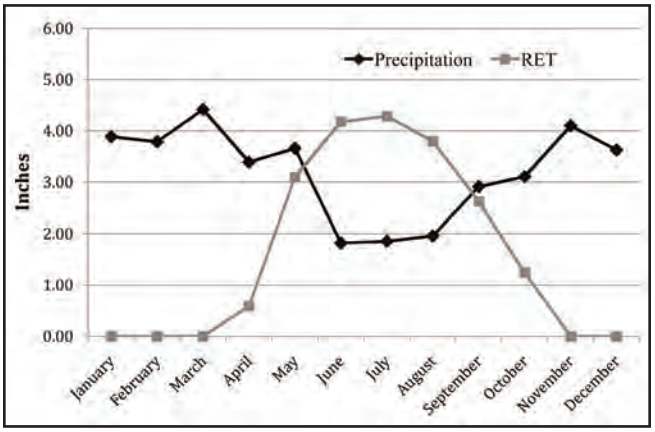


Figure 7.10. Monthly distribution of precipitation within the subalpine zone contrasted with modeled reference evapotranspiration (RET). Extracted from Daymet climate models (Thornton et al., 1997).

Table 7.3. Distribution of generalized SWReGAP land cover types across the subalpine zone in Utah. The miscellaneous category is the sum of all other land cover types occurring less than 2 percent over the area of the life zone.

LANDCOVER	ACRES	PERCENT
Spruce-Fir	288,989	32
Bedrock Scree	138,651	15
Subalpine Meadow	117,166	13
Aspen	66,959	7
Lodgepole Pine	64,513	7
Subalpine Big Sagebrush	63,045	7
Miscellaneous	165,286	18
TOTAL	904,608	100

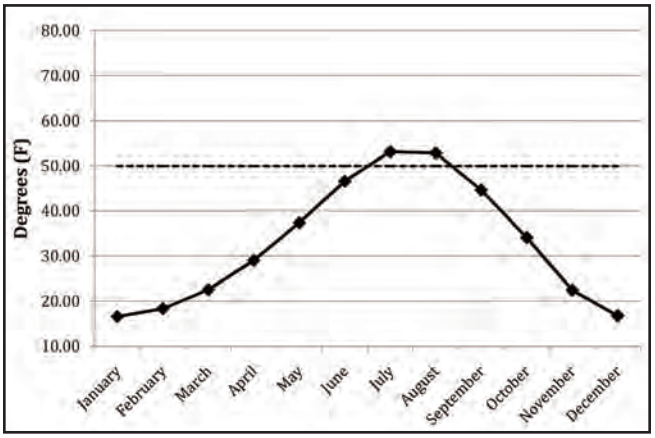


Figure 7.11. Average monthly temperatures within the subalpine zone showing number of months with average temperatures over 50 degrees Fahrenheit. Extracted from Daymet climate models (Thornton et al., 1997).

Commercial harvest of forest products from the subalpine zone takes place, but at a much reduced level from historical practice. Van Hooser and Green (1983) rank only half of the subalpine forests as commercial.

The high water yield (in excess of an average of 8 inches per year) from deep snowpacks makes this zone extremely important as watersheds, even if no other products are harvested from the land. It should not be surprising that logging and livestock grazing are excluded from a considerable portion of the zone identified as critical watersheds. Another large fraction is concomitantly wilderness where non-motorized recreation is the only permitted use. Most recreational use is centered on backpacking and fishing, although winter skiing and snowmobiling regularly occur.

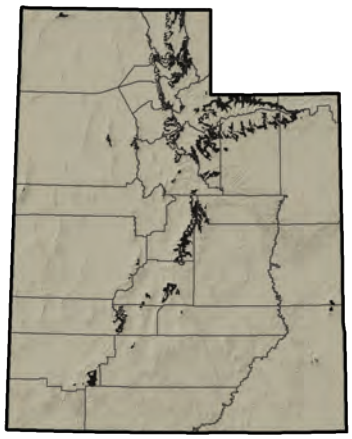
The boundaries between community types are usually abrupt because trees develop distinctly different microclimates under their canopies. How much of the mosaic is due to inherent differences in physical and chemical site factors as opposed to biological or mediated changes due to competition and succession has been widely debated. For instance, the existence of meadows has been variously attributed to disturbance by fire, cold air drainage, impeded water tables, fine-textured soils, competition of the herbaceous vegetation with tree seedlings, pocket gopher disturbance, and differential snowpacks. Each of these causes could be controlling in particular circumstances. Normally, causes are interlinked, making simple cause-effect assessments unrealistic. Interpretation of the interplay of environmental factors with successional pathways is, however, important to the land manager.

The flora of the subalpine zone is rich in species, if all habitats and successional stages are considered. Reese (1981) found an average of 182 higher plant species in a cross section of the subalpine zone on 4 square miles of northern Utah. Forbs are more numerous than grasses. Perennials are much more common than annuals. Shrubs, such as Oregon boxleaf (*Paxistima myrsinites*), found on basic soils, or huckleberry (*Vaccinium* spp.) found on acid soils are few in number and only patchily dominant in terms of cover or weight. There is usually a very pronounced week-to-week change in conspicuousness of herbaceous species during the growing season as the various species grow, flower, and set seed at different times (Reese, 1981).

The spruce-fir association, typical of undisturbed forested sites in the zone, usually has very sparse understory vegetation covering less than 5 percent of the surface. If the sites have been disturbed since the advent of Europeans, the forest is very likely to be an open woodland with a dense understory population of grasses and herbs. The most important portion of the subalpine zone from the ungulate grazing standpoint is the mixed upland herb communities, or open meadows. The ephemeral community is dominated by plants that die in midsummer. These are usually annuals of low grazing value. Unfortunately, much of the subalpine zone has had its productivity limited in the past by excessive grazing and consequent erosion. While livestock use has been reduced in recent decades, the impact from increased elk has not necessarily led to improved rangeland conditions. In fact, while livestock use is required to abide by range readiness guidelines, elk do not. The result is often patches of early heavy utilization by elk before livestock are allowed on. The net result is a lowered condition of those rangelands. Cooperation between land management agencies and the Utah Department of Wildlife Resources will be required to mitigate these problems.

Certain cover types mentioned here straddle several zones. In particular, meadow, aspen, lodgepole pine, and sagebrush in the subalpine zone are encountered. Fuller consideration of the cover types that compose their highest fraction of contribution to a zone will be deferred. Thus, for instance, spruce-fir and lodgepole pine communities will be discussed in the high mountain zone and aspen will be discussed in the mountain zone.

HIGH MOUNTAIN ZONE



The high mountain zone occurs just below the subalpine zone, at approximately 7,800 to 10,000 feet in elevation. This zone occupies 1,792,646 acres or 3.3 percent of the state, and is widely distributed along the central mountain spine going down the middle north-south axis and around the Uinta Mountains. The climate in the high mountain zone is cool and sub-humid. Reference evapotranspiration (RET) exceeds precipitation for approximately 5 months centered on summer (Figure 7.12). This zone relies on a significant amount of snowfall and slow melt during spring, leading to soil moisture lasting into the summer months to sustain vegetation growth. Summers are warm and dry in the north, but have a period of convectional showers, particularly to the south. Mean annual precipitation ranges from a high of 13.2 inches during winter (December to March) to a low of 5.5 inches in summer (July to September). Total mean annual precipitation when all months are considered is 32.3 inches. Mean annual temperatures vary from 21 degrees Fahrenheit during the winter to 54 degrees Fahrenheit during the summer. The growing season based on agricultural norms of consecutive days above 50 degrees Fahrenheit normally begins the first of June and extends until the latter part of August (Figure 7.13).

The topography within this zone varies from steep rocky peaks, slopes, and ridge tops to plateaus or gently sloping meadows. The soils range from Entisols in the former to Inceptisols and Mollisols in the latter.

The vegetation within this zone involves a diversity of forms from forests (63 percent), low shrublands (16 percent), tall shrublands (6 percent), and meadows (4 percent). While Table 7.4 shows that the top four major land cover types within this zone consist of aspen, spruce/fir, big sagebrush, and lodgepole pine, the distribution of these types across life zones shows a different story (Table 7.1). Aspen is found primarily in the mountain zone, and big sagebrush has only a minor component in the high mountain. As far as the high mountain zone is concerned, its small distribution across the state (3.3 percent) as a narrow band between the mountain and subalpine enforces

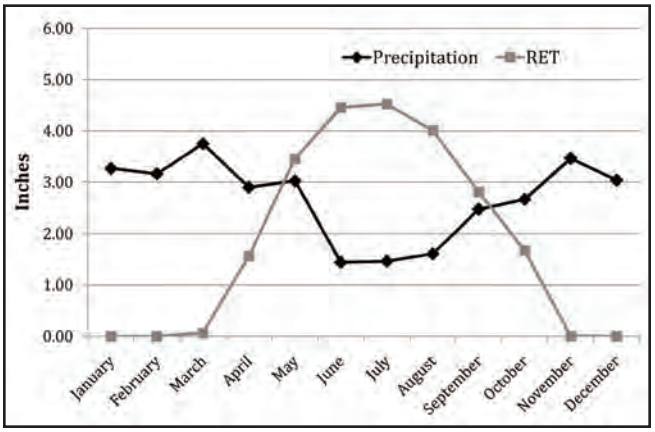


Figure 7.12. Monthly distribution of precipitation within the high mountain zone contrasted with modeled reference evapotranspiration (RET). Extracted from Daymet climate models (Thornton et al., 1997).

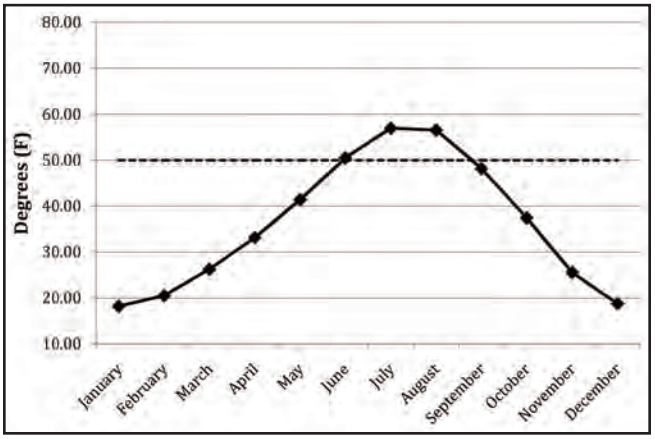


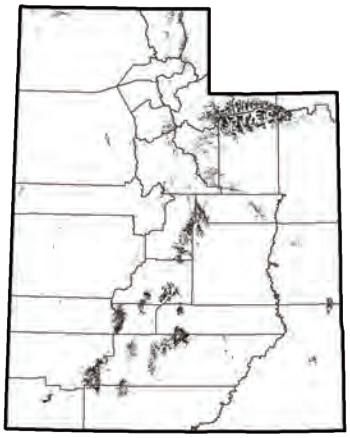
Figure 7.13. Average monthly temperatures within the high mountain zone showing number of months with average temperatures over 50 degrees Fahrenheit. Extracted from Daymet climate models (Thornton et al., 1997).

Table 7.4. Distribution of generalized SWReGAP land cover types across the high mountain zone in Utah. The miscellaneous category is the sum of all other land cover types occurring less than 2 percent over the area of the life zone.

LANDCOVER	ACRES	PERCENT
Aspen	510,720	28
Spruce-Fir	362,651	20
Big Sagebrush	291,733	16
Lodgepole Pine	190,697	11
Mixed Conifer	73,908	4
Meadow	72,286	4
Oak Brush	63,067	4
Bigtooth Maple	42,705	2
Miscellaneous	184,840	10
TOTAL	1,792,607	100

its role as an ecotone (zone of transition) between the next higher and next lower zone. The two major components of spruce/fir forest and lodgepole pine, which show dominance in the high mountain zone, will be considered in more detail in this section. The high mountain zone is found predominantly in the Wasatch and Uinta Mountain MLRA (93 percent) with a 4 percent component in the Great Salt Lake Area MLRA. The remainder of this life zone is spread among MLRAs that have mountain "islands" within areas largely occupied by lower elevation life zones.

SPRUCE-FIR COMMUNITIES



Engelmann spruce and fir forests often represent the highest elevation forests in an area. The area covered by this type occurs across all life zones for a total of approximately 1.1 million acres. Most of it is found from the mountain to subalpine zones, with a slight majority occurring within the high mountain zone (Figure 7.14; Photograph 5). Tree canopies commonly consist of Engelmann spruce (*Picea engelmannii*) and subalpine fir (*Abies lasiocarpa*) dominating either mixed or alone. Blue spruce (*Picea pungens*) is common in the most southerly locations and spruce, being slower growing, is found largely where fire has been absent for a longer period of time. Douglas fir (*Pseudotsuga menziesii*) may persist for long periods without true fir or spruce regeneration. Lodgepole pine (*Pinus contorta*) is common in many places, and patches of pure lodgepole pine are not uncommon, as well as mixed conifer/quaking aspen (*Populus tremuloides*) stands where fire has been most frequent. There are two basic versions of this ecosystem, xeric (dry) and mesic (moist) types. Xeric understory species may include common juniper (*Juniperus communis*), twinflower (*Linnaea borealis*), creeping barberry (*Mahonia repens*), or grouse whortleberry (*Vaccinium scoparium*). Mesic variants show more sedges (*Carex* spp.) and forbs.

