Elevation, elevation, elevation.

I remember as a kid from Texas taking family vacations to the western states, and we always wondered why the city limit signs listed elevation instead of population. Living in relatively flat country I guess I did not think too much about how high above sea level I was. Even later, as I worked in agriculture and natural resource management, the effects of elevation on climate, vegetation communities, etc... was not something I thought a great deal about, even though I knew it was important. Spending some time working in the Trans Pecos region of West Texas, and especially moving to Arizona changed that pretty quickly. In fact it became very important the first week I was here when we got a truck stuck at about 6,500 ft. Digging it out reminded me that oxygen is precious. We weren’t that high up but I had been living at about 300 ft above sea level in College Station for 9 years. So yes, I got a little winded and no, it did not take long to get that way. Later that year I returned to Texas A&M to help out with an oral exam for a grad student. One of the questions I asked involved designing an experiment to obtain vegetation samples on a landscape and I gave her a set of conditions; i.e. that the land was in a semi-arid region, it had 3 major ecological sites, altitude ranged from 5,000 to 7,000 ft, etc... She stratified everything pretty well but did not really address the elevation component until I asked follow up questions. So, we walked though some of the effects of elevation and why accounting for it was important.

And why is it important? Well, let’s start with my “getting stuck” story. We all know the air is “thinner” at higher elevations and if you have ever moved to or visited a place that is higher above sea level than where you live; that becomes evident. Even a short brisk walk may find you out of breath. The air pressure is lower so the molecules are farther apart, especially oxygen molecules. At least it seems that way. The fact that the air is less dense is also why the air is cooler. This is referred to as “adiabatic cooling”, i.e. no heat is actually released but the temperature drops due to the lower pressure. On a local scale, temperature drops about 4 to 5°F for every 1,000 ft gain in elevation. Meteorologists refer to this as the “lapse rate”. So if the temperature on a clear day at the bottom of the lift at Snowbowl (~9,000 ft) is 25°F, it will be approximately 14°F at the top (11,500 ft). Even within a given elevation zone, slope and aspect will affect the amount of sunlight, precipitation, etc... and so there will be micro-climates that vary with topography. South slopes receive more sun than north slopes. Range sites that are more perpendicular to the sun receive more solar radiation than those on slopes that are more parallel to the sun’s rays. This amount changes during the day and with the season. Wildland firefighters pay attention to these factors as they can affect fuel moisture and fire behavior.
Regionally, average temperature decreases by about 1^\circ F for every 330 ft increase in altitude. For instance in Figure 1 we see the climatic differences between Yuma at approximately 100 ft above sea level and Greer at approximately 8,500 ft. Average temperature in Yuma is 75^\circ F and at Greer it is 44^\circ F, a difference of 31^\circ. If we do the math, 8,400/330 = 25; and that is close enough for government work. Interesting that the January average temperature for Yuma and the July average for Greer are almost equal. Higher elevation sites are not only cooler but will usually be wetter. As wet air rises, expands, and cools it will reach its dew point (temperature at which condensation occurs) and form a cloud. If these condensed water particles merge and become large enough they will fall as rain. For comparison, Yuma averages 3 inches of rain per year while Greer averages 23. OK, so elevation affects climate. Why does that matter? It matters to a range/livestock specialist because climate affects vegetation and vegetation affects animals.

Those of you reading this who are not familiar with the state may be surprised to learn that Arizona has significant variation in elevation, precipitation, and vegetation (Figure 2). Humphreys Peak northwest of Flagstaff, at 12,633 ft is the highest point in the state and at only 70 ft above sea level, San Luis on the Colorado River at the border with Mexico is the lowest. We of course have true desert with less than 5 inches of rain per year but also dense forest with over 25 inches. We have mountains with tundra above the timberline. We have almost “jungle” conditions along some riparian corridors. Add to that list, grasslands, mountain meadows, and the largest contiguous stand of ponderosa pine in the world and one can understand why we say that Arizona is not just sun, sand, and cactus. In addition to large scale vegetation communities varying with elevation, certain individual plant species are good small scale
indicators of elevation just as certain plants can be used to delineate wetlands or clay soils, etc... For instance, the saguaro cactus is most often found below 4,000 ft. If you do find them above this level they will be on south facing slopes. Paleobotanists use such characteristics to infer past climates at certain sites and at what distribution or elevation certain plants were found in the past.

