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Water Wise

Wendy Mee

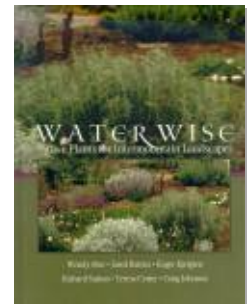
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INTRODUCTION

Adaptations of Intermountain Plants

The Intermountain West (IM West) is a high, semi-arid, and edgy region of rock bordered to the north and east by several spurs of the Rockies, and to the south by the Sonoran, Mojave, and Chihuahuan Deserts. To the west, the Sierra Nevada and the Cascade Range block Pacific moisture, casting a vast rain shadow that creates high, cold, desert valleys. Numerous mountain ranges corrugate the IM West north to south, creating three distinct regions. The Snake River Plain and Columbia Basin occupy the land east of the Cascade Range and are drained by their eponymous rivers to the Pacific. To the east of the Sierra Nevada is the Great Basin, a large, nondraining bowl in western Utah and nearly all of Nevada, crossed by numerous medium to large mountain ranges separated by often salty valleys. The third region is the Colorado Plateau, tucked into southeastern Utah and adjoining areas of Colorado, New Mexico, and Arizona. The Colorado Plateau is a sandwich of seemingly endless layers of colorful sandstone pushed up by a large volcanic bubble that has occasionally broken through to form protruding mountain ranges. It is cut through by the mighty and much litigated Colorado River.

While low rainfall is the overarching factor that makes the IM West semi-arid, the mountains create other environmental extremes that characterize it and shape its native vegetation. The Cascade/Sierra rain shadow conspires with summertime high pressures to limit summer precipitation in the drier valleys to an inch or two, although the Colorado Plateau receives somewhat more summer rainfall from monsoonal flows out of the Gulf of California. Because of its elevation, the bulk of the precipitation the IM West does receive is in the form of snow in winter, which increases with elevation. Winter snowfall benefits native vegetation only to the extent that it replenishes the soil water reservoir. The lower, drier valleys especially depend on snowmelt to replenish this reservoir. The limited and very intermittent summer rainfall is not enough to support anything but very sparse, low vegetation of the type found in the Mojave Desert. A consequence of limited summer rainfall is that humidity in the IM West is very low, often 10%–15% at midday. Low humidity and high elevation mean that little solar radiation is blocked; thus- summers are hot, with midday highs averaging 90–95° F in most of the region, and up to 100° F in the lower regions bordering the Mojave Desert. High solar radiation, low humidity, and high air temperatures then combine to generate a very high

evaporation rate compared to the more humid and high-rainfall regions of the country. The difference between evaporation and precipitation rates is the water balance of a region, and in the Intermountain West the large gap in this balance is a factor to which the native plants must adapt.

The water balance gap is diminished at higher elevations. The many mountains of the IM West are natural obstacles to weather fronts, creating orographic effects that corral and herd clouds up to where the colder temperatures characteristic of high elevations wring out precipitation. During the summer this orographic process increases the number of thundershowers and total rainfall in the mountains. The increased rainfall and reduced evapotranspiration due to lower temperatures means a favorably moist water balance that nourishes a dense plant cover and several communities of trees not found at lower elevations. Cold air drainage down ravines and washes with the right orientation allows some high-elevation species to survive at lower elevations because of a lower evapotranspiration rate. In turn, during the winter, the mountains of the IM West are magnets for copious blankets of winter snow. It is this snow that most cities in the IM West depend on for survival, either directly as seasonal runoff, or indirectly through ground water recharge.

The wide variations in precipitation and temperature in the IM West are reflected in a remarkable diversity of soil types. This soil diversity is due to variable parent material and interactions with climate. In general, most soil of the IM West is derived from somewhat alkaline parent material, such as limestone and old lake or ocean sediments. Most of central Idaho, the eastern Sierras of Nevada, and sections of the Colorado Plateau are derived from more acidic rock such as granite. Interspersed throughout the IM West are recent, oozing volcanic flows of basalt that tend to be alkaline but are rich in nutrients. Plant species distribution can be strongly influenced by soil type. An example is ponderosa pine (*Pinus ponderosa*), which is found largely on more acidic soils, and therefore has a patchy distribution in the IM West. The most important factor creating soil differences is climate. Rainfall, runoff, and elevation conspire to erode rock and soil at higher elevations and deposit it in valleys. Where the water and sediment are trapped at the lowest points in the Great Basin, vast salt flats dominate. Where water does drain, such as in the Columbia Basin and Snake River Plain and on the bottom slopes of many mountains, historic flooding or lakes have produced deep soils which have been thoroughly exploited by agriculture. In the Colorado Plateau there is little deposition because the rivers coming off the high plateaus scour and carry off sediments into the muddy Colorado River.

The greatest diversity of soils in the IM West is further governed by climatic effects due to the orientation and exposure of various parent materials in eroded mountains and plateaus. At midelevations in the mountains, southern orientations are hot and dry due to direct exposure to sunlight, which shortens snowpack duration, increases seasonal drying, and enervates the soil-forming processes that are dependent on water. The resulting shallow, coarse soils hold little water and thus support small, sparse vegetation. Slopes with northern orientations receive less direct solar radiation and snowpacks linger longer, allowing percolation of water to create deeper soils that hold more water and can support larger, denser vegetation stands. At the highest elevations, soil formation is temperature-limited by the short

growing season; hence, soils again tend to be shallow. Again, the Colorado Plateau presents a slightly different twist, as over the millenia, the rivers that cut through the bubble of rock there have sliced narrow slot canyons, excavated wide stair-step canyons such as the Grand Canyon, or overpowered softer rock to leave buttes and mesas. The end result is expanses of remarkable and colorful rock strata that expose nearly the full geologic history of the earth.

The kaleidoscope of climates and soil-based habitats of the IM West nourish, in a lean and parsimonious manner, a breathtaking diversity of plants. This is not apparent when driving through the IM West, where one sees seemingly endless vistas of blue-green shrublands (composed of *Artemisia* species but also including some *Atriplex* species) that seem to form a monotone blanket. The notion that this arid region has a botanic richness that surpasses that of the wetter areas of the country would appear to be the delusion of someone who has been sniffing too much sagebrush.