The mesic variant of this type occurs typically in locations with cold-air drainage or ponding, or where snowpacks linger late into the summer, such as north-facing slopes and high-elevation ravines. These variants can extend into the subalpine zone on drier sites and also down into the mountain zone in places where cold-air ponding occurs; northerly and easterly aspects predominate. The xeric variant forests are found on gentle to very steep mountain slopes, high-elevation ridgetops and upper slopes, plateau-like surfaces, basins, alluvial terraces, well-drained benches, and inactive stream terraces. Mesic understory shrubs include thinleaf huckleberry (*Vaccinium membranaceum*), Saskatoon serviceberry (*Amelanchier alnifolia*), thimbleberry (*Rubus parviflorus*), and willow (*Salix* spp.). Herbaceous species include forbs, such as red baneberry (*Actaea rubra*), starry false lily of the valley (*Maianthemum stellatum*), sprucefir fleabane (*Erigeron eximius*), and yellowdot saxifrage (*Saxifraga bronchialis*). A common grass is bluejoint (*Calamagrostis canadensis*). Disturbances include occasional blow-down, insect outbreaks and stand-replacing fire.

Prior to the migration of Europeans to these landscapes, disturbance regimes typically consisted of fires, insects, disease, and herbivory from native animals. These impacts maintained a diversity of stand conditions. Following settlement by Europeans, additional impacts consisted of logging and grazing. The suppression of fire has also impacted these types by creating dense, even-aged stands that connect to each other in space. This connectivity between stands increases the risk of very large wildfires in contrast with wildfires that occurred before fire suppression. The lack of stand size and age class diversity also increases the potential for devastating attacks by insects and pathogens including the mountain pine beetle, which can and has killed large tracts of these forests. This larger scale impact by pathogens also increases the chance of stand-replacing wildfires by providing large tracts of dead and dry timber.

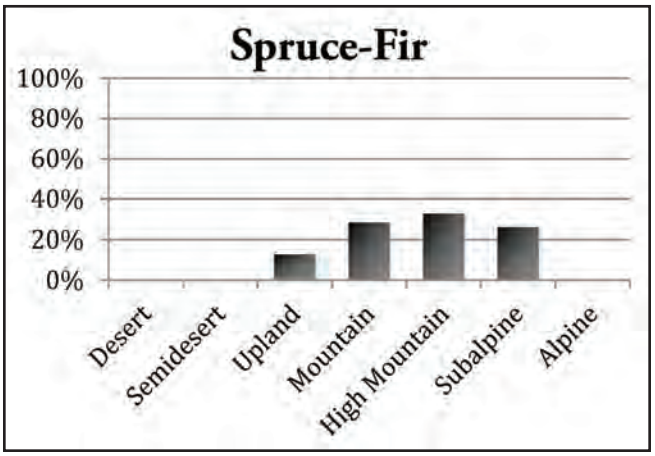


Figure 7.14. Distribution of spruce-fir communities across life zones.

LODGEPOLE PINE COMMUNITIES

There are more than 440,000 acres of this community type across Utah spanning the mountain through subalpine zones, with a modal occurrence in the high mountain zone (Figure 7.15). These forests are closely related to fire history and topoedaphic conditions. Following stand-replacing fires, lodgepole pine will rapidly colonize and develop into dense, even-aged stands, but usually are re-burned before an even-age class structure has developed. Most of these forests are found particularly on sites that are too extreme for other conifers to establish. These include excessively well-drained pumice deposits, glacial till, and alluvium on valley floors where there is cold air accumulation, warm and droughty shallow soils over fractured quartzite bedrock, and shallow moisture-deficient soils with a significant component of volcanic ash. Soils supporting these forests are typically well drained, gravelly, coarse-textured, acidic, and rarely formed from calcareous parent materials. Understory production is low to none in mature stands, but open, immature stands support a variety of shrubs and grass (Photograph 6). Sometimes there are intermingled mixed conifer/aspen stands with the latter occurring with inclusions of deeper, typically fine-textured soils (Photograph 7). Common understory shrub species include kinnikinnick (*Arctostaphylos uva-ursi*), snowbrush ceanothus (*Ceanothus velutinus*), twinflower (*Linnaea borealis*), creeping barberry (*Mahonia repens*), antelope bitterbrush (*Purshia tridentata*), Russet buffaloberry (*Shepherdia canadensis*), dwarf bilberry (*Vaccinium caespitosum*), grouse whortleberry (*Vaccinium scoparium*), thinleaf huckleberry (*Vaccinium membranaceum*), mountain snowberry (*Symphoricarpos oreophilus*), and currant (*Ribes* spp.).

European men began exploiting forested lands in the mid- to late-1800s with significant extraction of timber for building projects in growing settlements. This led to significant denudation of forests and general land degradation. With the creation of the first forest reserve in Utah (the Uinta Forest Reserve in 1897), these landscapes came under additional management to protect watershed and timber resources. The combination of excessive logging and grazing by domestic livestock caused significant erosion and subsequent loss of range and forest productivity, as well as impacts to water quantity and quality.

During the latter part of the 20th century, grazing was significantly reduced and timber harvesting more tightly managed. With the growth and development of towns and cities along the Wasatch Front, extractive industries have seen increased competition by recreational and leisure industries, which rely on viewshed quality. These two industries, in combination with the need for increased watershed management to provide water to a growing population, pose significant challenges to the Forest Service. The Forest Service must find a balance of multiple uses while maintaining forest health.

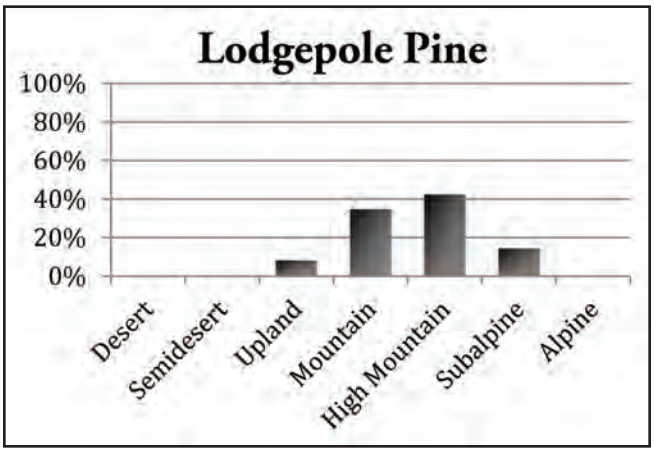


Figure 7.15. Distribution of lodgepole pine communities across life zones.

The state of Utah is not a major timber producer when compared to regions to the northwest and southeast. In fact, Utah has been a net importer of lumber since 1880 to support rural and urban development. With the majority of timber extraction restricted to private lands, the ability of this industry to support local sawmills has decreased significantly. The lack of locally accessible sawmills reduces profits for landowners and further reduces timber harvesting. While some laud the reduction of timber harvest in the state, the net effect may be an overall loss in landscape diversity, wildlife habitat, changes in fire intervals and intensity, and a loss in water yield. During the settlement period of the 1800s, mean fire intervals decreased (increased number of fires per unit time) due to an increase in combustion sources (accidental ignition by humans) (Wadleigh and Jenkins, 1996). This activity created landscape mosaics of different land cover. As fire suppression activities came into vogue after the start of the United States Forest Service in 1905, mean fire return intervals increased (fewer fires per unit time) when compared to pre-settlement conditions. This increase in mean

fire return interval reduced general landscape diversity. Shade-intolerant species, such as lodgepole pine and aspen, have given way to the more shade-tolerant subalpine fir. A decrease in forest stand spatial diversity increases the chance of larger catastrophic fires. The need, therefore, is to somehow balance management activities to maintain these forests in a healthy and diverse condition.

Mature lodgepole pine communities do not provide significant forage habitat for domestic or wild grazers. The relatively closed canopy limits sunlight penetration to the forest floor, thus reducing understory production by grasses, forbs, and shrubs. This denser forest, however, does provide significant thermal and hiding cover for wildlife that forage in adjacent plant communities. Elk and deer use lodgepole pine communities during summer when snow has receded or melted completely (USU Extension, 2009).

There are a number of insect pathogens that impact these communities. These include the lodgepole terminal weevil, pandora moth, and the needle miner. While they slow production and may kill some trees within a stand, they do not significantly impact the entire stand (Amman, 1975). However, the mountain pine beetle (*Dendroctonus ponderosae*) can significantly impact entire stands by attacking the larger diameter trees with thick phloem layers. Since lodgepole pine communities tend to be relatively even aged, beetles can kill entire stands. Management to reduce the impact of the mountain pine beetle can include maintaining uneven-aged stands. Since pine beetles prefer older, dense stands, selective thinning and propagation of younger trees can increase the resiliency of forests to beetle attacks (Leatherman et al., 2007).

MOUNTAIN ZONE

The mountain zone in Utah generally occurs between 6,900 and 9,200 feet in elevation. The mountain zone occupies about 3,561,884 acres, or 6.6 percent of the state. The zone is widely distributed where moderately high mountains or plateaus rise up. The climate at such elevations involves cool, humid winters and warm, dry summers. The reference evapotranspiration exceeds precipitation for approximately 5½ months (Figure 7.16). Mean annual precipitation varies between 10.4 inches in the winter months (December to March) and 5 inches during the summer. Total mean annual precipitation in this zone is 26.3 inches. Mean annual temperatures vary between 23.4 degrees Fahrenheit during the winter months and 57.3 degrees Fahrenheit during the summer with wide variations. The growing season ranges from mid-May to the first week of September (Figure 7.17). At times, the growing season can be longer than either areas above or below this zone because drainage of cold air to valleys below often pushes up warmer air into this "thermal belt" during periods of wind-free, high air pressure.

The topography within this zone varies from steep, rocky, lower mountain slopes or hills to plateaus or gently sloping meadowlands. The soils range from Entisols and Inceptisols to Mollisols, respectively.

The vegetation within this zone varies from big sagebrush steppe to conifer and aspen forests, and pinyon-juniper woodlands to tall shrublands. The tall shrublands are found more abundantly in the upland zone and will be discussed there. The variety of current vegetation is reflected in Table 7.5. In the discussion of the mountain zone, the mountain big sagebrush and aspen communities are considered.

Approximately 87 percent of the mountain zone is found within the Wasatch and Uinta Mountains MLRA, with 8 percent occurring in the Great Salt Lake Area MLRA. Other MLRAs that contain this zone include the Owyhee High Plateaus, Southern Rocky Mountains, and Southern Nevada Basin and Range.

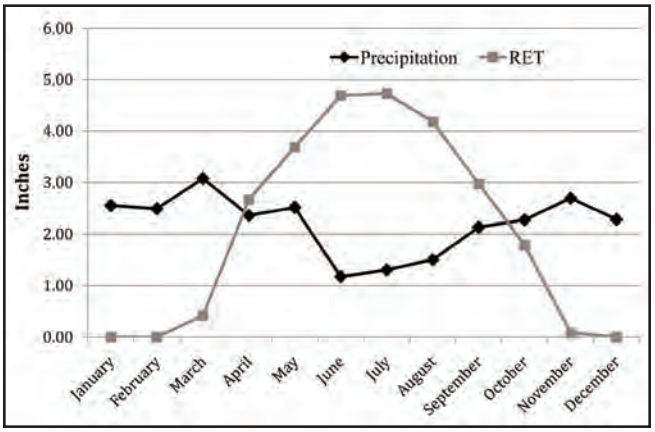


Figure 7.16. Monthly distribution of precipitation within the mountain zone contrasted with modeled reference evapotranspiration (RET). Extracted from Daymet climate models (Thornton et al., 1997).

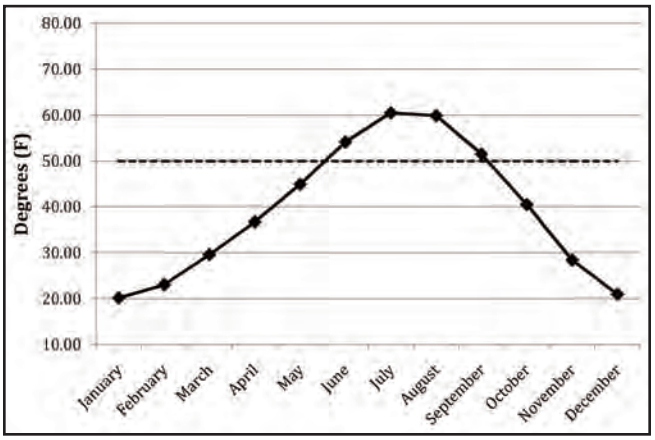
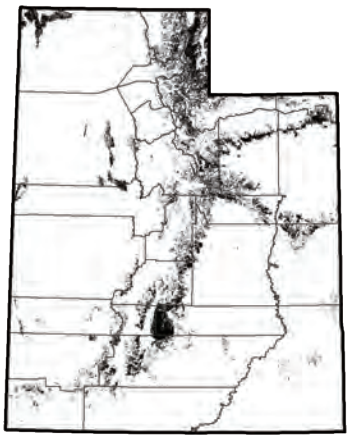


Figure 7.17. Average monthly temperatures within the mountain zone showing number of months with average temperatures over 50 degrees Fahrenheit. Extracted from Daymet climate models (Thornton et al., 1997).