Earlier I stated that elevation affects vegetation and vegetation affects animals. Actually, elevation also directly affects animals. We have all heard of altitude sickness. In humans, this illness presents a combination of symptoms such as headaches, nausea, and vomiting. High altitude may also cause a decrease in food intake, and if combined with increased physical exertion, a negative energy balance. Extreme altitude can affect grazing animals as well (not just old baldheaded fat men with shovels). The llama is a grazing animal adapted to high elevations. They have red blood cells with high concentrations of hemoglobin, the protein responsible for binding oxygen. They also have lower concentrations of organic phosphates in the blood. These compounds decrease the affinity of hemoglobin for oxygen. Animals living at high elevation will thus experience different environmental and forage conditions than their flat land cousins and they will have the physiological adaptations to handle it.

Now let’s see if we can put all this information into a range management perspective. Here on the V Bar V Ranch, we have an approximate 3500 ft elevation change and this translates into 3 distinct vegetation/climate zones (Figure 3). The elevation gradient is one of the characteristics that make the V Bar V such a great place to do range research. If we want to stratify vegetation types for some experimental design or examine the interactions between climate and grazing, we have 3 built-in treatments (Table 1). From a ranch management

<table>
<thead>
<tr>
<th>Vegetation</th>
<th>Elev.(ft)</th>
<th>Precip. (in)</th>
<th>Temp. (F)</th>
<th>First Frost</th>
<th>Last Frost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Desert Shrub</td>
<td>3,500</td>
<td>10</td>
<td>60</td>
<td>3-Nov</td>
<td>3-Apr</td>
</tr>
<tr>
<td>Piñon-Juniper</td>
<td>5,000</td>
<td>15</td>
<td>55</td>
<td>18-Oct</td>
<td>7-May</td>
</tr>
<tr>
<td>Ponderosa Pine</td>
<td>7,000</td>
<td>20</td>
<td>45</td>
<td>1-Sep</td>
<td>10-Jun</td>
</tr>
</tbody>
</table>

Figure 3. Vegetation Types and Elevation: V Bar V Ranch
Elevation, elevation, elevation…..continued

standpoint, we use the elevation gradient to plan grazing through the year in order to provide nutrition to the cow herd. We graze the lower, warmer desert country in the winter with late pregnant and early calving cows. We move to mid-elevation piñon-juniper during breeding and mid-lactation to take advantage of cool-season grasses during this critical period, and then we move up to the higher, cooler pine country for late lactation and weaning in late summer to early fall. Dry cows graze downhill during fall and early winter. So, for grazing management, elevation is a good thing. And when you get right down to it, who cares how many people live in a town anyway?

Other tidbits of information about elevation…

Aviation

Density altitude is a term that sometimes causes confusion to the uninitiated. A high density altitude is NOT a good thing. Density altitude is defined as the pressure altitude corrected for non-standard temperature variations. And while this is a correct definition, my definition is perhaps more appropriate: DENSITY ALTITUDE IS THE ALTITUDE THE AIRPLANE THINKS IT IS AT, AND PERFORMS IN ACCORDANCE WITH THIS COMPUTED VALUE.
Suppose an airport is situated at an elevation of 3,000 feet. It is possible with a low pressure system and hot temperatures for this airport to have a density altitude of more than 6,000 feet due to the effects of the pressure and temperature. An airplane operating at the 3,000-foot airport on a day with a 6,000-foot density altitude would have the performance normally found when flying at 6,000 feet during a day with standard conditions.