This floristic explosion is not in trees, however, because the semi-arid IM West has too little rainfall to support more than a handful of species that huddle on cool, moist upper-mountain slopes. Rather, this plant diversity is found in small-statured plants, which can reduce transpiration due to their smaller leaf area and are therefore better adapted to drier conditions. Since tree cover diminishes at lower elevations with decreasing rain and increasing evaporation, there is more room and sunlight available for growth and diversification of the smaller herbaceous species and shrubs. Certain genera are particularly successful in adapting to the great number of ecological niches in the IM West. Sagebrush (*Artemisia* sp.) is a nimbly opportunistic genus that has diversified into the dominant species of the IM West. It can take advantage of lower, drier habitats just above the Great Salt Lake by shrinking in size, then it can increase to nearly the size of small trees on deeper midelevation soils, and finally, it can return to diminutive dwarf forms in higher, colder habitats. Rabbitbrush (*Chrysothamnus* sp.) has speciated into numerous forms varying in leaf color and size that effectively colonize disturbed, rocky areas. Another adaptable shrub is saltbush (*Atriplex* sp.); any given species in a lower area with heavier soils seems to cross with other saltbush species with a cheery promiscuity that readily produces forms that can take advantage of different ecological niches. Among herbaceous species, *Penstemon* claims the same reigning position as sagebrush possesses among shrubs, with over 67 species in Utah occupying habitats from low desert to the highest alpine settings. Buckwheat (*Eriogonum* sp.) and milkvetch (*Astragalus* sp.) are other genera with a large number of species adapted to diverse Intermountain habitats. *Eriogonum umbellatum* in particular shows up in an astonishingly wide variety of forms and colors around the region. Globemallow (*Sphaeralcea* sp.) is the herbaceous counterpart to *Atriplex* in its proclivity for seeking out related species with which to cross. The rocky outcrops and other substrates throughout the region harbor a large number of endemic species; those that are found only in a small, confined area and are usually associated with a particular soil type. The Colorado Plateau in particular, with its broad array of exposed parent material, can claim a very large number of these specialist species.

The breadth of species carving out a low-growing existence in the arid to semi-arid areas in the IM West is due to their adaptations to the limited available resources. Drought adaptation is clearly the crucial trait that most native plants

share to one degree or another, apart from the riparian and wet meadow species. The most obvious adaptive trait is leaf area, largely a function of plant size, which determines total plant transpiration. The more negative the water balance, the less leaf area can be supported; hence the progression from trees at higher elevations to small-statured shrubs at the lowest. Transpiration rate is the key partner with leaf area in a plant's total transpiration, and is governed by the humidity of the atmosphere, leaf temperature, and the opening of stomates, the pores that allow transpired water to pass into the atmosphere. Plants cannot do much about the humidity of the atmosphere, but drought-adapted species use an array of traits to control the other two factors. Bigger leaves will get very hot relative to air temperature unless they stay cool through high transpiration rates; a safe tactic when plenty of water is available in rainy regions, but suicide in dry regions.

Nearly all shrub, perennial wildflower, and grass species native to the IM West have leaves less than an inch across. This small size allows plants to get rid of heat more easily and keeps leaf temperatures close to air temperatures, thereby reducing water loss. Many species have distinctly blue foliage (such as blue spruce, sagebrush, singleleaf pinyon, and some rabbitbrush species), which reflects solar radiation in the high-energy blue band that reduces leaf temperature. Some species, such as grasses and yuccas, maintain a leaf orientation that minimizes exposure to direct midday sun. Plants exercise a great deal of control over stomatal opening. Stomates are the pores through which CO₂ is taken in for photosynthesis and water is lost through transpiration. Many species open their stomates and transpire freely in spring when water is plentiful, but in the heat of summer the stomates close and the plants, such as Utah juniper (*Juniperus osteosperma*), take a vacation from growing for the rest of the season. Many species have stomates that are sunken into the leaf surface or have hairs on their leaves to reduce wind speed, thus slowing the movement of water into the air and reducing transpiration.

Plants with small leaves, less total leaf area, and well-designed stomates can control their water demand. However, increasing water supply is an equally important drought adaptation mechanism. Deep rooting gives a large number of species, particularly those found on the deeper, depositional soils along mountain foothills, such as Gambel oak (*Quercus gambelii*), a larger supply of water and thereby helps to stave off drought as long as possible. Many lower elevation species have deep roots, but there is also wide spacing among plants due to lateral rooting, such that the plants scavenge water as widely as possible. Similarly, many species can extract more water from a given volume of soil, sucking it drier than conventional plants. Deep rooting is particularly important for those species found on sandy soils that hold very little water or on gravelly slopes or rock outcroppings. Finally, most species possess an integrated drought-adaptation mechanism that combines control over demand with increased supply via rooting. For example, species that put roots into soils with very low water holding capacity depend on keeping all competition away. This allows them to seek the limited amount of water available to their roots and keep transpiration to a minimum. A good example is rockmat (*Petrophytum caespitosum*) with its seeming ability to grow out of rock.

Drought is not the only environmental stress plants must cope with. Some species in saline soils avoid salt desiccation by sequestering salt in spe-

cial leaf cells. When the leaves drop, the salt content of the soil surface increases, thus reducing competition. Some specialist endemic species growing on the many parent materials in the Colorado Plateau can tolerate certain toxic elements such as selenium that keep the neighborhood clear of competition. Probably the most important resource limitation besides water is nutrient availability, particularly nitrogen. In dry and coarse soils at low elevations, and in cold soils at high elevations, the microbes that fix nitrogen, or decompose and release nitrogen from dead plant matter, rarely have the optimum temperature and moisture conditions to function. Evergreen foliage and the efficient internal recycling of nitrogen are key adaptations to nitrogen deficiency in very dry and cold habitats.

Species with different combinations of these remarkable adaptive features coalesce in any given habitat into plant communities of woody, herbaceous, grass, and cacti species that characterize a given set of environmental conditions. In this publication we present the IM West species we believe to be most suitable for landscaping in the context of their plant associations or communities. Keep in mind, however, that many of the environmental habitats and plant communities present in the IM West are found in adjacent areas, particularly the subalpine association that is found throughout the west. Certain high-elevation species, such as aspen, may be found throughout the northern tier of North America, and others are circumboreal, found throughout the high-elevation and high-latitude climates of the northern hemisphere. Therefore, the key to understanding these plants and the types of landscapes in which they could grow best is to examine the key characteristics of the habitats to which they are adapted, and to match those with the conditions in the landscape.

Plant Selection Considerations

A successful native landscape is based on selecting the right plants for the right locations. The right plants will vary with the type of native landscape chosen. Since the IM West encompasses a wide range of plant communities and habitats, a native plant landscape at its most authentic and successful is one where a particular plant community is matched to the environmental conditions and aesthetic expectations of the landscape in question. How to translate the creation of a native landscape to the consumer level is a challenge. Embedding isolated native plants into a garden center display gives the consumer no way to discern what options may be available for a native landscape, and what the potential is for water conservation or low maintenance. Similarly, at the design level, placing a few native plants in with petunias could work aesthetically with some species, but it would have no potential for water or labor savings, and would probably kill the native plants from overwatering. Therefore, a successful landscape using native plants is one that combines plants that are naturally found together in communities based on adaptations to a set of climatic and soil conditions that best match the climatic and soil conditions in the landscape.

