

Plant Communities, Mountains and Climate in Arizona

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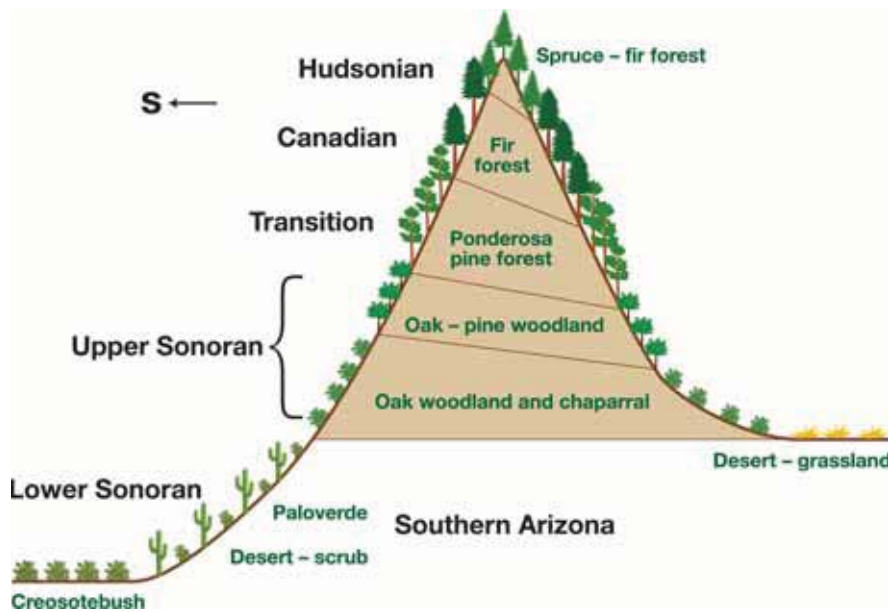


Figure 1. Elevation life zones along an elevation gradient in the southwestern USA (from Brown 1994).

As you travel about Arizona you may have observed the striking differences in the kinds of plants you encounter. Changes in vegetation abundance and patterns of distribution from one location to another reflect variations in landforms, geology, soils and topography. Across the state, vegetation also reflects differences in climate as you go east into New Mexico (Chihuahuan Desert where most rainfall occurs in summer) or west into California (Mojave Desert, with most rainfall in winter). The Sonoran Desert, situated between the Mojave and Chihuahuan Deserts, gets roughly equal amounts of summer and winter rainfall.

Moving from low to high elevation, distinct and predictable changes in plant communities occur (Figure 1). These changes can be observed as you drive between Phoenix and Flagstaff along I-17 and as you drive the Mt. Lemmon Highway in the Santa Catalina Mountains near Tucson. Arizona, and much of the western USA. It is characterized by what geologists call Basin and Range topography: a series of separate, roughly parallel mountain ranges separated by broad valleys. The forested mountains in these ranges are known as 'Sky Islands': islands of trees surrounded by seas of desert and grassland. Although not depicted in Figure 1, taller mountains, such as those in the San Francisco Peaks, will have an above-timberline Alpine Zone characterized by sedges, lichens, grasses and wildflowers. The rich diversity of Arizona plant life reflects the state's diversity of climate and landforms and the fact that patterns of plant survival and growth depend on environmental conditions.

The dramatic changes in climate and vegetation one sees moving higher in elevation in the Sky Islands mirrors the changes that occur with latitude within North America. Climbing 1,000 feet in elevation will produce

about a five degree F drop in temperature, roughly equivalent to driving north 300 miles. No wonder Arizonans living on the desert floor like to spend their summer weekends in the mountains!

Ecologists simplify the complexity of ecosystems by grouping plant species into functional groups based on similarities in growth patterns, growth potential and how they cope with water and temperature stress. Some plants endure the hottest, driest or coldest seasons as dormant seeds. When the rains come, their seeds germinate and the new plants mature rapidly, produce more seeds, then die. This all occurs within a month or two. Such plants, known as 'annuals' or 'ephemerals', escape the stressful periods by growing and completing their life cycle during narrow windows of opportunity when climatic conditions are favorable. Annual plants can be grasses or broad-leaved herbs known as forbs. The beautiful desert blooms that occur in years where favorable temperature and moisture conditions coincide are characterized by annual forbs.

In contrast to annuals, perennial plants live for many years. Perennial forbs and grasses arise from seed and go dormant or quiescent during unfavorable seasons. Herbaceous perennials typically die back to ground level each year, then produce new leaves and stems from bulbs, tubers, rhizomes or stolons when better conditions return. Perennial forbs often have showy flowers that add color to the landscape and contribute to desert blooms; additionally, they are an important food source for a variety of wildlife. Perennial grasses have dense, fibrous root systems which bind the soil, shielding it from wind and water erosion; they are also the foundation for sustainable livestock production.