Table 7.5. Distribution of generalized SWReGAP land cover types across the mountain zone in Utah. The miscellaneous category is the sum of all other land cover types occurring less than 2 percent over the area of the life zone.

LANDCOVER	ACRES	PERCENT
Big Sagebrush	933,994	26
Aspen	881,192	25
Oak Brush	423,798	13
Spruce-Fir	314,603	9
Mixed Conifer	245,362	7
Lodgepole Pine	156,360	4
Bigtooth Maple	105,781	3
Pinyon-Juniper	76,317	2
Miscellaneous	369,020	11
TOTAL	3,561,123	100

MOUNTAIN BIG SAGEBRUSH COMMUNITIES

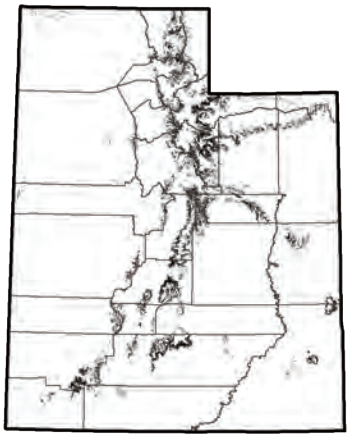


Mountain big sagebrush dominated communities occur across 26 percent of the mountain life zone. Big sagebrush communities occur across the mountain, upland, and semidesert zones. Each zone supports a different subspecies of big sagebrush. The three most common subspecies of big sagebrush (*Artemisia tridentata*) are basin big sagebrush (*Artemisia tridentata* ssp. *tridentata*), which is predominantly found in the lower basins, Wyoming big sagebrush (*Artemisia tridentata* ssp. *wyomingensis*), which is found on higher elevation foothills, and mountain big sagebrush (*Artemisia tridentata* ssp. *vaseyana*), which occurs at higher elevations in the mountain zone (Photograph 8). Mountain big sagebrush communities are not a significant source of forage for domestic grazers. Use by cattle and sheep is variable. Grazing by domestic livestock relies on associated understory plants.

Mountain big sagebrush prefers moderately deep (approximately 30 inches), well-drained, gravelly loam soils and is typically associated with dry-to-moist mountain meadows that can support a significant amount of forage production in the form of grasses and forbs. These communities can also be found on flat ridge tops and mountain slopes. Understory production of perennial forbs and grasses varies depending on site quality. Other shrubs typically associated with mountain big sagebrush communities include antelope bitterbrush (*Purshia tridentata*), snowberry (*Symphoricarpos* spp.), serviceberry (*Amelanchier* spp.), wild crab apple (*Peraphyllum ramosissimum*), and wax currant (*Ribes cereum*). The associated herbaceous cover can exceed 25 percent of the total ground cover. Graminoids include Idaho fescue (*Festuca idahoensis*), needle and thread (*Hesperostipa comata*), muttongrass (*Poa fendleriana*), slender wheatgrass (*Elymus trachycaulus*), sandberg bluegrass (*Poa secunda*), spike fescue (*Leucopoa kingii*), tufted hairgrass (*Deschampsia caespitosa*), pinegrass (*Calamagrostis rubescens*), and bluebunch wheatgrass (*Pseudoroegneria spicata*).

As with most habitat types in the upper elevation life zones, mountain big sagebrush communities host a number of wildlife species from large ungulates, such as elk and mule deer that browse on the more fleshy parts of this variety of big sagebrush, to small, ground-dwelling mammals. These communities also support a wide range of predators from raptors to mountain lions, foxes, weasels, and snakes.

ASPEN COMMUNITIES



Aspen communities are considered a seral type, giving way to coniferous communities, including Douglas fir (*Pseudotsuga menziesii*), white fir (*Abies concolor*), subalpine fir (*Abies lasiocarpa*), Englemann spruce (*Picea engelmannii*), blue spruce (*Picea pungens*), lodgepole pine (*Pinus contorta*), limber pine (*Pinus flexilis*), and/or ponderosa pine (*Pinus ponderosa*), depending on location and environmental conditions (Photograph 9). While usually seral, aspen can occur as a relatively pure (pseudo-climax) community depending on seed availability of conifers and stability of the soils. This is particularly the case where the churning clays of Vertisols predominate.

Aspen stands occur across the upland, mountain, and high mountain life zones, but have a modal occurrence in the mountain zone (Figure 7.18). These plant communities are highly productive and are known for their significant understory production that can range from 180 pounds per acre to more than 1,300 pounds per acre, depending on site conditions for pure aspen stands. As conifers invade, this production can drop to less than 100 pounds per acre when conifer canopy cover reaches 50 percent and approaches zero pounds per acre as conifers reach 100 percent canopy cover (Stam et al., 2008).

Recent studies have shown that this community type has shown a marked decrease in its occurrence in Utah and across the Intermountain West (Bartos, 2008). There is no single reason for aspen decline, but it is generally attributed to fire suppression activities as well as overgrazing by wild and domestic animals. Aspen suckers are readily eaten by elk, which occurs throughout the aspen range. Aspen regeneration is predominantly dependent on sprouting from roots rather than from seed. Due to its dependence on root sprouting, aspen communities require a regular

disturbance regime to retain dominance on the landscape and to maintain stand health. The absence of disturbance, which includes fire or mechanical removal, allows shade-tolerant conifers to invade that eventually eliminate the more shade-intolerant aspen.

Aspen communities support a large number of birds and mammals, including most large raptors and many songbirds. Large mammals that rely on aspen communities for habitat include elk, mule deer, moose, black bear, mountain lion, and bobcats. Additionally, aspen host a number of squirrels, gophers, mice, and rabbits, as well as medium-sized mammals, such as badgers, porcupines, skunks, and foxes.

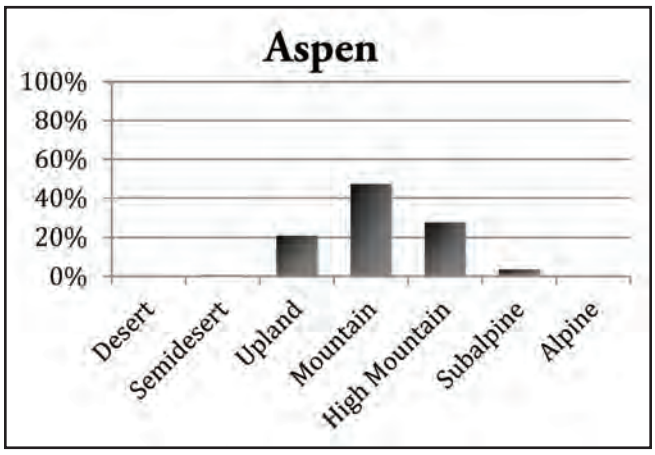


Figure 7.18. Distribution of aspen communities across life zones.

UPLAND ZONE

The upland zone occurs below the mountain zone at approximately 5,800 to 8,300 feet in elevation. This zone occupies 9,271,582 acres, or 17 percent of the state. This zone is predominantly defined by foothills around the higher mountain ranges, as well as tops of lower mountains and escarpments. The upland zone is associated with the majority of the urban and rural development. The climate of the upland zone is warm during summers, cool during winters, and drier than the adjacent higher elevations. The reference evapotranspiration exceeds precipitation for approximately 6½ months (Figure 7.19). Mean annual precipitation ranges from 7.1 inches during winter months and 4.3 inches during summer for a total mean annual precipitation of 19.6 inches. Mean annual temperatures vary between 26.7 degrees Fahrenheit during the winter months and 61.8 degrees Fahrenheit during the summer. The growing season ranges from the beginning of May to mid-September (Figure 7.20).

The topography of the upland zone is generally gentler than the zones above, although some steep, rocky areas are to be expected locally. The soils range from shallow Entisols on steeper slopes to Mollisols on gentler terrain and Aridisols in the lower portions of the life zone.

The vegetation of the upland zone is dominated by three major kinds of widespread taxa, including sagebrushes, pinyon and juniper trees, and oak and mountain brush (Table 7.6). Since pinyon and juniper communities are more prevalent in the semidesert life zone, they will be discussed in that section. A smaller component of the upland zone (4 percent) is the ponderosa pine ecosystem. Although it is a small component, it has the majority of its distribution in the upland zone.

This life zone is spread across multiple NRCS MLRAs, but is dominant in the Wasatch and Uinta Mountains (52 percent) and the Great Salt Lake Area (25 percent). Smaller occurrences of this zone can be found in the Southern Rocky Mountains (6 percent), Central Desertic Basins, Mountains, and Plateaus (5 percent), the Owyhee High Plateaus (3 percent), and Arizona and New Mexico Mountains (2 percent). All other MLRAs have trace amounts of the upland zone except for the San Juan River Valley, Mesas, and Plateaus MRLA that has no occurrence within this zone.

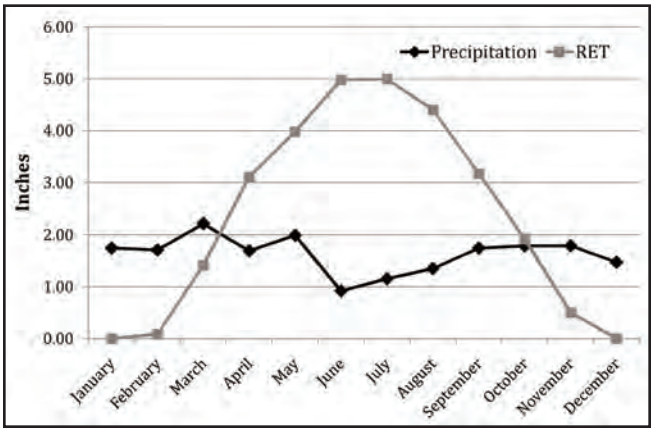


Figure 7.19. Monthly distribution of precipitation within the upland zone contrasted with modeled reference evapotranspiration (RET). Extracted from Daymet climate models (Thornton et al., 1997).

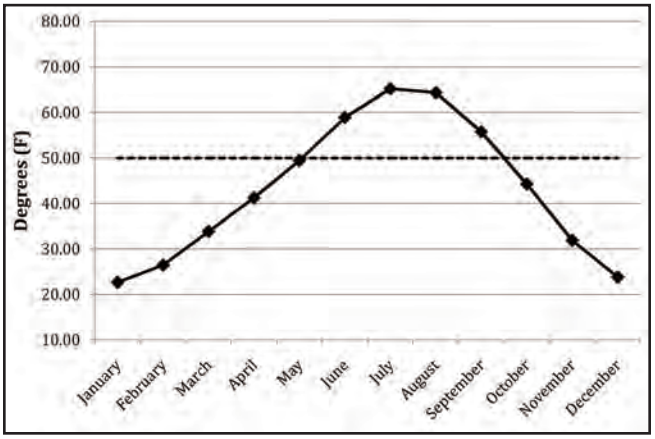
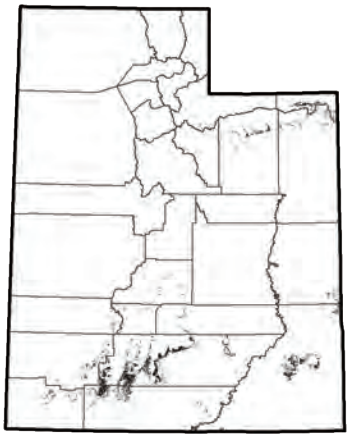


Figure 7.20. Average monthly temperatures within the upland zone showing number of months with average temperatures over 50 degrees Fahrenheit. Extracted from Daymet climate models (Thornton et al., 1997).

Table 7.6. Distribution of generalized SWReGAP land cover types across the upland zone in Utah. The miscellaneous category is the sum of all other land cover types occurring less than 2 percent over the area of the life zone.

LANDCOVER	ACRES	PERCENT
Big Sagebrush	2,638,458	28
Pinyon-Juniper	2,492,596	27
Oak Brush	1,070,979	11
Agriculture	556,133	6
Aspen	393,170	4
Mixed Conifer	350,378	4
Ponderosa Pine	332,481	4
Developed	269,176	3
Cliff and Canyon	162,820	2
Spruce-Fir	141,533	2
Miscellaneous	848,260	9
TOTAL	9,255,984	100

PONDEROSA PINE COMMUNITIES



Ponderosa pine communities are most common in southern Utah along the southern flank of the Markagunt and Aquarius Plateaus. They are also found in the Colorado Plateau region in the Henry, Abajo, and La Sal mountains. The only occurrence of this type in northern Utah is along the south slope of the Uinta Mountains stretching to the east and north into Daggett County. These communities occur at the lower extent of coniferous forests forming an ecotone between the higher elevation, more mesic forests and the lower elevation, pinyon-juniper and shrubland types (Photographs 10 and 11).

Common trees include ponderosa pine (*Pinus ponderosa*) as the dominant conifer. Douglas-fir (*Pseudotsuga menziesii*), two-needle pinyon (*Pinus edulis*), and junipers may also be present. The understory is usually shrubby and somewhat productive, with big sagebrush (*Artemisia tridentata*), greenleaf manzanita (*Arctostaphylos patula*), kinnikinnick (*Arctostaphylos uva-ursi*), alderleaf mountain mahogany (*Cercocarpus montanus*), Stansbury cliffrose (*Purshia stansburiana*), antelope bitterbrush (*Purshia tridentata*), Gambel oak (*Quercus gambelii*), mountain snowberry (*Symphoricarpos oreophilus*), chokecherry (*Prunus virginiana*), Saskatoon serviceberry (*Amelanchier alnifolia*), and wild roses (*Rosa* spp.) commonly found. Bluebunch wheatgrass (*Pseudoroegneria spicata*), needle and thread (*Hesperostipa* spp.), needlegrass (*Achnatherum* spp.), fescues (*Festuca* spp.), muhlys (*Muhlenbergia* spp.), and gramas (*Bouteloua* spp.) are some of the common grasses.