The first step is assessing the climate and soils at the landscape site, and then identifying the plant community that matches those conditions. For example,

portions of Salt Lake City are located on the Wasatch Mountain foothills, so a landscape based on foothill communities, mountain brush, pinyon-juniper, shrub steppe, mountain mahogany, or any of the desert communities, would be well adapted. A subalpine landscape using large conifers, or a riparian landscape using river plants, may be no more adapted to the rainfall conditions of a location like Salt Lake City than most exotic plants, and would need to be irrigated just as often to succeed. The other climatic factor to consider is shade. Native plants tolerant of shade are only found naturally in the understory of forests where there is enough moisture at higher elevations and along waterways. A number of shrub and forb species native to montane forests are tolerant of shade, and as an added bonus, they are fairly tolerant of drought as well when there is enough shade. When evaluating soil conditions, texture—sand, silt, and clay—and drainage are two of the most important factors to consider in a potential landscape. Many native plants, particularly those found in coarse soils or sandy deserts, are adapted to very well-drained conditions and will die if placed in poorly draining soil. Many of these plants can be used in poorly drained soil if they are planted on a berm or some other kind of elevated soil that gets the roots out of the muck. The exposure to sun is also critical, again because most natives are found in full sun in their native habitats, particularly the most drought-adapted, and they will become gangly and unattractive in shade.

How these plants are assembled is the most important step in creating a successful IM West native landscape. If water savings is the goal, the most successful landscape is achieved by grouping plants from similar communities, and not mixing plants from different habitats. The blue foliage of Palmer penstemon (*Penstemon palmeri*) may look attractive against red-osier dogwood (*Cornus sericea*), but irrigating to meet the needs of the dogwood will kill the penstemon from too much water, and watering appropriate for the penstemon will cause water stress for the dogwood. The most creative potential for a native landscape is to use the layout of the habitats as an inspiration for creating innovative landscapes that still honor the native communities, yet go beyond a simple facsimile. A forested landscape patterned on a montane forest would have small groves of trees like Gambel oak or bigtooth maple (*Acer grandidentatum*) interspersed with grasses and forbs, with drifts of low-growing shrubs. A lower elevation, more drought-tolerant landscape would have medium-sized shrubs as a structural backdrop to clusters of attractive forb-grass mixtures. Since much of the IM West is rock-exposed in one way or another, native stone as a hardscape element will be a key visual and low maintenance element in a native landscape. Lichen-covered basalt or half-buried boulders can be graceful specimens or visually integrating backdrop elements in a landscape. Similarly, red sandstone gravel mulch or slab flagstones can be the highlight of a Colorado-Plateau-style landscape.

Two questions in selecting native plants are whether it is appropriate to use horticultural cultivars, and whether source identification of seed is important. Almost all cultivars are clones, genetically identical to a parent plant, and are reproduced through vegetative propagation. Cultivars are usually selected on the basis of appearance such as improved flowering, but sometimes are selected on the basis of greater ability to withstand environmental stress, as in selecting a clone from the

most northerly population of a species to increase cold tolerance. Using genetically identical plants in the landscape generally ensures a uniform appearance. The disadvantage of cultivars, particularly those selected for aesthetic traits, is reduced tolerance of environmental stress, and increased susceptibility to disease and insect attack.

The alternative to cultivars and genetic uniformity are source-identified plants, where seed is collected from plants at a general location. Source-identified plants are useful to those seeking to restore native ecosystems, since by defining the probable cold, drought, and nutrient tolerance range of these genetically diverse plants, they can be matched to a given set of environmental conditions. This is not all that different from selecting horticultural cultivars for cold tolerance, for example, except for greater genetic uniformity. Source-identified plants work well for restoration on disturbed, high-elevation sites with extreme temperatures and short growing seasons, where slight variations in adaptation are the difference between successful establishment and death. In places, source identification has been carried to the extreme of requiring the seed source to be at the site to be restored.

In landscapes, source-identified plant material has less benefit because growing conditions are rarely so extreme that specialized adaptation is important, and it adds to plant cost. The middle ground for landscapes is using genetically diverse and broadly adaptable native plant material that offers a broader range of environmental tolerance than genetically uniform cultivars, apart from selecting plants for increased cold tolerance. Of the plants listed in this book, the greatest cultivar development has been among the high-elevation conifers such as limber pine (*Pinus flexilis*) that have a very broad native range, and riparian species such as red-osier dogwood. Little to no work has been done on the lower-elevation, more drought-adapted shrubs and perennial wildflowers.

Maintenance of Native Landscapes

Like any other kind of landscape planting, an IM West native plant landscape will need supplemental water until established. Perennial plants usually have established enough new roots into the surrounding soil within one to two months after transplanting that irrigation can be scaled back. Shrubs and trees are usually established within one year, often by late summer, and water can be scaled back somewhat at that time.

Once established, a native plant landscape can be very low-maintenance and low-water-use if the plants are properly selected. Weed control, however, can cause a native landscape to fail if not addressed. Weed types need to be identified and a control strategy selected. Winter annual weeds can be reasonably controlled through proper mulching and even hand pulling. If necessary, some pre-emergent or directed post-emergent herbicide sprays can be used, since winter annuals are often growing before many of the native species, and thus are easily targeted. Summer annual weeds are somewhat more difficult because their rapid growth is concurrent with many natives, making them difficult to target, but mulching can be an effective control. The most challenging weeds are the perennial types, such as morning glory, quack grass, and thistle, as they can sometimes grow through

mulch, tend to be more drought-tolerant than annuals, and are controlled by hand pulling only temporarily, at best. Perennial weeds are best controlled with a selective post-emergent herbicide before planting.

Subsequent irrigation will depend on the plant community or species grouping selected. Landscapes using foothills and desert communities will need very little water in most of the IM West urban areas, most of which happen to be at similar or higher elevations. Less irrigation in a foothills or desert community landscape assumes that the soil is not too shallow or compacted, such that the ability of the plants to avoid drought is reduced. Excess irrigation is more of a concern in native low-water landscapes, as most plant species found in the foothills, montane, and cold sand desert communities require very well-drained soils. Any kind of excess irrigation can rapidly kill a great many of these species.

Mulching is a very desirable practice in low-water, sustainable landscapes because it suppresses weeds and holds moisture in the soil. Organic mulch, such as shredded wood chips, is suitable for landscapes with communities and/or species selected from habitats with a natural organic layer, typically at mid- to higher elevations. However, species normally found in very rocky soils where rainfall is low enough that no natural mulch layer forms may not be adapted to the different microbes found in organic mulch. Species such as Palmer penstemon normally live five to six years, but in organic mulch it is often an annual because of root rot. In a landscape using plants from desert or other communities without a natural mulch layer, an inorganic mulch such as rock or sand should be used.

Managing vegetative growth on most IM West natives is not difficult because there are few large trees that need intensive, high-cost pruning. Cottonwood (*Populus* sp.) is clearly the exception, as its fast growth rate results in large, brittle limbs that can become lethal projectiles if grown too close to traffic. Willows (*Salix* sp.) fall into a similar category in terms of pruning, and red-osier dogwood will also need frequent pruning to remove old limbs and maintain the ornamental red new stem growth.