From: Mountain Flying LLC

Cooking

At altitudes above 3,000 ft...
...preparation of food may require changes in time, temperature, or recipe. The reason, lower atmosphere pressure due to the thinner blanket of air above. At sea level, the atmosphere presses on a square inch of surface with a weight of 14.7 pounds, at 5,000 ft with 12.3 pounds, and at 10,000 feet with only 10.2 pounds- a decrease of about 1/2 pound per 1,000 feet. This decreased pressure affects food preparation in two ways:

1. Water and other liquids evaporate faster and boil at lower temperatures.
2. Leavening gases in bread gases in breads and cakes expand more.
The boiling point is the temperature at which the pressure of the water vapor equals atmospheric pressure and the bubbles of water vapor are able to break through the surface and escape into the air. If the atmospheric pressure is less, the temperature required for water to boil is less. Therefore, cooking food in water boiling at this lower temperature takes longer. A "3-minute egg" will take more time. Also, a bowl of boiling soup is not as hot.
Elevation, elevation, elevation…..continued

Table: Approximate boiling temperatures of water at various altitudes.

<table>
<thead>
<tr>
<th>Altitude</th>
<th>Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sea Level</td>
<td>212 degrees F</td>
</tr>
<tr>
<td>2,000 ft.</td>
<td>208 degrees F</td>
</tr>
<tr>
<td>5,000 ft.</td>
<td>203 degrees F</td>
</tr>
<tr>
<td>7,500 ft.</td>
<td>198 degrees F</td>
</tr>
<tr>
<td>10,000 ft.</td>
<td>194 degrees F</td>
</tr>
</tbody>
</table>

From: Colorado State Extension

Driving

When driving at high altitudes, remember the following:
Thin mountain air can affect your car’s engine and diminish your acceleration and climbing power
The potential for overheating is greater
The potential for vapor locks is greater
During very hot weather, gasoline can simmer or boil and turn to a vapor, developing a condition called vapor lock. Your engine stops running or locks up. If your engine becomes vapor locked, turn it off and let it cool.
According to experts in altitude sickness prevention, the effects of high altitude can be decreased by following these recommendations:
Drink two to three times more fluids than usual—water and juices are best.
Avoid alcohol and minimize caffeine.
Decrease salt intake.
Eat frequent small meals.
Take frequent breaks.

From: DriversEd.com
John’s Plant of the “week”

In the vast area of earth we call rangelands, many don’t see the smaller plants greening up and beginning their growth. Annual plants like filaree and annual cool season grasses are among some of the first to sprout and push through the soil. For many, the first sign of spring is when we see the tall grey branches of the cottonwood start to change color. A tinge of yellowish green starts the process, and then in a matter of days the tree is full of leaves. This month I will discuss the mighty cottonwood, its use in cultures that preceded European settlement and also its place in present day.

The Basics

The common name is Fremont’s Cottonwood the scientific name *Populus fremontii*, and it is distributed throughout the Southwest, extending from California eastward to Nevada, Colorado, Arizona, Texas, New Mexico, and southward into Mexico. Cottonwood occurs in alluvial bottomlands and stream sides at elevations less than 6000 ft. Cottonwood requires a bare gravel or sand substrate with adequate moisture for germination and development. Cottonwoods grow very rapidly when their roots are in contact with the permanent water table; they can grow as much as 12 to 18 feet in 3 years.

Fremont's cottonwood range from 36 to 105 feet in height, and trunk diameter ranges from 1 to 5 feet. The bark is smooth in younger trees, becoming deeply furrowed with whitish cracked bark with age. The leaves are heart-shaped with white veins and coarse serrate teeth on the margins. Their shape causes them to flutter in the wind. These trees are dioecious, meaning there are male plants and female plants. Cottonwoods bloom from March-April. The fruit is an achene, which is attached to a silky hair, en masse looking like patches of cotton hanging from the limbs, thus the name cottonwood. The seeds are wind dispersed.