This type covers nearly 500,000 acres and occurs most dominantly in the upland zone (67 percent) with some occurrence in the semidesert zone (26 percent) (Figure 7.21). The plant communities in ponderosa pine woodlands vary from open meadow in valleys with seasonally high water tables and cold air drainage to open forest on drier, steeper sites with shallow soils. Even on the better sites, the trees are not dense and grow in open, park-like stands, especially if fire has been allowed to periodically carry through them (McAvoy et al., 2004).

This community is adapted to a high-frequency, low-intensity fire environment that maintains its open condition. Ponderosa pine have evolved with fire, and consequently, they have developed a thick bark to protect themselves from fire damage. It was originally thought that an average fire return interval of 4 to 8 years was common in these environments prior to European settlement. However, recent research by Sherriff and Veblen (2007) shows that 80 percent of ponderosa pine woodlands in Colorado had a mean fire return interval of greater than 30 years prior to 1915. Madany and West (1983) showed that surface fires once every 50 years are required to keep the less fire-tolerant trees (true firs, Douglas-fir, Rocky Mountain juniper) at low densities if livestock grazing is absent.

Ponderosa pine communities provide seasonal habitat for a variety of vertebrates. The most permanent large mammals are mule deer and elk. Cougar and coyotes are important predators. The Kaibab squirrel is a unique game animal. Red squirrels and porcupines harvest cones and cambial tissues of the pines, respectively.

Prominent birds of the ponderosa pine ecosystem are the white-breasted nuthatch, Steller's jay, common flicker, and Merriam's turkey. Among invertebrates, one insect is particularly notable, the western pine beetle (*Dendroctnus ponderosae*). This insect periodically infests stands of ponderosa pine and can cause considerable mortality.

Europeans began selectively harvesting timber and grazing livestock in the ponderosa pine type in the 1870s. There were abundant herbaceous species under the widely

scattered trees (Madany and West, 1983). Unrestricted livestock numbers, however, quickly reduced the desirable forages. Without the fine herbaceous fuels, light ground fires can not spread through these forests to thin and prune the pines and keep out invading conifers. There was also conscious control of fire that exacerbated successional changes. It was not until about the 1950s that most managers began to realize that fire had a role in maintaining more desirable and sustainable conditions. By 1980, a great portion of these forests were not capable of supporting much livestock use.

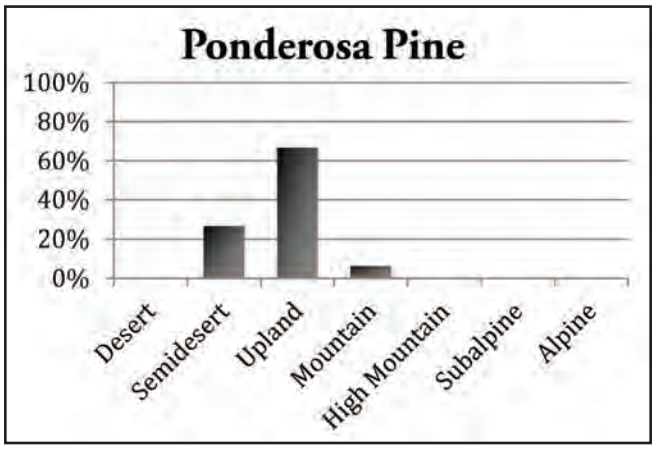


Figure 7.21. Distribution of ponderosa pine communities across life zones.

OAK AND MOUNTAIN BRUSH COMMUNITIES

Oak and mountain brush communities are defined by tall, shrub-dominated vegetation. They typically occur at elevations between 5,000 and 8,000 feet in Utah and usually form a transition zone between the coniferous forests above and the pinyon-juniper woodlands below. Oak and mountain brush communities are best developed along the flanks of the Wasatch Mountains and Wasatch Plateau in the northern half of the state (Photograph 12). Outliers occur in the Book Cliffs, the Pine Valley, La Sal and Abajo Mountains, and on other higher prominences in the Colorado Plateau. The type is largely limited to small patches on the mountains within the Great Basin. The Southwest Regional Gap Analysis project estimated that there were over 1.07 million acres of oak brush and approximately 74,000 acres of the mountain browse type, located predominantly in the upland type of Utah (Figure 7.22). Mountain brush or mountain browse communities are sometimes known as Wasatch chaparral or mountain mahogany-oak scrub.

Because the great majority of lands dominated by tall shrubs are steep and dissected, their major values are as watersheds and wildlife habitat. Mountain brush areas on gentler topography and deeper soils get some spring and fall use by livestock. Sites close to roads where shrubs are of sufficient size for firewood are becoming more popular. Since these types are found along foothills, a majority is in private ownership. The United States Forest Service manages the remainder.

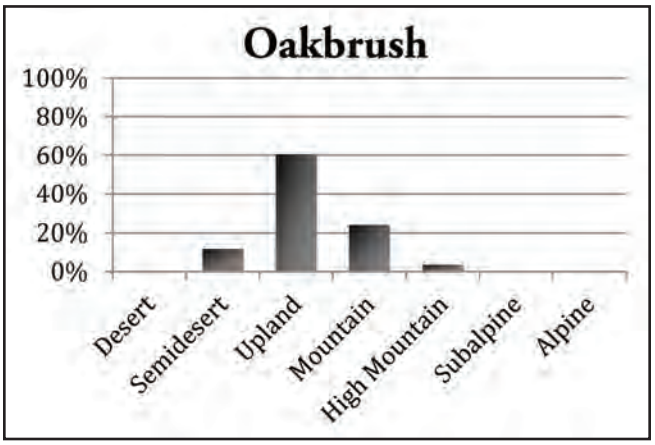


Figure 7.22. Distribution of oakbrush communities across life zones.

Oak and mountain brush communities frequently form a thermal belt in winter and spring because cold air drains to the valley bottoms during periods of high atmospheric pressure. Thus, a longer growth period is produced than would otherwise be expected at these elevations. When combined with a total average annual precipitation of 14 to 25 inches, Mollisols can form on sites of moderate slope. Soil pH tends to be acidic where these shrubs dominate. The deciduous species cycle more nutrients than evergreen species, and thus, the soils are often rich in nutrients.

The flora of mountain brush zones is moderately rich in plant species in a variety of life forms. Major tall shrubs are curlleaf mountain mahogany (*Cercocarpus ledifolius*), true mountain mahogany (*Cercocarpus montanus*), Gambel oak (*Quercus gambelii*), scrub oak (*Quercus turbinella*), big tooth maple (*Acer grandidentatum*), skunkbush sumac (*Rhus trilobata*), and cliff rose (*Cowania mexicana*). Common, shorter-statured shrubs are serviceberry (*Amelanchier alnifolia*), bitterbrush (*Purshia tridentata*), Apache plume (*Fallugia paradoxa*), snowberries (*Sympboricarpos* spp.),

deerbrushes (*Ceanothus* spp.), and manzanitas (*Arctostaphylos* spp.). The oaks seem to thrive on calcareous soils of clayish texture. The mountain mahoganies, particularly the evergreen species, occur on steeper sites with shallower soils and typically have less understory vegetation.

There are abundant grasses and forbs in the interspaces between shrub clumps (mottes). Major grasses are needlegrasses (*Stipa* spp.), bluegrasses (*Poa* spp.), junegrass (*Koeleria macrantha*), wheatgrasses (*Agropyron* spp.), and perennial bromes (*Bromus* spp). Major forbs are yarrow (*Achillea millefolium*), fleabanes (*Erigeron* spp.), vetches (*Vicia* spp.), showy golden eye (*Heliomeris multiflora*), and hairy false golden aster (*Heterotheca villosa*).

Herbage and browse production vary with site favorability and condition class, but in general are much higher than for the forest types previously discussed. An additional food value is derived from the oak mast (acorns). Very little community classification has been done in this vegetation type in Utah (Harper et al., 1985), but such study is needed to aid more sophisticated research and management. Clary and Tiedemann (1985) pointed out that the standing crop biomass of oakbrush approximates the lower range of coniferous stands in the interior West. The extraordinarily high caloric values of the wood also confer clear fuel wood values.

Oak and mountain browse communities are very important for deer and elk, particularly in winters with low-to-moderate snow packs. A wide range of birds and small mammals also use these communities (Hayward, 1948). Valley quail, Merriam's turkey, band-tailed pigeon, and blue and ruffed grouse are the main game birds found here. Little is known of the insects and pathogens in this ecosystem, but none seem to drastically reduce the dominant shrubs.

There is abundant evidence that oaks were shorter in stature and occupied a smaller fraction of the land before livestock grazing and fire control took place (Harper et al., 1985; Madany and West, 1984). Livestock grazing reduced herbaceous production resulting in less fine fuels to carry fire. The high tannin load in oakbrush leaves can cause cattle poisoning, but have been grazed by goats supported by dietary supplements. Selective avoidance of these shrubs only adds to the dominance of these woody species. Nearly all of the major woody species can spread by sprouting. Mottes (clones) of oak have spread into what were formerly interspaces dominated by herbaceous species (Harper et al., 1985). Part of the mountain browse type is not climax, but is sub-seral to white fir, Rocky Mountain juniper, or maple (Harper et al., 1985). This trend is probably due to lengthening of the fire return interval through livestock grazing and direct fire prevention. The vigorous resprouting of oak and mountain mahoganies on most sites following fires assures their continued dominance, whereas the other species succumb to burning.

The amount of woody vegetation is related to water yield. Because Gambel oak has been shown to deplete about 3 inches more water from the soil than perennial range grasses on the same site (Tew, 1967; Tew, 1969), there has likely been a decline in water yield as woody plants have expanded. This has not been total loss, however, because the woody plants send their roots deep into the cracks between the rocks to better stabilize the soil. The problems will come from the greater chance of catastrophic fire, particularly in years when late frosts kill oakbrush leaves. The high fraction of private land means that more of this type has been put into urban and rural development. Consequently, fire prevention may continue to be encouraged and use by wildlife may be discouraged.

Aboriginals apparently used oak and mountain brush communities only as hunting and gathering grounds. Oak acorns were used as a food source. Major changes followed the introduction of livestock, beginning about 1850. Early settlers recount how easy it was to see livestock moving through the generally low and scattered brush. Unrestricted grazing and direct fire control eventually led to higher and thicker growth of the brush. During this transition, the land was partially bared, leading to accelerated erosion. The over harvest of deer and elk led to reduced pressure on the browse portions. The tightening of wildland use with the creation of forest reserves and water conservancy districts led to reduced livestock use on most of this land and its removal from the steeper areas of municipal watersheds. Herbaceous understories recover very slowly after removal or reduction of livestock. Therefore, beginning in the late 1940s, private landholders and the Utah Division of Wildlife Resources developed ways of reducing brush on the gentler sites with deeper soils. Mechanical, herbicidal, or prescribed burning treatments are generally short-lived, and repeated brush control is usually necessary. Although Bowns (1985) reported an instance where shrub control and seedbed preparation were not necessary for establishment of a good stand of grass, the usual approach has been to seed after shrub control

and site preparation. A wide variety of desirable grasses, forbs, and shrubs can be used in the type (Stevens and Davis, 1985).

Conflicts between livestock and big game animals and between recreation and urban development will probably continue to intensify. The large fraction of the type in private ownership makes changes in land use more rapid. The relative ease of converting overgrown oak with poor understories to more productive pastures will make it possible to greatly increase both domestic and wild red meat production on these ranges, when and if greater demand should return. The possibilities of more systematic harvests of oak for firewood should be explored. The additional returns from the land (Wagstaff, 1984), plus enhanced water yields, may accelerate a trend toward more sophisticated management of this range type.

SAGEBRUSH STEPPE COMMUNITIES

Sagebrush steppe communities occur where there is roughly equivalent dominance of sagebrush and herbaceous species, provided that the land is free from human disturbance. There is a gradient of increasing occurrence of sagebrush dominance from northern to southern latitudes and from high elevations in the foothills to valley bottoms. The dividing lines between the sagebrush steppe and sagebrush shrublands are arbitrary. These two types are thus closely related, and it is more the degree to which phenomena are expressed than the fundamental nature of the phenomena that is important. The sagebrush steppe is predominantly located in the northern part of the state and is most dominant in Rich and Box Elder counties (Photograph 13).

The primary use of the sagebrush steppe communities has been grazing by domestic animals and habitat for wildlife. Some occurrences of this type on gentler slopes with deeper soils and appropriate climate have been converted to farmland. Shrub steppe provides critical spring-fall range for livestock grazing operations, being located between the summer mountain ranges and winter desert ranges.

Sagebrush steppe communities generally occurs on foothills or on the upper parts of valleys where total annual precipitation averages 9 to 12 inches. About half of this precipitation occurs between December and March. The frost-free period is 80 to 120 days. Soils vary from Mollisols to Aridisols, depending on meso-relief and the amount of herbaceous vegetation needed to supplement organic matter in the soil.