Native conifers have sufficiently appealing natural growth habits and controlled crown forms that they need very little pruning, and for most native small trees their frequently irregular growth habit is more picturesque than unruly. Most shrub species native to drier habitats in the IM West grow small and tight enough that they have appealing forms without the need for pruning. On occasion, a number of species may become leggy and somewhat rank if grown with too much water or particularly fertile soil, assuming they don't die from overirrigation first. Such species can benefit from thinning out the older growth, similar to red-osier dogwood, and can sometimes benefit from complete shearing to the ground. This is not as drastic as it sounds, for many of these shrub species are adapted to severe animal browsing and periodic fire that removes much top growth. The many latent buds at the bases of these plants allow them to rapidly produce vigorous new growth. The Native American tribes in the Great Basin region took advantage of this trait in squawbush (*Rhus trilobata*) when they burned it to the ground and used the resulting long, straight new growth in basket weaving.

A large group of native plants needs yearly pruning. Fast-growing, multi-stemmed shrubs such as rabbitbrush will be more visually appealing when the

previous year's growth is sheared to the ground. Nearly all the native perennial wildflower and grass species also need to have the previous year's growth stalks removed during winter or spring. For almost all of these plants, which are found in all of the plant communities, vegetative growth dies back to the ground or to an evergreen or woody base in winter, so in the landscape this growth should be removed annually to make these plants more attractive and enhance growth.

Intermountain West Plant Communities

The central theme of this book is that using IM West native plants in urban landscapes is best understood in the context of the plant community in which they are found. Paying careful attention to plant communities, species composition, vertical and horizontal structure, and species response to microclimate and physical features is the key to successful designing with native plants. The following section describes and illustrates IM West plant communities grouped according to elevation.

In the natural landscape, plants and animals have evolved over thousands of years into complex, highly interdependent communities. Climate, topography, elevation, aspect, soils, hydrology, and other nonliving elements create the conditions in which living organisms reside. Living organisms like plants interact with each other and the physical environment, which they in turn modify over time. Plants in a location with similar requirements for water, sunlight, soil type, elevation, and aspect form a community, such as the salt desert and pinyon-juniper forest communities. The boundaries between plant communities are mostly subtle and graded, forming transitional areas called ecotones. Typically, ecotones include species from both associations dispersed across a gradient from one community to another.

As repeated elsewhere in this book, anyone designing an IM West native plant landscape is advised to select plants from a community that thrives in climatic and physical conditions similar to those of the site being planted. Often, this will be the plant community that historically grew on the site. Soil type and conditions are variable within each plant community and should be researched for each site and compared with individual species preferences and restrictions. Further, if the designer wishes to create a natural-looking landscape, the composition of plants should reflect the vertical and horizontal structure of the plant association. The plant association photographs and generalized plan views and elevation drawings in this section graphically illustrate the general structural characteristics of each community. The reader may find the illustrations useful as conceptual planting design templates.

In the community descriptions where elevation ranges are presented, the upper range is generally more southerly, and the lower range is characteristic of the northern part of the IM West. The plant cover estimates are also an approximate range, but are presented to convey awareness of the spatial layout of a community. Prominent species typical of the overstory and understory of each community are presented in the description to provide a starting point for selecting appropriate groups of species. The communities in which individual species are found are listed in the data sheets, and a table listing communities for each species in this

publication is available in the index. Finally, since the major focus of this book is on water conservation, the degree of adaptability and irrigation requirements are described for the average plants in each community if they were to be grown in a typical IM West urban landscape.

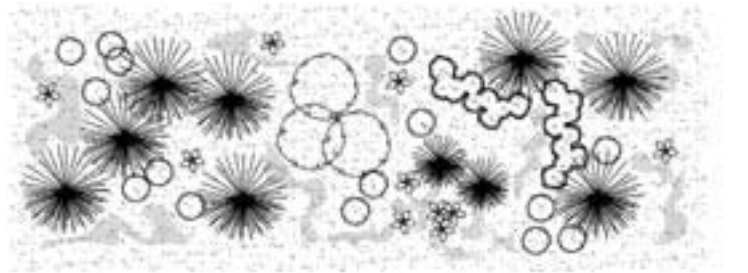
Subalpine

A generalized elevation range for the subalpine plant association is between 8,000 and 11,000 feet, varying with aspect, and pushing timberline at its highest edge. Total vegetal cover is moderately dense to dense (65 to 90 percent). The annual precipitation ranges from 20 inches to greater than 40 inches. Soils are generally shallow and rocky. However, the growing season is very short, and frost can occur at any time of the year. This association typically has more than 30 percent tree cover, of which 70 percent or more is conifer.

Representative species include Douglas-fir (*Pseudotsuga menziesii*), white fir (*Abies concolor*), subalpine fir (*Abies lasiocarpa*), and Engelmann spruce (*Picea engelmannii*). Quaking aspen (*Populus tremuloides*) is also common in this association. Limber pine (*Pinus flexilis*) and lodgepole pine (*P. contorta*) occur at low frequency in certain locations. On the dry south- and west-facing slopes, the primary tree species is Douglas-fir. Shrub species include a mixture of species such as sagebrush (*Artemisia tridentata* ssp. *vaseyana*), chokecherry (*Prunus virginiana*) and twinberry (*Lonicera involucrata*). On northeast slopes, Douglas-fir is replaced by subalpine fir and Engelmann spruce, with a rich mixture of understory species such as western mountain-ash (*Sorbus scopulina*), blue elderberry (*Sambucus caerulea*), mountain snowberry (*Symphoricarpos oreophilus*), Colorado columbine (*Aquilegia caerulea*), glacier lily (*Erythronium grandiflorum*), sticky geranium (*Geranium viscosissimum*), and nettleleaf giant hyssop (*Agastache urticifolia*). The subalpine association is essentially an island floating above lowland habitats throughout the west, all the way from the salt flats of the Great Basin to the temperate rain forests of the Olympic Peninsula in Washington. While some of the forbs, grasses, and shrubs are adaptable and could grow in lower elevation landscapes, many of the woody species in this association do not do well there due to their intolerance of the higher air temperatures and lower humidity. Most plants



Typical Subalpine Plant Association



Plan View - Typical Subalpine Plant Association



Section - Typical Subalpine Plant Association

from this community would need regular irrigation similar to non-native species in order to survive at lower elevations.

Montane

This community consists of four types or subcommunities with a generalized elevation range between 6,000 feet in the north and 9,000 feet in more southerly regions. The water balance at this elevation range is clearly more negative than that of subalpine communities, as annual precipitation ranges from 16 to 20 inches, and the warmer temperatures of lower elevations mean greater evapotranspiration. Soils in this community are generally rocky in the forest associations, but can be quite deep and loamy in the wet meadows. This association intergrades with the subalpine association at higher elevations and on north-facing slopes, with the mountain brush association across much of its range, and with the shrub steppe association at its lower elevational limits. The four plant community types differ based on soil and fire incidence.