Shrubs and trees are perennial plants that produce woody stems that carry over from year to year. Buds on these perennial stems are then

activated during periods favorable for growth (for example, in spring or early monsoon) to produce additional stems and new leaves. Shrubs, like trees, vary greatly in their growth potential. Some are small and diminutive, looking much like a large forb (e.g. snakeweed, burroweed). Others are tall with large canopies and look much like a small tree (e.g. catclaw). Shrubs and trees fall into two main groups: evergreen and deciduous. Leaves or needles on evergreen plants may live one or more years (in some pines, needles live for 40+ years!), whereas leaves on deciduous plants are shed during unfavorable times of the year, then produced anew from dormant buds during the next favorable period. Evergreens do lose their leaves, just not all at once as do deciduous plants. Examples of evergreens include creosote bush, jojoba, junipers, pines and some oaks. Mesquite, sycamore, elm, ash and other species of oaks are deciduous.

Shrubs on the desert floor are challenged with surviving the hot, dry conditions that occur year in, year out. Some, like creosotebush and jojoba, have special cell structures and chemistry that enable leaves to resist wilting, tolerate desiccation and still retain their functional capabilities. Others, such as mesquite, have normal leaves but develop deep and extensive root systems that enable access to stores of soil water deep in the ground and thus avoid the drought conditions occurring in shallower soils and aboveground. These plants demonstrate two very different approaches to solving the same problem.

In nature, there are clear trade-offs between the ability to tolerate stress and the ability to compete when conditions favor growth. In harsh environments, opportunities for rapid growth are infrequent, and plants that make large investments in leaves and stems have a high risk of losing them. Here, adaptations favoring stress tolerance are more valuable than those enabling rapid growth and large size. Higher elevations mean cooler temperatures and more rain; and lower temperatures reduce rates of evaporation and transpiration. So, the rain that falls and enters the soil persists longer, giving plants more opportunity to access it. As climatic conditions improve, the environment supports higher densities of larger plants adapted to take advantage of the more favorable growth conditions.

Why don't plants in high stress, low elevation environments occur at higher elevations where conditions for growth are more favorable? In milder environments, plants that can grow rapidly and achieve larger sizes out-compete slower-growing and smaller plants. The conservative growth strategies that enable survival in hotter, drier environments at lower elevations (short stature, canopies with fewer and smaller leaves) may prevent those plants from competing effectively with faster-growing plants that can achieve larger sizes. Conversely, plants that compete well in conditions favorable for rapid growth and large sizes cannot survive the acute stresses that are routine in harsher environments.

So, it is not that plants on the desert floor would not do well with more water and milder growing season temperatures. Rather, their confinement to the lower elevations partially reflects the fact that they are out-competed by other plants at the higher elevations. The transitions in vegetation with elevation also reflect differences in adaptations to cold. Many plants from the hotter, drier elevations might thrive at upper elevations during the growing season, but they cannot survive the cold winter temperatures. Trade-offs between stress tolerance and competitive ability help explain why the desert scrub and grassland communities that characterize low elevations give way to shrublands (chaparral) that in turn give way to woodlands (ecosystems dominated by small trees at relatively low densities) and ultimately to forest (dominated by large trees at high densities). The trees that characterize upper elevations eventually succumb to the colder temperatures and short growing seasons that occur above about 11,500 feet and give way to grasses, forbs and small shrubs. Notice in Figure 1 that the Upper Sonoran and Transition zone boundaries occur at higher elevations on south-facing slopes compared to

north-facing slopes. This reflects the fact that south-facing slopes get more direct solar radiation than north-facing slopes and are therefore warmer and drier.

Knowledge of how vegetation varies with elevation in Sky Islands will help us understand and predict the changes in vegetation that might accompany changes in climate. Slight changes in temperature or precipitation or a difference in the frequency and magnitude of extreme climatic events like frost or drought could substantially alter the composition, distribution, and abundance of species along the elevation gradients. Changes in climate will affect the nature of this zonation, with arid land communities potentially moving up in elevation in response to warmer and drier conditions. Plants currently on Sky Island mountain tops may be replaced by lower elevation plants as temperatures increase and snowpack and runoff decrease.

A wide-spread pinyon pine mortality in the Colorado Plateau in 2002-2003 could be a preview of things to come. The reductions in rainfall leading up to this die-off were comparable to those that occurred during the 1950s drought; however, pinyon pine die-off from the recent drought was far more extensive. This recent drought was more devastating because consistently high temperatures coincided with low precipitation. Interestingly, while pinyon pine mortality was high, co-occurring juniper trees were minimally impacted, for reasons not clearly understood. This underscores the need to improve our understanding of plant adaptations so we can anticipate and better predict the consequences of environmental change.

Climate, elevation and landform may determine what plants might potentially occur at a given location, but past land use and disturbance history often determine what plants actually occur there. While some landscapes might have once been capable of supporting forests, many are now savannas and annual grasslands because of periodic fire. Conversely, areas that were once grasslands may become dominated by desert scrub owing to historically heavy livestock grazing and the elimination of naturally occurring fires. Exotic plant invasions can also profoundly influence plant community dynamics. Non-native, invasive shrubs such as salt cedar have transformed the vegetation of many riparian landforms. Introduced non-native annual grasses such as red brome and Arabian schismus and perennial African grasses such as buffelgrass and Lehmann lovegrass threaten to transform lower elevation desert scrub and grassland ecosystems.

To learn more about these plants and others, visit your county extension agent, look over some plant field guides (many of which have drawings and photographs to help identify plants), and consult the Natural Resources Conservation Service's on-line Plants Database (<http://plants.usda.gov/>).

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