The vertical and horizontal structure of vegetation is remarkably uniform unless fires have been periodic and patchy. The shrub layer reaches 3 to 6 feet high and may have cover varying from 10 to 80 percent, depending on site and successional status. The grass and forb layer reaches 18 to 24 inches during the growing season. Herbaceous cover may vary between 0 and 100 percent, depending on site and successional status.

Floristic diversity in this vegetation type is moderate. An exception is the sagebrush/grass type occurring in higher elevation habitats with 12 to 20 inches of precipitation where the floristic diversity is higher. Subdivision of this vegetation type requires identification of different species and even sub-species of big sagebrush. This is because these taxa prefer different kinds of sites (West, 1983a). Bluebunch wheatgrass (*Pseudoroegneria spicata*) is probably the most widespread and important grass associate. Thurber's needlegrass (*Achnatherum thurberianum*) and Indian ricegrass (*Achnatherum hymenoides*) are also important grasses.

Total aboveground phytomass can vary between 1 and 5 tons per acre (West, 1983a). Because sagebrush develops long-lived, woody tissues and over-wintering leaves, as little as 15 percent of the phytomass may be due to current annual growth if the sagebrush is particularly old or dense. Sagebrush may contribute up to 70 percent of the total aboveground phytomass, even on sites where livestock grazing has been light or absent. Brush dominance is even greater where livestock grazing has reduced the perennial herbaceous species.

These rangelands are important winter range for mule deer and elk. The smaller native animals are a mix of grassland and desert species. An important game bird here is the sage grouse. Their populations have been lowered by the loss of herbaceous species, increase in height and densities of sagebrush, as well as other factors. Sage grouse chicks need forb buds and insects found most abundantly along riparian inclusions. At breeding time, adults need open "booming" grounds.

There are occasional outbreaks of insects that greatly influence this vegetation. The sagebrush web worm (*Aroga websteri*) can defoliate sagebrush. Grasshoppers and Mormon crickets occasionally damage the herbaceous vegetation. Relatively little is known of the other insect fauna and their influences (West, 1983a). Snow mold also greatly reduces sagebrush some years (Allen et al., 1987).

The major ecological interactions center on the balance of brush and herbaceous species. The shrubs have the physiological and competitive advantages in the absence of fire or insect outbreaks. The pristine ecosystem was apparently only weakly stable. The perturbations triggered by the introductions of livestock and European weeds are essentially irreversible without considerable effort. An increase in big sagebrush can cause a drying out of the soils because they carry on transpiration year-round, leading to reductions in water discharge. If cheatgrass becomes dominant, the frequency and seasonality of fire changes, reducing the ability of big sagebrush to re-establish itself.

Sagebrush steppe communities were greatly affected by livestock owned by European colonists from 1850 to 1870. Mere reduction of livestock numbers and control of season of use does little to repair damage to forage production, especially in the face of continuing waves of weed introductions. Rest rotation grazing in only fall or winter may allow more regeneration of perennial herbaceous species. Due to the overgrazing of the herbaceous species and the subsequent increase in sagebrush cover during the mid 1900s, a significant amount of sagebrush control in the form of tillage and the application of herbicide and fire was applied in an attempt to restore the herbaceous component. With the introduction of invasive species, such as cheatgrass that can quickly become dominant in these environments and permanently remove sagebrush, more effort has been focused on the retention and expansion of sagebrush-steppe in order to restore proper ecosystem functions. This effort is largely due to the loss of sage grouse habitat. Sage grouse are currently being considered as a possible threatened or endangered species. Restoring proper functioning conditions to sagebrush-steppe environments can also improve large ungulate habitat, livestock production, and water discharge.

The lands with steeper slopes and shallower soils will remain as rangelands. Better understanding of how these ecosystems function, and improved means to enhance production through prescribed burning, grazing management, herbicides, and seeding of exotic species, provide opportunities for increased production.

SEMIDESERT ZONE

The semidesert life zone occupies approximately 60 percent of the state and occurs throughout the Great Basin, Colorado Plateau, and Uinta Basin regions. The zone ranges in elevation from 4,500 feet to 6,400 feet ASL. Semidesert environments are characterized by a mean annual precipitation between 8 and 12 inches. The annual reference evapotranspiration is higher than precipitation for 10 months of the year yielding an annual water deficit (Figure 7.23). Precipitation during the winter is generally higher than during other seasons (approximately 4.1 inches). The Great Basin component of this life zone has a drier summer than the Colorado Plateau due to monsoonal storms that pass through the area in mid-to-late summer. Mean annual temperatures range from 32 degrees Fahrenheit in the winter to 69 degrees Fahrenheit in the summer. The growing season generally starts in early- to mid-April and runs through the end of September (Figure 7.24).

Vegetation consists of shrub-dominated landscapes with a small component of herbs and a lower component of succulents. Because this life zone occupies such a large portion of the state, most of Utah rangeland occurs here. Fifty-five percent of the developed land and 74 percent of irrigated agriculture occurs within this zone. Natural landscapes predominantly include pinyon-juniper, salt desert shrub, and big sagebrush shrublands (Table 7.7). Smaller, but relatively unique vegetation types consist of greasewood, mat saltbush, and creosote-white bursage communities. Invasive species are also a large component of this landscape, with the primary exotic being cheatgrass (*Bromus tectorum*). The topography is relatively flat compared to the more mountainous portions of Utah, but it is dissected by canyons, cliffs, and scarps, especially within the Colorado Plateau region. Soils in the semidesert life zone consist of Aridisols and Entisols, with a smaller component of Mollisols in the upper elevations where more forage production occurs. The majority of this zone falls within the Great Salt Lake Area (48 percent), Colorado and Green River Plateaus (19 percent), and the Central Desertic Basins, Mountains, and Plateaus (17 percent) MLRAs. Smaller components are spread across the remaining MLRAs that occur in Utah.

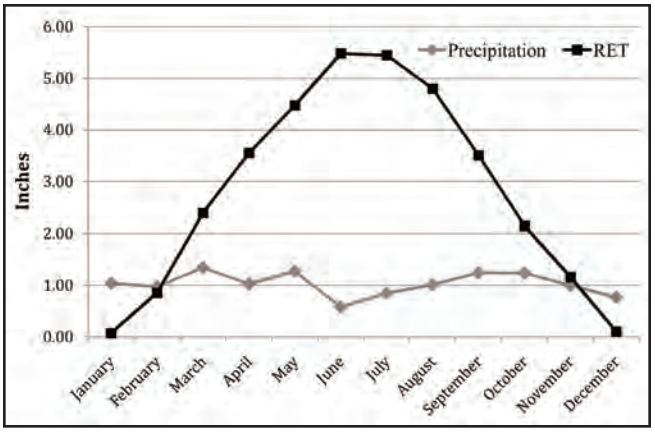


Figure 7.23. Monthly distribution of precipitation within the semidesert zone contrasted with modeled reference evapotranspiration (RET). Extracted from Daymet climate models (Thornton et al., 1997).

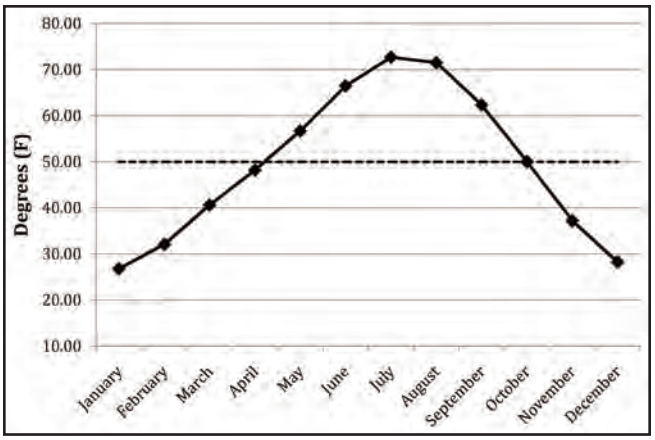
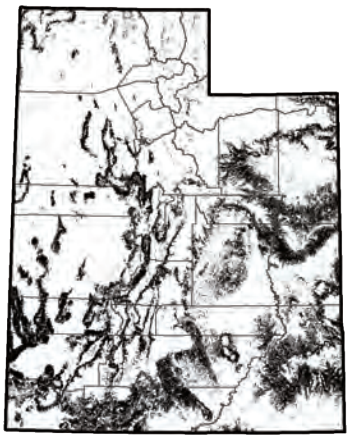


Figure 7.24. Average monthly temperatures within the semidesert zone showing number of months with average temperatures over 50 degrees Fahrenheit. Extracted from Daymet climate models (Thornton et al., 1997).

Table 7.7. Distribution of generalized SWReGAP land cover types across the semidesert zone in Utah. The miscellaneous category is the sum of all other land cover types occurring less than 2 percent over the area of the life zone.

LANDCOVER	ACRES	PERCENT
Pinyon-Juniper	7,864,329	24
Salt Desert Shrub	5,770,808	18
Big Sagebrush	4,559,135	14
Tableland	2,002,820	6
Shrub Steppe	1,880,287	6
Playa	1,837,523	6
Agriculture	1,683,680	5
Open Water	1,346,235	4
Low Sagebrush	1,219,863	4
Invasive	1,021,793	3
Blackbrush-Mormon Tea	832,000	3
Miscellaneous	2,603,977	8
TOTAL	32,622,450	100

PINYON-JUNIPER COMMUNITIES



A large fraction (24 percent) of the semidesert zone is dominated by pinyon-juniper woodlands. Seventy-five percent of all pinyon-juniper communities in the state fall within the semidesert zone (Figure 7.25). In the Great Basin, Utah juniper (*Juniperus osteosperma*) occurs either alone or together with singleneedle pinyon (*Pinus monophylla*). On the Colorado Plateau, Utah juniper and true pinyon (*Pinus edulis*) dominate. One seed juniper (*Juniperus monosperma*) occurs in the extreme south. Pure juniper stands are usually found at lower elevations and, thus, on drier sites in both regions (Photographs 14 and 15).

There is a considerable difference between what existed before European colonization and what exists now. This is because trees have increased in density, especially within the mountain zone, or have invaded adjacent zones. This is thought to be due to a combination of excessive utilization of understory by livestock and big game, reduced competition from diminished understory, subsequent reduction in chance of burning, conscious fire control, climatic trends favorable to tree establishment, and dispersal of tree seeds by livestock, birds, and small mammals (West, 1999). Because all of these influences act concomitantly, it is impossible to separate their individual effects except under most unusual circumstances.

Pinyon-juniper woodlands now generally have a remarkably poor flora, especially considering the huge area they occupy (West et al., 1998). Additionally, most stands have only a shrub species or two, chiefly big sagebrush, and about a dozen species of grasses and forbs. This is because there is a negatively exponential decline in forage production with successional thickening and enlargement of the trees (Tausch et al., 1981).

The uppermost part of the woodland structure is characterized by scattered trees rarely amounting to more than 50 percent canopy coverage. Aboveground phytomass, largely due to trees, can reach 125 tons per acre. This translates to about 40 cords per acre on the very best sites. Accumulation rates for wood are very poorly known. Pinyon nuts (seeds) are known to be produced at the rate of up to 165 pounds per acre (Spencer, 1984). Such production is very temporally and spatially erratic, although there is some potential for increasing nut production with management.

Shrubs are scattered in the interspaces between the trees, if tree density is not too great. However, the influence of the trees extends over an area two to three times wider than their crowns through a widespread fibrous root system that heavily competes with understory species in the interspaces. A few herbs are successful under the tree canopies. Soil microphytic crusts (mosses, lichens, algae, fungi, and liverworts) often cover the interspaces where tree litter or vascular understory plants are sparse or lacking on sites with fine-textured soils.

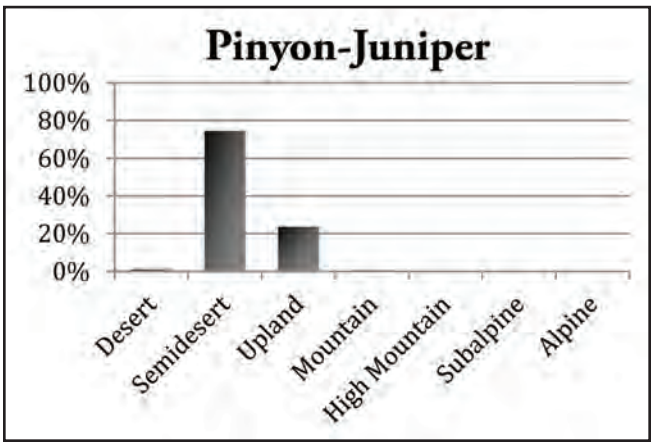


Figure 7.25. Distribution of pinyon-juniper communities across life zones.

Pinyon-juniper woodlands are seasonal habitats for deer and elk and many songbirds. Notable year-round residents are the pinyon jay and pinyon mouse. No insects have evolved to utilize the vast store of plant tissues in any major way. The high loads of secondary chemicals in pinyon and juniper tissues apparently protect them from significant herbivory. This, along with high ecophysiological efficiency, allows the trees to greatly expand at the expense of understory when fire is removed as a regulatory feature (West et al., 1979; West, 1999).