Native American Cultural Uses:

Here are some ways the cottonwood was used by Native American cultures:

The Hopi Indians of Arizona consider the cottonwood tree sacred and carve Kachina dolls from the roots of the tree. They believe the rustle of the wind through the quaking leaves to be the gods speaking to people.

Several California tribes used *Populus* roots to make loosely twined baskets. The Hupa, from Northern California, use cottonwood roots to begin making twined baskets. The Maidu and Yokuts Indians use cottonwood twigs in their basketry.

Chumash skirts were made of fibers of *Populus* inner bark. Cordage, made from the inner bark of cottonwood or milkweed, held the rest of the fibers hanging freely. Sometimes small teardrop-shaped pieces of asphaltum, shell beads or *Pinus* seeds were used as weights to make the fibers hang properly. Wintun also used *Populus* fibers for skirts and for padding baby cradles.

The sweet and starchy sap can be consumed raw or cooked. The bark is bitter, but edible. It can be scraped off and eaten, cooked in strips like soup noodles, or dried and powdered as a flour substitute.
The inner bark of cottonwoods and aspens were used for man and horse in hard times. Some Indians preferred it because of its sweetness. The active biochemical constituents are salicin and populin, the precursors of aspirin that are useful wherever a fever needs reducing or an anti-inflammatory is appropriate.

The bark is the most effective part for tea but is rather bitter; for this reason the leaves are often preferred. Leaf buds make an excellent ointment for burns and skin irritations.

A wash of the bark is applied externally for cuts, bruises, abrasions, burns and fetid perspiration, as well as healing chafing sores on horses. A poultice can be used for sprains, muscle pain, and swollen joints. A salve can be made that cleanses and conditions the skin when used regularly. Taken internally, it is an anti-inflammatory agent, reduces fever, indigestion, aids coughs from colds, expels worms and intestinal parasites, is effective against scurvy, heart troubles, back pain, excessive menses, urinary tract infections, is a diuretic, and is used to prevent premature birth.

Post European Settlement:

Riparian ecosystems, where Fremont’s cottonwood grows, offer water, shade, and food for wildlife and domestic livestock. The leafage, twigs and shoots of Fremont cottonwood are browsed by all domestic grazing animals and deer. The twigs are cropped especially close by sheep, goats, and deer. The browse rating for cottonwood is good to fair for goats; fair to poor for sheep and deer; poor for cattle; and useless for horses.

Recreational use of the riparian zone is many times that of other habitats. People are drawn to the cool, shady environment along flowing streams for camping, picnicking, hiking, birding, photography, hunting, and fishing. These areas contain water, interesting plants and animals, shade, and numerous other enjoyable features in the otherwise arid and semiarid environments.

The impact of recreational use on wildlife varies with the season and with the type, intensity and duration of use. Construction of trails, picnic tables, and docks encourages recreational use and increases conflict with wildlife. Recreational use may also reduce water quality because of proliferation of human wastes.

Western riparian ecosystems have been greatly altered by human activity. Riparian forests have been reduced to fragmented, discontinuous patches because of human intervention. For example, estimates are that 70 - 90 percent of the natural riparian ecosystems in the U.S. have been lost to human activities. Regional losses in these ecosystems have been estimated to exceed 95% in Arizona. Many factors have contributed to these resource losses, including urbanization, alteration of stream flows through dam construction and ground-water withdrawal, modification of biotic conditions through grazing, agriculture, and introduction of non-native species; and alteration within watersheds.
The Rimrock Report

**John’s Plant of the “week”…continued**

**Here and Now:**

On the V Bar V Ranch we are monitoring a particular riparian area. Recent evaluations have determined that it is in a Non Proper Functioning Condition. One of the discussions between the Forest Service and the University “ologists” is about the cottonwood. Are enough young plants being recruited, are the old trees too thick to survive, are we receiving proper flood events to enhance recruitment? While the discussion ranges from global climate change to OHV use and grazing, we all agree that it is imperative to maintain the health of riparian ecosystems. We agree it is the ecosystem that is important. We don’t key in on saving cottonwood trees. We agree we may use them as indicators of ecosystem health.