The **montane parkland** occupies the lower rainfall range in this zone, and is typified by open stands of ponderosa pine (*Pinus ponderosa*) with varying stands of aspen (*Populus tremuloides*) and Douglas-fir (*Pseudotsuga menziesii*), with total vegetal cover low to moderate (30 to 60 percent). The ponderosa forests are characteristically found on soils derived from more acidic (granitic) parent material; hence it is intermittent in distribution in the IM West. The understory consists of a sparsely distributed shrub layer with plants such as currant (*Ribes* spp.) and bearberry (*Arctostaphylos uva-ursi*), and a mixture of bunchgrasses such as Idaho fescue (*Festuca idahoensis*), junegrass (*Koeleria macrantha*), Indian ricegrass (*Achnatherum hymenoides*), timber oatgrass (*Danthonia intermedia*), and desert needlegrass (*Stipa speciosa*). These species, along with buckwheat (*Eriogonum* spp.) and cacti, typify the ground layer. Most plants at this elevation are adaptable to lower elevation landscapes, are moderately drought-tolerant, and would require only occasional irrigation.

The **montane coniferous forest** dominates the higher elevations and north- and east-facing slopes of this zone, and includes habitats with deeper soils, slightly cooler temperatures, lower evapotranspiration rates, and slightly higher rainfall. Because of the more favorable water balance, vegetal cover is moderately dense to dense (65 to 90 percent). Douglas-fir is the dominant tree species and forms dense stands with an understory comprised of shrubs such as ninebark (*Physocarpus* spp.), currant (*Ribes* spp.), snowberry (*Symphoricarpos* spp.), snowbrush ceanothus (*Ceanothus velutinus*), and mountain lover (*Pachystima myrsinites*). Shade-tolerant herbaceous species such as columbine (*Aquilegia* spp.) and bluebells (*Mertensia* spp.), and some grass species, comprise the ground layer. Lodgepole pine (*Pinus contorta*) also forms dense stands, mostly on acidic quartzite soils. Understory composition depends upon the density of the stand, and is sparse in very dense stands. Shrubs, forbs, and grasses in this community generally have low to medium drought tolerance, are reasonably adaptable to lower elevation landscapes, and can survive with periodic irrigation.

The **aspen forest** is intermixed with the other montane communities, and is typified by groves that are actually clonal stands and can be quite dense. Aspen

forest is generally located in areas that have undergone some form of disturbance such as fire. Plant cover is also moderately dense to dense (65 to 90 percent) due to the slightly higher precipitation and cooler temperatures than in the montane parkland community. Dependent upon the density of the groves and light penetration, a rich mixture of understory species completes the community type. The shrub layer is comprised of such species as western mountain-ash (*Sorbus scopulina*), snowberry (*Symphoricarpos* spp.), rose (*Rosa* spp.), ninebark (*Physocarpus* spp.), and common juniper (*Juniperus communis*). The ground layer is composed of a mixture of tall forbs such as delphinium (*Delphinium* spp.), sticky geranium (*Geranium viscosissimum*), and goldenrod (*Solidago* spp.), with mountain brome (*Bromus marginatus*) and elk sedge (*Carex geyeri*) representative of the grasses and sedges. All these plants have a low to moderate degree of drought tolerance, and can perform reasonably well in lower elevation landscapes with periodic irrigation.



Typical Aspen Forest Association

The **montane meadow** community is found where drainage is impaired and coniferous and aspen forests cannot survive; thus it occupies openings within the montane coniferous and aspen forest zones. A broad mixture of mostly herbaceous species, bulbous species, grasses, and sedges comprise these meadows, the composition varying according to soil moisture. Such species as Indian paintbrush (*Castilleja* spp.), aster (*Aster* spp.), sticky geranium (*Geranium viscosissimum*), onehead sunflower (*Helianthella uniflora*), wild sweetpea (*Lathyrus* spp.) leafy Jacob's ladder (*Polemonium foliosissimum*), showy cinquefoil (*Potentilla gracilis*), mule's ears (*Wyethia amplexicaulis*), and blue camas (*Camassia quamash*) typify this community, along with the grasses mountain brome (*Bromus marginatus*), wild rye (*Elymus* spp.), and timber oatgrass (*Danthonia intermedia*).



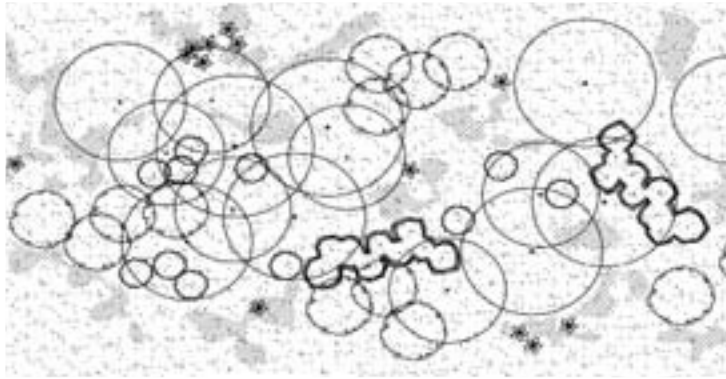
Typical Montane Meadow Association

Foothills

The broad foothills community includes the swath of lower mountain slopes just above valley floors from 4,000 to 7,000 feet, again somewhat lower in the north and higher in the south. Precipitation is not a lot less than in the montane communities, ranging from 12 to 18 inches, but since this is a lower elevation community, temperatures and evapotranspiration are high enough to push the water balance into the semi-arid arena. This is the zone where the greatest urbanization is occurring. Soil types range from deep loams on north slopes to shallow, skeletal soils on



Typical Mountain Brush Association



Plan View - Typical Mountain Brush Plant Association



Section - Typical Mountain Brush Plant Association

southern exposures and rocky outcrops. Like the montane zone, the foothills zone has four communities that vary with soil type and rainfall.

The **mountain brush** community is composed of the small deciduous tree species, Gambel oak (*Quercus gambelii*) and bigtooth maple (*Acer grandidentatum*), which are found in the precipitation range of 14 to 18 inches over the full elevational range of this zone, and reach their maximum along the central spine of Utah and on the Colorado Plateau. Total vegetal cover ranges from moderate to moderately dense (45 to 75 percent). Soils tend to be calcareous but are somewhat deep and developed. Rocky Mountain juniper (*Juniperus scopulorum*) is common at the middle to upper reaches of this community, while Utah juniper (*Juniperus osteosperma*) is found at the lower reaches. The understory and space between forests is composed of large numbers of mountain big sagebrush (*Artemisia tridentata* ssp. *vaseyana*) and mountain snowberry (*Symphoricarpos oreophilus*), interspersed with other shrubby species such as serviceberry (*Amelanchier utahensis*), alderleaf mountain mahogany (*Cercocarpus montanus*), creeping Oregon grape (*Mahonia repens*), and Woods rose (*Rosa woodsii*). Herbaceous understory species in dry mountain brush associations are typical of the shrub steppe association. These species include mountain brome (*Bromus marginatus*), nettleleaf giant hyssop (*Agastache urticifolia*), bluebells (*Mertensia* spp.), longleaf phlox (*Phlox longifolia*), scarlet gilia (*Gilia aggregata*),

lupine (*Lupinus* spp.), and aster (*Aster* spp.). Total plant cover is moderately dense (60 to 80 percent). Plants in this community have medium drought tolerance and perform well in urban landscapes with infrequent irrigation.