Periodic fires, about once every 50 years on a given piece of ground (Wright et al., 1979), apparently created open woodlands or savannas in the pristine vegetation. This was probably more the case in the Great Basin than the Colorado Plateau because broken topography in the latter region would have kept fire sizes smaller (West and Van Pelt, 1987). In both regions, extremely old trees are largely limited to steep, rocky, fireproof sites. As trees thickened on most portions of the landscape during the twentieth century, animal dispersal of seed probably became more

important in augmenting tree dominance. Birds, such as pinyon jays and Clark's nutcrackers, collect and cache pinyon seeds. Townsend solitares, robins, and cattle consume juniper fruits and deposit the seeds in their defecations. Unlike other coniferous tree dominated ecosystems in the Intermountain West, no insect, pathogen, or parasite buildups that noticeably reduce tree dominance have been observed. Extended drought in the 1990s did, however, result in expansive die off, particularly in southern Utah.

Humans affected pinyon-juniper woodlands at least 800 to 1,000 years ago. In fact, some (Samuels and Betancourt, 1982) believe that utilization may have exceeded growth increments of the trees when the ancestral Puebloans were occupying portions of the Four Corners Region. Although information on prehistoric and historic land use is tenuous, it should not be assumed that all of these woodlands were pristine when Europeans arrived. It is interesting to note that some of the earliest European explorers of this region would have probably died had the Indians not shown them how to gather and eat pinyon seeds.

Livestock grazing, fire control, and wood harvest by European settlers have had profound impacts on these woodlands. Charcoal makers harvested the trees around mining districts of the Great Basin in the 1870s, but there was simultaneous intense, unrestricted livestock grazing. Loss of herbaceous understory has apparently led to accelerated soil erosion during the past century (Carrara and Carroll, 1979). Because the majority of these woodlands are heavily invaded by trees and possess little understory, this is of no small concern. The problem is that the roots of pinyon and juniper grow far beyond their crowns. When the understory dies through competitive displacement, bare soil is exposed.

It has been only in the past 20 years that these successional processes have been understood and some reversals have been attempted. A logical action would be to use prescribed burning. Unfortunately, there is now so little fine fuel in the understory that this is not possible on the more productive sites. Crown fires can only take place under high winds in the dry summer. These fires are often so hot that everything living is burned. Soil seed reserves of desirable native plants are also usually minimal under such stands, resulting in slow natural recovery. Second generation herbicides can also be used to kill pinyon and juniper (Clary et al., 1985). It would, however, be desirable to utilize the wood, but no one has yet developed an economical way to do so over large acreages distant from population centers.

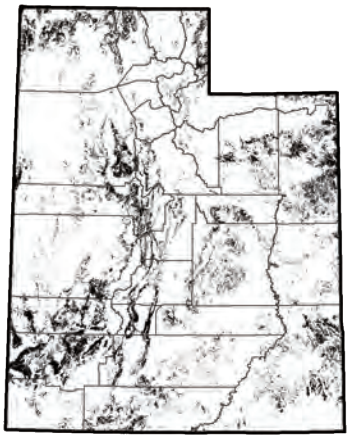
During post-World War II years, range and wildlife managers used cables and chains drawn between large crawler tractors to pull over the trees. Grasses were seeded either between chaining or after ricking and burning of debris so that seed drills could be used. The increase in forage production was 20 to 30 fold (West, 1984a). The longevity of these treatments was primarily related to thoroughness of treatment, but also to other pre-and post-treatment influences (West, 1984b). Planting a variety of browse and forbs and designing the chaining to provide nearby escape cover enhanced big game utilization. Whether these treatments have slowed erosion and what effects they have had on other species of wildlife and on archeological evidence have been hotly debated. Environmentalist pressure largely stopped such actions before the high costs of energy and low meat prices put a moratorium on such conversions in the 1970s and 1980s. As a result, these communities continue to thicken and expand of the trees (West, 1999), with further reduction of understory vegetation and accelerated soil erosion. Additionally, chainings are also being reinvaded by trees and brush.

It seems logical to place first priority on recapturing the forage production on previously chained areas. These are generally the most productive sites and they already have fences and water developments. Scenic, archeological, and other natural features were disturbed by the first treatment. Prescribed burning or second-generation herbicides could now be used to reduce the undesirable woody species (West and Van Pelt, 1987). Genetically improved forage plants could be replanted if inadequate residual stands of forage plants remain.

Recently, the tree masticator, colloquially known as the "bull-hog," followed by seeding, if necessary, has been successfully used to quickly change woodland to savanna in selected locations, especially where fire threatens high-value real estate. Unfortunately, this process is too expensive to employ over large areas.

Thus, little hope is seen in the near future for reversing the successional changes in the much larger area that has not been mechanically treated. Until some means of generating additional revenue from tree harvest is developed, more active management is unlikely. Managers must show that harvest/conversions have largely positive influences on the total ecosystem and that potential actions make economic sense. Larger and more frequent fires should be expected in these areas. Reseeding after these fires may offer the main opportunities for re-directing succession in more positive directions.

BIG SAGEBRUSH SHRUBLAND COMMUNITIES



Big sagebrush shrubland communities predominantly occur as a shrubland as opposed to a steppe environment. In this particular case, basin big sagebrush (*Artemisia tridentata* spp. *tridentata*) and Wyoming big sagebrush are the dominant shrubs. A portion of this type (particularly in northern Utah) that occurs on Mollisols may have at one time been regarded as a shrub-steppe, but overgrazing, lack of fire, and soil erosion have reduced the herbaceous component and allowed the big sagebrush to become denser.

Big sagebrush shrubland communities typically occur in broad basins between mountain ranges, plains, and foothills and are spread over 2.7 million acres (Photographs 16 and 17). Soils are typically deep, well-drained and non-saline. Scattered juniper species, greasewood, and saltbushes may be present in some stands. Yellow rabbitbrush and antelope bitterbrush (*Purshia tridentata*) may co-dominate disturbed stands. Perennial herbaceous components typically contribute less than 25 percent vegetational cover. Common grasses include Indian ricegrass, blue grama (*Bouteloua gracilis*), Idaho fescue (*Festuca idahoensis*), needle and thread grass (*Hesperostipa comata*), basin wildrye (*Leymus cinereus*), James' galleta (*Pleuraphis jamesii*), western wheatgrass (*Pascopyrum smithii*), or bluebunch wheatgrass (*Pseudoroegneria spicata*). Although big sagebrush shrublands share some physical and biological characteristics associated with the sagebrush steppe, they differ in the preponderance of sagebrush in the community, on some sites approaching a monoculture. Generally this type lies above salt desert shrub communities and below pinyon-juniper communities in elevation, but can be found intermingled with them in complex patterns.

These communities have seen little sustained human use other than as a source of forage for range livestock, especially by sheep in the winter. It has more recently shifted to cattle use in winter as well as in other seasons. A small amount of the most favorable land has been converted to irrigated agriculture.

The climate on these rangelands is characterized by cold winters, hot summers, and semiarid to arid conditions. Mean annual total precipitation varies from 8 to 12 inches. The soils are usually classified as Aridisols. Relative cover of the sagebrush is usually over 70 percent. The absolute cover, however, is between 10 to 40 percent. Microphytic and/or vesicular crusts often cover interspaces between the shrubs.

Before European men came to the Intermountain West, vegetation was apparently rarely dense enough to carry fire and thus make way for many perennial grasses (West and Hassan, 1985). Now that cheatgrass has entered the scene, fires are common and an even more rapid decline with less chance of recovery is expected here (West et al., 1984) than in the more mesic-related ecosystems.

The flora of this type is usually poor because of the overwhelming dominance of sagebrush. Total aboveground standing crop phytomass in this type can vary between 2 and 12 tons per acre, depending on site and successional differences. Only about 15 to 20 percent is current annual growth, and most of that is due to sagebrush tissues well loaded with secondary chemicals that make them unpalatable to livestock. The average livestock grazing capacities are thus much lower than for the sagebrush steppe. Forage availability apparently increases on areas in poor condition because sagebrush is reduced, and introduced annuals, such as cheatgrass, can actually provide more short-lived forage than the higher condition range.

The native fauna that are present in this ecosystem are reduced compared to the other big sagebrush types, again primarily related to the dominance of sagebrush. Large native ungulates have apparently not been abundant since the end of the ice ages. The major vertebrate herbivore, by far, is the black-tailed jackrabbit. The population fluctuations of this animal may be related to the influences of humans on vegetation and predators. Insects known to visibly affect the vegetation are webworms, psyllids, thrips, grasshoppers, and Mormon crickets (West, 1983b). Other possible influents are harvester ants and cicadas.

This deceptively simple ecosystem was so weakly stable that unrestricted livestock grazing and the introduction of weeds, particularly cheatgrass, have led to successional patterns that may or may not reach new levels of stability in the near future. In other words, this vegetation type has shown poor resilience, and may never again approximate its original structure (West et al., 1984). Soil erosion has been greatly accelerated over the past 130 years. Whether

nature or humans should heal the damage remains a critical policy question.

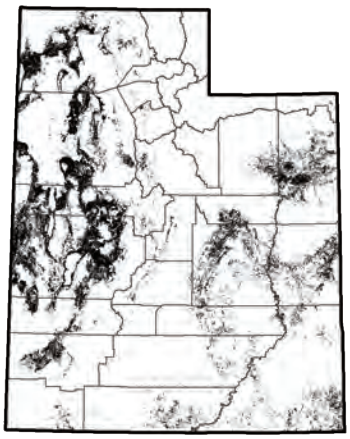
Aboriginal people looked for the sandier or alluvial portions of this type where grasses were more abundant. They harvested the grains from Great Basin wildrye and Indian ricegrass, dug bulbs of forbs in the lily family, and dug root stalks of plants in the celery families. The low productivity prevented the frequent harvest of large ungulates and adoption of a horse-based culture. Native peoples occupied this area at very low densities (West, 1983b).

The early explorers encountered difficulties in traveling through these regions and colonists could develop sustainable settlements only with irrigation systems to enhance the production of a very small but critical fraction of the land. Ranchers had to learn how to grow and store hay to get their livestock through occasionally difficult winters. Sheep were better suited to such ranges than cattle and became abundant in the late 1800s. Such ranges were typically used in the spring and autumn as part of a migratory pattern, including use of deserts in the winter and mountains in the summer. Spring use was very harmful to the herbaceous species and range conditions declined rapidly.

In order to get deferment of use during the spring, the period when desirable forages are most susceptible to damage from livestock, federal researchers brought in grazing-tolerant Eurasian species of wheatgrasses and ryegrasses. The livestock grazing capacities of these seeded pastures are 10 to 20 times that of the native range. Large acreages were converted to introduced grasses in the three decades after 1940. Wildlife managers and environmentalists became concerned about what was happening to the diversity and population levels of wild animals in these seeded areas. There was also worry that the large areas of grass monoculture would be susceptible to insect and pathogen outbreaks. Although these problems have not materialized to any great extent, shrub re-invasion of the seedings has occurred.

The majority of big sagebrush shrubland communities has never been sprayed with herbicide, tilled or seeded, or had much in the way of intensive management. These communities continue to have accelerated soil erosion following extreme events. Cheatgrass has made this type susceptible to wildfire damage, and other weeds, such as halogeton and bur buttercup, are now problems.

SALT DESERT SHRUB COMMUNITIES



Salt desert shrub communities typically occupy lower-lying areas of the semidesert life zone on soils that tend to be saline and calcareous, medium to fine textured, and alkaline. More than 80 percent of the salt desert shrub communities fall in the semidesert life zone (Figure 7.26). There are major subdivisions of this type. The uplands that have well drained Argid or Orthid soil. They are occupied by the euhalophytes, plants that survive on limited soil moisture, largely the saltbushes (*Atriplex* spp.), and particularly shadscale (*Atriplex confertifolia*). The second subdivision consists of hydrohalophytes that are rooted in brackish moisture zones with at least a seasonal water table. These occupy the lowlands around ephemeral lakes in the Great Basin, or along water courses in the Colorado Plateau. They predominantly consist of greasewood (*Sarcobatus vermiculatus*) (Photographs 18, 19, and 20).

The traditional use of this type has been extensive livestock grazing, typically by sheep in the winter when snow is a water source. With the decline of the range sheep industry, these rangelands are being used by cattle in the winter as well as other seasons. Apparently because of low productivity and few competing uses for these lands, an increased tendency to site various nuisance activities in these rangelands has occurred. For instance, a large fraction of these lands in Utah is reserved for military training, material and waste storage, research, and development. Some large power plants have also been sited on salt desert ranges, and perhaps more will be in the future, including solar and wind power sites. Thus to many, these seemingly wastelands are fit only for activities not permissible elsewhere.

Total average annual precipitation on these rangelands varies from 5 to 10 inches. Temperatures are cold in the winter and hot in the summer. The shrubs on upland sites typically grow only in late spring. Shrubs near surface water tables have their main growth period in summer. Late summer-early fall rainy periods in the southeast can produce a flush of growth by warm-season grasses.

Soil salinity aggravates lack of soil moisture. Sodium causes dispersion of soil particles when wet, leading to sealing of surface crusts and more rapid runoff. This is especially a problem on the marine shale-derived badlands of the Colorado Plateau. Few exotic plants can tolerate the combinations of atmospheric and soil-induced aridity.