Recently, I brought a group of Camp Verde FFA students to Russell Spring. Their demeanor changed as we descended out of the dry chalky hills into the cool cathedral like feeling established by the tall cottonwood trees. The laughter flowed melodious matching the gurgling water along the rocks and pebbles. The banter of teenagers changed, becoming kind hearted as the harsh dryness of the surrounding hills was replaced with the cool moist riparian air (it could happen, couldn’t it?). The point I want to make is our youth sensed the rarity of this riparian area in a dry and sometimes harsh land. They admittedly place value on places like this and want to ensure they are kept in good condition. They were interested in volunteering to help with restoration efforts that may be needed to make this happen.

While our culture doesn’t use the cottonwood to heal injuries or ailments or carve kachinas, we still value it. To some it signals the arrival of spring others enjoy the cool shade it provides in the heat of summer, or maybe as a great jungle gym to climb on. In one of the cottonwood trees in the riparian area mentioned earlier a pair of hawks fledge their young.

To find more information on this and other culturally significant plants check out the USDA Natural Resources Conservation Service website: [http://plants.usda.gov/java/factSheet?cultural=yes](http://plants.usda.gov/java/factSheet?cultural=yes)
From the “You can always tell a Texan but you can’t tell ‘em much” department:
As much as I love Arizona I am still considered a foreigner here and catch a lot of good natured grief about it. A couple of times I have had someone remind me that Palo Duro Canyon in the panhandle of Texas is just a ditch compared to the Grand Canyon. To which I reply that: “I guess we just got a handle on our erosion problem before y’all did”.

The View from the Rim

Well if you like college basketball this was a great version of March Madness. Congratulations to the TX A&M women’s team on their first ever national championship. I used to talk to coach Blair in the McDonalds on the south side of campus every now and then. During the season he would usually have some tickets in his pocket and invite people to come to the games. He and the players from the last 8 years are a great example of what hard work will do for you. He probably does not have to give away tickets now. On the men’s side, the Wildcats made great strides and the Aggies have something to build on. Next year should be fun. We were again late getting this issue out so it is mid-April and I am watching it rain. There is snow down to about 4,000 ft. I drove through snow on the way home from the AZ/UT Range Livestock Workshop. We had about 125 people all 3 days including the field trip. Rob Grumbles and his crew put on another great workshop. Plans are already being discussed for next year. In March we finished our 3-part series of monitoring workshops for ranchers on the southern end of the Coconino National Forest. About 20 were in attendance to hear the “now we have monitoring data, how do we use it” presentations highlighted by Reuben Verner from the Verde Ranch and Bob Prosser from the Bar T Bar. They both gave great practical ranch management examples of how to collect and use monitoring data. The individual mineral intake study is ongoing. Jim Sprinkle and I are working out the kinks of electronic equipment, etc… and now know more than we really want to about solar panels, load cells, signal attenuation… We received a grant from the Arizona Cattle Industry Research and Education Foundation to improve the Blue Collar Plants website, thanks to those folks we should be adding plants and images over the summer. Range Rocks! carries on, we had the students from Northpoint HS on the ranch again and the second week, they taught range science to about 75 elementary students from Villa Montessori in Phoenix. We should finish a couple of studies this summer, one being the Phygrow validation work with TX A&M and the other being the climate/grazing effects study on soil C and N, using portable NIRS. Plans are to continue the fecal NIRS diet quality work on the ranch and possibly start collecting individual animal samples to continue the early pregnancy detection work with this technique. The planning committee for the AZ SRM summer meeting is in full swing. Dates are Aug 3-5 at the V Bar V. Should keep us busy for awhile.

Till next time,

Doug