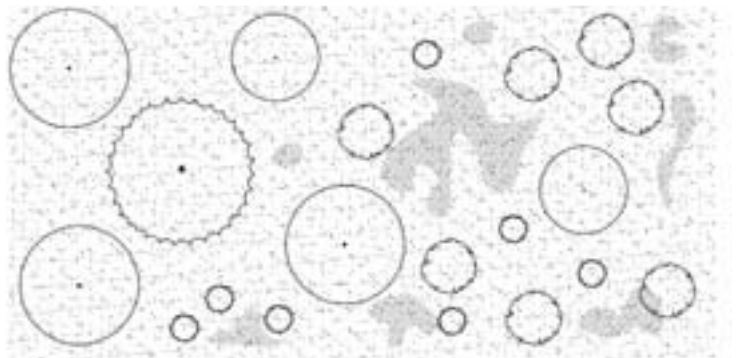
The **pinyon-juniper** community occupies slightly drier sites (12 to 16 inches of precipitation) than mountain brush, but occurs over the same elevational range. The pinyon-juniper forest is found mostly on very well-drained soils that may be rocky, sandy, or shallow. It is the dominant forest type throughout much of the Great Basin and southeastern Utah into Colorado and Arizona. This forest is constrained at its upper limit by cold, and at its lower limit by summer drought and

cold, since below this limit, winter inversions in Great Basin valleys trap brutally cold air that limits many woody species. The pinyon-juniper forest historically was not as widespread as today, but due to fire suppression and overgrazing of bunchgrasses it has expanded beyond its historic range. In any pinyon-juniper forest the more drought- and cold-tolerant Utah juniper (*Juniperus osteosperma*) usually defines the lower edge, grading into a mixed juniper-pinyon forest, then finally giving way to solid pinyon stands at the upper edge. Plants from the pinyon-juniper community have medium to high drought tolerance and will perform well in IM West urban landscapes provided they are given excellent drainage. Total plant cover is sparse to moderately dense (40 to 70 percent)

A variation on the mountain brush community is the **mountain mahogany forest** that is found from 6,000 to 7,000 feet on very well-drained and rocky soils. These forests do not burn often, resulting in a sparse to moderate plant cover of 40 to 60 percent. The mountain mahogany forest forms small stands on these drier soils and intersperses with the mountain brush community, while it generally resides at a slightly higher elevation than the pinyon-juniper forest in the Great Basin and Colorado Plateau. Because mountain mahogany is an evergreen, the lack of light for vegetation results in scant understory vegetation. Black sage (*Artemisia nova*), cacti, and a number of grasses can occupy gaps within the mahogany forest. Mountain mahogany (*Cercocarpus* spp.) and its associated species have medium drought tolerance and can do very well in landscapes with excellent drainage. There a number of plants that are characteristic of rocky outcrops in the montane zone that could be considered sufficiently similar in terms of the habitat to include in this community. These include tree and shrub species such as limber pine (*Pinus flexilis*), curl-leaf mountain mahogany (*Cercocarpus ledifolius*), waxflower (*Jamesia americana*), and tufted rockmat (*Petrophytum caespitosum*) along with crevice- and rock-dwelling forbs such as some *Penstemon* species, *Astragalus* species and grasses such as Sandberg bluegrass (*Poa secunda*) and desert needlegrass (*Achnatherum speciosum*).



Typical Pinyon-Juniper Association



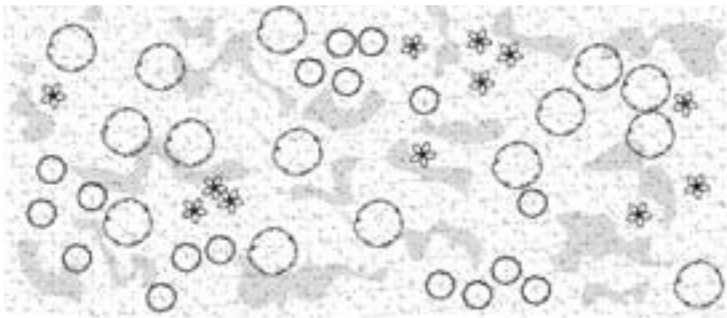
Plan View - Typical Pinyon-Juniper Plant Association



Section - Typical Pinyon-Juniper Plant Association



Typical Shrub Steppe Association



Plan View - Typical Shrub Steppe Plant Association



Section - Typical Shrub Steppe Plant Association

The **shrub steppe** plant association lies at the lower, drier (12 to 16 inches of precipitation), and higher evapotranspiration edge of the foothills communities, from 4,000 to 6,000 feet, and is distinguished by the absence of a dominant tree species. It may also occur on valley bottomland and river terraces where the soil is nonalkaline. Plant cover ranges from moderate to moderately dense (50 to 75 percent).

Basin big sagebrush (*Artemisia tridentata* ssp. *tridentata*) and mountain big sagebrush (*A. tridentata* ssp. *vaseyana*) are the dominant overstory shrub species and, depending on grazing pressure, may be the dominant species. Other shrub species present in this association include rubber rabbitbrush (*Chrysothamnus nauseosus*), bitterbrush (*Purshia tridentata*), and dwarf smooth sumac (*Rhus glabra* var. *cismontana*). Grass and forb species include prairie junegrass (*Koeleria macrantha*), bluebunch wheatgrass (*Pseudoroegneria spicata*), western wheatgrass (*Pascopyrum smithii*), Idaho fescue (*Festuca idahoensis*), Great Basin wildrye (*Leymus cinereus*), Indian ricegrass (*Achnatherum hymenoides*), mountain brome (*Bromus marginatus*), sticky purple geranium (*Geranium viscosissimum*), arrowleaf bal-

samroot (*Balsamorhiza sagittata*), sulfur buckwheat (*Eriogonum umbellatum*), scarlet globemallow (*Sphaeralcea coccinea*), and a variety of *Penstemon* species. Since most of the urbanization in the IM West is taking place in this particular plant community, species from the shrub steppe are excellent choices for urban landscapes in the IM West. The shrub steppe species have medium to high drought tolerance, but again need excellent drainage.