There are often distinct boundaries within this and adjacent community types. These, at times, are probably due to the sharp changes in salt content related to sedimentary history. In addition, clusters of shrubs are often found on mounds of soil different than the surrounding area.

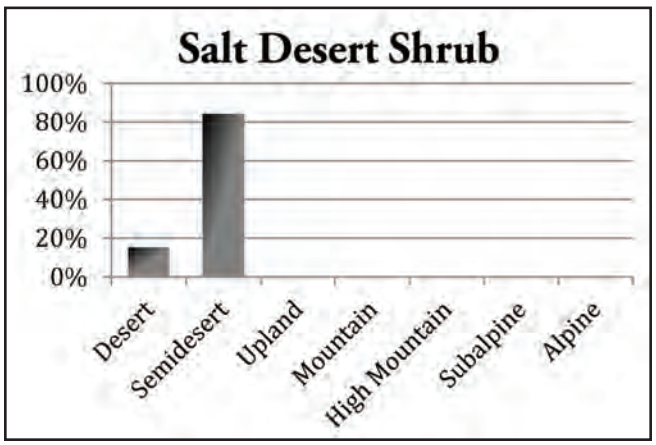


Figure 7.26. Distribution of salt desert shrub communities across life zones.

Floristic lists are short in this type because few plants can tolerate these harsh environments. Some perennial grasses and forbs, largely in the aster and legume families, occur on upland sites. Annual grasses and forbs, mainly in the mustard and goosefoot families, can be seen during years with abundant precipitation.

The height of the shrubs is generally less than 1½ feet, and they are widely scattered in clusters. Total perennial plant cover rarely exceeds 20 percent. The interspaces are often covered with microphytic crusts if animal traffic has not been extreme.

In the group of euhalophytes, dominant shrubs can be separated into two basic groups that tend not to intermingle due to a large degree of soil differences. The first group occurs in relatively coarser textured soils and consists of a mixture of different salt bushes, grasses, and forbs. The second group occurs predominantly on marine shales. These shales consist of the Mancos Formation. The soils are particularly alkaline and fine textured and can only support a few distinct species of plants. Shrubs surviving on the Mancos-derived soils consist predominantly of mat saltbush (*Atriplex corrugata*) and Gardner's saltbush (*Atriplex gardneri*).

The second group of euhalophytes is more diverse and tends to occupy soils that are not as fine textured. Shrubs generally consist of combinations of shadscale (*Atriplex confertifolia*), four-wing saltbush (*Atriplex canescens*), winterfat (*Krascheninnikovia lanata*), spiny hopsage (*Grayia spinosa*), bud sagebrush (*Picrothamnus desertorum*), gray molly (*Bassia americana*), yellow rabbitbrush (*Chrysothamnus viscidiflorus*), Mormon Tea (*Ephedra* spp.), horsebrushes (*Tetradymia* spp.), and Wyoming big sagebrush (*Artemisia tridentata* ssp. *wyomingensis*). Common grasses consist of Indian ricegrass (*Achnatherum hymenoides*), blue grama (*Bouteloua gracilis*), western wheatgrass (*Pascopyrum smithii*), and alkali sacaton (*Sporobolus airoides*).

Aboveground standing crops of vegetation vary from 0 on the salt flats to about 6 tons per acre on the best upland sites. About half of this or less is production from the current year. There can be an eight-fold difference in production, primarily depending on the precipitation of the previous 12 months. Much of this herbage is not suitable as forage; however, a considerable fraction can be woody, spiny or poisonous, leading to low livestock carrying capacities.

Unrestricted livestock grazing from about 1870 until 1935 led to great reductions in the more palatable and nutritious half shrubs such as winterfat, budsage, and gray molly (West, 1983c). The less palatable species such as shadscale and yellow rabbitbrush increased. Shadscale was, however, negatively affected by drought. Recovery of grazing capacity after excessive grazing and drought has been slow (West, 1983c).

The only large native mammal making regular, if marginal, use of these rangelands is the pronghorn. Rodents and jackrabbits make up the bulk of the users. The only game bird of importance is the introduced chukar partridge. This bird, however, thrives only near rocky escape cover. It eats the winter annuals throughout the colder months. There are numerous small birds who pass through the area, but only the horned lark stays and reaches any abundance.

Invertebrates have largely been ignored. The most conspicuous are the harvester ants that can denude 5 to 10 percent of these ranges for their mounds. Occasional loss of browse plants has been attributed to round-headed borers or cutworms (West, 1983c).

Fires have not been a factor in altering salt desert shrub vegetation until recently when an influx of annuals became more noticeable (Rogers, 1982). Major annuals are the mustards (*Sisymbrium altissimum*, *Descurainia pinnata*), cheatgrass (*Bromus tectorum*), Russian thistle (*Salsola kali*), peppergrass (*Lepidium perfoliatum*), bur buttercup (*Ranunculus testiculatus*), and halogeton (*Halogeton glomeratus*). The latter two have been the biggest worry because they are poisonous to livestock.

The best microsites for plant regeneration are the nutrient-enriched mounds where pedestals of shrubs occur or did occur. Destruction of many of these "islands of fertility" may make regeneration very difficult. Soil erosion is naturally rapid in these areas because there is so little plant cover to protect it. Salt loading of the Colorado River is greatly augmented by arroyo formation in the Colorado Plateau. It is doubtful, however, that reductions in livestock grazing would make much difference because the natural rates of erosion are so great, and potential plant cover is below the threshold for positive feedback.

This ecosystem type was lightly used by native people because there was very little to hunt or gather. Livestock grazing by Europeans started later in these communities than on the previously discussed types. So little water was available in these communities that sheep grazing had to occur during the winter. The great demand for wool during World War I led to drilling of wells so that ranges could be grazed year around. Such areas quickly degraded to bare, blowing sores upon the land. As water hauling later came into play, there was a tendency to graze into the spring growing season. Because most of the desirable forage species die when more than about 40 percent of their new leaves and twigs are removed, late spring grazing was destructive.

The process of adjusting livestock numbers to carrying capacity was initiated in the 1930s, but not really accomplished until the 1950s. By then, halogeton had spread. It took this scare to begin adjusting numbers and season of use. The only feasible way to prevent halogeton from spreading is to keep the range in good condition. Halogeton is not very competitive and requires disturbed sites to thrive.

Unfortunately, the decline of the sheep industry has led to attempts to graze these browse-dominated ranges with cattle. However, only cattle that are bred for such conditions do well. Blaisdell and Holmgren (1984) are convinced that concentration of grazing in the winter and rotation of spring use, interspersed with rest, will lead to improved range conditions. It should be pointed out that all of their evidence comes from sheep-grazed ranges that have always been in higher condition than most of this type. Without means to consistently and economically repair damage by seeding, however, careful grazing management is the only hope to improve these lands.

DESERT ZONE

The desert zone is the lowest elevation life zone occurring in Utah, found at approximately 2,050 feet to 5,063 feet elevation. This zone occupies just over 6 million acres or 11 percent of the state. There are two major places this zone occurs: in the lowest portions of former Lake Bonneville in the West Desert and near the Green River and Colorado River in the southeast. A smaller portion of this life zone is found in the extreme southwestern portion of the state where the Mojave Desert extends into Utah.

Mean annual precipitation ranges from 1.4 inches in the fall to 2.4 inches in the winter for a yearly average of 7.5 inches. There is an increase in precipitation in the southwestern and southeastern portion of this zone during the late summer due to monsoonal storms originating in the Gulf of California. Mean annual temperatures are the warmest, ranging between 36 degrees Fahrenheit to 74.6 degrees Fahrenheit from winter to summer. The growing season is also the longest, starting in late March-early April and extending to the end of October (Figure 7.27). While the growing season may be longer than any other life zone, water is very limiting since the reference evapotranspiration (RET) is higher than precipitation for every month except January, where the RET is roughly equal to precipitation (Figure 7.28).

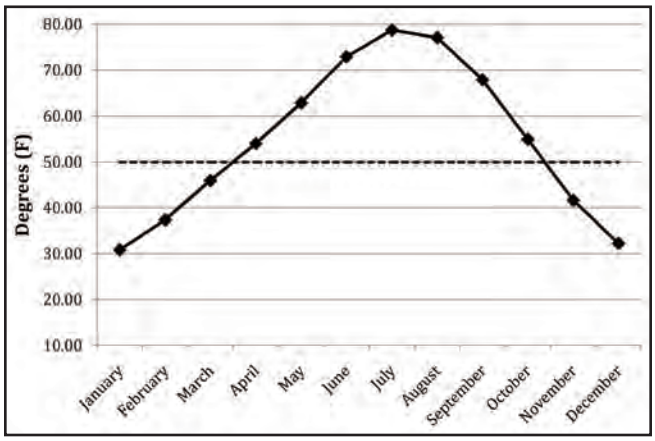


Figure 7.27. Average monthly temperatures within the desert zone showing number of months with average temperatures over 50 degrees Fahrenheit. Extracted from Daymet climate models (Thornton et al., 1997).

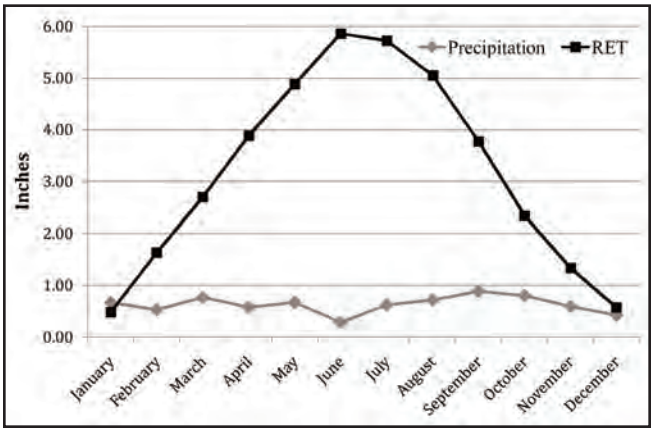


Figure 7.28. Monthly distribution of precipitation within the desert zone contrasted with modeled reference evapotranspiration (RET). Extracted from Daymet climate models (Thornton et al., 1997).

The desert zone in extreme western Utah is dominated by playas, the bottoms of former lakes. The high concentration of salts in the nearly flat terrain contributes to the paucity of vegetation and lack of soil development. The Green River and Colorado River portions are dominated by tablelands and blackbrush-Mormon tea communities. The extreme southwestern portion of the state consists of the Mojave Desert, and the characteristic vegetation is unique to the state, consisting of mesquite, Joshua tree (typically found with blackbrush), and creosote-white bursage communities.

The deserts around the lower Green and Colorado river drainages, in addition to being atmospherically dry, are effectively dry because of additional influences. First, the sandstones under such dry conditions may have such little vegetated that geologic erosion keeps bare rock exposed. This is locally called slick rock. The shales which are also prevalent in this portion of the life zone are exposed beds of ancient seas. Because they are so salty and impenetrable to rainfall, few plants can occupy them and hold and build soil. The result is development of badland topography. In other places, gypsum-bearing rocks have led to crusted soil surfaces also inhibiting plant and soil development.

This life zone is composed of a relatively short list of community types when compared to the other life zones with the exception of the alpine zone. Tablelands composed of sandstone slick rock cover 25 percent of this zone, followed by blackbrush-Mormon tea communities (23 percent) (Table 7.8). Salt desert shrublands are also common here, but the majority of this type occurs in the semidesert zone. The portion of salt desert shrubs that occur here are similar to what occurs in the semidesert zone, but with lower productivity. As far as MLRAs are concerned, the

desert life zone can mostly be found within the Colorado and Green River Plateaus (70 percent), the Great Salt Lake Area (23 percent), and the Mohave Basin and Range (2 percent). Given the unique nature of this life zone, the blackbrush-Mormon tea will be discussed, along with the creosote-white bursage occurring in the Mojave Desert.

Table 7.8. Distribution of generalized SWReGAP land cover types across the desert zone in Utah. The miscellaneous category is the sum of all other land cover types occurring less than 2 percent over the area of the life zone.

LANDCOVER	ACRES	PERCENT
Tableland	1,481,931	25
Blackbrush-Mormon Tea	1,401,045	23
Salt Desert Shrub	1,050,575	17
Playa	952,188	16
Dune	270,754	4
Creosote-White Bursage	181,421	3
Miscellaneous	725,684	12
TOTAL	6,063,598	100

BLACKBRUSH-MORMON TEA COMMUNITIES

Blackbrush-Mormon tea communities occur mostly in the desert zone (63 percent) with the remainder in the semidesert zone (Figure 7.29). These communities are mainly on well-drained benchlands, colluvial slopes, pediments, or bajadas, with a strong affinity to shallow, calcium-enriched Paleosols. These communities are extensive open shrublands dominated by blackbrush (*Coleogyne ramosissima*) with Mormon tea (*Ephedra viridis*), Torrey joint fir (*Ephedra torreyana*), and spiny hopsage (*Grayia spinosa*). Sandy portions may include sand sagebrush (*Artemisia filifolia*). Microphytic crusts are abundant in the interspaces where livestock or human traffic has not been excessive (Photographs 21 and 22).

The lands within these communities that are not completely isolated or poorly watered can be used for some seasonal livestock grazing. Much of the type is isolated by deep canyons and mesas and is rarely visited.