Lowland Desert

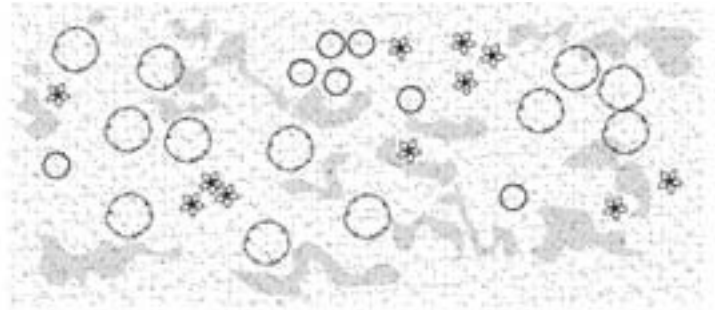
The lowland deserts of the Intermountain West occupy the flat areas from 3,000 to 6,000 feet between mountain ranges or plateaus, and are characterized by the hottest temperatures and lowest rainfall (5 to 10 inches) in the entire region. Because of the high evaporation and low rainfall in this zone, the land can support only sparse vegetative cover, from 10 to 40 percent. The dominant plants are drought- and salt-tolerant shrubs, with grasses occupying a secondary role. This zone also has three plant communities differentiated on the basis of soil salinity and texture.

The **cool desert** shrub community in Utah occurs where soils are neither salty nor sandy, spanning a range of soil types from exposed parent material to deep

alluvium. The dominant shrub species is Wyoming big sagebrush (*Artemisia tridentata* ssp. *wyomingensis*), along with Mormon tea (*Ephedra viridis*) and winterfat (*Ceratoides lanata*), with rubber rabbitbrush (*Chrysothamnus nauseosus*) and matchbrush (*Gutierrezia sarothrae*) colonizing the many disturbed areas. Understory and intershrub areas support species such as Dorr sage (*Salvia dorrii*), and grass species such as Indian ricegrass (*Achnatherum hymenoides*), Sandberg bluegrass (*Poa secunda*), needle and thread grass (*Hesperostipa comata*), and desert needlegrass (*Stipa speciosa*). Color in the cold desert community is largely from forb species such as globemallow (*Sphaeralcea* spp.), numerous Penstemon species, prince's plume (*Stanleya pinnata*), prickly poppy (*Argemone munita*) a number of cacti species, and shrub species such as Dorr sage (*Salvia dorrii*) and spiny hopsage (*Grayia spinosa*). Plant cover varies from 20 to 40 percent. Plants from this community are very drought-tolerant, and in local urban landscapes do not require water after establishment.



Typical Mixed Desert Association

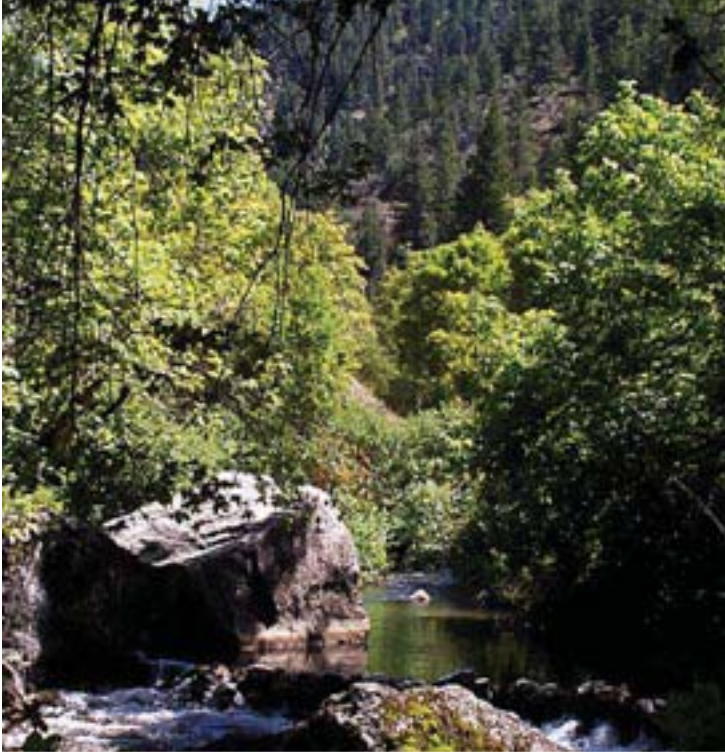


Plan View - Mixed Desert Plant Association



Section - Mixed Desert Plant Association

The **salt desert shrub** plant community is found in fairly deep soil with fine textured clay and silt due to runoff deposition from adjacent highlands. This community is often found where drainage is poor and salts build up, or on particularly saline parent material such as Mancos shale in eastern Utah, creating a very hostile environment for plants. The dominant shrub species include Gardner saltbush (*Atriplex gardneri*), shadscale (*Atriplex confertifolia*), mat saltbush (*Atriplex corrugata*), lacy buckwheatbrush (*Eriogonum corymbosum*) and black greasewood (*Sarcobatus vermiculatus*). Secondary species include rubber rabbitbrush (*Chrysothamnus nauseosus*), low rabbitbrush (*C. viscidiflorus*), matchbrush (*Gutierrezia sarothrae*), and winterfat (*Ceratoides lanata*). Intershrub areas are typically vegetated with such species as bottlebrush squirreltail (*Elymus elymoides*), desert saltgrass (*Distichlis stricta*), and alkali sacaton (*Sporobolus airoides*). Color is added to this plant community from species such as globemallow (*Sphaeralcea* spp.), prince's plume (*Stanleya pinnata*) desert larkspur (*Delphinium andersonii*), yellow catspaw (*Cryptantha flava*), and numerous daisies (*Erigeron* spp.). The plants from this community are extraordinarily drought- and salt-tolerant, can survive heavier soils more than most other native plants, and can be used to create a distinctive nonirrigated landscape in urban areas.



Typical Riparian Association

The **sand desert** community is probably one of the smallest, found in dune situations in the Great Basin and Idaho, and associated sandstone parent material such as the Kayenta, Navajo, and Wingate formations on the Colorado Plateau. Plant cover is very sparse and similar to the salt desert, but with fewer, bigger plants since establishment in these droughty soils is difficult. The dominant shrub species include sand sage (*Artemisia filifolia*), fourwing saltbush (*Atriplex canescens*), green Mormon tea (*Ephedra viridis*), and various yuccas such as Harriman yucca (*Yucca harrimaniae*). Typical herbaceous species in this community are sand verbena (*Abronia fragrans*), pale evening-primrose (*Oenothera pallida*), bush penstemon (*Penstemon ambiguus*), palmer Penstemon (*P. palmeri*), Indian ricegrass (*Acnatherum hymenoides*), galleta (*Hilaria jamesii*), little bluestem (*Schizachyrium scoparium*), and blue grama (*Bouteloua gracilis*).

Plants from this community are extraordinarily drought-tolerant, but the sand plants demand excellent drainage, even beyond the normal good drainage requirements for most of the plants in this text.