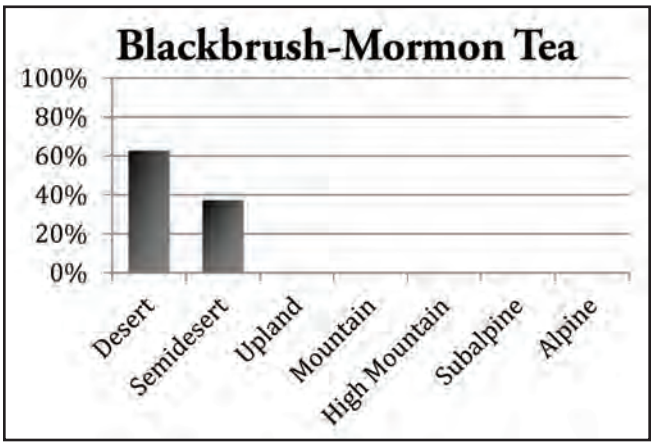


Figure 7.29. Distribution of blackbrush-Mormon tea communities across life zones.

Growth rates of blackbrush are extremely slow (West, 1983e). Only the sites with deeper soils have much in the way of grass available for animal use. These sites generally occur in the semidesert zone where moisture is in greater supply. The best time to utilize these ranges is in the early spring when protein from the grasses is much higher. The bulk of the type is, however, not highly regarded for livestock production.

There are not many species of plants that can tolerate the rigors of this environment. A total species list for representative samples would not include more than a dozen species, even with the spring annuals. Other than the aforementioned dominant shrubs, the following can also be found: desert almond (*Prunus fasciculata*), turpentine bush (*Ericameria laricifolia*), and if disturbed, broom snakeweed (*Gutierrezia sarothrae*). Some occasional yucca and cacti may also be found on some sites. Joshua tree (*Yucca brevifolia*) is frequently associated with blackbrush in extreme southwestern Utah.

The perennial herbaceous component is limited to a few bunchgrasses, such as Indian ricegrass (*Achnatherum hymenoides*), James' galleta (*Pleuraphis jamesii*), sand dropseed (*Sporobolus cryptandrus*), big galleta (*Pleuraphis rigida*), threeawn (*Aristida* spp.), needlegrasses (*Achnatherum aridum* and *Achnatherum speciosum*), and gramas (*Bouteloua eriopoda* and *Bouteloua gracilis*). The density of these grasses is strongly related to soil depth, with abundance of grass increasing with soil depth (West, 1983d).

Annuals can be abundant for about 6 weeks in the spring during wet years, but composition and production vary greatly, making them undependable for forage and cover. Only opportunistic use can be made of this community

during this time. Given the resinous nature of blackbrush and the high cover of vegetation, wildfires are a common threat.

Because of dominance by blackbrush and its relatively poor palatability and nutrition, livestock grazing capacities are very low. Livestock grazing has caused a decline of the perennial grass component on sites with deeper soils. More profound changes occur, however, following fire. Blackbrush does not resprout after fire, and even regeneration from seedlings is rare. Post fire vegetation is usually dominated by less desirable shrubs (turpentine bush, snakeweed) and introduced annual grasses, namely red brome (*Bromus rubens*) and cheatgrass, which are less dependable as forage and have effectively reduced fire return intervals. Accelerated soil erosion frequently follows burning. Reestablishment of the original dominants after mechanical disturbance is also very slow (West, 1983d).

Blackbrush is the keystone species and plays a critical role in maintaining the structure of this community. The vegetation that comes in after fire or other disturbance varies much more erratically in species composition and production. Because fires usually occur in the summer, the land may be unprotected for several months before winter annuals germinate. With the introduction of red brome or cheatgrass, chances of reburning increases and thus a downward spiral of degradation may set in. This degradation is of great concern in these areas because soils are typically shallow. A small, erosional loss at the surface results in a greater percentage loss of the total soil profile than in other types. Thus, if wildfires are allowed to burn uncontrolled, permanent loss of the potential for the land to produce vegetation in the future may occur. It is thus probably best to restrict attempts at improvement to sites with deep soils and control fires elsewhere in the type. There is little evidence that extant grazing systems improve range condition (West, 1983d), and recovery after removal of livestock is very slow (Jeffries and Klopatek, 1987).

The fauna of these areas is a mix of Great Basin and Mojave Desert elements. Because this vegetation forms an important part of its winter range, the only native ungulate of any importance is the desert bighorn sheep. Snakes are relatively abundant here, probably related to the abundance of seed-eating rodents and warmer temperatures of the region.

Aboriginal people made very few marks on this land. European influences also came relatively late. Roads into blackbrush-Mormon tea communities were lacking until the uranium exploration boom of the 1950s. Cattle generally do poorly on these ranges, but sheep or goats can utilize blackbrush.

CREOSOTE-WHITE BURSAGE COMMUNITIES

Creosote-white bursage communities occur in the hottest, driest valleys, bajadas, and low hills in the Mojave Desert portion of Utah. Soils are well-drained and caliche deposits at 15 to 20 inches deep are commonly covered with lag gravel called desert pavement. According to the SWReGAP land cover dataset, this type occurs more frequently in the semidesert zone (Figure 7.30). However, these communities are restricted and more characteristic of the Mojave Desert portion of Utah. Creosote-white bursage communities are characterized by sparse to moderately dense vegetation cover (2 to 50 percent). Creosote bush (*Larrea tridentata*) and white bursage (*Ambrosia dumosa*), also known as burrobush, are the dominants. Many different shrubs, dwarf-shrubs, and cacti may co-dominate or form typically sparse understories (Photographs 23 and 24).

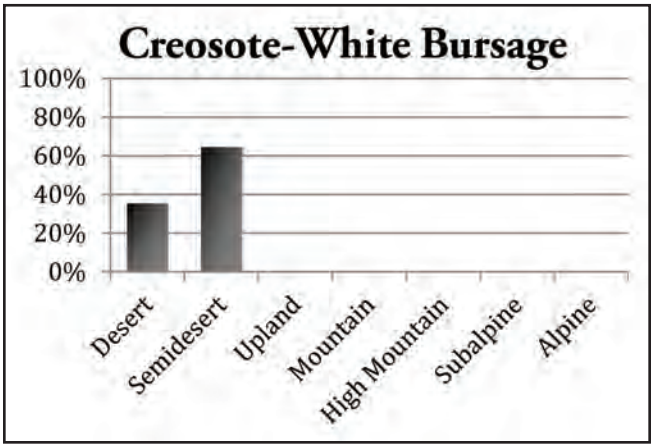


Figure 7.30. Distribution of creosote-white bursage communities across life zones.

Livestock grazing was the historic land use and it continues to be the major use of these lands. Livestock are put on these ranges in winter and left until early spring, especially in wet years when ephemeral forage is abundant.

The flora of these deserts is mostly composed of annuals, and their composition varies greatly from year to year. Many are too short in stature to be of use to ungulates. The perennial flora is very limited on the upland sites. Associated shrubs may include four-wing saltbush (*Atriplex canescens*), desert holly (*Atriplex hymenelytra*), brittlebush (*Encelia farinosa*), Nevada jointfir (*Ephedra nevadensis*), ocotillo (*Fouquieria splendens*), water jacket (*Lycium andersonii*), beavertail pricklypear (*Opuntia basilaris*), wolfberry (*Lycium torrey*), and dalea (*Psorothamnus fremontii*). The herbaceous layer is typically sparse, but may be seasonally abundant with ephemerals. Herbaceous species such as desert trumpet (*Eriogonum inflatum*), threeawn (*Aristida* spp.), Cryptanthas (*Cryptantha* spp.), phacelia (*Phacelia* spp.), bush muhly (*Muhlenbergia porteri*), and big galleta (*Pleuraphis rigida*) can be found, usually under the shrubs.

Primary production in these ecosystems is low due to the wide spacing of the shrubs with widely ramifying root systems and scanty occurrence of other perennials in the interspaces. The annuals put 30 to 50 percent of their aboveground production into seeds. The shrubs can grow through the winter, whereas the herbaceous species make a burst of growth in the spring and again after any large rainstorms.

Succession is best described as auto-succession because so few perennials can exist here that the same ones come in after disturbance as were there originally. Because of low production, mainly creosote bush tissues that are unpalatable to livestock, as well as widely scattered and undependable water supplies, the livestock grazing capacities are around 0.01 animal unit months (AUMs) per acre per year. Lack of water for livestock has apparently prevented the deterioration typical of more mesic areas.

Despite the low primary productivity, the fauna are surprisingly diverse on these ranges (MacMahon and Wagner, 1985). There are many small mammals that either live off the reserves of seeds or predate on the seed eaters. These areas also have the greatest variety of snakes and reptiles, such as the desert tortoise, of any area in Utah.

Because of the harshness of this environment, impacts upon it are slow to heal. Fortunately, vegetation is rarely thick enough to make fuel for wild fires. Natural erosion has typically already produced the self-protecting desert pavement. Few introduced plants have become serious weeds in these environments.

Until the advent of super-highways and air-conditioned conveyances and homes, it has been difficult for humans to travel through or live on these lands. Consequently, major impacts have largely been limited to the last few decades. There were a few itinerant graziers of sheep in the early part of the 20th century. Options for measurable improvement have been almost nonexistent. Short water supplies have also greatly limited conversions to intensive agriculture.

These environments have seen significant urbanization in the last few years. The 2008 population of Washington County was estimated to be approximately 137,500. This is an increase of over 47,000 people since 2000. In 2007, this area, particularly St. George, Utah, was named by the United States Census Bureau as the fastest growing metro area in the nation, with a 6-year growth rate of 40 percent. The St. George Chamber of Commerce has estimated that the population will grow to 607,334 by 2050, given current trends. This current and projected growth will have significant impact on the natural landscape through urbanization and the recreational impacts of the population. Since water is a significant limiting factor, it should logically reduce future growth. However, to date, it seems that limited water availability has not hindered population growth.

Photograph 1
Alpine Bedrock and Scree
High Uintas

Photograph 2
Alpine Fell Field
Mt. Ellen, Henry Mountains

Photograph 3
Alpine Tundra
High Uintas

Photograph 4
Alpine Dwarf Shrub
High Uintas

Photograph 5
Spruce/Fir Forest
Bear River Range
Cache National Forest

Photograph 6
Lodgepole Pine Forest Understory
South Slope of the High Uintas

Photograph 7
Lodgepole Pine Forest
North Slope of the High Uintas

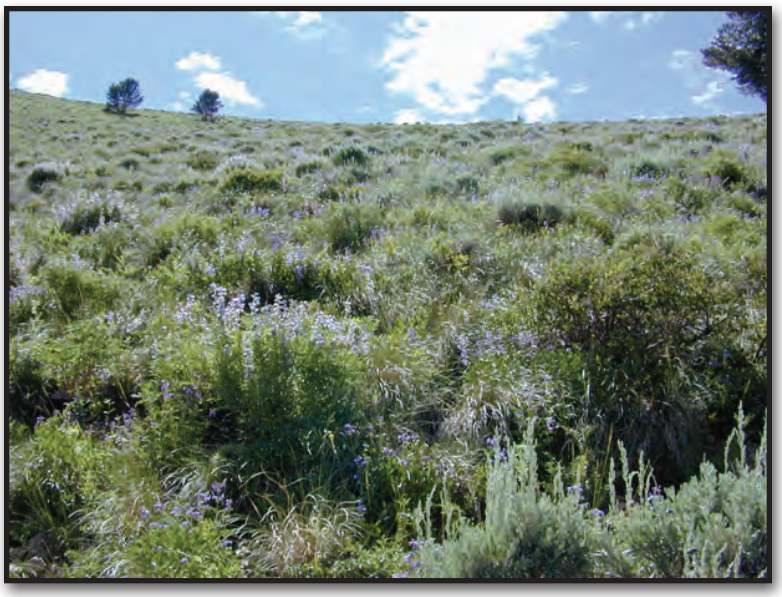
Photograph 8
Mountain Big Sagebrush
Uinta National Forest

Photograph 9
Aspen Forest
Stansbury Mountains
Wasatch National Forest

Photograph 10
Ponderosa Pine Forest
Aquarius Plateau
Dixie National Forest

Photograph 11
Ponderosa Pine Forest
East Slope of the La Sal Mountains
Manti-La Sal National Forest

Photograph 12
Gambel Oak Community
Oquirrh Mountains
Wasatch National Forest



Photograph 13
Big Sagebrush Steppe Community
Mt. Ellen
Henry Mountains

Photograph 14
Pinyon-Juniper Woodland
Oquirrh Mountains

Photograph 15
Pinyon-Juniper Woodland
Grand Staircase-Escalante
National Monument

Photograph 16
Big Sagebrush Shrubland
West of Kanab, Utah

Photograph 17
Big Sagebrush Shrubland
Canyonlands National Park

Photograph 18
Mat Saltbush
Near Emery, Utah

Photograph 19
Mixed Salt Desert Shrub
Great Basin, Utah

Photograph 20
Greasewood Community
Uinta Basin, Utah

Photograph 21
Blackbrush-Mormon Tea Community
South of Wahweap Marina, Lake Powell
Kane County, Utah

Photograph 22
Blackbrush-Mormon Tea Community
West of Wahweap Marina, Lake Powell
Kane County, Utah

Photograph 23
Creosote-White Bursage Community
Southwestern Utah

Photograph 24
Creosote-White Bursage Community
Southwestern Utah