Riparian Communities

Riparian plant communities are found wherever there is water moving into the plant root zone during the growing season, typically along rivers, but also in seeps. The elevation range of the riparian communities is between 3,000 and 10,000 feet. Riparian vegetation in the IM West ranges from forests at the lower elevations to a more shrubby community at higher and colder elevations. Typical riparian trees include cottonwoods (*Populus deltoides*, *P. fremontii*, and others) and willows (*Salix* spp.). Other tree species found along riparian corridors are western water birch (*Betula occidentalis*), thinleaf alder (*Alnus incana*), black hawthorn (*Crataegus douglasii*), and aspen (*Populus tremuloides*). This association generally has an average crown cover of 45 percent, with trees reaching up to 120 feet tall. A riparian shrub layer is sometimes present at lower elevations and is dominant further upslope where cold temperatures limit tree cover. Common species include willows (*Salix* spp.), red-osier dogwood (*Cornus sericea*), and Rocky Mountain maple (*Acer glabrum*). A number of exotic species have invaded riparian areas and often devastated the native vegetation. These include tamarisk (*Tamarix* spp.), Russian olive (*Elaeagnus angustifolia*), and sometimes Siberian elm (*Ulmus pumila*).

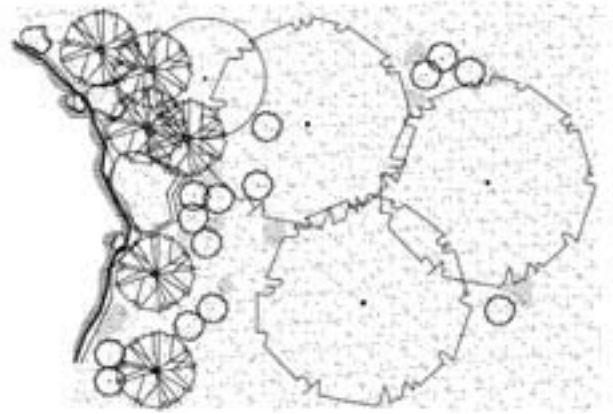
There are two general phases within this community. The dry riparian phase has shrub and perennial wildflower species similar to the coniferous forest, often the more shade-tolerant types. Where soil moisture is greater, the wet phase has some species found in the montane wet meadow community, including a number of columbine species (*Aquilegia* spp.). A variation on the dry phase is plants found in washes that may only have water several times a season. These plants are typically shrubs which are able to utilize water when it becomes intermittently available, but which also have a higher degree of drought tolerance than conventional riparian species, and would be more suitable for a low-water landscape. Examples of these species are desert olive (*Forestiera neomexicana*) and Apache plume (*Fallugia paradoxa*).

Interpretation of Data Sheets

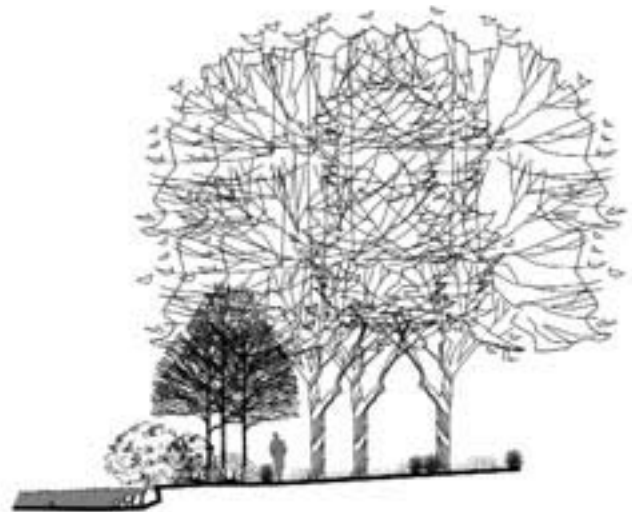
The individual species data sheets in this section are intended to appeal to modest botanical interests as well as the horticultural interests of the reader. Each data sheet contains information organized into four general categories: appearance (in botanical terms), natural habitat, landscape use, and comments. Appearance provides information that can be used to identify the key characteristics of the plant.

Natural habitat gives a picture of the environmental conditions to which the species is adapted. Landscape use presents the data, as much as is known, on plant features important to use in urban landscapes, particularly drought tolerance. Linking natural habitat and landscape use provides the basic information to achieve the goal of this book, to create sustainable water-conserving native plant landscapes based on plant communities that project a natural aesthetic quality. Finally, the comments section talks about how a given species can be used in the landscape in a conversational and more engaging manner.

For the convenience of the reader, plants have been organized into categories based on plant type: woody plants (trees and shrubs), forbs, grasses, and cacti. Within each broad category, plants are listed in alphabetical order based on the scientific name of the species. Also, for each perennial forb genus that includes three or more species, a detailed discussion of the general characteristics of the genus and its habitat is presented. Some individual categories are only associated with certain plant types, such as season for grasses and bark for trees and shrubs. The information is divided into categories that can be interpreted as shown on the following page.



Plan View - Typical Riparian Plant Association



Section - Typical Riparian Plant Association

Genus and species name

COMMON NAME

Latin family name (Common family name*)

PHOTOS: For trees and shrubs, three photos are intended to present a closeup of the leaves, any fall color, and an overall form of the plant. For the forbs, grasses, and cacti, generally three photos show a closeup of the plant, generally in flower, and a pulled-back shot shows the growth form, where possible.

Appearance

FORM/SIZE (separate entries for trees and shrubs): Overall shape, such as rounded, broad, etc., and general height range in feet.

ROOTS: Overall root form, such as taproot versus spreading.

LEAVES: Leaf color, shape and other particular characteristics such as scent, presence of hairs, etc., expressed in more common botanical terms. We suggest referring to a botanical text when a particular meaning is unclear.

INFLORESCENCE: Shape and color of the flower, characteristics such as scent, and season of bloom.

SEASON (grass only): Whether or not the grass is a warm-season, C4 species that is summer-active, or a cool-season, C3 species that tends to be spring- and fall-active and summer-dormant.

FRUIT: Type of fruit, such as nut, capsule, etc.

BARK (trees and shrubs only): Texture of the bark.

DORMANCY PERIOD (shrubs only): When the species is dormant, summer or winter.

WINTER (trees and shrubs only): Appearance during the winter.

Natural Habitat

HABITAT AND RANGE: General habitat in which the species is found (wet versus dry, meadows versus forest), and the states and provinces in which it is found.

ELEVATION: Elevation range in which species is found, generally higher in the north, lower in the south.

PLANT COMMUNITIES: The plant communities described in this text in which the species can grow.

SOIL: General soil in which the species grows.

EXPOSURE: How much sun the species receives in its native habitat.

Landscape Use

HARDINESS ZONES: USDA hardiness zone ratings approximate the lowest temperature a species can survive; this is a very approximate estimate based largely on anecdotal information and guesswork based on species distribution.

DROUGHT TOLERANCE: Five levels, low to high, where low is a riparian plant and high is one found in desert habitats and which can survive without water all season.

ESTABLISHMENT: Considerations in getting the species established in the landscape.

GROWTH RATE: (trees and shrubs only): How fast the tree or shrub grows in a season on average; most all perennials and grasses reach full size in two seasons, and cacti are generally slow in expanding.

BEST USE: How the species can be used in the landscape.

WILDLIFE VALUE: What wildlife species are attracted to the plants.

Comments

Conversational and colloquial observations about the merits of the plant.

* We follow Welsh (1987) regarding nomenclature except for family names, where we follow the recent convention of the “aceae” ending.

Sources

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